The uptake of modern contraception in a Gambian community: the diffusion of an innovation over 25 years.

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Abstract

In this study we examine first use of modern contraception in four Gambian villages over 25 years. This is the first such study showing micro-level change over time from the first availability of this new technological innovation. In 1975, a medical centre was opened in one village providing contraceptive services free of charge to those who wished to use it. We examined determinants of women's age at first use of modern contraceptives, from 1975 or from age 15 if younger than that in 1975. The ideal of large family size remains strong, and those at low parity are significantly less likely to start using contraception than those at high parity for their age. Wealth was also significantly related to the probability of contraceptive use, but negatively, with the wealthiest ranked women being the least likely to adopt the innovation. But we find that the largest effects on the probability of uptake were village and calendar year. Over the last 25 years, there is a doubling time of about 10 years in the risk of progressing to first use of contraception. Villages with strong social ties proceed at a similar rate, whereas one village that had fewer social ties with the others proceeded at a much faster rate. These patterns of uptake suggest that cultural transmission has an important effect on the spread of this technological innovation. We also compare the reproductive success (i.e. completed fertility) of users and non-users, and find that women using contraception actually have higher reproductive success than those that do not. The dynamics of uptake are discussed in the light of both evolutionary and social network models of cultural diffusion.

|Introduction.

The diffusion of innovations through communities has been a topic of interested for both sociologists (Rogers, 1995) and demographers, and, in a parallel literature, for those interested in cultural evolution (Boyd & Richerson, 1985). Demographers, trying to understand the demographic transition to low fertility, have found the study of social networks a useful tool for understanding the diffusion of ideas about reducing fertility (Kohler, 1997), and about using modern contraceptives to achieve this. But whilst demographers are now reasonably happy to explain demographic transitions through proximate mechanisms, such as the spread of modern ideas about low fertility through populations, human evolutionary ecologists interested in trends in fertility are still unsatisfied with such explanations because they do not resolve a deeper problem of why should anyone voluntarily limit their fertility, when this would ostensibly reduce their reproductive success and thus their Darwinian fitness. Economic demographers and evolutionary ecologists have both emphasized the quantity/quality trade-off inherent in raising children as a possible explanation (Borgerhoff Mulder, 1998; H. Kaplan, 1996). The higher the levels of parental investment required for children to be successful in marrying and establishing viable households of their own, then the smaller the optimal family size that will maximise long-term reproductive success and wealth (Mace, 1998). However whilst there is evidence that having a smaller family may promote economic success, the evidence that limiting fertility (other than by very small amounts) enhances long-term reproductive success is not evident (H. S. Kaplan, Lancaster, Bock, & Johnson, 1995). Gene-culture co-evolutionary theorists have argued that innate biases to copy those in prestigious positions may have lead to the trend to reduce fertility: if children hamper our ability to achieve wealth and status in the modern world, then copying the wealthy could lead to the spread of notions of low fertility (Boyd & Richerson 1985). Thus, they argue an adaptive, evolved bias leads to a maladaptive outcome in a novel environment. Demographers have also stressed the importance of influential members of the community to help promote the spread of ideas about contraception. In this study, we follow the adoption of contraception in a rural Gambian community over 25 years. We examine determinants and patterns of uptake in the light of both sociological and evolutionary theories.

Whilst most developing regions of the world followed fairly rapid fertility decline during the 20th century, sub-Saharan African countries were the last to start on what is now a worldwide phenomenon and appear to be proceeding rather slowly. Typically the onset of fertility decline is associated with mortality decline, but beyond that very broad generalisation, the precise timing of the onset of fertility decline has proved hard to associate with any particular feature of the demographic or economic profile of a region (Cleland & Wilson, 1987). After decades of research on this topic, favour was found with the hypothesis that cultural diffusion of an idea was a major determinant of the variation in the timing of the onset of fertility decline (Bongaarts & Watkins, 1996).

Top down political programs urging small family size are less influential than one might expect, at least in the absence of coercion. It has been hypothesized that women in social groups who come into contact with other women who are using modern contraception successfully are far more likely to start using modern

contraception themselves. There is evidence that ideas or information about contraception may diffuse horizontally between proximal regions (Bocquet-Appel & Jakobi, 1997), through social networks (Paz Soldan, 2004; Valente, Watkins, Jato, VanderStraten, & Tsitsol, 1997) and across regions speaking the same language (Amin, Basu, & Stephenson, 2002; Lesthaeghe, 1977). It is also possible that women who are in a position to observe the benefits to children and mothers of smaller family size are encouraged the change their preferences with respect to family size.

