

DRAFT/preliminary

The prevalence and risk factors of infertility in Moshi in Northern Tanzania

Short title: Prevalence and risk factors of infertility

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Each authors role in the research and manuscript preparation:

Ulla Larsen participated in all aspects of the research process and manuscript preparation.

Joseph Mlay assisted with the analysis of the risk factors of infertility.

Said Aboud contributed to the questionnaire design and guided the survey fieldwork.

Noel Sam was in charge of the laboratory serology testing at KCMC.

John F. Shao was responsible for the administration of the project at KCMC.

Ronald Ballard guided the laboratory work at CDC on urine samples and contributed to the study of various sexually transmitted infections.

Saidi Kapiga participated in the design of the study, the interpretation of statistical findings and in finalizing the manuscript for publication.

Ethical approval:

The project was approved by the Harvard School of Public Health IRB (HSC Protocol # 0108ACOM), University of Maryland IRB (Protocol # 05-0031), Kilimanjaro Christian Medical Centre Ethics Committee, Research & Ethical Clearance of the Tanzanian National Institute for Medical Research and Centers for Disease Control and Prevention IRB.

Abstract (<250words)

OBJECTIVES: To determine the prevalence and risk factors of infertility in an urban population.

SETTING: Moshi Urban District in the Kilimanjaro Region in northern Tanzania.

METHODS: A representative survey of 2,019 women age 20-44 was conducted in 2002-2003. Infertility was measured by the absence of conception after 24 months of regular, unprotected intercourse following the WHO recommendation (Rowe, Comhaire, Hargreave and Mellows 1993). Univariate and multivariate logistic regression models determined odds ratios (OR), adjusted odds ratios (AOR) and 95% confidence intervals (95% CI) of infertility by risk factors and background characteristics.

RESULTS: The prevalence of infertility was 8.1% (95% CI, 6.3 – 9.8). The risk of infertility was associated with obstetric care, as measured by obstructed labor at most recent abortion or delivery (AOR=2.14; 95% CI, 1.26-3.66) and ever had an abortion (spontaneous or induced) (AOR=2.09; 95% CI, 1.19-3.65). Women with Chlamydia antibodies had significantly higher risk of infertility (OR=2.15; 95% CI, 1.32-3.51). The effects of Chlamydia antibodies were attenuated, but still significant, when the effects of other sexually transmitted infections, obstetric and disease history were controlled (AOR=1.79; 95% CI, 1.04-3.09), while also controlling for background characteristics, such as sex with more than one partner in last 12 month, times married, education and tribe, mediated the effects of Chlamydia antibodies (AOR=1.52; 95% CI, 0.85-2.70). Trichomoniasis infection at survey date was associated with infertility (AOR=2.15; 95% CI, 1.05-4.44).

CONCLUSIONS: Infertility was relatively rare in Moshi in comparison with other African urban communities. Improved services for family planning and delivery

combined with efforts to prevent sexually transmitted infections may reduce infertility further.

Keywords: Childlessness, reproductive health, sexually transmitted infections, obstetric care, abortion, Africa.

Introduction

In sub-Saharan Africa infertility has received relatively little attention from researchers and policy makers, although it is a significant public health problem with serious social consequences (Cates, Farley and Rowe 1985; Larsen 2000). Infertility has been obscured by the region's high total fertility rates and attributed largely to the high incidence of sexually transmitted infections (STIs) (Caldwell and Caldwell 2000; Mayaud 2001).

Infertility was a neglected issue in population and health policy debates until the 1994 UN International Conference on Population and Development (ICPD). The 'Programme of Action' of the ICPD calls for reproductive health for all by the year 2015 (Programme of Action of the 1994 International Conference on Population and Development 1995, pp.187-215, 437-463). To implement the 'Programme of Action', more analyses of specific aspects of reproductive health are required, and there has been a recent surge in research on reproductive health, including infertility (see, for example, Murray and Lopez 1998; Boerma and Mgalla 2001; Inhorn and van Ballen 2002).

