Title:

Is there a link between paternity concern and female genital cutting in West Africa?

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ABSTRACT

Here we explore the relationship between female genital cutting (FGC), sexual behaviour, and marriage opportunities in five West African countries. Using large demographic datasets (n 72,438 women, 12,704 men, 10,695 couples) we explore key (but untested) assumptions of an evolutionary proposal that FGC persists because it provides evolutionary fitness benefits for men by reducing non-paternity rates. We identify and test three assumptions implicit in this proposal. We test whether cut women have reduced extra-pair sex before or within marriage; whether FGC is associated with a younger age at marriage as an indication of partner preference; and whether individual and group-level indicators of paternity concern are associated with a stronger preference for marriage to women with FGC.

Our results show that FGC status does not affect the odds of women engaging in several indicators of premarital sex, however women with FGC have significantly lower odds of having more than one lifetime sexual partner. We also show that women with FGC get married at a younger age which supports the argument that FGC status influences women's marriage opportunities, even when it does not restrict sexual activity. Finally, we find that in population groups where reported sexual activity and perceived risk of women's extra-pair sex is high, men have higher odds of marrying a first wife with FGC. Together, these results indicate that paternity certainty may be one of several factors contributing to the persistence of FGC in this sample, and that group-level sexual norms are key to maintaining the practice of FGC through the marriage market.

KEY WORDS: Female genital mutilation, evolutionary anthropology, sexual conflict, extra-pair sex, marriage, paternity certainty.

1. INTRODUCTION

1.1 The paternity certainty theory of female genital cutting (FGC)

Paternity uncertainty is an evolutionary problem for men who risk investing in offspring they are not genetically related to and reducing their own evolutionary fitness, if their partner engages in extra-pair sexual activity. This is particularly true for men with high paternal investment (Trivers, 1972). To reduce this risk, it has been argued that men use a range of so called 'anti-cuckoldry' tactics to prevent their long-term partner from conceiving with another man (Geary, 2005). At the individual level these may include partner preferences, 'mate guarding' (preventing loss of partner to competitors), and sexual jealousy behaviours (Buss, 1989;Goetz and Shackelford, 2006). At the population level, some cultural practices have also been described as mechanisms to control female sexuality and increase paternity certainty. Examples include virginity testing, foot binding, female claustration, marriage to prepubertal girls, and religious dogmas restricting female behaviours (Dickemann, 1981;Strassmann et al., 2012). Female genital cutting (FGC) is also described as such a mechanism.

The idea that FGC impedes women's sexuality is consistent with some local views of FGC (Adongo et al., 1998;Skaine, 2005), however Hartung was the first evolutionary scientist to suggest that FGC might provide a fitness benefit for men by reducing their wives' desire for extramarital sex, and thus enhancing men's paternity certainty (Hartung et al., 1976). Paternity concern is proposed as one of the key drivers behind the persistence of the practice leading to a preference for marriage to women with FGC, which in turn encourages families to have FGC performed on their daughters to enhance their marriageability (Van Rossem and Gage, 2009;Onyishi et al., 2016). Unlike individual anti-cuckoldry behaviours, it is proposed that FGC (and other similar harmful cultural practices which restrict women) may be enforced indirectly by men's marriage preferences (Boyden et al., 2012;Mackie, 1996;Shell-Duncan et al., 2011;Gruenbaum, 2005). Paternity certainty is not the only theory which has been put forward to explain the persistence of FGC, other explanations refer to its function as a marker of group identity (Wilson, 2008), female alliance formation (Shell-Duncan et al., 2011), and conformity to social

norms (Mackie, 1996;Hayford, 2005). Multiple factors almost certainly contribute to the persistence of FGC, however, it has become widely accepted by both social scientists and policy-makers that FGC also controls women's sexuality for the benefit of men (Dorkenoo, 1994;UN, 1995;Mackie and LeJeune, 2009;WHO, 2014;Toubia and Sharief, 2003).

As women's genitals are cut it seems likely that sexual control may have been a motivating factor for the origin of FGC. However, the suggestion that paternity concern can explain the persistence of FGC in present day communities involves a number of unproven assumptions which require scrutiny. Firstly, this proposal assumes that FGC reduces women's extra-pair sex. Here extra-pair sex is defined as sexual intercourse with someone other than a woman's husband or long-term partner, which can take place either before or during marriage. Secondly, it assumes that there is a preference for men to marry women with FGC. And thirdly, it implies that evolutionary forces are driving men (and their families) with the greatest uncertainty over paternity to show a stronger preference for marriage to women with FGC. Elements of this sequence have been tested in the existing literature (described in section 1.2), but to our knowledge this relationship has not been addressed as a whole.

1.2 Prior literature

Here we only review studies relevant to FGC and paternity certainty. There is a large body of literature beyond the scope of this study which explores alternative or complementary non-evolutionary explanations for FGC (Shell-Duncan et al., 2011;Shell-Duncan and Hernlund, 2000;Ross et al., 2016;Dorkenoo, 1994).

Reduced sexual desire is the crux of the paternity certainty theory of FGC. The comparative sexual functioning of women with FGC has been the subject of numerous studies using a variety of indicators (arousal, pain and/or orgasm during intercourse, sexual desire and frequency of intercourse) to assess the impact of FGC. A systematic review of 16 studies published between 1997 and 2005 found no effect of FGC reducing women's sexual function or enjoyment of sexual relations (Obermeyer, 2005). However

a subsequent systematic review of 15 further studies found that women with FGC were significantly more likely to report painful sexual intercourse, no sexual desire and less sexual satisfaction (Berg and Denison, 2012). Additional studies have found support for FGC attenuating sexual feelings (Anis et al., 2012;Oyefara, 2015;Onyishi et al., 2016) while others have not (Nyairo, 2013). Qualitative ethnographic studies also present contrasting accounts, with some documenting sexual enjoyment by women with FGC (Lightfoot-Klein, 1989;Ahmadu, 2007;Esho et al., 2010) while others describe painful sexual experiences (El Dareer, 1982;Dorkenoo, 1994;Dopico, 2007). These mixed findings may reflect varying FGC severity and the methodological difficulties involved in such studies, but they also imply that FGC does not necessarily reduce women's sexual function or desire.

