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Cultural Evolution and the Interethnic Transfer of Female Genital Modification in the African Diaspora and Indigenous Populations of Colombia

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Abstract We present a quantitative account based on ethnographic and documentary research of the prevalence of female genital modification (FGMo) occurring in the African diaspora and Indigenous populations of Colombia. We use this data to test hypotheses concerning the cultural evolutionary drivers of costly trait persistence, attenuation, and inter-group transmission. The uptake of FGMo by Indigenous populations in Colombia is consistent with frequency-dependent hypotheses for the social transmission of the FGMo trait from the African diaspora population in the time period following the era of slavery in Colombia. The prevalence and severity of FGMo declines with level of sociocultural integration into mainstream Colombian culture. Our results provide empirical support for the cultural evolutionary models proposed by Ross et al (2015) to describe the transmission dynamics of FGMo and other costly traits. Analysis of costly trait dynamics contributes knowledge useful to applied anthropology and may be of interest in policy design and human rights monitoring in Colombia and elsewhere.

Keywords Female Circumcision · FGM · Cultural Evolution · Social Transmission · Costly Traits · African Diaspora · Colombia

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1 Introduction

We intend this research report to advance empirical understanding in two literatures. To begin: 1) we provide a quantitative account of the frequency, severity, and types of FGMo (Female Genital Modification)[1] occurring in the African diaspora and Indigenous populations of Colombia, then 2) we conduct an empirical test of hypotheses concerning the cultural evolutionary mechanisms which may drive the persistence, transmission and attenuation of costly cultural traits, such as FGMo.

Recent United Nations reports (MDG-F 2010; UNFPA 2011) indicate that FGMo was adopted and is still being practiced by the Emberá Chamí people of Colombia. While these reports were some of the first widely known publications to demonstrate that FGMo was present in non-African, non-Islamic cultures, Colombian anthropologists and journalists have described the practice in field notes since the 1960-1970s (Cayón 1973; Reichel-Dolmatoff 1960), and into the 2000s (Zuluaga Gómez 2007; Zuluaga Gómez and Granada Echeverri 1997). The earliest documentation of practices similar to FGMo

[1] Also known as female circumcision, female genital mutilation, and *ablación de clitoris*, *ablación femenina*, *clitoridectomía*, or *clitoristomía*, in Spanish. There has been concern over the terminology one should use when discussing this practice. We purposefully avoid using the term "mutilation" in the text of this paper, as we did during interviews with respondents, as we feel that the use of the term "mutilation" is unduly value-laden and insensitive to the women who have endured the practice. Portraying females as mutilated beings is likely to be offensive and disrespectful to many, and may decrease the willingness of respondents to discuss the practice with researchers. Likewise, we feel that it is inappropriate to distance the practice of female genital modification from male genital modification (circumcision), as such an action seems to validate one type of non-consensual amputation of genital tissue (common in "Western" culture) while stigmatizing a similar practice in other cultures. Consequently, we use the more neutral term FGMo broadly, to include clitoral and labial excision, as well as similar but less damaging practices (called Category IV FGM by WHO (1998)), such as the application of heated metal instruments to burn the clitoris, or the vaginal application of chemicals such as camphor, salt, and alcohol.

in the Indigenous populations of Colombia date to the late 1780s, when explorer Joseph Palacios de la Vega noted that some Indigenous would sever the hymens of infant girls, in order to "prevent them from feeling such pain when they lay with men in the future" (Reichel-Dolmatoff 1955:23).

Despite this ethnographic and historical record, little is known about the origins of the FGMo practice in Colombia. Ethnographers state in passing that the origins of the practice are uncertain, but are likely to be external to the Indigenous populations (Cayón 1973; Reichel-Dolmatoff 1960). In conversations with ONIC (Organización Nacional Indígena de Colombia) in Bogota, Colombia, it was argued to us that FGMo was not a traditional practice of the Emberá Chamí, and was instead the result of contact during the colonial period. ONIC personnel noted that the tools used to perform FGMo were not present during pre-contact times, and were acquired only during the period of colonization. These arguments are consistent with the claims of anthropologists who have conducted long-term research in Indigenous Colombian communities; for example, Cayón (1973:327) has argued that the genesis of FGMo in the Indigenous of Colombia appears to be "a case of cultural diffusion, although we lack sufficient data to establish the group from which the practice originated."

The social transmission of FGMo in Colombia provides an opportunity to investigate the dynamics of costly trait persistence, transmission and attenuation, with implications for effective social policy design and human rights advocacy. We investigate if the inception of the FGMo cultural trait in the Emberá Chamí and other Indigenous groups in Colombia can be linked to the cultural diffusion of the FGMo trait from the African diaspora, whose ancestors were brought into the country during the Atlantic slave trade (Gilberto-Murillo 2001). Further, we present qualitative and quantitative evidence on the prevalence, severity, and types of FGMo practices utilized (historically and contemporaneously) in the Afrocolombian and Indigenous populations of Colombia. We utilize these data to test the predictions of recently developed cultural evolutionary models of FGMo, and more generally, costly trait evolution (Ross et al 2015).

We begin by briefly outlining the ethnographic background and history of the Emberá and Afrocolombian peoples. Following this, we describe recent developments in cultural evolutionary modeling proposed to explain the origins, persistence, and transmission dynamics of the FGMo cultural trait (Ross et al 2015). We then detail our study design, methodology, and results, and conclude with a discussion of the relevance of our results to both theoretical models of cultural evolutionary dynamics and applied anthropology.

1.1 Afrocolombians and the History of Slavery in Colombia

During the late 1500s through the 1800s, Spanish colonizers in Colombia imported hundreds of thousands of African slaves in order to replace the work performed by the rapidly declining Native American population (Benson Latin American Collection 1779-1852; Gilberto-Murillo 2001). These African slaves labored primarily in gold and emerald mines, sugar cane plantations, cattle ranches, and haciendas—most notably in the coastal states of Chocó and Cauca. With the abolition of slavery in Colombia in 1851, the descendants of African slaves settled into various areas. On the Pacific Coast, the African population took refuge in the isolated forests of Chocó, which today remain predominantly Black-Afrocolombian areas with strong African cultural traditions (Gilberto-Murillo 2001). Throughout this history there was interaction and cultural admixture between Afrocolombians and the local Indigenous populations, opening the possibility of cultural trait transmission.

The Atlantic slave trade brought populations from several dozen ethnic groups and different regions of West Africa (Midlo Hall 2007). In an effort to better understand the ethnic and tribal background of the imported slave populations, Cantor (2000) identifies twenty-three distinct groups represented in the records of 166 slaves alive in the year 1759 in the historic province of Citará.[2] Cantor's groups represent a mixture of ethnic groups, language groups, and groups of individuals from a shared geographical area. For instance, in the historical record, the word *Mina* refers to two distinct African ethnic groups, as well as to the country of Ghana, or even the Gold Coast more generally. These ambiguities complicate interpretation, as we wish to use the contemporary levels of FGMo in Africa in these ethnic groups to infer that FGMo was likely to have been imported into Colombia during the slave trade. In Table 1, we reproduce Cantor's list and supplement his records with data on the contemporary prevalence of FGMo in these ethnic groups. In cases where we could not find evidence of an ethnic group contained in Cantor's list, but found reasonable evidence (especially in SwissAid 2007) that the name listed made reference to a geographical area, language family, or derived ethnic group, we report published FGMo prevalence rates for these groups, and include their names in parentheses. It is notable that FGMo is practiced contemporaneously

[2] Citará is now the city of Quibdo, in the district of Chocó.

in at least 11 of the 23 ethnics groups reported by Cantor (2000), with prevalence rates of more than 75% in 5 contemporary populations (Table 1).

[Table 1 about here.]

While data on the time depth of FGMo in Africa is difficult to locate (Mackie 1996), there is solid evidence that FGMo was practiced in Africa for several hundreds of years prior to the Atlantic slave trade, especially in Egypt (Kouba and Muasher 1985). There is also evidence that FGMo was linked to the intra-African and Arab slave trades prior to the peak of the Atlantic slave trade. For example, in 1609, Dos Santos reported that in Mogadishu, Somalia, there was a custom in which slave traders would "sew up their females, especially young slaves to make them unable for conception, which makes them sell dearer... for their chastity" (Freeman-Grenville 1962:180; cited in Wilson 2013). Such evidence gives us reason to believe that the practice of FGMo would have been imported into Colombia during the Atlantic slave trade.