Nationally representative surveys, such as the World Fertility Surveys (WFS) and Demographic and Health Surveys (DHS), provide data for country level analyses of infertility, while the sample size is too small for regional and other small area studies (Larsen 2003). However, there is evidence suggesting that infertility in sub-Saharan Africa varies markedly within small geographic areas, and there is a need for in depth studies in defined areas of factors relevant for the local communities (Larsen and Raggars 2001). In addition, infertility is more prevalent in urban compared to rural areas

throughout sub-Saharan Africa (Larsen and Ridders 2001) and most infertility research has been done in rural populations (Boerma and Mgalla 2001). On this background we conducted a survey in Moshi Urban District (Moshi) in northern Tanzania to obtain evidence for an analysis of the prevalence and risk factors of infertility in an urban population.

The clinical definition of infertility is the absence of conception after 12 months of regular, unprotected intercourse. The World Health Organization (WHO) recommends 24 months of unprotected intercourse as the preferred definition for population based studies (Rowe, Comhaire, Haregreave and Mellows 1993). Demographers define infertility as the inability of a non-contracepting sexually active woman to have a live birth (Pressat and Wilson 1985). Based on simulation studies, Larsen and Menken recommended using seven years of exposure to measure childlessness and five years to measure the proportion subsequently infertile (Larsen and Menken 1989; Larsen and Menken 1991). Primary infertility denotes infertility of women who have never been pregnant, and secondary infertility denotes infertility of women who have been pregnant at least once. In demographic research primary infertility is approximated by childlessness and secondary infertility by the proportion subsequently infertile measured from parous women (Larsen 2000). A recent assessment of several definitions of infertility suggests that the WHO definition (Rowe, Comhaire, Haregreave and Mellows 1993) of 24 months of unprotected intercourse and the demographic definition suggested by Larsen and Menken (1989, 1991) result in similar levels and risk factors, as long as

the demographic definition includes the condition that the couple wants a child (Larsen 2005).

Background: Literature on the prevalence, trend and risk factors of infertility in sub-Saharan Africa

Prevalence and trend of infertility

Larsen and Ruggers (2001) showed using Larsen and Menken's (1989) definition that infertility is prevalent throughout sub-Saharan Africa ranging from 6% in Togo to 28% in Central African Republic for women age 20-44. Infertility declined between the 1970s and the 1980s in six countries (Benin, Cameroon, Nigeria, Rwanda, Senegal and Sudan), it remained at about the same level in five countries (Cote d'Ivoire, Ghana, Kenya, Mali and Uganda), and it increased in Zimbabwe. In the latter study current users of a modern contraceptive method were considered as fertile at the survey date, and the observed increase in infertility was not due to voluntary fertility control, although this factor needs further investigation. The countries with declining infertility are located in both East and West Africa. Further trend analyses are required to assess the possible causes of changing levels of infertility, and the demographic and social consequences.

In the early 1980s a number of countries, in collaboration with WHO, conducted detailed sample surveys designed to analyze infertility (Farley and Belsey 1988). These surveys employed the WHO definition of infertility of two years of exposure to the risk of pregnancy without conceiving (Rowe, Comhaire, Haregreave and Mellows 1993). In Tanzania, Mtimavalye et al. (1984) conducted a WHO infertility survey in villages in

seven randomly selected districts. This community-based study revealed several important findings, as follows: 1) average primary infertility was 4.3% and secondary infertility was 18.3%; 2) primary and secondary infertility were higher in south-east compared to north-west Tanzania; and 3) fertile women had fewer pregnancy wastages (abortions or stillbirths) than infertile women. It should be noted that only 4.3% of women experienced primary infertility (no conception), but 19.1% were childless, suggesting that pregnancy wastage was prevalent. This study provided the first nationally representative community estimates of infertility in Tanzania, although these national estimates were based on only seven districts. The present study is based on self-reported data collected in a community-based survey, similar to the study of Mtimavalye et al. (1984), but it goes beyond the study of Mtimavalye et al. by including information about selected STIs based on laboratory testing of urine and blood samples.