Sexual desire, however, is not a prerequisite for sexual intercourse and women may engage in extra-pair sex for other reasons, including being coerced. Several studies have analysed women's sexual activity in relation to their FGC status, often in relation to women's sexual health or HIV/AIDS rather than from an evolutionary perspective. These show no significant difference in; the incidence of premarital sex; the total number of lifetime sexual partners; or the age at first sex (Odimegwu and Okemgbo, 2000;Okonofua et al., 2002;Msuya et al., 2002;Klouman et al., 2005a;Van Rossem and Gage, 2009;Smolak, 2014;Mpofu et al., 2016). The results of the few studies examining extra-pair sex during marriage are mixed. One found a higher proportion of women with FGC reported extra-pair sex (Oyefara, 2014), another found no significant difference (Yount and Abraham, 2007), and another found that women with FGC had a significantly lower incidence of extra-pair sex although the sample size was small (Onyishi et al., 2016). In summary, the majority of these studies find that FGC status is not a clear predictor of reducing women's sexual activity.

Men's stated preferences in relation to their wife's FGC status have only been addressed to a limited extent in the literature. Qualitative studies have found that women's FGC status can have an impact on marriage preferences for men, although the reasons given and direction of preference vary (Adongo et al., 1998;Missailidis and Gebre-Medhin, 2000;Abathun et al., 2016). Quantitative studies analysing men's stated preferences using small sample sizes have also found contrasting results depending the

man's age, education and nationality, making it clear that context is important in determining preference (Almroth et al., 2001;Sakeah et al., 2006;Gele et al., 2013). An alternative approach to understanding marriage preferences is to consider age at first marriage in relation to FGC status. Earlier age at marriage can be used as an indicator of preference, which is supported by the fact that male fitness is enhanced by marrying a younger wife (Bereczkei and Csanaky, 1996;Fieder and Huber, 2007). Two West African studies (in Guinea and Nigeria) found no significant difference in age at first marriage by FGC status (Okonofua et al., 2002;Van Rossem and Gage, 2009), while a further study (in Ghana) did find that women with FGC marry earlier than women without FGC (Reason, 2004). Therefore, the question of whether FGC improves marriageability for women is still open.

Although a range of male behaviours (e.g. mate guarding, sexual jealousy) motivated by paternity concern have been documented (Daly et al., 1982), individual variation in paternity concern is not well understood. Studies have typically examined sex-specific displays of such behaviours to demonstrate the concept of paternity concern, rather than identifying why some individual men have higher paternity concern prior to marriage or conception. To our knowledge no studies have tested individual variation in the expression of paternity concern through marriage preferences. Further, no studies have tested the link between a man's level of paternity concern and the FGC status of his wife. Possible reasons for men having higher paternity concern preceding marriage could include either their perceived risk of their partner engaging in extra-pair sex and/or their anticipated paternal investment. The theory of parental investment predicts that paternal investment and paternity certainty are correlated (Trivers, 1972) and it follows that men who expect to invest less (time, resources, and status) in their offspring should have less concern about paternity (Alvergne and Lummaa, 2014). For example, less paternity concern is anticipated in matrilineal groups where males invest in their sister's offspring (not their own) (Hartung, 1985;Holden et al., 2003).

Studies examining male mate preferences have typically tested preferences for phenotypic variation of potential female partners, such as waist-hip ratio or facial symmetry as an indicators of fecundity or good genes (Thornhill and Gangestad, 1999;Sorokowski et al., 2014). Only a few have considered male

preference for female attributes which could be associated with paternity concern. Preference for certain female facial features have been suggested to be motivated by paternity concern, for example neutral or recessive features which would allow the man's dominant or 'sender' features to be expressed in offspring thus providing evidence of paternity (Salter, 1996;Bovet et al., 2012). In other studies men have shown preference for characteristics such as faithfulness and chastity, and a dislike of promiscuity and sexual experience, in selecting their long-term partner (Buss, 1989;Buss and Schmitt, 1993). These studies investigate mate preference, however marriage preference (which has different motivating factors and does not necessarily align with mate preference) is more relevant to our research question. As far as we know, no studies have addressed marriage preference in relation to paternity concern.

1.3 Our approach and predictions

Here we identify and explore three assumptions underlying the paternity certainty theory of FGC and test the extent to which these assumptions may be driving the persistence of FGC in current populations. We used datasets from five countries in West Africa collected by the Demographic Health Survey programme (DHS) (see Section 2.1 below). We anticipate behaviour will vary according to individual circumstances, and a cross-cultural approach allows us to explore contextual variation at national and ethnic group levels.

We test three hypotheses;

1) Women with FGC are less likely to have extra-pair sex. Women with FGC are predicted to have lower incidence of several different indicators (see Table 1) of extra-pair sex compared to women without FGC.

2) Women with FGC marry earlier than women without FGC. Younger age at marriage for women is used as a proxy for marriage preference.

3) Men with high paternity concern are more likely to marry a first wife with FGC. Here we examine the relationship between the FGC status of a man's first wife and several different individual and contextual proxies for paternity concern; a) individual sexual experience and indicators of paternity concern; b) the prevalence of extra-pair sexual activity within a man's community; and c) expected levels of paternal investment within the man's community (matrilineal versus patrilineal groups).

2. METHODS

2.1 Data and study site

The Demographic Health Surveys Program (DHS) conducts surveys using nationally representative population samples, collecting data on a wide range of variables concerning health, fertility, and reproduction (www.dhsprogram.com) (ICF International, 2012). Women and men surveyed by the DHS are 15-49 and 15-59 years old respectively. The data is intended for policy formation, programme planning, monitoring and evaluation by the host country, and is also widely used by the UN and WHO. The datasets are publicly available, and the large sample sizes and wealth of variables collected in a comparable format across many countries also make it an excellent source of information for examining our hypotheses (Corsi et al., 2012). Relevant data is collected on female genital cutting, sexual experiences, marriage and socioeconomic profile. We have addressed the limitations of the data for our research purposes (reporting bias and survey relevance to research question) where possible, as explained in Sections 2.2-2.4.

For this study, countries from West Africa were selected based on the range of FGC prevalence in the ethnic groups within them (1-99%) which allowed us to explore the contextual effect of FGC prevalence on behaviour; Ivory Coast 2011-12, Mali 2006, Nigeria 2008, Burkina Faso 2010 and Senegal 2013. Together these datasets provided data on 72,438 women, 12,704 men, and 10,695 couples where FGC status was known, from 47 ethnic groups.