The adoption of technological innovations that arise from such cultural diffusion usually follow an S-shaped curve. Sociologists have typically interpreted this S-shape as a reflection of different levels of risk aversion in populations, with innovators acting first, followed by the less adventurous individuals, with conservatives and laggards taking much longer to adopt new technologies (Rogers, 1995). However cultural evolutionary modellers have pointed out that even in a population of identical individuals, if all individuals are influenced by the frequency of their contacts with users of the new technology, then uptake rates will accelerate as the density of potential 'cultural parents' that use the innovation increases, followed by a decline only when the number of non-users becomes sparse (Boyd & Richerson, 1985; Henrich, 2001). Alternatively, if women are not responding to each other, but to advertising or other forms of public information, then uptake curves might be expected to be linear (if advertising rates are constant) or r shaped, or even highest at the point of the advertisement, followed by decline. Thus the shape of the uptake curves over time can give us information about how ideas about modern contraception are being propagated.

In the Gambia, fertility decline is only very recently observed (Cohen, 1998), and contraceptive use is low: the most recent data suggests only 8.9% of Gambian women are using modern methods of contraception (UN 2003). The ideal of large family size persists, especially in rural areas, as it does in most of rural Africa; although modern contraception nonetheless provides a useful alternative to sexual abstinence for those wanting to space births, preserve maternal health and to prevent extremely large family sizes (Bledsoe, Hill, D'Alessandro, & Langerock, 1994). One barrier to contraceptive uptake is fear of the new technology, often associated with the fear that fertility might not return after contraceptive use has stopped. Another is opposition from husbands; the women reported to us that their husbands were less concerned or aware of the high health costs to mothers and children of high fertility. However some men reported that problems with school fees and clothing costs resulted in large families being problematic. Some religious leaders also oppose birth control.

Our study takes place in four, neighbouring villages in rural Gambia, three of which have unusually good access to health care due to the presence of a medical centre. This was set up by the MRC as part of a long-term medical research project. The majority of villagers are Mandinka farmers, living and working in an environment characterised by strong seasonality and high disease burdens; and are Muslim. Medical research started at the site in 1949, which, for the next 25 years, included the recording of dates of all births and deaths in the four villages, but did not involve the year-round presence of medical staff in the villages. Prior to 1974, the villages experienced high fertility and high mortality, due to high levels of general parasitism and specifically malaria (Billewicz & McGregor, 1981). In 1975 the medical centre was opened in one of the villages, providing free medical care, which was available

throughout the year; mortality rates began to decline immediately (Lamb, Lamb, Foord, & Whitehead, 1984; Rayco-Solon, Moore, Fulford, & Prentice, 2004), although fertility remained high. It was at that time that contraceptive services first became available. Before 1975, one village (D) had withdrawn from the research project, so only 3 villages had access to the contraceptive and other services provided by the medical centre. Much of the research being conducted in villages A, B, and C was on mothers and babies, so mothers had frequent contact with midwives, from whom contraceptive advice and the contraceptives themselves could be obtained. Our main interest here is in how contraceptive uptake spread through these villages over time.

Evolutionary ecologists (and hence evolutionary demographers) make a distinction between the proximate and ultimate causes of a behaviour (Krebs & Davies, 1993). By ultimate causes, we mean the factors influencing the fitness of individuals following that behaviour and thus the evolutionary forces that cause it be maintained in the population over time. By proximate explanations, evolutionary ecologists mean the mechanisms that might drive the behaviour, which include both the biological influences that influence fecundity and the mechanism by which a behaviour is learned or enforced.   We are interested in the ultimate explanations for fertility decline (i.e. its fitness implications), as well as the proximate mechanisms by which this decline is brought about (such as the diffusion of ideas); so we have also investigated whether contraceptive use appears to be maladaptive (reducing biological fitness) in this particular setting.

Methods

760 married women between the ages of 15 and 92, currently living in the four villages, were interviewed in a single-round survey in the year 2001. This included all women living in the four villages who were present at the time of the survey (women who moved to the villages soley to work at the health clinic and research station were not included in the survey). The characteristics of the villages are given in Table 1. The survey included questions on whether they were currently using modern contraceptives and when, if ever, they had first used modern contraceptives. For the latter question, they could answer before their first birth, or after which birth they had first used contraception if ever.   Only those women whose year of birth was on record and whose children's years of birth were known were included in our analysis. Further, women who were 50 or over in 1975 were excluded as they would not have had need of contraception by the time the medical centre was opened. This reduced the sample size to 707.