Using the 1973 National Demographic Survey (NDS) Henin (1981) found that the percentage childless reached 11.1 for all rural areas of Mainland Tanzania, 20.5 in the north-west Highlands and 18.0 in the Coastal Zone, which included south-east Tanzania. Thus, the estimates of childlessness from the 1973 NDS are in line with the estimates from the later WHO infertility study (Mtimavalye et al. 1984), although it is not known whether the prevalence of infertility changed during the period from the early 1970s to the early 1980s.

Comparing estimates of infertility from the 1973 National Demographic Survey of Tanzania to the 1991/92 Tanzania DHS (1991/92 DHS) Larsen (1986) documented a

very substantial decline in childlessness and subfertility in Mainland Tanzania. In contrast, there was no change in infertility, as approximated by the demographic definition of childlessness and subsequent infertility, between the 1991/92 DHS, 1996 DHS and 1999 Tanzania Reproductive and Child Health Survey (Larsen 2003). About 16 % of women age 20-44 was infertile in Mainland Tanzania based on the 1996 DHS (Larsen 2000).

Risk factors of infertility

Considerable research on infertility in sub-Saharan Africa has stressed the importance of STI-induced infertility (Cates, Rolfs and Aral 1990; Mayaud 2001). Gonorrhea and Chlamydia are the two main STIs documented to result in infertility of women and men. HIV-1 infection enhances the risk of early fetal wastage, while it is not well understood whether HIV-1 infection results in reduced risk of conception (Gray 1998; Sedgh, Larsen, Spiegelman, Msamanga and Fawzi 2005). Syphilis does not affect the fallopian tubes, but it causes fetal wastage and stillbirth. Current HIV-1 and Herpes simplex virus type 2 (HSV-2) infections as well as trichomoniasis might be markers of a history of high risk sexual behavior for infertility also associated with STIs, such as gonorrhea and Chlamydia. *Mycoplasma genitalium* is a microorganism, that has recently been implicated not only as an etiological agent in non-gonococcal urethritis in men and mucopurulent cervicitis in women, but also in pelvic inflammatory disease and endometritis (Horner, Gilroy, Thomas, Naidoo and Taylor-Robinson 1993; Taylor-Robinson 2002). Each of these conditions might precede tubal damage and infertility.

Although the ideal research design for analyzing the association between STIs and infertility requires longitudinal data, the present analysis is based on cross sectional data. We propose to determine the association between infertility at survey date and antibodies to Chlamydia (ever had Chlamydia). There is no sensitive test for antibodies to gonorrhoea. It is not possible to demonstrate an association between infertility and an STI (e.g., Chlamydia or gonorrhoea) at survey date, because infertile individuals may have had an STI in the past and been successfully treated. Also, individuals may have an STI infection at survey date, but the subsequent complications have not yet resulted in infertility.

Little research has been done on linking infertility to complications from last delivery or abortion in sub-Saharan Africa. Even less attention has been paid to infertility from iatrogenic factors, such as female circumcision, spontaneous and induced abortion, treatments including dilation and curettage, insufflations and various reproductive surgeries (Inhorn and Buss 1994; Larsen and Yan 2000). Finally, there is evidence suggesting that infertility is linked to fibroids and diabetes (Okonofua, Menakaya, Iribhogbe, Onemu and Bergstrom 2003)

The etiology of infertility in Africa is poorly understood, and it is possible that the extent of STI-induced infertility is exaggerated. For one, it is difficult to distinguish the multiple causes that can result in infertility. Second, the medical information is often incomplete. For example, medical histories are often absent, laboratory tests have not been performed and researchers frequently conjecture about STI related infertility from

scanty evidence about sexual behavior. Third, there are a number of diseases prevalent in Africa, such as genital schistosomiasis and genital tuberculosis, which may result in infertility of the woman or man. Farley and Belsey (1988, p. 2.1.26) noted almost two decades ago that tubal factor infertility due to STIs or sepsis following complications at delivery and abortion is prevalent and not well studied. Knowledge about the etiology of infertility in sub-Saharan Africa is still limited (Mayaud 2001).