In the selected countries FGC typically takes place in infancy (75.6% of women in this sample were cut by age five) and is therefore under parental control. The DHS surveys ask women if they have been

circumcised (translated into the local term as appropriate) and those who respond affirmatively are asked what procedure was performed; 'skin nicked', 'flesh removed' or 'sewn closed'. The most common FGC type in the five study countries is 'flesh removed' (69.1% of women with FGC) (SI Table 1). Where FGC type is used in our statistical analysis, women are classified by the most severe procedure that they responded affirmatively to, excluding those who did not respond to the procedure-type question.

The DHS treats cohabitation and marriage equivalently. Respondents are asked if they are currently married or living with a partner as if married, and the date of first cohabitation is coded as the date of marriage. This reflects marriage practices in West Africa, where marriage is not necessarily a discrete event and the order of events may vary; a union may be preceded by cohabitation and/or consummation, and the union may be unofficial until bridewealth is received by the bride's family (Meekers, 1992). Most marriages are between individuals from the same ethnic group; Mali 75%, Senegal 83%, Burkina Faso 92%, Nigeria 94% and Ivory Coast 96%.

Multilevel models were used for all statistical analysis, pooling data from the five study countries. Multilevel models deal with hierarchically structured data and partition the sources of behavioural variance at different levels within the model. This approach is particularly appropriate for DHS datasets as ethnic group affinity has been shown to be a strong determinant of individual behaviour(Yoder and Wang, 2013), and the multilevel model structure allows for this clustering at the ethnic group level. Three levels were used here; individuals (n varies depending on the model), nested within ethnic groups (n 47), nested within countries (n 5). All women from an identified ethnic group were included in the analysis, excluding women in grouped or 'other' ethnic group categories.

2.2 Methods Hypothesis 1: Women with FGC are less likely to have extra-pair sex

To test whether FGC status affects incidence of women's extra-pair sexual activity, we calculated a number of different indicators of extra-pair sex from variables collected by the DHS surveys; age at first sex, age at first marriage, age at first birth, total lifetime number of sexual partners and the number of

sexual partners excluding their spouse in the preceding 12 months. Responses for sensitive subjects such as sexual experiences may be subject to reporting bias. While there is no reason to believe that this would vary across ethnic groups or countries, it could influence our results. We attempted to allow for reporting bias in two ways; firstly, we only included data for women who were surveyed alone. The DHS records the presence of others during the survey interviews and our analysis (not included here) showed significantly less sexual activity was reported by women when others were present. Excluding these women (n6,280) gave a sample of n65,618 women with known FGC status. Secondly, we calculated 6 different indicators of extra-pair sex (Table 1) each of which allowed for different reporting biases, and which also let us explore extra-pair sex by married and unmarried women.

Multilevel multivariate logistic regression models were used to test whether FGC status is a significant predictor of these extra-pair sex indicators when controlling for socioeconomic variables which have been shown to affect the prevalence of sexual activity (Okonofua et al., 2002;Van Rossem and Gage, 2009;Smolak, 2014;Mpofu et al., 2016). These control variables were included as appropriate in the different models depending on the outcome variable; religion (Muslim/Christin or other), education (none/some), residence type (urban/rural), woman's age at survey, woman's age at first marriage, woman's age at first sex, descent pattern (matrilineal/patrilineal), household wealth (quintiles), and marital status. Household wealth is not included in models relating to married women as this variable reflects household wealth, which for married women relates to their husband rather than their natal wealth.

To test whether more extreme forms of FGC have a greater impact on extra-pair sex we ran the same 6 models for the different extra-pair sex indicators but replaced FGC status (no, yes) with FGC type as categorised by the DHS ('skin nicked', 'flesh removed', 'sewn closed', and 'type unknown').

We also performed a simple bivariate Pearson correlation to examine the relationship between the prevalence of FGC and the prevalence of the extra-pair sex indicators by ethnic group. If FGC is associated with reduced sexual behaviour the correlation would be negative.

Table 1 Extra-pair sex indicators: calculation and sample criteria

	Indicator	Sample	Calculation	Notes
PREMARITAL	**Sex before marriage**	All ever-married women	Calculated from age at first marriage and first intercourse, both in whole years.	This is a conservative measure as premarital sex in the year of marriage is not identified as such.
PREMARITAL	**Sex 2 years + before marriage**	All ever-married women	Calculated from age at first marriage and first intercourse, both in whole years.	This indicator further reduces the probability that reported intercourse before marriage was with the woman's ultimate husband and therefore not extra-pair sex.
PREMARITAL	**Sex before marriage**	All never-married women	All never-married women who gave a date of first intercourse.	
PREMARITAL	**Childbirth before marriage**	Unmarried women who have given birth or are pregnant, plus married women	Married women whose age at first birth was lower than age at first marriage (in months).	This indicator removes reporting bias associated with underreporting of sexual activity. However, as not every incidence of sexual intercourse results in pregnancy this will underestimate absolute levels of sexual activity.
EXTRAMARIAL	**Sex other than husband in preceding 12 months**	All women who have been married for the preceding 12 months or more.	Calculated from number of self-reported sexual partners excluding husband, in the 12 months preceding the survey.	Only 3.0% women reported extramarital sex in preceding 12 months. This is highly sensitive and most likely to be subject to underreporting bias due to social sanctions and risk of divorce.
GENERAL	**2 or more lifetime sexual partners**	All sexually active women, excluding women who are divorced/widowed or have married more than once.	Calculated from respondents self-reported lifetime number of sexual partners.	Includes married and unmarried women.

2.3 Methods Hypothesis 2: Women with FGC marry earlier than women without FGC

Multilevel cox (proportional hazard) regression models were performed to examine the effect of FGC status on age at first marriage. Cox regression is an event history analysis which examines the effect of different variables upon the time a specified event takes to happen. The model takes into account censoring i.e. not all individuals in the sample experience the event, which makes it preferable to a linear regression model examining age at first marriage. A hazard ratio (the exponent of the coefficient) over 1 indicates that the predictor variable is associated with a shorter time to event (Mills, 2011). In

our model the specified event was marriage, the time was age (in years and months), and the model incorporated the marital status (married/unmarried) of women at each age. The model controlled for socioeconomic variables known to affect women's age at first marriage; religion (Muslim/Christian or other), age, type of residence (urban/rural) and education (none/some) (Larsen and Yan, 2000;Boyden et al., 2012). The model also controlled for FGC frequency in the woman's ethnic group as the social norms within the marriage group may affect marriage preferences (Howard and Gibson, 2017;Shell-Duncan et al., 2011). All women with data for the control variables were included in the analysis (n 48,231).