It is assumed that women started using contraception in the year of the opening of the birth interval in which they stated they first used contraception. Event history analysis (a logistic regression of yearly probability of first use) was used to investigate which covariates influenced age at first use. Methods of modern contraceptive use were either injectables and pills. Our response variable was a simple dichotomy of use/non-use of modern contraception, and we did not distinguish between contraceptive methods in our analysis. Records were right censored in 2001 or when the woman reached age 50; and records were left censored in 1975 or at age 15.   Sample sizes of those included, by village, are shown in Table 1.

The households in which women lived were wealth ranked into three categories, according the judgement of three independent villagers – the wealth rank used was the median rank. Covariates examined included age, age squared, parity and date (which were entered as time-varying covariates) and village of residence, wealth rank of head of household in 2001, and comprehension of the English language (which were entered as fixed).

In order to see whether the shape of the uptake curves over time were following a different pattern in different villages, we repeated the model including only villages A&B (together) and another model including only village C.

We analysed the reproductive success (controlling for maternal age) of users compared with non-users. GLM was used to determine whether women who had ever-used contraception had fewer living children (a measure of reproductive success) than women who had never used contraception.

Results.

There were 152 events of contraceptive uptake among the 707 women, representing a minority of the women interviewed (21.5%). Current use of contraception in these villages is 7.9% (see Table 1). However these figures mask a great deal of variation over space and time. Mean level of current contraceptive use is only marginally lower than that observed amongst married women in the Gambia as a whole, but it varied form 0.5% in village D to 18.3% in village C. All women stated they had not used contraception prior to their first birth. Furthermore, the first use of contraception was only rarely associated with an end to reproduction. Most women went on to have further births after they had become contraceptive users, consistent with the notion that women were mostly using contraception to space births or avoid post-partum sexual abstinence.

The cumulative probability that women will have become users at a certain age, over the decades, is shown in Fig 1. The probability of starting to use modern contraception at a given age is roughly doubling each decade since 1975.

Fig 2 shows the cumulative adoption rate by age and by village. Village D did not have access to the medical centre in village A and women living there had to travel to government health services 15 miles away in order to obtain contraceptives. The very low rates of uptake in this village thus illustrate the well-known finding that easy access to contraceptive services is an extremely important determinant of contraceptive prevalence (Tsui & Ochoa, 1992). Village D represents a control for the effect of access to the medical centre. The very low rates of uptake indicate that there are indeed still areas of rural Gambia where effective access to contraceptive services is almost non-existent. These women would not have had the regular contact with mid-wives, who were an important way of accessing knowledge of contraceptives for women in the other villages. Thus the low uptake rates in village D are as likely to be to do with lack of information as much as with lack of supply, as has been found in another area of rural Gambia (Luck, Jarju, Nell, & George, 2000).

Figs 1 and 2 show the raw data, which conflates a number of effects. The event history analysis on age at first use allows us to untangle these effects, and results are

shown in Table 3.   The significant influences are age, age squared, parity, village, wealth rank and date.

The effect of age is broadly negative (whilst the age term is positive, the larger age-squared term is negative causing a decline over most of the relevant age range); but this is combined with a strongly positive effect of parity. Because parity increases with age then actually older women are more likely to be users within cohorts. This pattern is strongly suggestive of strategic use of contraception to space births among those who have a large number of children relative to others of their age.

Only a very few individuals spoke English (an indication of educational level), and this did not significantly influence contraceptive uptake.   The effect of wealth was significant, although not in the direction predicted by the notion that wealthy (thus high status) individuals are generally the innovators with respect to contraceptive uptake. The wealthiest families were significantly slower than medium or poor families to first use contraception. This is, however, consistent with the evolutionary ecological perspective, which predicts that wealthy families will have more children because they have more resources with which to successfully raise children.