To enhance understanding of the etiologies of infertility it is important to analyze specific risk factors, such as sexual practices. Women who initiated sexual relations in their early teenage years might have elevated risks of infertility for several reasons: 1) young women have sexual contacts often with substantially older men, who may have an STI; 2) women who have not yet fully matured physically experience more complications at childbirth that may result in infertility; 3) the reproductive tract is more susceptible to infections in very young women; 4) sexually active teenage women may have more induced abortions; and 5) the younger the age at which a woman became sexually active the more time she has had to catch a pelvic inflammatory disease (PID), either from an STI or from complications following an abortion or a delivery, and subsequently to become infertile.

The risk of infertility is hypothesized to be higher for couples where the man is a migrant laborer. The idea is that industrial development in Africa has been based largely on a migrant labor system. The combination of large concentrations of migrant male workers and long periods of familial separations may lead to men having extra-marital partners

and hence increased risk of STIs. Henin (1981) showed that childlessness was associated with marital patterns, i.e., women in polygamous unions and women married more than once had higher childlessness. To achieve the number of children desired a man might add another wife (usually a younger woman) to a sub-fertile or infertile union, or he may abandon his wife and initiate a new union (Collet, Reiners, Frost et al. 1988). Thus, polygamous unions and being married more than once may be sequellae of infertility. It is also possible that women and men in polygamous unions and higher order marriages became infertile because they had more exposure to STIs (more sexual partners). On this background the present study aimed at determining the association between Chlamydia antibodies, obstructed labor at most recent abortion or delivery, history of abortion, circumcision, diabetes and fibroids, selected risk factors and infertility.

Materials and methods

The study was conducted in Moshi of the Kilimanjaro Region in northern Tanzania. Moshi is one district and it had 144,336 inhabitants in the 2002 census (<http://www.Tanzania.go.tz/census>) and it is the capital of the Kilimanjaro Region. Moshi is a vibrant town with a local airport, an international airport within about 30 minutes drive and major bus lines passing through on their routes from Dar es Salaam to Arusha. Moshi has several markets, extensive in-and out labor migration and it is the center for business and trading in the Kilimanjaro Region. The trading, labor migration and extensive tourism are all potential factors contributing to sexual networking, high risks of STIs/HIV and infertility.

Data

A two-stage sampling design was used (Larsen et al. 2006). In stage one, 150 census enumeration clusters were selected proportional to the population of women age 20-44. In the second stage, 18 households were randomly selected from each of the 150 clusters to participate in the survey. A brief household listing was done for each household selected to enumerate the eligible women. All women age 20-44 years living in the selected households (de jure and de facto) were interviewed in the period November 2002 to March 2003. Two thousand and nineteen women completed the face-to-face interview (92% of eligible women). The survey collected a complete pregnancy history, information about marriage and sexual practices, contraceptive use, symptoms of STIs, perception of suffering from infertility, treatment seeking for infertility, as well as demographic and socioeconomic characteristics. STIs/HIV counseling was offered and blood samples were collected for testing of HIV-1, HSV-2, syphilis and Chlamydia antibodies, and urine samples for testing of trichomoniasis and mycoplasma genitalium. Respondents gave informed consent before the face-to-face interview and another informed consent before providing blood and urine samples. Post-test STIs/HIV counseling and results were offered within a week of the interview. Individuals testing positive for treatable STIs were given medication at no cost and women with infertility were invited to come to KCMC for a medical examination and possible treatment at no cost (for more detail, see Larsen et al. 2006).

The project was approved by the Harvard School of Public Health IRB (HSC Protocol # 0108ACOM), University of Maryland IRB (Protocol # 05-0031), Kilimanjaro Christian Medical Centre Ethics Committee, Research & Ethical Clearance of the Tanzanian

National Institute for Medical Research and Centers for Disease Control and Prevention
IRB.