1.2 The Interactions of Afrocolombians and Indigenous Populations

Afrocolombian historians and political leaders (Gilberto-Murillo 2001), as well as anthropologists working with Indigenous groups in Colombia (Cayón 1973), have documented that in the time period following the cessation of slavery in Colombia a close relationship formed between the descendants of escaped slaves and Indigenous communities in the remote areas of the Pacific coast. For instance, Cayón (1973) argues that the knowledge transmitted from the Indigenous population to the Afrocolombians played an essential role in the survival and development of the early Afrocolombian groups. The Indigenous populations were the source of information needed to subsist in the tropical forest environment. The relations formed sometimes amounted to *compadrazco*, or co-parenting/god-parenting relationships (Cayón 1973). The closeness of interethnic relations in the Chocó provides reason to believe that the cultural diffusion of the FGMo trait from the Afrocolombians to the Indigenous of Colombia would have been possible, assuming as we do that FGMo was present in the Afrocolombian population.

1.3 Evolutionary Accounts of FGMo Emergence, Transmission, and Persistence

To better understand the cultural dynamics responsible for the emergence and persistence of costly traits such as FGMo, Ross et al (2015) derive formal mathematical models from evolutionary anthropological theories which link population sex ratios, gender roles, power dynamics, and marriage markets (Kokko and Jennions 2008) to cultural practices, such as bride price, dowry and divorce. These models aim to disentangle the forces hypothesized to be responsible for the origins of the FGMo trait [virginity assurance (Buss 1989), and/or costly signaling (Grafen 1990; Zahavi 1975)], from those which cause its persistence in contemporary populations [frequency dependence (McElreath et al 2008)].

Ross et al (2015) contend that the practice of FGMo can be understood as arising from the constraints of marriage markets in much the same way as bride-wealth and marriage payments (Anderson 2003; Bell and Song 1994; Borgerhoff Mulder 1995; Chiappori et al 2002). During the origins of FGMo, parents may have chosen to subject their daughters to the practice in order to ensure and signal their virginity, and thus enhance their marriageability, especially to high status marriage partners. Furthermore, insofar as women who have undergone FGMo practice more sexual restraint—possibly as a consequence of the associated social customs—FGMo might also signal higher paternity certainty to a prospective groom, and thus increase his likelihood of selecting a circumcised woman over a non-circumcised woman. However, as soon as some individuals or their families begin to practice FGMo in order to gain higher standing in marriage markets, others would have an incentive to adopt the practice in order to be competitive. Such cultural dynamics would lead to a high prevalence of the FGMo practice. At equilibrium, the overall ranking of females in the marriage markets would be unchanged relative to the pre-FGMo state, but the health status and fitness of all females would be reduced.

In its more extreme forms, such as infibulation or clitorectomy, FGMo can endanger the lives of women, hinder their reproductive potential, and increase the risk of maternal complications during childbirth (Mackie 1996). In the indigenous Embera Chamí of Colombia, FGMo in the form of clitoral excision is sometimes practiced on the very young (newborns), frequently leading to infection and sometimes mortality (MDG-F 2010). The models advanced by Ross et al (2015) demonstrate how frequency-dependent cultural dynamics can account for the persistence of FGMo in populations, despite the fact that the FGMo equilibrium is sub-optimal for all women in terms of health and reproductive outcomes. Frequency-dependent maintenance of cultural traits is similar to what Mackie (1996) calls "belief traps." Belief traps are self-reinforcing cultural norms that are hard to attenuate because the perceived costs of testing the beliefs by not participating are too high to risk. For ex-

ample, Mackie (1996:1009) cites ethnographic accounts of infibulation in Nigeria being practiced due to a belief that "a baby will die if its head touches the clitoris during delivery" (Lightfoot-Klein 1989:38-39). Once such a belief becomes widespread, few individuals will choose to challenge it due the severe costs associated with error.

Ross et al (2015) extend Mackie's concept of belief traps in the context of FGMo to include beliefs related to paternity certainty, virginity assurance and female marriageability. If there is a widespread cultural belief that FGMo is necessary to ensure pre-marital virginity and post-marital paternal certainty, then the practice may be maintained by social pressures and parental concerns for the marriageability of their offspring, despite its costs. Ethnographic accounts of FGMo derived from intensive interviews with mothers and FGMo practitioners in rural and urban Egypt (Ericksen 1995) find that FGMo is practiced for this very reason. Notably, it is irrelevant whether or not the practice actually attenuates women's sexuality or assures virginity or paternal certainty; so long as parents believe that their daughter's chances of marrying a desirable individual are determined by her value as a potential mate in the eyes of partners who believe that FGMo is necessary for a successful marriage, they will continue the practice of FGMo. In Mackie's terminology, "as soon as women believed that men would not marry an unmutilated woman, and men believed that an unmutilated woman would not be a faithful partner in marriage, the convention was locked in place" (Mackie 2000:pg. 264).

Evaluating the role of frequency-dependent cultural dynamics in FGMo trait diffusion and persistence would be an important step in advancing knowledge relevant to creating effective and culturally sensitive FGMo abatement programs. As Mackie (1996) demonstrated is his research on Chinese footbinding, once the dynamics underpinning the persistence of a costly cultural trait are empirically understood, effective, non-putative interventions become possible, with the possibility that damaging cultural practices can be ended rapidly.

Mathematical models (Ross et al 2015), ethnographic evidence (Ericksen 1995), and verbal reasoning indicate that frequency-dependent cultural dynamics are likely to be a key force maintaining the practice of FGMo. However, there have been few empirical studies which test that assertion. Cultural trait dynamics during cross-cultural migration in the context of diaspora communities offer opportunities for such tests. A small group of FGMo practitioners migrating into a non-FGMo practicing population would be expected lose the FGMo cultural trait, conditional on sufficient sociocultural integration and on the reasonable marriage prospects of non-circumcised females in the host country. Likewise, non-FGMo-practicing individuals migrating into FGMo-practicing areas would be apt to adopt the FGMo practice, conditional on sufficient sociocultural integration and a reasonably strong linkage between the marriage prospect of females and the uptake of the FGMo practice.

1.4 FGMo in the African Diaspora

While the practice of FGMo in Africa has received significant scholarly attention, there has been much less research on FGMo in the African diaspora (Kaplan et al 2008). Qualitative research (IOM 2009; Kaplan et al 2008), freelance news reports (WHO 1998), and testimony from affected women (Ngehndab 2012), have indicated that FGMo is, in fact, practiced regularly in the African diaspora; however, there is little data on the frequency of the practice in diaspora populations (IOM 2009; WHO 1998). This lack of quantitative data hampers understanding how sociocultural integration into host countries affects the likelihood of abandonment or attenuation of FGMo.

A study of the Somali diaspora in London in the early 2000s is one of the few to investigate the effects of social-cultural integration into a host country on the likelihood of abandonment of FGMo (Morison et al 2004). Girls less than six years old who arrived in London before the ritual age of circumcision were much less likely to be circumcised than girls (>11 years old) who arrived after the ritual age of circumcision (42% vs 91%). More than 50% of Somali males who arrived in London when they were older than 11 years wanted a circumcised wife, while less than 25% of males who arrived in London before age 11 wanted a circumcised wife. In general, Morison et al (2004:pg. 75-76) found that "living in Britain from a younger age appears to be associated with abandonment of female circumcision and with changes in the underlying beliefs on sexuality, marriage and religion that underpin it." Individuals who held to the traditional view of FGMo were predominantly "males, older generations, new arrivals and those who show few signs of social assimilation." Such findings appear to support the assertion that the frequency of local beliefs and attitudes concerning FGMo augments the likelihood of abandoning the traditional cultural practice.

The Morison et al (2004) study design suffers, however, from several methodological issues: the sample was small and was constructed using snowball sampling, which has the potential to bias outcomes and lead to incorrect generalizations (Biernacki and Waldorf 1981). These concerns are especially problematic

because the authors primarily used university students (who we might expect would differ from other subpopulations in terms of social attitudes and beliefs) as seeds for the sampling methodology. Additionally, the effects of sociocultural integration are confounded to some extent by both the volitional nature of the migration, and possibly by the immigration policies of the UK. Somalis who were permitted by the UK government to reside in England might be very different in their *a priori* social attitudes and beliefs from Somalis not permitted to reside in England. Finally, fear of legal repercussion for FGMo in the UK may play a larger role in driving the abandonment of the practice in the diaspora population than frequency-dependent cultural dynamics and sociocultural integration *per se*. To address these methodological issues and produce a stronger test of the hypothesis that sociocultural integration modulates the transmission and attenuation dynamics of the FGMo practice we have conducted a similar study in the African diaspora of Colombia.