2.4 Methods Hypothesis 3: Men with high paternity concern are more likely to marry a first wife with FGC

Multilevel multivariate logistic regression analysis was used to test this hypothesis in which the outcome variable of interest is the FGC status of a man's first/only wife, and indicators of paternity concern were included in the model in addition to control variables. The DHS survey does not include direct questions about men's paternity concern, therefore we systematically reviewed all available variables to identify those which could be used to create individual-level and ethnic group-level proxies for paternity concern. Previous studies have shown that group-level norms are important determinants of behaviour (Howard and Gibson, 2017). Individual-level proxies include factors which prevent men from 'mate-guarding' (absent ever, and absent for more than one month during the 12 months preceding the survey), whether the man is polygamous, and the man's personal sexual experience (incidence of premarital sex, and lifetime number of sexual partners) which could influence his assessment of women's sexual activity. Ethnic group-level proxies concern sexual activity by men and women within the man's ethnic group; prevalence of premarital sex and extra-marital sex, and the average number of lifetime sexual partners. These indicators were calculated from the wider population, and varied substantially between ethnic groups (SI Table 2). As the individual and ethnic group-level proxies are confounded, several models were performed adding each experimental variable separately to the control variables.

To remove differences in marriage preference which may be due to wife rank in polygamous or second marriages, only couples comprising a man and his first wife (whose FGC status is known) were included in the analysis. This gave a sample of 10,693 couples across the five countries. The probability of marriage to a woman with FGC is highly correlated with the FGC prevalence in a man's ethnic group, as within ethnic group marriages are predominant (see 2.1 above). The multilevel model allowed FGC prevalence at the ethnic group level to be controlled for as a level 2 contextual variable. Additionally the multilevel model controlled for individual male variables; age at survey, age at marriage, wealth (quintiles), education (none/some), religion (Muslim/Christian or other), and residence type (urban/rural).

We also tested three variations of the basic multilevel model: 1) A model which only included ethnic groups in which FGC prevalence ranges from 20% - 80% as marriage choices may reflect availability rather than preference in groups where FGC prevalence is close to 0% or 100%. This model excluded 20 ethnic groups, leaving 27 ethnic groups (n 6,850); 2) A model which excluded the Ivory Coast. There are a number of anomalies found in the Ivory Coast which could affect the results; the level of reported sexual activity among men and women is substantially higher than in the other countries (SI Table 2), and four out of the eleven ethnic groups are matrilineal (n398 out of 1081); and 3) A model with matrilineal ethnic groups only, to explore expected levels of paternal investment as a proxy for paternity concern. D:Place (https://d-place.org) was used to identify ethnic group descent pattern as this is not collected by the DHS. Just 6.0% of the couples in the sample are from matrilineal groups (n 639, 7 ethnic groups) with a range of FGC prevalence of 1.4% - 84.4%.

SPSS v23 was used for single level modelling, and MLwiN v3.01 was used for multilevel modelling.

3. RESULTS

3.1 Results Hypothesis 1: Women with FGC are less likely to have extra-pair sex

The multilevel logistic regression results (Table 2) show that a woman's FGC status is not a significant predictor of any of the four indicators of premarital sex; sex before marriage (OR 0.937, 95%CI(0.869-1.009) p=0.081), sex 2 years before marriage (OR 0.989, 95%CI(0.907-1.078) p=0.951), unmarried sex (OR 1.097, 95%CI(0.985-1.222) p=0.113), or childbirth before marriage (OR 1.113, 95%CI(0.970-1.279) p=0.128). Likewise, a woman's FGC status is not a significant predictor of whether a woman had extra-marital sex in the preceding 12 months (OR 1.031, 95%CI (0.868-1.227) p=0.175). However women with FGC do have significantly lower odds of having more than one sexual partner in their lifetime (OR 0.821, 95%CI (0.756-.0881) p<0.000). In all models the ethnic group level variance is significant (p<0.000) whereas the country level variance is not. This suggests that ethnic group affinity is a stronger predictor of these behavioural outcomes than country affinity.

Table 2 Multilevel multivariate logistic regression analysis investigating the odds of different extra-pair sex indicators among female respondents aged 15-49 years