The effect of village is very significant: the three villages that have access to the same medical centre do not have the same rate of uptake. Village A and the smaller Village B follow roughly the same trajectory and time to first use of contraception is not significantly different in these two villages. However village C is following a much faster trajectory; non-users have almost three times the annual probability of first using contraception than in villages A and B. This is not related to geographic distance from the medical centre, which is in fact located in village A, with villages B, C and D roughly equidistant (and nearby). However villages A and B have much stronger social ties with each other than either do with village C, most of the residents of which are members of a different clan. This can be illustrated quantitatively by looking at statistics on inter-marriage, shown in Table 2. Most women in our sample remain in their native village after marriage. Table 2 shows that although a few women did migrate between villages A, B and D for the purpose of marriage, this was not the case for village C. No woman born in village A, B or D married into village C and only one girl from village C married into any other study village (A, and in this case she married a migrant who had moved into village A for employment). Thus the similar rates of contraceptive uptake in villages A and B, and the very different rate of uptake in village C, seems to reflect the degree of social contact between these villages. Diffusion of infectious disease has already been demonstrated to run along these lines of social contact. In 1961 villages A, B and D were afflicted with a measles epidemic that caused high mortality of young children. Village C did not suffer from an outbreak of measles in this year, but did so 5 years later when a village 16 miles away, whose inhabitants do intermarry with village D, also suffered an outbreak (McGregor, 1976).

Fig 3 shows the rates of uptake by village, having controlled for other relevant effects. These results were obtained by running the model again, first only including villages A and B together (as Table 3 shows they did not differ significantly in their rate of uptake), and then just including village C. After a slow start, it is clear the uptake rates in village C have escalated – a pattern characteristic of a frequency-dependent effect i.e. social contact with other users influencing the decision to use contraception

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for the first time. Uptake rate in villages A and B is much lower, and whilst obviously increasing over time, it is hard to tell whether they have yet reached the beginning of any 'take-off' in uptake rate. The early sections of an exponentially rising curve are notoriously hard to extrapolate. However it is clear that, if current rates of uptake continue, within a generation women who have used modern contraception will become the norm, and non-users the minority, in villages A, B and C.

Table 4 shows the fertility (number of live births) and mortality (number of children born alive that have died), corrected for age, of those that have ever used modern contraception and those that have not. It is clear that adopters of modern contraceptives have higher fertility than non-adopters. There is no evidence that infant mortality is significantly different in the two groups.   This is consistent with the finding that women with high fertility for their age are more likely to become contraceptive users. However they are not using contraception for long enough periods to reduce their fertility to a lower level than that of the non-users of a similar age. Thus there is no evidence that contraceptive use is necessarily maladaptive, from a Darwinian perspective, in this population.

Discussion.

Patterns of contraceptive uptake show several characteristics indicative of an innovation that is spread, in part, by social contact with other users. There is some indication that uptake rates accelerate as the number of users increases over time – an S-shaped adoption curve, with a flat base, is likely to emerge. However it should be noted that there are a number of models of uptake that could produce curves not dissimilar from those shown in Fig 3.   More convincing evidence of social transmission of ideas come from the fact that it is clear that the villages linked through strong social ties, including links through kin, have similar rates of uptake whereas the more socially isolated village is proceeding at a different rate. Fig 4 shows a schematic representation of social links and the geographic relationship between the villages (not to scale). It is interesting to note that strong social ties with village D, where no-one is adopting the innovation (because they do not have easy access to it), is likely to increase the relative frequency with which women encounter non-users; thus it is interesting to speculate that lack of access to contraception in village D could be slowing the rate of uptake in villages A and B. Those sociologists interested in modelling the spread of ideas and of contagious diseases, have pointed out that a social structure made up of small groups, who all know each other but some of whom have links with other groups, can lead to the dynamics of spread that are rather different from that of homogeneous, large populations (Watts & Strogatz, 1998). For example, connected small groups can greatly accelerate uptake across populations as 'infection' spreads rapidly within small groups with repeated, close contacts, and then jumps on to another group via a small number of contacts. Furthermore, groups from which the innovation or infection is blocked influence uptake rates in other groups to which that group is connected (Newman, Watts, & Strogatz, 2002). It seems likely that such models are applicable in this situation. Whilst we do not have specific data on connectedness to villages outside our sample, it is clear that village C did not have any more girls marrying in from outside the 4 villages than did villages A and B (in fact rather fewer, Table 2), whereas their

contact with their immediate neighbours was more limited. Hence, once contraception began to be used, contact with other users becomes rapidly more likely in this more isolated community. However, there is no evidence that the faster rate of uptake is due to a founder effect, as the first few cases of contraceptive use were in fact in village A.