The African diaspora in Colombia provides a more suitable context in which to study the role of frequency dependence, sociocultural integration and other ecological factors on the transmission dynamics of FGMo for three reasons: 1) the Afrocolombian and Indigenous populations in Chocó and Risaralda are *de facto* self-policing communities. Individuals are more likely to openly discuss the practice of FGMo honestly than individuals in other African diaspora communities, and are less likely to have changed their behaviors as a result of fear of legal repercussions; 2) the African diaspora in Colombia is composed almost entirely of the descendants of slaves imported into Colombia during the Atlantic slave trade, with little in-migration since. Neither the temporal window in which migration occurred, nor contemporary immigration law and policy serve to confound inference as might be the case in the African diaspora of European countries; and finally, 3) in Colombia there is a large amount of variation in terms of sociocultural integration at the village/city level and relatively little variation in sociocultural integration within villages/cities, which facilitates data collection and analysis.

1.5 Research Goals

Our goals are to: 1) provide an ethnographic and quantitative characterization of the prevalence, severity, and type of FGMo practices being utilized in the Afrocolombian and Indigenous population of Colombia, and 2) test model-based predictions concerning the social and ecological drivers of FGMo persistence/attenuation and transmission.

We present city/village-level data on the prevalence and severity of three forms of FGMo in Colombia: 1) the excision of clitoral or labial tissue, 2) the vulvic application of camphor, and 3) the practice of *pringa*, which varies in severity from the burning of the clitoris with metal instruments to the customary application of ash to the clitoris. We then operationalize and test the hypotheses derived from cultural evolutionary models of FGMo persistence/attenuation and transmission dynamics:

Hypothesis 1: FGMo is attenuated as a function of the sociocultural integration of the African diaspora community into dominant Colombian culture. If frequency-dependent cultural beliefs concerning FGMo are the principal ecological drivers of the persistence of FGMo, then we would expect that the practice of FGMo would be attenuated at higher rates in subpopulations of the African diaspora with stronger sociocultural integration into the host culture (e.g. where the frequency of interaction with non-FGMo practitioners is high, and social learning mechanisms, such as prestige bias (Henrich and Gil-White 2001), would lead individuals to copy the cultural practices of the dominant culture).

Prediction 1: The prevalence and severity of FGMo and related practices will be lower among Afrocolombians in cities and villages with more numerous linkages into Colombia's infrastructure, press, and telecommunications systems, than in cities/villages with fewer linkages.

Prediction 2: The prevalence and severity of FGMo and related practices will be lower among Afrocolombians in the current generation than in the previous generation, since there has been a substantial increase in the accessibility of press, television, internet, and telecommunications systems in Afrocolombian areas in recent years.

Prediction 3: The frequency and severity of FGMo and related practices will be lower in Indigenous populations living in centralized cities or villages with linkages into Colombia's infrastructure, press, and telecommunications systems, than Indigenous populations living in more remote forest locations.

Hypothesis 2: The transmission of FGMo is governed by frequency-dependent social dynamics. If frequency dependence is a major driver of the transmission of the FGMo practice, then we would expect that Indigenous populations will be more likely to adopt the FGMo practice when they are the demographic minority in a region and Afrocolombians (who practice FGMo) are the demographic majority.

Prediction 4: Indigenous groups will be more likely to adopt the FGMo practice when they are the demo-

graphic minority in a region and there is a high proportion of Afrocolombians in their village/city.

2 Methods

We utilized three methods of data collection: 1) we conducted archival research in Bogota and Risaralda, with the assistance of the Biblioteca Luis Ángel Arango and the Hospital San Rafael en Pueblo Rico, to determine the frequency and severity of the FGMo practice in difficult to sample, remotely located Indigenous populations, inaccessible due to security concerns and lack of transportation infrastructure; 2) in the late summer of 2013, the first two authors (CTR and PJC) traveled to 12 cities and villages in Chocó and Risaralda, conducting informal interviews with a random sample of women in each city or village; and 3) we conducted interviews with local doctors, pharmacists, and midwives in each city/village, in order to corroborate the information gathered during informal interviews with local women.

2.1 Site Selection and Sampling

We utilized a multi-level cluster sampling methodology to structure data collection. Due to security concerns and severely limited infrastructural connections, a random selection of top-level clusters was not feasible. Instead we purposefully selected 12 top-level cities and villages in the districts Chocó and Risaralda, with the intent of roughly capturing the relevant variation in city size, geographic locale, infrastructural connection to Colombia-at-large and exposure to sources of media (press, TV, and internet). Figure 1 displays the locations sampled in this study, as well as the geographical distribution of the Afrocolombian and Indigenous populations.

[Fig. 1 about here.]

We conducted sampling by walking every road and footpath in each sample village/city, and inviting every woman or group of women we saw sitting/standing in or in front of their home or place of work to take part in a brief informal interview.[3] We did not enter onto private property without consent to knock on closed doors, and we did not (with very few exceptions) invite women to participate in an interview if they were in the presence of males, due to the sensitive nature of the subject matter. These were choices undertaken to protect the privacy and comfort of respondents. While these methodological choices have the potential to confound inference, we feel confident, given our ethnographic experience, that neither significantly biased our results. In the vast majority of cases, we observed groups of men or women segregated by gender sitting on their front porches chatting. In the capital city of Quibdo and the small town of Jurubirá we conducted sampling using different methodologies.[4]

Failing to approach houses when no-one was visible from the view of the road or footpath has the potential to bias our results if these are the homes of women who are 'cloistered' by males to a greater degree. However, we found no direct indication that such a distinction between women existed in the communities we visited, and no respondents indicated that such practices or differences existed in their communities.

2.2 Data Collection

Our field research objective was to obtain a rapid comparative sample of the frequency of FGMo and related practices in the Afrocolombian and Indigenous populations in the districts Chocó and Risaralda. Accordingly, we limited our interactions with respondents to brief informal conversations and collected no individual-level demographic data, opting instead to assess the type and severity of FGMo practices in each community using a city/village-level tally. Local approvals to conduct research in Colombia were sought from the Instituto Colombiano de Antropologia e Historia (ICANH), who indicated that no further review was necessary. The research procedures utilized in the study were reviewed and approved by the UC Davis IRB in protocol 488684-1.[5] All respondents provided informed consent prior to taking part in conversations. Conversations were not conducted with members of Indigenous

[3] Informal interviews were conducted primarily by Patricia Joyas Campiño, female. If respondents requested that Cody Ross, male, be present for these conversations, he accompanied Patricia.

[4] In Quibdo, a large capital city, it was not feasible to walk through every road in the city. Instead, we conducted two samples; in the first, we walked through the local farmer's market and invited all women or groups of women we encountered to take part in a brief interview. In the second, we walked through the city center and invited women shop keepers to take part in interviews. We believe this methodology gives us a very rough, but reasonable sample of individuals in the two main social classes of Quibdo: the middle-class city dwellers and the more impoverished farmers participating in the market. In Jurubirá we conducted brief interviews with four women encountered at random when our boat stopped for gas on the way from El Valle to Nuqui.

[5] UC Davis IRB approved the use of informal conversations, and only permitted collection of village/city-level information. Even anonymous demographic data (age, number of kids, etc.) collected at the individual-level could easily lead to individual-level identification in the small communities studied here. FGMo could of course have legal ramifications, and collection of individual-level data on its prevalence would entail a large responsibility (and require a much longer process of written documentation of consent). Given that no-one had ever determined the prevalence of FGMo or related practices in the Afrocolombian population before, we believed that a rapid assessment of its prevalence would be the most useful first step, even if data was only collected at the village, and not individual level.

populations, with the exception of some officials in ONIC, as: 1) special permissions are required by ONIC and local Indigenous groups in order to conduct research in Indigenous populations, and 2) narco-violence and forced displacement of civilians in Indigenous areas during the time of data-collection rendered such fieldwork impossible (OCHA 2012a,b).

2.3 Statistical Methodology

We operationalize prediction P1 in three ways:

OP1a) the percentage of women in our sample who report having received the camphor treatment (see Results for an explanation of the practice) from their mothers to 'lower the libido' will be lower in cities/villages with roadways connecting the city/village to Colombia-at-large;

OP1b) the percentage of women in our sample who report using camphor on their daughters will be lower in cities/villages with roadways connecting the city/village to Colombia-at-large; and,

OP1c) the frequency of the practice of *pringa* on infants will be lower in cities/villages with roadways connecting the city/village to Colombia-at-large.