Laboratory procedures

A subset of 1,418 women (70% of interviewed women) provided a blood sample for serology testing. HIV-1 testing was done using enzyme-linked immunosorbent assay (ELISA) (Vironostika HIV Uni-Form II plus O, Organon, Boxtel, the Netherlands) and reactive samples were confirmed by a second ELISA (Murex 1.2.0., Murex Biotech Ltd., England, UK). Indeterminate results were confirmed by Western blot (Genetic Systems HIV-1 Western blot, Bio-Rad Laboratories, Redmond, Washington, USA). Antibodies to Herpes simplex virus type 2 (HSV-2) were determined by using type-specific HSV-2 EIA according to manufacturer's instructions (HerpeSelect 2 ELISA, Focus Technologies, Cypress, California, USA). Antibodies to Chlamydia were tested using an ELISA (). Past syphilis infection was diagnosed if the serum was reacting to the Treponema Pallidum Hemagglutination assay (TPHA) (Wecosyph HA, Murex Biotech Ltd., England, UK).

Another subset of 1,440 women (71% of eligible women) gave a urine sample for testing of *Trichomonas vaginalis* (trichomoniasis) and *Mycoplasma genitalium* (mycoplasma genitalium) by using the real-time multiplex PCR (M-PCR) assay. At first, DNAs were extracted using the Qiagen Viral RNA kit (Qiagen), and then DNA was extracted from all specimens falling within positive pools and tested by the M-PCR assay. Sequence-specific detection of M-PCR amplification products was based on TaqMan technology

and was performed using the Rotor-Gene 3000 instrument (Corbett Research, Australia). Amplification targets were: MgPa for mycoplasma genitalium; and repeat DNA fragment for trichomoniasis. The real-time M-PCR assay allows detection over a broad range of target concentrations with analytical sensitivities of 1-10 genomic copies for mycoplasma genitalium; 0.01-0.1 genomic copies for trichomoniasis.

The women who provided a blood sample differed from those who did not on a number of characteristics (Kapiga et al. 2006). For instance, the women providing blood were more likely to report STIs symptoms, have experienced problems getting pregnant, want another child and be circumcised, and they were younger and less educated. The discrepancies between women who gave a urine sample and those who did not were similar (Klinger et al. 2006). Virtually all the 1418 women providing a blood sample provided also a urine sample, while an additional number of women consented to only providing a urine sample resulting in a total of 1440 women with urine samples. Thus, information about the various STIs, including HIV-1, HSV-2, past syphilis, Chlamydia antibodies, mycoplasma genitalium and trichomoniasis is more likely to be available for women at higher risk of an STI and infertility.

Infertility measure

Infertility was measured by the absence of conception after 24 months of regular, unprotected intercourse following the WHO recommendation (Rowe, Comhaire, Hargreave and Mellows 1993). Each woman was asked the question “How long have you tried to get pregnant?”. Based on responses to this question women were assigned

the status as infertile at interview date, if they reported that they had tried to get pregnant for a period of at least 24 months. In addition, to minimize bias from inconsistent reporting, responses to various other questions were used to define an infertile case. Thus, in this study, a woman was defined as infertile, if she wanted to have a child, she was not pregnant, not using contraception, not sterilized, non-lactating and she had tried to get pregnant for at least two years (Larsen 2005). Primary infertility refers to infertility of women who reported they had never conceived and secondary infertility to infertility of all other women.

Statistical analysis

The analyses were done using STATA version 8.0 (STATA Corporation, College Station, Texas, USA). The sampling design was taken into account in the estimation of prevalence and risk factors of infertility using the appropriate procedures available in STATA (the *svy* commands). The association between infertility and selected characteristics was analyzed using a Pearson χ^2 test. Crude odds ratios (OR), adjusted odds ratios (AOR) and 95% confidence intervals (CI) of infertility were estimated using logistic regression analysis. The multivariate analysis was done in two stages. For one, an adjusted model (Model 1) was estimated including variables measuring laboratory confirmed, self-reported symptoms and history of STIs, obstructed labor at previous abortion or delivery, induced or spontaneous abortion, age at circumcision and disease history (risk factors). Next, in Model 2 background characteristics were added to Model 1 to determine whether the effects of risk factors on infertility were mediated through the

background characteristics. The adjusted models included variables associated with infertility at the .10 level of significance.