	PREMARITAL												EXTRAMARITAL			GENERAL		
	Sex before marriage			Sex 2 or more years before marriage			Unmarried women who have had sex			Childbirth before marriage			Extramarital sex during previous 12m			2 or more lifetime sexual partners		
Sample			**n 40,585**			**n 40,585**			**n 12,395**			**n 41,196**			**n 38,838**			**n 39,164**
Women with outcome:			*25.5% n 10,346*			*18.5% n 7,502*			*35.0% n 4,448*			*7.0% n 2,915*			*3.0% n 1,167*			*24.2% n 9,476*
Fixed effects	**OR**	**(95% CI)**	**p**	**OR**	**(95% CI)**	**p**	**OR**	**(95% CI)**	**p**	**OR**	**(95% CI)**	**p**	**OR**	**(95% CI)**	**p**	**OR**	**(95% CI)**	**p**
FGC (No FGC)	0.937	(0.869-1.009)	0.081	0.989	(0.907-1.078)	0.951	1.097	(0.985-1.222)	0.113	1.113	(0.970-1.279)	0.128	1.031	(0.868-1.227)	0.715	0.821	(0.756-0.881)	0.000
Some education (none)	1.179	(1.102-1.264)	0.000	1.195	(1.103-1.295)	0.000	1.153	(1.009-1.317)	0.047	1.438	(1.273-1.623)	0.000	3.497	(3.019-4.051)	0.000	2.206	(2.035-2.390)	0.000
Rural (urban)	0.888	(0.835-0.943)	0.000	0.954	(0.889-1.023)	0.191	0.841	(0.743-0.951)	0.002	0.788	(0.843-1.163)	0.899	0.406	(0.355-0.465)	0.000	0.634	(0.594-0.676)	0.000
Muslim (Christian other)	0.817	(0.751-0.886)	0.000	0.798	(0.725-0.878)	0.000	0.875	(0.767-0.998)	0.046	0.990	(0.959-0.970)	0.000	0.604	(0.492-0.739)	0.000	0.754	(0.695-0.859)	0.000
Matrilineal (patrilineal)	0.867	(0.453-1.658)	0.666	0.918	(0.482-1.745)	0.496	1.178	(0.545-2.545)	0.676	1.212	(0.756-1.945)	0.415	1.355	(0.745-2.464)	0.315	0.972	(0.418-2.258)	0.948
Age at survey	0.976	(0.972-0.980)	0.000	0.977	(0.973-0.981)	0.000	1.240	(1.216-1.264)	0.000	0.964	(0.706-0.879)	0.000	0.959	(0.951-0.966)	0.000	1.013	(1.009-1.017)	0.000
Age at 1st marriage	1.290	(1.277-1.307)	0.000	1.381	(1.359-1.403)	0.000	..	..	..	1.608	(1.579-1.636)	0.000	1.009	(0.989-1.029)	0.409	..	..	..
Age at 1st intercourse	..	..	..	..	..	..	..	..	..	0.616	(0.603-0.631)	0.000	0.932	(0.905-0.960)	0.000	0.906	(0.895-0.916)	0.000
Ever married (never)	..	..	..	..	..	..	..	..	..	..		..	..	..	..	0.623	(0.623-0.741)	0.000
Wealth (5 point scale)	..	..	..	..	..	..	0.933	(0.890-0.978)	0.508	..	..	..	..	..	..	..		..
Random effects	**Variance**	**(S.E.)**	**p**	**Variance**	**(S.E.)**	**p**	**Variance**	**(S.E.)**	**p**	**Variance**	**(S.E.)**	**p**	**Variance**	**(S.E.)**	**p**	**Variance**	**(S.E.)**	**p**
Ethnic group variance	0.507	(0.116)	0.000	0.481	(0.112)	0.000	0.629	(0.156)	0.000	0.211	(0.058)	0.000	0.353	(0.097)	0.000	0.885	(0.200)	0.000
Country variance	0.639	(0.439)	0.150	0.821	(0.556)	0.140	1.426	(0.956)	0.136	0.273	(0.192)	0.155	0.177	(0.145)	0.313	0.641	(0.473)	0.175
Ethnic group ICC	13.3%			12.8%			16.1%			6.0%			11.0%			21.2%		
Country ICC	23.3%			20.0%			30.2%			7.7%			15.4%			16.1%		

Notes: 1) Individual sample size varies, but for all models level 2 (ethnic group) n=47, and level 3 (country) =5

2) See methods section 2.2, Table 1, for inclusion criteria and calculation of outcome variables for each model

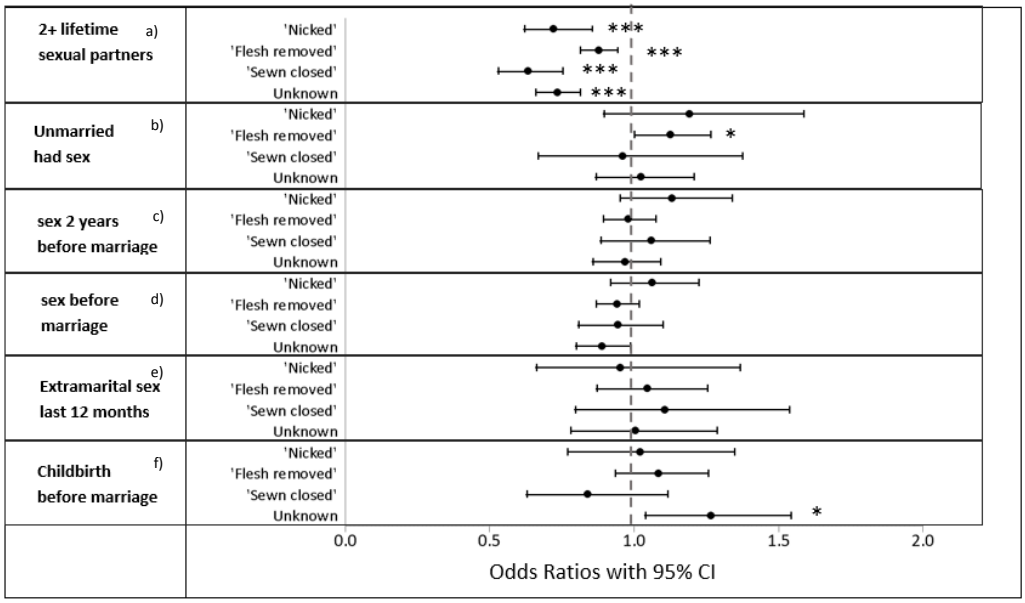
3) The reference category is given in brackets for categorical variables

4) Not all predictor variables are relevant to all models, see methods section 2.2

5) ICC is the intra-class correlation coefficient, also known as the variance partition coefficient. This gives an measure of the variance in outcome attributable to the different levels in the model. The remaining unexplained variation is due to individual-level factors.

The models examining effect of FGC type showed that FGC type is not a strong differentiator of most indicators of extra-pair sex (Figure 1, full model shown in SI Table 3). Women with all types of FGC have significantly lower odds of having more than one lifetime sexual partner compared to women without FGC and women who are 'sewn closed' have the lowest odds ('nicked' OR 0.720, 95%CI(0.620-.0855) p<0.000, 'flesh removed' OR 0.875, 95%CI(0.813-0.943) p<0.000, 'sewn' OR 0.631, 95%CI(0.528- 0.75) p<0.000 and unknown OR 0.732, 95%CI(0.660-0.812) p<0.000). The other indicators of sexual activity show no significant difference between women with different FGC types, with just two exceptions; unmarried women with 'flesh removed' have higher odds of having had sex (OR 1.125, 95%CI(1.000-1.266) p=0.050) and women with unknown FGC type have higher odds of birth before marriage (OR 1.265, 95%CI(1.038-1.542) p=0.019).