To test these predictions we use logistic regression to estimate the effect of a city/village-level binary variable (presence or absence of a roadway linking the specified city/village to Colombia-at-large), and use AICc and BIC (Burnham and Anderson 2002) to compare the models which include the roadway variable to the intercept-only models.

We operationalize prediction P2 as:

OP2) across all villages, the percentage of women who apply camphor to their daughter will be lower than the percentage of women who received the camphor treatment from their mothers.

To test OP2, we utilize a hierarchical Bayesian case-comparison model which implements exact binomial likelihood (SAS 2013). This model is structurally identical to models utilized in Bayesian meta-analysis of clinical trial data in cases where Gaussian approximations to likelihood are untenable. This method of analysis is an optimal way to estimate the change in frequency of a cultural trait across a generational time window, when: 1) populations are clustered into groups, 2) sample sizes vary across groups, and 3) the likelihood of the estimated events occurring is low (SAS 2013).

We operationalize prediction P3 as:

OP3) the frequency of FGMo will be higher in Indigenous communities located distantly from city centers than in areas where the Indigenous population live in, or close to, city centers.

We test OP3 by utilizing a hierarchical Bayesian Beta regression model (Ferrari and Cribari-Neto 2004) to estimate the lower limits of FGMo rates as function of distance between 49 Indigenous communities in the municipalities of Pueblo Rico (Risaralda), Tadó (Chocó), and Bagadó (Choco) and the nearest urban center to each community. Estimates of the lower limits of the community specific FGMo rates were produced from census records and the number of cases of FGMo documented by the Hospital San Rafael of Pueblo Rico in the years 2011-2013.

We operationalize prediction P4, that frequency-dependent social transmission drove the diffusion of FGMo from the Afrocolombian population into the Indigenous population, as:

OP4) the percentage of Indigenous populations that practice FGMo in each municipality in Colombia will be positively associated with the relative frequency of Afrocolombians, and negatively associated with the relative population size of Indigenous peoples. We test OP4 by utilizing logistic regression to estimate the effect of the relative densities of Afrocolombian and Indigenous populations at the municipal-level on the log odds that the Indigenous populations in a given municipality will be one of the four groups known to practice FGMo. We use AICc and BIC to compare the models with covariate data to the null model.

The R 2.15 statistical programming environment (R Development Core Team 2008) was used for non-Bayesian model fitting and comparison, and the Stan 1.3.0 C++ library (Stan Development Team 2013) was used to implement the Bayesian models. The complete statistical methodology and model code used in our analyses are included in the Supplementary Materials.

3 Results

3.1 Qualitative Results

Here we detail the type, frequency, and severity of FGMo and related practices occurring in the Afrocolombian and Indigenous population in the districts Chocó and Risaralda, Colombia. Table 2 provides a city/village-level summary of the results, which we elaborate on in the following sections of the paper.

[Table 2 about here.]

3.1.1 The Practice of FGMo in Colombia

Within the Afrocolombian communities, we find no evidence of the contemporary practice of FGMo in the form of clitoral or labial excision. In a single case, an

Afrocolombian woman indicated that a young Afrocolombian girl underwent some form of surgery during puberty because her period would not *bajar* (come down). In another case, an Afrocolombian woman indicated that her son's daughter was excised. Her son, notably, was married to an Indigenous woman and resided matrilocally. She indicated that she observed the evidence of the excision when she was bathing her granddaughter. Finally, one Afrocolombian indicated that clitoral circumcision was, in fact, practiced in the past in her natal village, but that it is no longer practiced today. In no cases we were able to empirically verify these claims, nor corroborate them from a secondary ethnographic source due to privacy concerns; as such, these reports, although seemingly genuine, should be treated with some skepticism.

To corroborate the testimony of respondents, we conducted interviews with at least one local doctor, nurse, pharmacist, or midwife in each city/village. Every person interviewed indicated that he or she had not heard of a single contemporary case of FGMo in the form of clitoral or labial excision in the Afrocolombian population.

Security concerns prevented us from traveling into forest areas to conduct individual-level interviews in Indigenous populations. To assess whether or not FGMo in the form of clitoral or labial excision was practiced in the Indigenous communities in a given area, we conducted interviews with local doctors and nurses in our sample cities. Several doctors and nurses indicated that FGMo is present in the Indigenous population in the areas surrounding the cities of Pueblo Rico and Santa Cecilia (Risaralda); in all other cities and villages, local doctors and nurses reported that they had not encountered a case of excision in the local Indigenous populations.

3.1.2 Camphor Application

In the district of Bahia Solano, shortly after we began sampling, we heard accounts of a practice in which mothers apply camphor to the underwear of their young daughters in order to *baja la calentura*, or *baja la arechera* (directly translating as lowering the heat, or lowering the libido, of their daughters). This practice proved to be widely known across all sampled Afrocolombian cities and villages in Chocó and Risaralda, although its prevalence varies.

As detailed below, there is substantial evidence that the frequency of this practice diminishes with infrastructural connections to Colombia-at-large, and is declining with time. The frequency of the practice was significantly greater in the cities/villages of Bahia Solano, El Valle, Huina, and Nuqui (Table 2), all of which are areas with no infrastructural connections to Colombia-at-large, accessible only by charter flights or speedboat. Furthermore, across all sampled villages, women were more likely to have received the camphor treatment from their mothers than to use the camphor treatment on their daughters. Across all sampled cities/villages, most Afrocolombian women were aware of the camphor practice, with many women responding that it was once quite common, but that it is much less common at the present time. When asked why the practice was less common nowadays than in the past, respondents typically argued that the Afrocolombians were progressing, that science was progressing, and that access to television and internet were helping to educate the younger generation as to which traditional practices were harmful.

3.1.3 Pringa

In the district of Nuqui we heard the first accounts of a practice called *pringa* (from the Spanish verb *pringar*). *Pringar* translates into English in a variety of ways, but derives from its meaning in this context from the action of covering something in *pringue*, which is grease, oil or lard. The word is used to describe the basting of meat and also the scalding of a person with boiling oil, a punishment once used on slaves. Several older women described witnessing *pringa* being carried out on young girls, especially when the clitoris of the girl was "too large," or "extended too far." When asked to elaborate on what the word *pringa* meant in this context, these respondents indicated that it meant to burn the clitoris with a heated machete or spoon. When asked when they witnessed *pringa*, these respondents claimed that it occurred a long time ago. More generally, when women were asked if the practice was still common, many responded that it was, but that it had changed with time. Specifically, it was often claimed that the severity had attenuated first to the application of burned/heated cotton to the clitoris, and subsequently to a practice where a woman slightly heated her own fingers with a candle, and then tapped the clitoris to shape it and prevent it from growing. Several women said that *pringa* now entailed application of a mother's breast milk to the clitoris of the infant, which is also supposed to prevent the clitoris from growing. Several women indicated that the practice of *pringa* was quite brutal in the past, but that they found the application of a mother's breast milk, salt, or unheated oil to be just as effective as other methods of attenuating clitoral growth.

When asked why the practice was changing, a majority women responded that there has been a lot of in-

tellectual and infrastructural development in the Afrocolombian communities over the last two decades, and that nowadays individuals can inform themselves by watching television documentaries on the Discovery Channel, or by visiting an internet café and researching medical decisions. Several women also indicated that *parteras* (midwives) are receiving a greater degree of medical education in major cities, and are relying less on traditional knowledge or superstition to guide their practices.

We noted that the practice of *pringa* was much more common in cities/villages with no infrastructural connections to Colombia-at-large, than in cities/village with roadways connecting to Colombia-at-large. We also found that within the Capital City of Qubido, the use of *pringa* was more common in the sample of women working in the farmer's market (5 of 20), than in the sample of women working in the city shops (0 of 25, two sample test for equality of proportions p=0.029). Notably, most women in the city shops had never even heard of the practice of *pringa*.

3.2 Quantitative Results and Hypothesis Testing

3.2.1 OP1: Camphor Use, Pringa, and Roadway Integration

To test our predictions that sociocultural integration into Colombia-at-large, as measured by a city/village-level binary variable of a roadway connection to Bogota, functions to attenuate FGMo and related practices, we fit logistic regression models to count data on the city/village-level prevalence of practices related to FGMo. Table 3 illustrates the results. For each of the three practices modeled as functions of a roadway variable, the coefficient on the indicator variable for roadway integration is negative, and the 98% equal-tail posterior confidence intervals (98PCIs) do not include zero. This provides strong evidence that social integration, as measured by a binary roadway connection variable, is associated with the attenuation of the traditional practices relating to FGMo.