Whilst analogies with contagion are appropriate at some level, we have also presented evidence that the individual decision to become a contraceptive user is strongly determined by individual socio-demographic status, particularly with regard to fertility. Thus, whilst the general acceptability of modern contraception appears be increasing over time, the users are not passive recipients of 'infection'. To use the terminology of cultural evolutionary studies, contraceptive use does not have the characteristics of a 'selfish meme' (Dawkins, 1976), that is replicating in individuals as a means of spreading itself, possibly at the expense of their own reproductive interests. Conformism can emerge even when the decision to take up an innovation is based on some level of individual learning. For example, observing other users might help would-be users to evaluate social or health costs that they feared would be associated with contraceptive uptake, which might encourage them to try it for themselves i.e. uptake rates accelerate when there are more users from which they can learn the true costs and benefits of contraceptive use. Thus evidence that social contact influences uptake rates does not mean that the decision to use the innovation is not highly strategic for the individuals concerned.   Even though contraceptive users may have lower fertility than they might have experienced without contraceptives, they appear to remain, on average, among the higher fertility women in their cohort in their village.

Evolutionary anthropologists have long puzzled over why women limit their fertility, and in particular, the paradox that wealthy populations seem to be of lower fertility than poor populations when they have more resources that could theoretically be used to invest in more children. This pattern seen globally across populations is, to some extent, explicable if one considers that wealthy populations have higher standards of acceptable parental investment per child (Low, 2000; Mace, 1998). Across population differences may reflect differences in levels of aspiration, or in the opportunities available, and hence the returns on parental investment will vary in each population. However, within homogeneous groups, where levels of parental investment were comparable, evolutionary ecological theory would predict a positive relationship between wealth and reproductive success. Within this population, there is no evidence that women in wealthy (and thus presumably higher status) families were the first to use contraception. On the contrary; if different, they took longer to first use. Thus, within this homogeneous village setting, it appears to be those for whom resources may be stretched that contraceptive use is more appealing. This fits with the prediction from evolutionary ecology, but is at odds with much of the demographic literature on contraceptive uptake; although Bocquet-Appel and Jakobi (1997) found no evidence that the first fertility decline in Victorian Britain was associated with the elite. Cultural evolutionary theorists have also considered 'prestige bias' (Boyd and Richerson 1985) to be an important force in cultural transmission. Here we do not see evidence of prestige bias, if the wealth of the male head of household is what constitutes prestige; however it is interesting to note that if women can gain prestige through high fertility, it is actually those with high fertility

for their age that have the fastest rates of uptake, so they may indeed be the prestigious individuals that others are then copying.

Whilst there is plenty of evidence that social contact is related in some way to the rate of contraceptive uptake, this is clearly not the only explanation for the rate of spread of this new technology. Twenty-five years is a very long period of exposure to an innovation; so long that it becomes implausible to argue that ideas about contraception had not diffused into all those villages with access to the clinic long before many individuals started to use the technology. It is therefore necessary to ask why it took so long for contraceptive use to become more common. Whilst it has been conventional to evoke social and cultural barriers in this context, both have proved rapidly surmountable obstacles when women find themselves living in conditions favouring low fertility. To take an extreme example, rural Ethiopia has one of the highest birth rates in Africa. Yet in the Ethiopian capital city, Addis Ababa, where a large proportion of the population are actually recent migrants from rural areas, birth rates are below replacement (Gurmu, 2005; Sibanda, Woubalem, Hogan, & Lindstrom, 2003). Further, in Addis, it is the wealthier individuals that have the highest birth rates, despite the fact that their access to both news media and medical services are likely to be higher than those of the poor (Gurmu, 2005). It seems that competition for resources, and a society that favours high levels of investment per child, are important determinants of receptivity to ideas about limiting family size. In the Gambia, the rural, agrarian economy in these villages did not necessarily provide these ultimate reasons for higher parental investment in fewer children, until recently. Since 1975, as infant mortality has declined, the village populations are thought to have nearly doubled, without commensurate increase in farmland (indeed opportunities for rice cultivation have actually been reduced since the Sahel droughts of the 1970s). Education in the villages is not readily available beyond the basic level, and out-migration for women to look for work was not a common strategy. However, since the population density in the villages has increased, the reliance on out-migration as a strategy has also increased. Job opportunities outside farming usually require education and/or out-migration. Better nutrition may have been reducing birth intervals when contraception is not used. All these factors have been slowly moving in the direction of providing incentives of limiting family size through contraception over the last 25 years. Ideas may be diffusing through networks in villages, but only when conditions ultimately favour higher parental investment in each child are ideas about lower fertility and contraception converted into actual uptake.