Figure 1 Odds ratio plot with 95% confidence intervals showing the results of multilevel multivariate logistic regression results examining effect of FGC type on different indicators of extra-pair sexual activity



*** p<0.001, ** p <0.001, * p<0.05
Sample sizes: a) 40,585 b) 40,585 c) 12,395 d) 41,996 e) 38,838 f) 39,164
Odds ratios shown are compared to reference category of No FGC
Full models see SI Table 3

Bivariate Pearson's correlation was used to examine the relationship between the prevalence of FGC and the prevalence of extra-pair sexual activity by women at the ethnic group level (n 47). The results show that there is a small but significant negative correlation for all three indicators i.e. with higher

prevalence of FGC in the ethnic group, the proportion of women engaging in extra-pair sex decreases (premarital sex r=-0.316, p=0.031, extramarital sex: r=-0.373, p=0.010, average number of sexual partners: r=-0.379, p=0.009). Analysis by country shows that the correlations are not significant in Mali, Senegal, Nigeria and Burkina Faso and that the overall result is being driven by the significant negative correlations in Ivory Coast ethnic groups (n 11) for all three indicators (SI Table 4).

3.2 Results Hypothesis 2: Women with FGC marry earlier than women without FGC

The Cox regression model results show that women with FGC are at a significantly higher hazard for first marriage i.e. married earlier, than women without FGC after controlling for socioeconomic variables and FGC prevalence (HR 1.113, 95%CI (1.085-1.142) p<0.000). Women with FGC have an 11.3% higher hazard of being married at every age than women without FGC, when keeping the control variables constant. The country and ethnic group variance in age at first marriage are very low, indicating that the majority of the variance is explained by individual-level variables. (See Table 3)

Table 3 Multilevel cox regression hazard model predicting age at first marriage for women aged 15-49 years

CONTROLS	B	S.E.	HR	95% CI		p value
Fixed effects						
FGC (No FGC)	0.107	0.013	1.113	1.085	1.142	0.000
Age at survey	-0.292	0.001	0.971	0.745	0.748	0.000
Religion (other religion/Muslim)	0.117	0.015	1.125	1.092	1.158	0.000
Rural (urban/rural)	0.238	0.011	1.269	1.242	1.296	0.000
Education (none/some)	-0.363	0.012	0.696	0.679	0.712	0.134
Contextual variables						
Ethnic FGC%	-0.152	0.141	0.859	0.652	1.132	0.280
Random effects						
Ethnic group variance	0.064	0.259				
Country variance	0.031	0.175				
Ethnic group ICC		1.9%				
Country ICC		0.1%				

Individuals (n 42,381), Ethnic group (n 47), Countries (n 5)
(Reference categories for categorical variables are underlined)

3.3 Results Hypothesis 3: Men with high paternity concern are more likely to marry a first wife with FGC

The multilevel level logistic model results (Table 4) show that most individual-level proxies for paternity concern do not have a significant association with the FGC status of a man's first wife (Models 1-5), after controlling for individual SES variables and ethnic FGC prevalence. The exception is sex before marriage (Model 3) which is associated with higher odds of having a wife with FGC (OR 1.135, 95%CI (1.000-1.290) p=0.026). However, the ethnic group-level proxies of sexual activity by men and women all have a strong positive significant effect on the odds of a man having a wife with FGC (Models 6-11). Models 6 and 7 show that with every increase in the average number of sexual partners by women in the ethnic group the odds of having a wife with FGC increases by 81%, and for men the odds increase by 10%. Models 8-11 show the effect of prevalence of premarital and extramarital sex by men and women within the group. The results shown are for 1% prevalence, so to apply this to any individual ethnic group the results must be multiplied by the actual ethnic group prevalence of the behaviour (See SI Table 3). For example, in an ethnic group where 50% of men have had premarital sex (Model 8), the odds of a man in that ethnic group having a first wife with FGC is 1.822 (exp(0.012 x 50) or 82.2% higher.

The prevalence of extramarital sex within the ethnic group has a stronger effect (men OR 1.031, 95%CI(1.015-1.048) p<0.000; women OR 1.034, 95%CI(1.013-1.054) p<0.000) than the prevalence of premarital sex (men OR 1.013, 95%CI(1.002-1.022) p=0.006; women OR 1.015, 95%CI(1.005-1.025) p=0.001), although the prevalence of either behaviour among men or women in the ethnic group has a similar effect. However, the average number of sexual partners by women compared to men in the ethnic group has a much larger effect (men OR 1.100, 95%CI (1.042-1.163) p=0.001; women OR 1.813, 95%CI (1.302-2.525) p,0.000).

Table 4 Results of multilevel logistic regression models examining variables associated with the FGC status of a man's first wife; experimental variables were added to the control variables in separate models.

CONTROLS		B	S.E.	OR	95% CI	p value
Individual Male SES variables						
Age		0.022	0.003	1.022	(1.016-1.028)	0.000
Religion (<u>other religion</u>/Muslim)		0.655	0.078	1.873	(1.652-2.243)	0.000
Rural (<u>urban</u>/rural)		0.145	0.071	1.161	(1.006-1.329)	0.039
Age at marriage		-0.019	0.005	0.981	(0.972-0.991)	0.000
Education (<u>none</u>/some)		-0.112	0.070	0.903	(0.779-1.026)	0.134
Wealth (increasing 5 point scale)		-0.140	0.027	0.873	(0.825-0.917)	0.000
Polygamous (<u>no</u>/yes)		0.039	0.074	1.037	(0.899-1.202)	0.625
Contextual variables						
Ethnic FGC%		0.059	0.003	1.060	(1.055-1.067)	0.000
EXPERIMENTAL VARIABLES						
Proxies for paternity concern: Individual male variables (level 1)						
Model 1. Away last 12 months (<u>no</u>/yes)		0.037	0.059	1.037	(0.924-1.165)	0.211
Model 2. Away for 1m+ (<u>no</u>/yes)		0.097	0.078	1.101	(0.946-1.284)	0.639
Model 3. Premarital sex (<u>no</u>/yes)		0.127	0.065	1.135	(1.000-1.290)	0.026
Model 4. Extramarital sex (<u>no</u>/yes)		0.082	0.105	1.085	(0.884-1.333)	0.432
Model 5. No. sexual partners in lifetime		0.001	0.003	1.001	(0.995-1.007)	0.629
Proxies for paternity concern: Ethnic group variables (level 2)	**Range**					
Model 6. Av. no. sexual partners (men)	2.3 - 9.1	0.096	0.028	1.100	(1.042-1.163)	0.001
Model 7. Av. no. sexual partners (women)	1.2 - 3.9	0.595	0.169	1.813	(1.302-2.525)	0.000
Model 8. Premarital sex % (men)	12-93%	0.012	0.005	1.013	(1.002-1.022)	0.006
Model 9. Premarital sex % (women)	0-71%	0.015	0.005	1.015	(1.005-1.025)	0.001
Model 10. Extramarital sex % (men)	1-59%	0.031	0.008	1.031	(1.015-1.048)	0.000
Model 11. Extramarital sex % (women)	1-35%	0.033	0.010	1.034	(1.013-1.054)	0.000

Notes:

1) Level 3: Country n 5, Level 2: Ethnic group n 47, Level 1: Couples n 10,695

2) The experimental variables were added separately to the model in addition to the control variables; the effects shown above are individual not cumulative. The significance of the control variables did not change with the addition of any of the experimental variables, the results shown here are for the control variables alone.