[Table 3 about here.]

In addition to estimating the effect of village-level roadway connections on the attenuation of practices relating to FGMo, we compare the predictive power of models which include the roadway variable to the predictive power of the intercept only models using AICc and BIC in Table 4. These data extend the previous results to show that the parameter estimates are significant not only in the statistical sense of having a low posterior probability of being zero, but also it the pragmatic sense that including the roadway variable improves model predictions.

[Table 4 about here.]

Finally, to avoid the common inferential errors which result from reporting only odds ratios (Grimes and Schulz 2008), we use AICc weights to simulate model averaged predictions from the weighted posteriors of both models (M1 and M0), using the *rethinking* package in R, and derive predictions on the frequency scale. We conduct model criticism by comparing these predictions to the raw data, and by evaluating the robustness of our results to inference on the frequency scale.

Model averaged predictions for the frequency of receiving camphor from one's mother are 0.234 (95PCI: 0.169, 0.307) in the no-roadway group, and 0.087 (95PCI: 0.041, 0.164) in the roadway group. These predictions fit the true data, 35/150=0.233 for the no-roadway group, and 8/98=0.082 for the roadway group, quite well. The mean difference in predicted frequency of receiving the camphor treatment from mothers between villages with and without roadway connections was 0.148 (95PCI: 0.037, 0.236), a result which is both statistically robust and meaningful as a difference in frequency of the practice.

Model averaged predictions for the frequency of using camphor on ones daughters are 0.127 (95PCI: 0.079, 0.188) in the no-roadway group, and 0.027 (95PCI: 0.005, 0.084) in the roadway group. These predictions fit the true data, 19/151=0.126 for the no-roadway group, and 2/98=0.020 for the roadway group. The mean difference in predicted frequency of receiving the camphor treatment from mothers is 0.102 (95PCI: 0.015, 0.168), again a meaningful decline in the model-predicted frequency of the practice.

Model averaged predictions for the frequency of using *pringa* on ones daughters are 0.335 (95PCI: 0.141, 0.536) in the no-roadway group, and 0.087 (95PCI: 0.042, 0.160) in the roadway group. These predictions closely fit the true data, 8/24=0.334 for the no-roadway group, and 8/98=0.082 for the roadway group. The mean difference in predicted frequency of receiving the camphor treatment from mothers is 0.245 (95PCI: 0.000, 0.457). The 95% confidence interval on the frequency scale includes zero, due primarily to the lower sample size in this analysis. The 90% confidence interval (90PCI: 0.068, 0.422), however, does not include zero, indicating that we are over 95% confident that there are, in fact, structured difference between populations in the frequency of *pringa* as a function of roadway connections.

3.2.2 OP2: Change in Camphor Use over Time

To test our prediction of an intergenerational attenuation of FGMo and related practices in the Afrocolombian population, we fit a hierarchical Bayesian case control model to estimate the change in the frequency of camphor use across the generational time gap in each of the 12 sampled cities/villages in the districts Chocó and Risaralda, Colombia.

The estimated value of the difference in log-odds of camphor use across cities/villages (μ_δ, see Supplementary Materials for model specification), was -1.551 (95PCI: -3.675,-0.197), indicating that the daughters of the women in our sample saw a substantial average reduction in the odds of receiving the camphor treatment, as compared to the women in our sample. We note, however, that there is substantial heterogeneity across cities/villages in the rate at which the use of camphor is declining, as illustrated in Figure 2.

[Fig. 2 about here.]

We can translate these results onto the probability scale to show that the estimated mean decrease in the probability of camphor use across cities/villages in one generation is 0.081 (PCI95: 0.012, 0.16). Across cities/villages in the districts Chocó and Risaralda, there is strong support for the prediction that the use of camphor to attenuate the sexual desires of Afrocolombian women is declining with time.

Figure 3 plots the city/village specific estimates of frequency of camphor use. Note that the shrinkage (a result of the hierarchical model structure balancing information at global and local-levels) of city/village specific estimates toward the grand mean is especially strong when village-level sample size is low, and when village-level estimates are far from the grand mean. Even after accounting for shrinkage, we note that in the city of Bahia Solano (Village ID=1, N=28) the use of camphor has barely decreased across this generational gap, while in Nuqui (Village ID=5, N=50) the practice has essentially disappeared in a single generation, exemplifying inter-village heterogeneity.

[Fig. 3 about here.]

We note that there is at least one important factor missing from our analysis – whether or not the woman being interviewed had ever had a daughter of relevant age for camphor application. Every woman interviewed had or has a mother who chose to use, or not use, camphor to control her sexuality. However, it is not the case that every woman interviewed for this study had a daughter. As we noted in describing our sampling procedures, we did not collect individual-level demographic information. Thus, an unknown portion of the estimated decrease in camphor is attributable to interviewees not having a daughter, rather than to the decision to not continue the practice of camphor application.

To test the robustness of our statistical results to the error introduced by women who might not have had daughters, we use demographic data specific to the African diaspora population in Colombia published by (DANE 2005) to estimate the number of daughterless women in our sample (see Supplementary Materials for methodology). We then re-estimate model parameters for 500 random estimates of the number of daughterless women. Under this re-sampling analysis we observe only a small mean decrease in the difference in log-odds of camphor use across one generation, from -1.551 (PCI95: -3.675, -0.197), to -1.353 (PCI95: -3.493, 0.003). The confidence intervals on the re-sampled model, however, expand.

While the upper tail of the equal tail 95 percent posterior confidence interval crosses zero in the re-sampled model, the 90 percent posterior confidence intervals remains distant from zero (PCI90: -2.943, -0.199), indicating that we are 95% certain that the difference of the log-odds ratio is less than -0.199, even when accounting for daughterless women. This analysis indicates that our primary results are statistically robust to underreporting of camphor use due to daughterlessness. Ethnographically, we note that the majority of the women who we presume to be daughterless (mostly younger women) indicated that they would not practice the use of camphor on their future daughters, claiming that they are developing, becoming more educated, and learning about health decisions in school or on the internet. Verbal reports of intended practice suggest that the parameter estimates in the primary analysis are more representative of the ethnographic reality that the parameter estimates in the supplementary analysis.

3.2.3 OP3: FGMo Cases in Indigenous Populations as a Function Distance to Urban Center

To test OP3, the prediction that the frequency of the FGMo practice (as circumcision) will be greater in Indigenous populations with lower integration into Colombian culture, we utilized a hierarchical Bayesian Beta regression model to estimate the effect of distance to the nearest urban center on the lower limits of community-level prevalence of FGMo.

The estimated value of the coefficient on distance was 0.193 (PCI90: 0.004, 0.404), indicating that prevalence of FGMo increases with distance to the nearest

urban center. This result is consistent with the hypothesis that social integration into a non-FGMo practicing culture functions to attenuate the prevalence of the FGMo practice.

The estimates of FGMo prevalence presented here must be interpreted as lower limits, because we define the FGMo rate as the count of FGMo cases reported by the Hospital San Rafael in Pueblo Rico in each Indigenous community divided by community-level census data (see Supplementary Materials for more details on imputation of missing census records). More accurate estimates of the true population-specific FGMo rates could be calculated by using the counts of FGMo reported by the Hospital San Rafael in Pueblo Rico divided by the total number of Indigenous girls/women checked for FGMo status at the hospital, scaled to the census population sizes. Due to nature of record keeping on FGMo status at the Hospital San Rafael, such data were not available, and we were not able to conduct such an analysis. The true community-specific FGMo prevalence rates are likely to be higher than the lower limits reported here. Figure 4 plots the estimated lower limits of FGMo rates in 49 communities with 90% equal tail confidence intervals in communities where population size was imputed.

[Fig. 4 about here.]