At first, risk factors of primary and secondary infertility were estimated in separate models. However, the risk factors were almost identical (the effects of obstructed labor at previous abortion or delivery and an induced or spontaneous abortion were examined only for secondary infertility). Hence, the data were merged and risk factors of infertility (primary and secondary) were estimated. By merging the data we circumvented the bias from falsely considering some women as primarily infertile because they did not report pregnancies not carried to term (e.g., induced and spontaneous abortions).

Results

The sample interviewed included 2,019 women age 20-44 years. The analysis of infertility was based on a subset of 1,549 women, while 470 women (23%) were excluded because they were not married, cohabiting or in a regular sexual union during the last two years before survey. Information about regular partners and sexual unions is somewhat ambiguous. For instance, in response to questions about a regular male partner who could participate in male partner interviews, as many as 563 women reported that they did not have a regular partner. Thus, we recognize that some of the 100 women with no current partner might not have been regularly exposed to pregnancy the 24 months prior to survey data.

One hundred and eighteen women were infertile and the weighted prevalence of infertility was 8.1% (95% CI, 6.3 – 9.8). (If the 100 women with no current partner were excluded the prevalence of infertility would be 8.4% (95% CI, 6.8 - 10.5).) The weighted prevalence of primary infertility was 2.7% (95% CI, 1.9-3.5) and secondary infertility was 6.1% (95% CI, 4.6-7.6) (43 childless and 75 parous women were classified as infertile).

The weighted prevalence of Chlamydia antibodies was 47.9% (95% CI,44.0-51.8). As many as 11.0% (95% CI,9.0-13.0) had HIV-1 infection and 46.5% (95% CI,42.8-50.2) had HSV 2 antibodies suggesting that non-treatable STIs are common in this community. The weighted prevalence of past syphilis reached 2.3% (95% CI,1.2-3.4), while 3.3% (95% CI,2.2-4.3) had mycoplasma genitalium and 10.3% (95% CI,7.8-12.8) had trichomoniasis at survey date.

As few as 2.4% reported they had a sexually transmitted disease (STD) during the last 12 months (Table 1). This rate is very low compared to the prevalence of laboratory confirmed STIs described above, suggesting that either many STDs were asymptomatic, a very low proportion sought medical care and had a clinical diagnosis of STDs or vast underreporting of STDs. As many as 15.4% reported they experienced strong labor pains that lasted more than two days (obstructed labor) at last abortion or delivery, while 16.1% confirmed they had had an induced or spontaneous abortion. The percentages with self-reported diabetes and fibroids included 0.7% and 2.4%, and these low percentages reflect probably that many chronic diseases were not known to the individuals affected.

Table 1 about here

As expected, the prevalence of infertility was associated with Chlamydia antibodies, current STIs, self-reported symptoms of STIs and a history of STDs (Table 1). For instance, infertility reached 13.0% for women with Chlamydia antibodies compared to 6.5% for negative cases (OR=2.15; 95% CI, 1.32-3.51). Among HIV-1 positive women infertility was 14.5% compared to 8.9% among HIV-1 negative women (OR=1.75; 95% CI, 1.04-2.94), while 21.3% of women with trichomoniasis were infertile compared to 8.2% of non-infected women (OR=3.04; 95% CI, 1.58-5.86). In contrast, the risk of infertility was not significantly associated with mycoplasma genitalium or past syphilis. It should be noted, for each of the STIs analyzed, the groups not providing blood or urine samples had the lowest prevalence of infertility as anticipated from these women's characteristics (Kapiga et al, 2006; Klinger et al, 2006).

Women with strong labor pains that lasted more than two days at last abortion or delivery had 12.1% infertility compared to 5.6% for women with no complication (OR=2.34; 95% CI, 1.38-3.98). Infertility reached 25.2% among never pregnant women. Women admitting to having had an abortion (spontaneous or induced) had 12.8% infertility versus 5.2% for women with no abortion history (OR=1.90; 95% CI, 1.20-3.01). In contrast, there was only a marginal association between circumcision and infertility ($p=.06$). Infertility was higher for women with diabetes (OR=4.55; 95% CI, 1.23-16.83) and fibroids OR=4.45; 95% CI, 1.95-10.16).