3) Sexual behaviour by ethnic group are shown in detail in SI Table 2.

4) Reference categories for categorical variables are underlined

The variations to the basic multilevel models tested were as follows; the models which only included ethnic groups where the FGC prevalence ranged from 20-80% showed the same pattern of results as Table 4 with almost no difference in effect size or significance (SI Table 5); excluding individuals from Ivory Coast from the model also made no difference to the effect size or significance. However, the model which only included matrilineal groups showed that most ethnic group proxies of sexual activity had a smaller and non-significant effect on the odds of a man marrying a wife with FGC than in the full

403 model, and only premarital sex % (men) (OR 1.077, 95%CI (1.046-1.109) p<0.001) is a significant
404 predictor of men from matrilineal groups having a wife with FGC (SI Table 6).

405 **4. DISCUSSION**

406 **4.1 Hypothesis 1: Women with FGC are less likely to have extra-pair sex**

407 Our results do not support the hypothesis that FGC reduces extra-pair sex uniformly, rather they reveal
408 how FGC status is associated with different indicators of extra-pair sex. Women with FGC do not have
409 lower odds of engaging in premarital sex or extramarital sex than women without FGC. These findings
410 are in line with previous studies (Odimegwu and Okemgbo, 2000;Okonofua et al., 2002;Msuya et al.,
411 2002;Klouman et al., 2005b;Yount and Abraham, 2007;Van Rossem and Gage, 2009;Smolak,
412 2014;Mpofu et al., 2016). Further, we do not find that increasing severity of FGC significantly reduces
413 the odds of women having premarital or extramarital sex. This novel finding contrasts with commonly
414 held views, in particular, that infibulation prevents premarital sexual activity e.g. (Mackie, 1996).

415 However, women with all types of FGC are significantly less likely to report having had more than one
416 sexual partner in their lifetime. The contrast of this result with the premarital and extramarital
417 indicators is open to interpretation. One possibility is that families in which FGC is practiced have
418 cultural norms which permit premarital sex (particularly if with a potential future husband) but
419 discourage sex with multiple partners. Our results show that FGC status does not affect the incidence of
420 premarital sex, which therefore suggests that differences in sexual activity between women
421 with/without FGC are due to socially learned attitudes to sex rather than physiological consequences of
422 the FGC procedure. Under this interpretation FGC does not predictably inhibit sexual function, but does
423 covary with marital fidelity.

424 In view of our findings that FGC status does not predict women's premarital sexual behaviour, it is
425 interesting that the opposite perception is widespread locally and among policy makers (UNICEF,
426 2013;Adongo et al., 1998;Skaine, 2005;Mackie, 1996). In four of the study countries (Mali, Nigeria,

Burkina Faso and Ivory Coast) the DHS survey also collected opinions about FGC, showing that 4 – 24% of men agreed that FGC prevents premarital sex compared to 4 – 13% of women (SI Figures 1a & 1b). In Mali and Nigeria data is available which allows comparison of the actual incidence of women's premarital sex with men's opinion that FGC prevents premarital sex, by ethnic group. Our analyses indicate that men's perceptions are not aligned with actual incidence (i.e. it is not the case that more men think FGC prevents premarital sex in ethnic groups where fewer women with FGC have premarital sex) (SI Figure 2). However, perceived risk of infidelity may be more important than women's actual behaviour in determining marriage preferences.

4.2 Hypothesis 2: Women with FGC marry earlier than women without FGC

The Cox regression results confirmed the hypothesis and showed that after controlling for ethnic FGC prevalence and socioeconomic profile, women with FGC have a significantly higher hazard of marrying at a younger age than women without FGC. These results lend support to the idea that women with FGC may be preferred as marriage partners (Sakeah et al., 2006;Kaplan et al., 2013). The positive effect of a woman's FGC status means that even in ethnic groups where having FGC is not the norm (i.e. where you wouldn't expect women with FGC to be preferred) women with FGC get married earlier.

It has been shown that publicly stated opinions regarding FGC may understate true levels of support for the practice (Gibson et al., in press). This may explain the difference between men's higher support for FGC abandonment described in the literature (Varol et al., 2015) (and see SI Figure 1b), and the results found here which seem to indicate a preference for marriage to women with FGC. The FGC status of men's wives is likely to be a better measure or their views on FGC than hypothetical data on attitudes to FGC typically recorded in surveys.

Marrying a woman with FGC and marrying a younger woman have both been linked to paternity concern, as both factors theoretically increase the chances that a woman will not have had sex at marriage (Hartung, 1985;Voland, 1998). Men with high concern about paternity may be reducing their risk by marrying a younger woman who also has FGC. However, these marriage preferences may also be

452 motivated by the wife's reproductive potential. Starting reproduction at a younger age increases a
453 woman's fitness (Allal et al., 2004), and women with FGC have been shown to have higher evolutionary
454 fitness (Gruenbaum, 2000;Reason, 2004).

455 **4.3 Hypothesis 3: Men with high paternity concern are more likely to marry a first wife with FGC**

456 Using multilevel logistic models we examine how proxies for paternity concern at individual and group-
457 level affect the odds of a man's first wife having FGC. Few of the individual-level proxies for paternity
458 concern (absence from home, polygamy, men's own sexual activity) had a significant impact on the FGC
459 status of a man's first wife in the model. This may be because the proxy variables used are not reliable
460 indicators of pre-conceptual paternity concern (e.g. level of absence from home may have changed
461 since marriage) but may also reflect that a man's own sexual activity is not a cue for paternity concern.