3.2.4 OP4: The Social Transmission of the FGMo Practice

Ethnographically, we find no evidence that clitoral or labial excision is practiced in the Afrocolombian population. We also fail to find an association between proxies for FGMo (camphor use or *pringa*) in the Afrocolombian population and the adoption of FGMo by Indigenous populations in the surrounding areas. However, we find ethnographic evidence that many of the cultural beliefs and preoccupations underlying the practice of FGMo in Africa are present in the Afrocolombian population. Namely, many individuals in our sample reported beliefs that if the clitoris was too large, the girl would grow into a woman with an uncontrollable sexual appetite, and therefore practices needed to be adopted to stop clitoral growth and/or attenuate women's sexual desires. Such practices included burning the clitoris of young girls/infants, or applying chemicals, such as camphor to the genitals of young women and girls. The existence of such cultural beliefs, combined with the evidence of the attenuation of practices related to FGMo with time and social integration suggests that more severe practices were probably more common in the past, although direct evidence of this conclusion is lacking.

We argue that the key reason we fail to find strong evidence of the frequency-dependent social transmission of FGMo in our ethnographic data is that the evidence of such transmission has been obscured over the last several hundred years as social and technological integration lessened the prevalence of FGMo practices in the Afrocolombian communities, while the practice has been maintained in the less interconnected Indigenous populations. In order to work around these confounding factors we utilize nation-wide, fine-scale geographical data on the distribution of Afrocolombian and Indigenous populations, and investigate if there is an association between the geographic localization of the Indigenous populations who practice FGMo, and the relative densities of Afrocolombian and Indigenous populations.

This analysis provides evidence that the uptake of the FGMo trait by Indigenous groups is associated positively with the density of the Afrocolombian population and negatively with the density of the Indigenous population at the municipal level. Table 5 contains regression coefficients for each of the six fitted models and Table 6 illustrates the results of formal model comparison.

[Table 5 about here.]

Model comparison shows that the best performing models include information on the relative densities of the Afrocolombian and Indigenous populations. The parameter estimates are in the direction predicted by the frequency-dependent social transmission model, in that an increased density of the Afrocolombian population and a decreased ratio of Indigenous to Afrocolombians are associated with increased odds that the Indigenous groups in a municipality are one of the four groups known to practice FGMo. As illustrated in Table 5, in no case do the 95 percent equal confidence intervals for parameter estimates of slope include zero for models M3, M2, M1I, or M1A. This observation is important, as it shows that the effects estimated by the model are reliable in the direction indicated, and for models M2 and M3 it shows that the uptake of FGMo is determined not only by exposure to a cultural outgroup, but also by the relative population densities of each ethnic group. We note that the null model, M0, performs poorly relative to the best model M3, with a dAICc of more than 94, indicating that information on the density of the Afrocolombian population, as well as information on the ratio of Indigenous population size to the Afrocolombian population size at the municipal level, are critical variables in predicting the likelihood that the Indigenous populations in a municipality are from a group known to practice FGMo (Table 6).

[Table 6 about here.]

We fit the control model, M1C, in order to investigate if the adoption of the FGMo trait could also be positively associated with the density of the white-mestizo population. The parameter estimates indicate that residence in areas where the white-mestizo population is dense functions to lower the odds that the Indigenous population practice FGMo.

We conduct model criticism of the best model, M3, by calculating the correlation, r=0.46 (PCI95: 0.44, 0.47), between model predictions and the outcome data. This calculation indicates that the model is representative of the patterning in the data, but that a significant portion of variance remains unexplained.

4 Discussion

4.1 Descriptive Data

We demonstrate that a rapid, non-invasive survey procedure coupled with ethnography, careful statistical methods and evolutionary anthropology theory can provide a reliable and informative analysis of the prevalence of various FGMo practices in the Afrocolombian and Indigenous populations of Chocó and Risaralda, Colombia. This information may be of use in meta-analyses of the practice of FGMo in various African diaspora populations, and may be of use in policy design, human rights monitoring and educational programs in Colombia or elsewhere.

4.2 Evidence that Social Integration into a Non-FGMo Culture Attenuates FGMo

The quantitative and qualitative results of our study support the hypothesis that social integration and exposure to sources of national and international media (that frame FGMo in a negative light) function to attenuate several traditional practices related to FGMo. Furthermore, this study provides an empirical test of predictions derived from formal evolutionary ecological models of cultural trait diffusion and transmission (Ross et al 2015), and may provide insights into the dynamics which govern the persistence of other cultural beliefs with serious human rights implications, such as honor killing (Goldstein 2002) and gavage (Ouldzeidoune et al 2013), in that similar, frequency-dependent cultural beliefs may underlie these practices. As is the case with FGMo, increased social integration, increased access to technology, and increased access to education are likely to be important drivers of the attenuation of such practices.

4.3 Evidence that Frequency-Dependent Social Processes May Drive Inter-Group Transmission of FGMo

We provide some of the first evidence that the FGMo trait in some Indigenous populations in Colombia might have spread from the African diaspora due to frequency-dependent social transmission. Although we do not currently find evidence of clitoral or labial excision in the Afrocolombian population, we uncovered ethnographic evidence that it was once a somewhat common practice to burn the clitoris young Afrocolombian girls in order to prevent clitoral growth and decrease sexual desires. Colombian authors have claimed that there are also cultural beliefs in the Emberá that either burning or cutting of the clitoris is required to 'lower the temperature' of women, and ensure their faithfulness in relationships (El Tiempo 2009). We find quantitative evidence that the uptake of FGMo by Indigenous populations is associated with geographic proximity to Afrocolombians, especially in locations where the relative density of Indigenous to Afrocolombians is low.

It appears that, in the past, the frequency and severity of practices related to FGMo in the Afrocolombian population were elevated relative to current levels, and that social integration and media access have led to the attenuation of FGMo severity, and lowered the prevalence of FGMo in the Afrocolombian population. Our data is consistent with the hypothesis that FGMo was imported into Colombia during the slave trade, and soon after was transmitted to the local Indigenous population. Then, over the succeeding years, the practice attenuated in the Afrocolombian populations as a function of greater levels of technological development, media access, and social integration, while it remained more common in the Indigenous populations who have remained highly isolated from mainstream Colombian culture until very recently.

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The data on the extent of FGMo in the indigenous populations reviewed in this paper come from publicly available records published by Hospital San Rafael in Pueblo Rico. Census data and demographic data reviewed in this paper come from publicly available records published by the *Departamento Administrativo Nacional de Estadística* (DANE) of Colombia. All other primary data utilized in this study are included in Table 2.

The authors declare that they have no conflict of interest.

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1 Frames (a) and (b) plot the densities of the Afrocolombian and Indigenous populations across the departments of Colombia. Frame (c) plots the locations of sites sampled in this study. Frame (c) is the enlarged rectangle from Frames (a) and (b), and includes the Chocó and Risaralda departments. . . . 16

2 Caterpillar plot of the village-level random effects of the difference in log odds of camphor use across one generation. Each vertical bar represents the mean (center dot) and 95PCI (bar length) of each city/village-specific estimate. The horizontal solid line is zero, the value of no effect. The right-hand vertical bar labeled Mu and horizontal dashed line illustrate the mean estimated difference (pooled across cities/villages) in the log odds of camphor use across one generation. The confidence intervals on the vertical bar labeled Mu do not overlap zero, which indicates a significant general trend across villages of the decreasing likelihood of camphor application. 17

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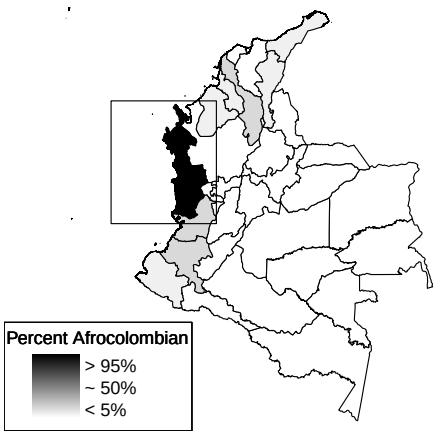
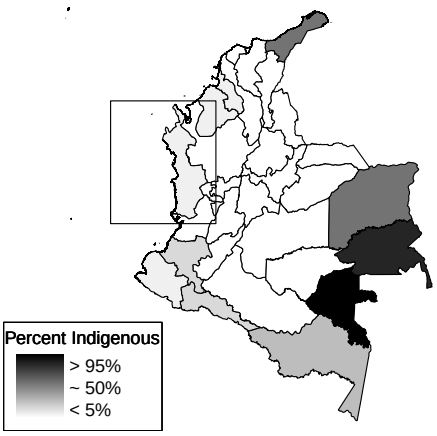
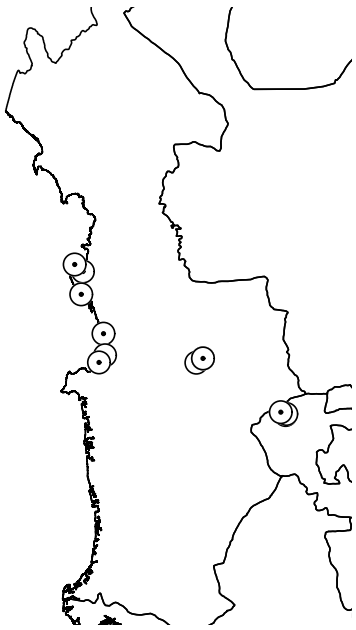
4 Caterpillar plot of the community-level estimates of the lower-limits of the frequency of FGMo (as female circumcision) in Indigenous communities in Bagado, Tado, and Pueblo Rico. Each large circle represents a mean estimate for a community. Vertical bars represent uncertainty (90PCIs) for communities where population size was imputed. We do not report community-level identifiers linking FGMo prevalence rates to community names. 19



(a) Afrocolombian population



(b) Indigenous population



(c) Locations of sampled sites

Fig. 1 Frames (a) and (b) plot the densities of the Afrocolombian and Indigenous populations across the departments of Colombia. Frame (c) plots the locations of sites sampled in this study. Frame (c) is the enlarged rectangle from Frames (a) and (b), and includes the Chocó and Risaralda departments.