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Table 1. Characteristics of study villages

Village	Population in 2001*	No. of households in 2001	No of women included in sample	Contraceptive prevalence in under 50s in sample in 2001
A	1676	174	288	10.4
B	425	53	87	15.3
C	550	80	142	29.6
D	1044	117	190	0.9
Totals	**3695**	**424**	**707**	**12.3(mean)**

*Population sizes are estimated to have increased by between 50-90% since 1975

Table 2. Respondents included in the analysis, by village of residence and area of
birth, also showing contraceptive use (self-reported).

	village of residence				
	A	**B**	**C**	**D**	**Total**
Total n	**288**	**87**	**142**	**190**	**707**
village of birth					
A	**238**	**11**	**0**	**4**	**253**
B	**2**	**49**	**0**	**9**	**60**
C	**1**	**0**	**125**	**0**	**126**
D	**2**	**3**	**0**	**158**	**163**
Other	**45**	**24**	**17**	**19**	**105**
Contraceptive use (self-report)					
Current users	**20**	**9**	**26**	**1**	**56**
Ever used	**70**	**19**	**59**	**4**	**152**

Table 3. Determinant of age at first use of contraception. Age, age squared, parity and date are time-varying. Village of residence, knowledge of English and wealth rank are fixed. Significant effects are shown in bold.

Parameter	Estimate	St.error	Odds ratio	p
Intercept	**-4.773**	**1.4154**		**0.0007**
Age	**0.2157**	**0.0942**	**1.241**	**0.0220**
Age squared	**-0.0062**	**0.0016**	**0.994**	**0.0001**
Date 75-77	**-1.8436**	**0.5492**	**0.158**	**0.0008**
Date 78-80	**-1.2040**	**0.4209**	**0.300**	**0.0042**
Date 81-83	**-1.0023**	**0.4026**	**0.367**	**0.0128**
Date 84-86	**-1.2364**	**0.4394**	**0.290**	**0.0049**
Date 87-89	-		1.000	-
Date 90-92	-0.2283	0.3355	0.796	0.4961
Date 93-95	0.4997	0.2925	1.648	0.0876
Date 96-98	**0.8788**	**0.2881**	**2.408**	**0.0023**
Date 99-01	**0.8636**	**0.3103**	**2.372**	**0.0054**
Village A	-	-	1.000	-
Village B	-0.2304	0.2673	0.794	0.3888
Village C	**1.0800**	**0.1913**	**2.945**	**<.0001**
Village D	**-2.5749**	**0.5165**	**0.076**	**<.0001**
No English	-	-	1.000	-
Some English	0.5562	0.3462	1.744	0.1082
Wealth 1	**-0.4793**	**0.2291**	**0.619**	**0.0365**
Wealth 2	-	-	1.000	-
Wealth 3	-0.1510	0.1889	0.860	0.4240
Parity 0-2	**-0.8798**	**0.2766**	**0.415**	**0.0015**
Parity 3-5	-	-	1.000	-
Parity 6+	**1.0223**	**0.2746**	**2.780**	**0.0002**

Table 4. Reproductive success of contraceptive adopters (those that have ever used modern contraceptives) and non-adopters, shown as number of currently living children and number children born alive that have died, assuming maternal age of 43 (standard error shown in brackets).

	living children	dead children
adopters	**4.953 (0.166)****	1.061 (0.113)
non-adopters	**4.196 (0.082)**	1.253 (0.056)