462 The ethnic group-level contextual proxies for paternity concern show a very strong positive association
463 with the FGC status of a man's first wife, while holding FGC prevalence in the ethnic group constant.
464 These results suggest that men are responding to the levels of sexual activity within their ethnic group,
465 and where the risk of a man's partner engaging in extra-pair sex appears higher, men are more likely to
466 marry a first wife with FGC. The stronger effect of the prevalence of extramarital compared to
467 premarital sex within the ethnic group provides further support that men are responding to the higher
468 risk of extra-pair sex during marriage. In addition, the stronger effect of women's average number of
469 sexual partners compared to men's supports the paternity certainty hypothesis. Restricting our sample
470 to matrilineal groups, we find few of the ethnic group-level sexual activity indicators have a significant
471 impact on the odds of men having a wife with FGC (SI Table 6). This supports the prediction that
472 paternity concern (or lack of it, as is believed to be the case in matrilineal societies (Holden et al., 2003))
473 may affect men's marriage choices.

474 Our findings are consistent with behaviour predicted by the paternity certainty theory, however,
475 whether these marriage choices result in higher evolutionary fitness is unknown. Here we used self-
476 reported extra-pair sexual activity to gauge the risk of misplaced paternal investment, however DNA

testing would be required to establish whether non-paternity rates are any different for men whose wives have FGC. To accommodate for the possibility that self-reported sexual activity levels may be inaccurate, we used three different indicators of group sexual activity, which are calculated from a number of data points for both men and women (Dare and Cleland, 1994;Nnko et al., 2004). However, men's perceptions of sexual activity within the marriage pool may be more important than the reality in their assessment of the risk of extra-pair sex. If men are over-reporting their sexual activity levels to survey interviewers, it is possible they are doing the same when talking with their peers.

While the results here suggest that men are making context-dependent marriage choices potentially motivated by paternity concern, in reality women are making choices too and many factors not covered by the DHS surveys influence the negotiations and economics of marriage. For example, bridewealth payments at marriage (from the groom to the bride's family) are common in West Africa, and may influence support for FGC (Groszngate, 1988;Hampshire and Smith, 2001;Mondain et al., 2007;Calv et al., 2007). The relationship between FGC status and bridewealth negotiations is not well understood, and has only been the subject of a few studies; finding that bridewealth payments can be dependent on a woman having FGC, or that bridewealth can be of higher value if the bride has FGC (Shell-Duncan et al., 2000;Apostolou, 2008). Likewise, family involvement is very important in West Africa where marriages are often arranged by the couples' parents or relatives (Mair, 2013). Cross-cultural studies have shown that parental rather than individual choice can be more influential in partner selection (Apostolou, 2008). This wider network of individuals involved in partner choice may result in competing evolutionary drivers. Parents' marriage preferences will often be aligned with their offsprings', but they may diverge, for example due to marital residence patterns or family composition (Trivers, 1974).

Alternative explanations for the marital preferences for men tested in Hypothesis 2 and 3 could include some phenotypic variation associated with FGC status which influence women's age at marriage and/or opportunity for marriage, but which are not captured in the data. One example could be religiosity; we have controlled for religious group, but not for variation in piety or devoutness. Likewise, men and their families may be selecting women for marriage based on some cultural trait which confounds with FGC

503 status (e.g. using FGC as a cultural indicator of fidelity as suggested by results testing Hypothesis 1,
504 section 3.1).

505 **5. CONCLUSION**

506 In this study DHS datasets from five West African countries were used to test the often-stated yet
507 unproven theory that paternity certainty is driving the persistence of FGC. This assumes that FGC
508 impairs women's sexual function and reduces the probability of women having extra-pair sex, which in
509 turn leads men to prefer marriage to women with FGC, particularly men with higher paternity concern.
510 Support was found for some but not all the assumptions tested. In our sample, having FGC does not
511 reduce the odds of women having premarital extra-pair sex, although it does reduce the odds of women
512 having more than one lifetime sexual partner. We find that women with FGC get married at a younger
513 age, which may be an indicator of marriage preferences for men. The strongest support for the
514 paternity certainty theory comes from the multilevel model results examining the odds of marrying a
515 woman with FGC. This shows that men living in ethnic groups with higher levels of reported extra-pair
516 sexual activity (and potentially a higher risk of unknowingly raising another man's offspring), have
517 greater odds of marrying a first wife with FGC. This suggests that marriage choices made by men and
518 their kin are context-dependent and may be influenced by sexual norms of the group in which they live.

519 While we do not find that FGC is universally associated with reduced extra-pair sex for women, our
520 results suggest that FGC status does improve women's marriage opportunities, particularly where the
521 incidence of extra-pair sex is higher. This apparent disparity raises some interesting questions. If
522 marriage preferences for men are based on inaccurate beliefs that FGC increases women's sexual
523 fidelity, why or how are these incorrect perceptions perpetuated? If FGC is a cultural marker signalling
524 sexual fidelity, either to potential marriage partners or to other women as a sign of non-competition,
525 this could be advantageous for women (Wilson, 2008). The disparities we have identified challenge
526 whether paternity concern is the only explanation for the marriage preferences found here. It is

possible that some behavioural or phenotypic characteristic not captured in our analysis such as religiosity or social status, which varies with FGC status, may better explain these results.

A further element of the paternity certainty theory of FGC (not tested here) is that marriage preferences of men (and their patri-kin) encourage families to have their daughters cut which indirectly perpetuates the practice. In contexts where women's socioeconomic security is often dependent on marriage, parents are motivated to ensure that their daughters attract marriage partners. In addition to enhanced marriageability, we speculate that FGC could also enhance women's reproductive success. If men are more convinced of their own paternity when married to women with FGC, they may invest more in their offspring. This extra investment could improve offspring survival, as would a lower incidence of child abuse, neglect and mortality which is also associated with higher paternity confidence (Daly et al., 1982). This potential for enhanced reproductive success for women with FGC may be part of the functional explanation for parental decisions over having FGC performed on their daughters (Tinbergen, 1963).

There are multiple documented reasons for having FGC performed, which at the proximate level include social acceptance, cleanliness, tradition and religion (Shell-Duncan, 2004). Previously, it has been shown how cultural and evolutionary forces may combine to influence the popularity of the practice (Howard and Gibson, 2017). Here we demonstrate the importance of FGC for women's marriage opportunities, most notably in contexts where the risk of extra-pair sex is higher. The results suggest that paternity certainty cannot be ruled out as a factor contributing to the maintenance of female genital cutting in these five West African countries.

Data availability

The data associated with this research are available at [https://dhsprogram.com/data/available-datasets.cfm].

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