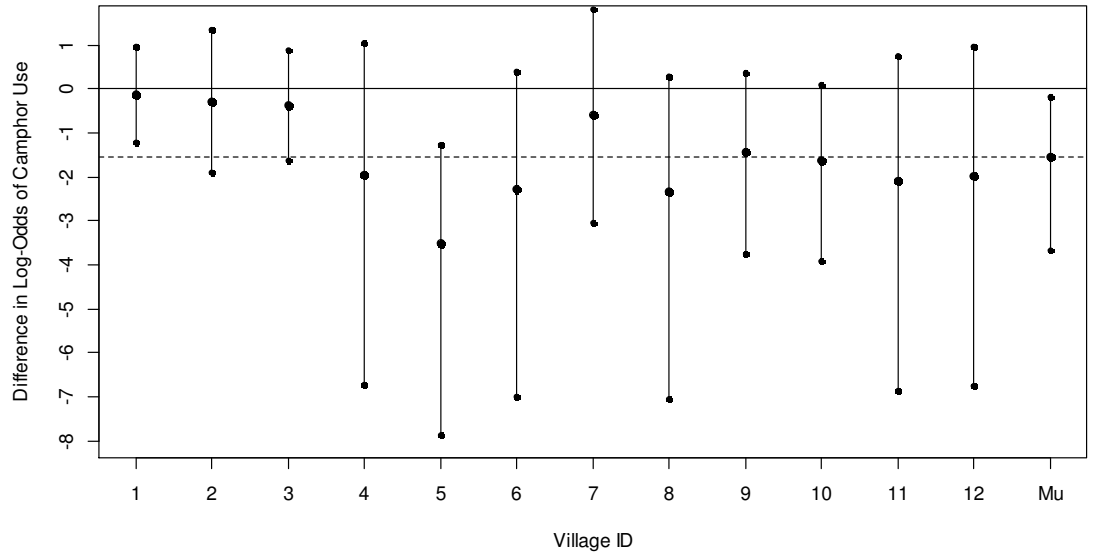


Fig. 2 Caterpillar plot of the village-level random effects of the difference in log odds of camphor use across one generation. Each vertical bar represents the mean (center dot) and 95PCI (bar length) of each city/village-specific estimate. The horizontal solid line is zero, the value of no effect. The right-hand vertical bar labeled Mu and horizontal dashed line illustrate the mean estimated difference (pooled across cities/villages) in the log odds of camphor use across one generation. The confidence intervals on the vertical bar labeled Mu do not overlap zero, which indicates a significant general trend across villages of the decreasing likelihood of camphor application.

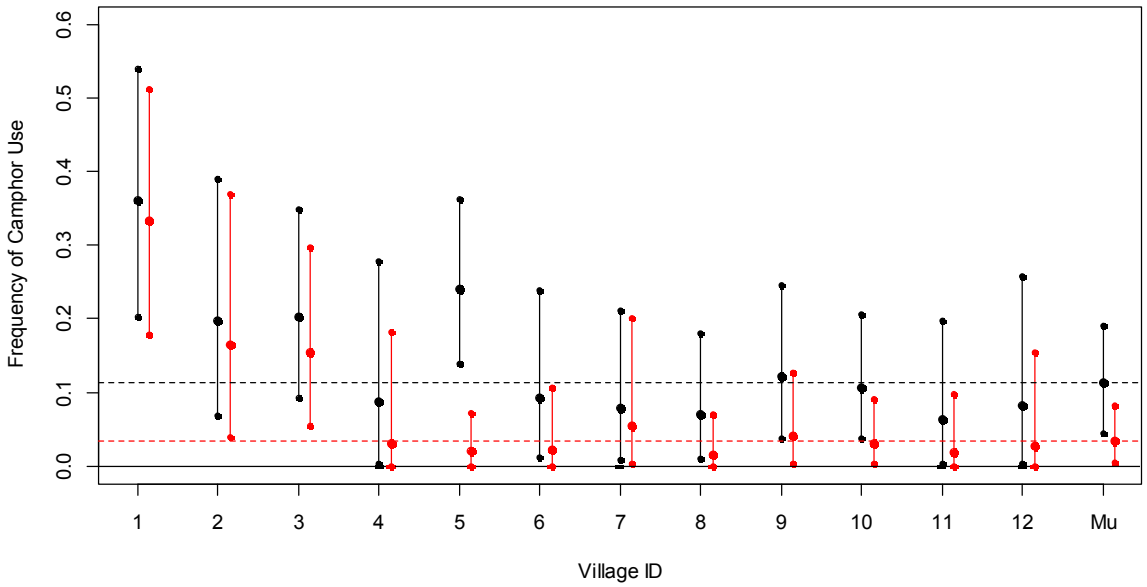


Fig. 3 Caterpillar plot of the village-level estimates of the frequency of receiving camphor from mothers (black), and using camphor on daughters (red). Squares represent the empirical data, large circles represent the posterior mean estimates from the Bayesian model, and small circles represent the 95PCIs. The horizontal dashed lines represent the estimated frequency of camphor use across villages. As in the previous figure, Mu represents the pooled estimate across cities/villages.

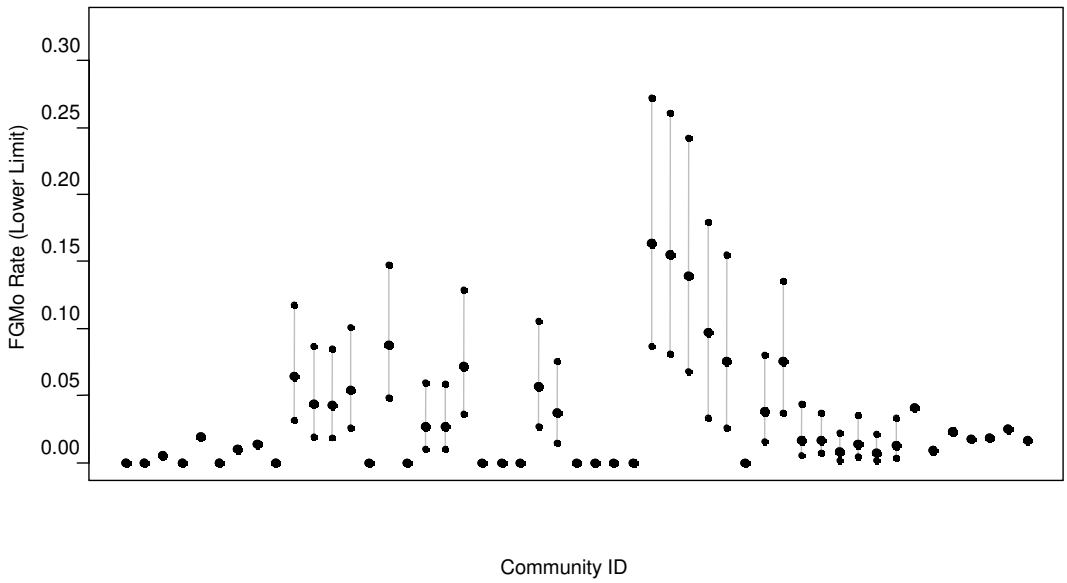


Fig. 4 Caterpillar plot of the community-level estimates of the lower-limits of the frequency of FGMo (as female circumcision) in Indigenous communities in Bagado, Tado, and Pueblo Rico. Each large circle represents a mean estimate for a community. Vertical bars represent uncertainty (90PCIs) for communities where population size was imputed. We do not report community-level identifiers linking FGMo prevalence rates to community names.