Fig 1. The cumulative uptake rate of first use of contraceptives by age by birth cohort.
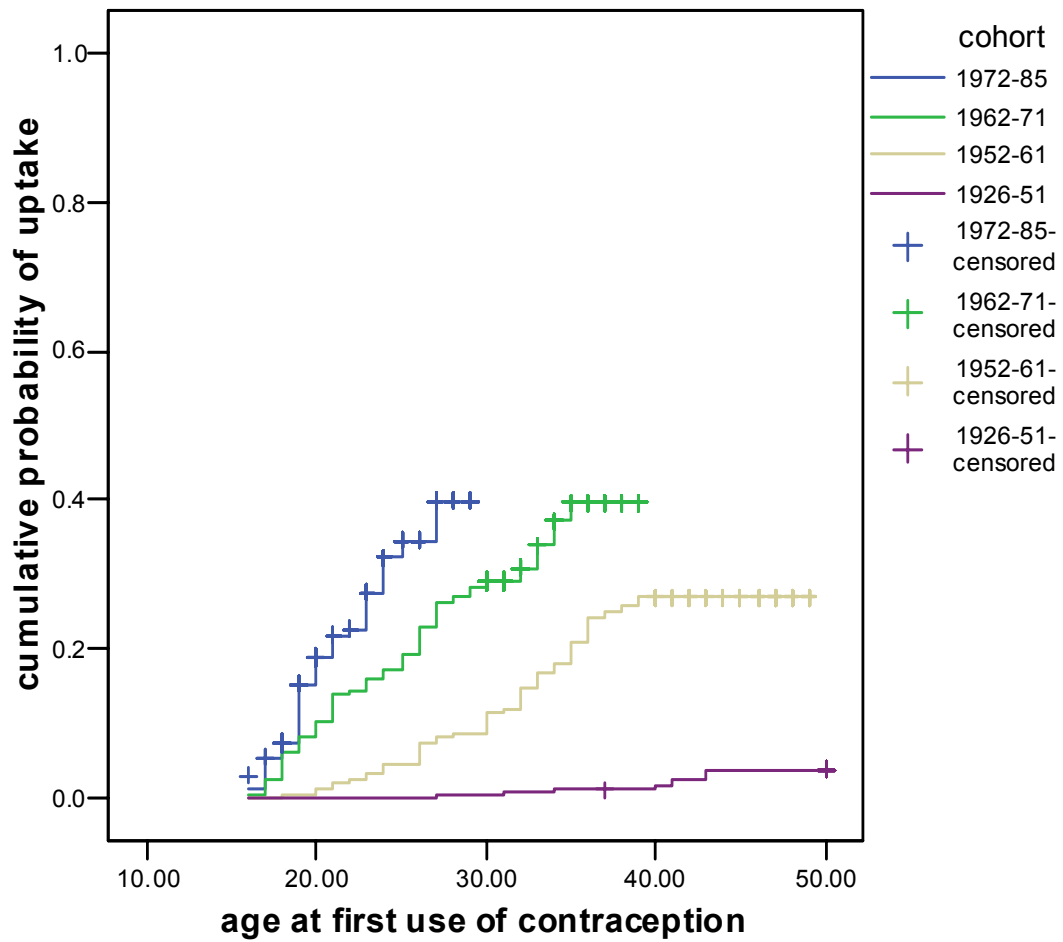
Fig 2. The cumulative uptake rate of first use of modern contraception by age by
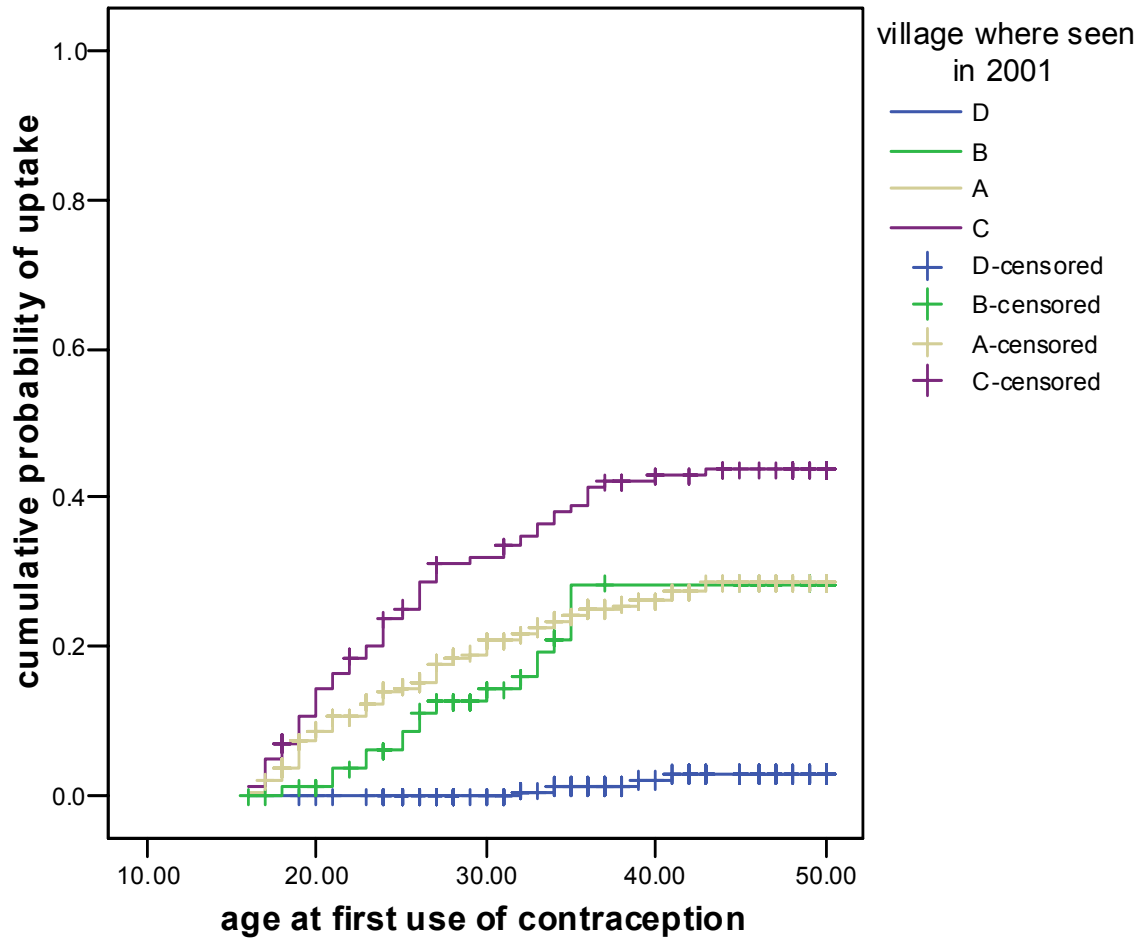village of residence.