Infertility was linked to the reported number of sexual partners in last 12 months ($p=.04$) (Table 2). Women with more than one partner had 17.4% infertility versus 7.8% for women with one partner (OR=2.48; 95% CI, 1.03-5.97). As suggested in the literature, women married twice or more had higher infertility than women married once (21.5% versus 7.6%) (OR=3.33; 95% CI, 1.93-5.75). Infertility was also higher for women with 0-6 years of education relative to 9⁺ years (14.8% relative to 6.0%) and for Pare relative to Chagga women (14.0% relative to 6.9%). In contrast, infertility was not associated with the type of marriage, where the husband works, age of the woman, her religion and whether she has a job outside the home.

Table 2 about here

The effects of Chlamydia antibodies on infertility were attenuated, but still significant (AOR=1.79; 95% CI, 1.04-3.09) in Model 1 controlling for other risk factors (Table 3). Model 2 controlled for the effects of risk factors and background characteristics and Chlamydia antibodies were no longer significant (AOR=1.52; 95% CI, 0.85-2.70) suggesting that the effects of Chlamydia antibodies were mediated through background characteristics, such as sex with more than one partner in last 12 months, married twice or more and 0-6 years of education. Trichomoniasis infection remained significant in the multivariate models, while HIV-1, HSV 2, self-reported STIs symptoms and history of STDs were attenuated and non-significant in the multivariate models.

Table 3 about here

The effects of obstructed labor remained about the same and significant in both Model 1 and Model 2 (AOR=2.15; 95% CI, 1.32-3.51). In contrast, for women who had never been pregnant relative to parous women who had not experienced obstructed labor the odds of being infertile increased substantially from (OR=5.72; 95% CI, 3.60-9.06) to (AOR=7.76; 95% CI, 4.66-12.92) in Model 1 to (AOR=33.40; 95% CI, 14.57-76.57) in Model 2. That is, women who had been in a union for more than two years were very likely to be infertile, if they had not yet been pregnant taking into account risk factors and background characteristics. The effects of an abortion on the risk of infertility were strongest in Model 2 (AOR=2.09; 95% CI, 1.19-3.65) when the effects of risk factors and background characteristics were controlled. Age at circumcision was not associated with infertility. Self-reports of diabetes and fibroids were associated with higher infertility, but the associations were not significant when risk factors and background characteristics were controlled. Finally, women with 0-6 years of education had more than 2 times higher risk of infertility compared to women with 9⁺ years of education (AOR=2.40; 95% CI, 1.04-5.55) in Model 2.

Discussion and conclusion

In Mainland Tanzania the prevalence of infertility was about 16% measured from the 1996 DHS (Larsen 2000). The Moshi and Mainland Tanzania infertility estimates were calculated using data from different survey questions and different infertility definitions,

but the estimates should be comparable (Larsen 2005). It is possible that the national estimates of infertility are exaggerated because they are based on the duration of unprotected intercourse since last birth or marriage, if childless. However, some women may not engage in regular sexual intercourse, although they are in a union, and some women might deliberately avoid getting pregnant even though they are not using a modern contraceptive method. These are issues that are difficult to measure using the Tanzania 1996 DHS and the absence of questions like “How long have you tried to get pregnant?”. On the other hand, Mtimavalye et al. (1984) found also that the north-west had lower levels of infertility than other areas of Tanzania, lending validity to the low levels documented in this study, although Mtimavalye et al. (1984) collected their data in the early 1980s. In general, Moshi and the Kilimanjaro Region are known for their relatively high economic development, extensive health care services and low rates of morbidity and mortality (do we have a ref for this? Setel?), which further supports that the low prevalence of infertility, as documented here, is real.