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Table 1 Relative proportions of ethnic groups imported into Colombia during the Atlantic slave trade, based on Cantor (2000), as well as contemporary data on the prevalence of FGMo in these ethnic groups. NI means that no information could be found on the contemporary prevalence of FGMo in the named ethnic group. 'Types' refers to the WHO (1998) classification of FGMo types.

Ethnic Group	Number of Slaves	Country	FGMo (Prevalence)[Types]	Citation
Mina (Ghana)	57	Ghana	Yes, (15%) [I, II, and III]	(US-DOS 2001)
Congo	21	Angola/Congo	Not Practiced	(UKBA 2008)
Chala (Volatic)	16	Ghana	Yes, (75%) [I and II]	(Ericksen 1989)
Carabali (Efik)	16	Nigeria	Yes, (20%) [No Data]	(Odujinrin et al 1989)
Setre (Kru)	11	NI	NI	NI
Arara (Fon, Ewe)	9	Benin	Yes, (<0.3%) [No Data]	(UNICEF 2005)
Chamba	7	Togo	Yes, (No Data) [No Data]	(Melchor 2007)
Mandinga	6	Gambia	Yes, (100%)[I and II]	(WHO 1998)
Guaji (Guagui)	4	NI	NI	NI
Bomba (Bantu)	3	Congo	Not Practiced	(UKBA 2008)
Bozal	2	NI	NI	NI
Fandi (Akan)	2	Cote d'Ivoire	Yes, (3%)[II]	(GIZ 2011)
Lucumi (Yoruba)	2	Nigeria	Yes, (67%)[I and II]	(Ericksen 1989)
Ocara (Ga)	2	NI	NI	NI
Acha	2	NI	NI	NI
Guambu	2	NI	NI	NI
Nongo (Sikasso)	2	Mali	Yes, (94%)[I and II]	(IPU 2006)
Tagui (Niamey)	2	Niger	Yes, (5%)[I and II]	(IPU 2006)
Dori	2	Burkina Faso	Yes, (92%)[I and II]	(Ericksen 1989)
Bambara	2	Mali	Yes, (95%)[I and II]	(US-DOS 2001)
Culango (Angola)	1	Angola	Not Practiced	(UKBA 2008)
Cosai	1	NI	NI	NI
Coto (Ga)	1	NI	NI	NI
Total	**173**			

Table 2 Prevalence of FGMo and related practices in the Afrocolombian and Indigenous populations of Colombia. Fractions are the counts of cases in each community over the number of individuals sampled. Check marks are a binary indicator of presence/absence. The Indigenous population do not live near roadways, even though they may occupy territories in the areas outside of cities with roadway connections. The symbol 'NA' indicates that the frequency of *pringa* was not queried in the specified community.

ID	City/Village	District	Road	FGMo-Afrocolombians	FGMo-Indigenous	Camphor	Pringa
1	Bahia Solano	Choco	-	0/86	-	16/31	NA
2	Huina (Bahia Solano)	Choco	-	0/16	-	3/16	NA
3	Valle (Bahia Solano)	Choco	-	0/29	-	9/29	NA
4	Jura Jira	Choco	-	0/4	-	0/4	NA
5	Nuqui	Choco	-	0/51	-	14/51	NA
6	Pangui (Nuqui)	Choco	-	0/12	-	1/12	5/12
7	Solitero (Quibdo)	Choco	-	0/12	-	1/12	3/12
8	Quibdo (Farmers Market)	Choco	✓	0/20	-	1/20	5/20
9	Quibdo (City Shops)	Choco	✓	0/25	-	4/25	0/25
10	Santa Cecilia de Pueblo Rico	Risaralda	✓	0/38	✓	5/38	3/38
11	El Silencio (Santa Cecilia)	Risaralda	✓	0/10	✓	0/10	0/10
12	Pital (Santa Cecilia)	Risaralda	✓	0/5	✓	0/4	0/5

Table 3 Logistic regression of practices related to FGMo on presence or absence of a roadway. In each of the three models, we find strong evidence of a negative effect of roadway connections on outcome variables. 98PCI-L and 98PCI-H indicate the lower and upper endpoints of the central 98% posterior confidence interval of each parameter estimate.

OP1a: Log-Odds of Receiving Camphor from Mother as a Function of Roadway Connection				
Parameter	Mean	S.E.	98PCI-L	98PCI-H
α	-1.19	0.19	-1.64	-0.74
β	-1.23	0.42	-2.2	-0.26
OP1b: Log-Odds of Using Camphor on Daughter as a Function of Roadway Connection				
Parameter	Mean	S.E.	98PCI-L	98PCI-H
α	-1.94	0.25	-2.51	-1.37
β	-1.93	0.76	-3.69	-0.18
OP1c: Log-Odds of Using *Pringa* on Daughter as a Function of Roadway Connection				
Parameter	Mean	S.E.	98PCI-L	98PCI-H
α	-0.69	0.43	-1.7	0.31
β	-1.73	0.57	-3.05	-0.4

Table 4 Model comparison using AICc and BIC. In each case we find that AIC and BIC select the model including roadway over the null model. The symbols wAICc and wBIC are AICc and BIC weights, which represent the posterior probability that the indicated model is the model of the suit of considered models that would make the best prediction on new, out of sample data. K is the number of parameters.

OP1a: Log-Odds of Receiving Camphor from Mother as a Function of Roadway Connection							
Model	k	AICc	BIC	dAICc	dBIC	wAICc	wBIC
M1 (Intercept+Slope)	2	222.45	229.43	0.00	0.00	0.98	0.92
M0 (Intercept Only)	1	230.78	234.28	8.33	4.85	0.02	0.08
OP1b: Log-Odds of Using Camphor on Daughter as a Function of Roadway Connection							
Model	k	AICc	BIC	dAICc	dBIC	wAICc	wBIC
M1 (Intercept+Slope)	2	137.85	144.83	0.00	0.00	0.98	0.91
M0 (Intercept Only)	1	146.06	149.56	8.21	4.73	0.02	0.09
OP1c: Log-Odds of Using *Pringa* on Daughter as a Function of Roadway Connection							
Model	k	AICc	BIC	dAICc	dBIC	wAICc	wBIC
M1 (Intercept+Slope)	2	90.07	95.58	0.00	0.00	0.97	0.88
M0 (Intercept Only)	1	96.84	99.61	6.77	4.04	0.03	0.12

Table 5 Parameter estimates from six models describing the log odds that the Indigenous groups in a district will be one of the groups noted to practice FGMo, as a function of the population density of Afrocolombian, Indigenous, and White-Mestizo groups.

Model	Variable	Parameter Estimate	S.E.	95PCI-L	95PCI-H
M3	Intercept	−0.91	0.17	−1.19	−0.64
	Afrocolombian Density	3.26	0.57	2.33	4.19
	Indigenous-to-Afrocolombian Ratio	−0.02	0.01	−0.04	−0.01
M2	Intercept	−1.35	0.15	−1.6	−1.1
	Afrocolombian Density	3.71	0.57	2.77	4.64
	Indigenous Density	−2.27	0.69	−3.4	−1.14
M1A	Intercept	−1.33	0.14	−1.56	−1.09
	Afrocolombian Density	4.21	0.55	3.3	5.12
M1I	Intercept	−1.31	0.14	−1.53	−1.08
	Indigenous Density	−3.13	0.63	−4.16	−2.09
M1M	Intercept	−0.83	0.24	−1.23	−0.43
	White-Mestizo Density	−0.79	0.39	−1.43	−0.15
M0	Intercept	−1.26	0.13	−1.47	−1.06

Table 6 Model comparison using AICc and BIC. The models which include joint information on the densities of the Afrocolombian and Indigenous populations carry almost all of the AICc and BIC weight.

Model	k	AICc	BIC	dAICc	dBIC	wAICc	wBIC
M3	3	289.84	301.53	0	0	0.99	0.99
M2	3	299.98	311.67	10.14	10.14	0.01	0.01
M1A	2	311.37	319.18	21.53	17.64	0	0
M1I	2	351.03	358.84	61.19	57.31	0	0
M1M	2	381.83	389.64	91.99	88.1	0	0
M0	1	383.92	387.83	94.08	86.3	0	0