Fig 3. Model adjusted uptake rate of first use of modern contraception for villages A and B (combined) and village C, as a function of date (model output shown for woman aged 30 of parity 3-5).
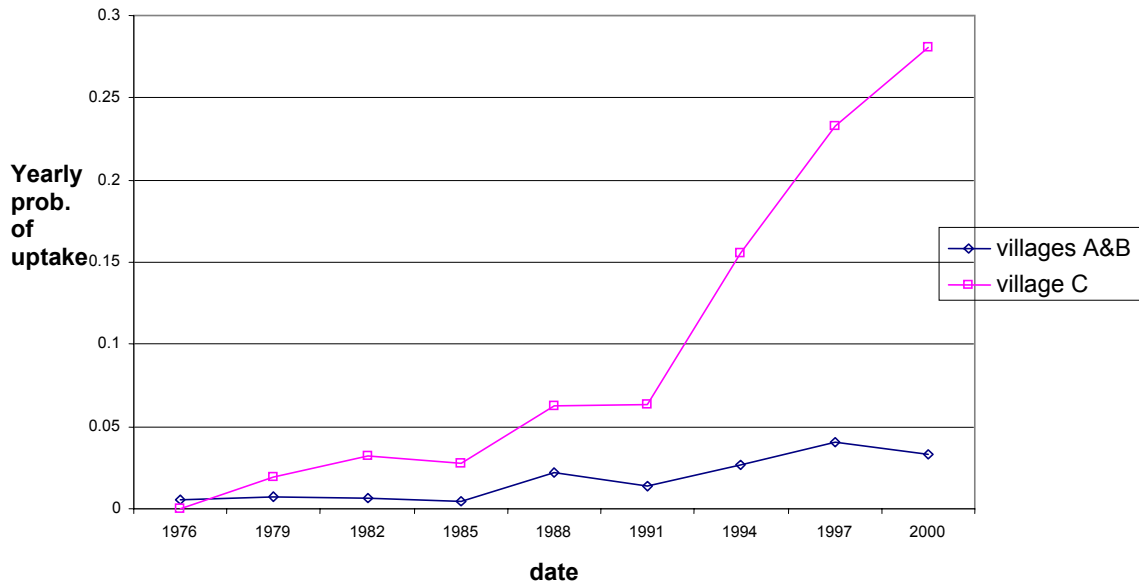
Fig 4. Diagram representing the spatial arrangement of the four villages, with the relative balance of A+ to A- indicating the balance of contraceptive adopters and non-adopters in each village, and with arrows representing social ties within and between villages (not to scale).