Even though infertility was relatively low in Moshi there was evidence suggesting that further reductions in infertility are possible. For instance, women with Chlamydia antibodies had more than the double odds of infertility, although the effects of Chlamydia antibodies were mediated through background characteristics, such as sex with more than one partner in the last 12 months, married more than once, only 0-6 years of schooling and tribe. Women infected with trichomoniasis at survey date had also significantly higher odds of infertility in both the univariate and multivariate analysis. Trichomoniasis is not an infertility causing infection, but it might be a marker for high risk sexual

behaviors and unobserved factors, such as previous gonorrhea infections. In general, STIs are common in this community, as evidenced by the findings that among the women tested as many as 47.9% had Chlamydia antibodies, 46.5% had HSV 2 antibodies and the prevalence of HIV-1 infection was 11%. The ABC (Abstinence, Be faithful, and Condom use) approach currently used in efforts to reduce HIV incidence may, if effective, also reduce STIs, such as Chlamydia, and subsequently the incidence of infertility (ref).

Women who experienced obstructed labor at most recent abortion or delivery had over twice the odds of being infertile at survey date and this complication affected as many as 15.4% of all women and 17.4% of parous women. Moshi has a regional hospital, a tertiary hospital and several private hospitals and the town is well served medically. The vast majority of women in Moshi receive prenatal care (Do I need a ref? I can cite the DHS) and at prenatal visits traditional birth attendants and nurses should inform women about the risks associated with childbirth and encourage women to seek health care, if complications arise. Women with characteristics suggesting that they are more likely to encounter difficulties at delivery should be encouraged to deliver at a health center or to seek help early on, if complications do arise.

Women reporting they had had an abortion (spontaneous or induced) had more than the double odds of infertility in the multivariate analysis. Based on our knowledge about this community and the frequent occurrence of women admitted to the tertiary hospital with sequelae of incomplete or unsafe abortion we deem that frequency of induced abortion

was severely underreported and the effects of abortion on infertility were underestimated. Spontaneous and induced abortions were merged because medical histories indicated that some women had reported induced abortions as spontaneous in the survey questionnaires. Family planning services are widely available in Moshi, total fertility is as low as 2.9 (measured from our data), and some women may experience unwanted pregnancies because of a contraceptive failure or an unmet need for contraception. Hence, better coverage of family planning needs may reduce rates of unwanted pregnancies, induced abortions and subsequent complications leading to infertility. The incidence of malaria and syphilis is relatively low in Moshi and spontaneous abortion is not considered a major reproductive health problem in this area.

This study did not confirm any association between mycoplasma genitalium and infertility. Age at circumcision was not associated with infertility and this study did not find any support for the hypothesis that circumcision causes infertility. In this community the extent of the cut is minor and it is possible that more extensive forms of circumcision might have harmful effects on the woman's reproductive health and her ability to reproduce.

Variables capturing high risk sexual behavior, such as sex with more than one partner in the last 12 months and age at first intercourse were not significant in the multivariate models. It is possible that these variables were not significant because we controlled for Chlamydia antibodies, but it is also possible that respondents deliberately underreported high risk sexual behaviors. The latter is supported by the finding that trichomoniasis

infection at survey date was significant and it may be a more valid marker for high risk behavior.

Limitations

The social implications of infertility were manifested by the finding that women married more than once had more than three times higher risk of infertility compared to women married only once. The analysis was based on cross-sectional data and we could only determine the association, not the causal direction between infertility and times married. However, women married more than once were significantly more likely to have Chlamydia antibodies, experienced obstructed labor or had an abortion compared to women married only once. Education was strongly associated with infertility. Women with primary incomplete education had in particular high odds of infertility. This finding is in line with STIs research documenting that low income and poorly educated women have higher risk sexual behavior and more STIs (Mamdani and Bangser 2004). Therefore, recent government initiated efforts to increase school attendance and to reduce poverty, if they prove effective, might lead to reduced incidence of infertility.

Further comparative studies of Moshi and communities with high levels of infertility are in order to provide evidence for the factors contributing to the high prevalence of infertility in Mainland Tanzania relative to Moshi. In general, Moshi could serve as a model for national efforts aimed at reducing infertility.

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Conflict of interest

None.

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