EVELINA LINNROS DEVELOPMENT DISSERTATION BRIEF



INFERTILITY RISK AND CHILD MARRIAGE



Infertility Risk and Child Marriage

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Sammanfattning

Fertilitetsproblem är vanligt förekommande i många låginkomstländer. Förutom att orsaka direkt lidande för de drabbade kan en hög förekomst av infertilitet leda till bredare samhälleliga konsekvenser. Här undersöker jag hypotesen att en hög risk för infertilitet kan leda till att människor gifter sig och försöker bilda familj tidigare, i syfte att öka sina chanser att få barn. Jag studerar kopplingen mellan infertilitetsrisk och tidpunkten för familjebildning i Madagaskar, med särskilt fokus på förekomsten av barnäktenskap. För att undersöka detta använder jag geografisk variation i infertilitetsrisk orsakad av parasitsjukdomen schistosomiasis och jämför effekterna av två vanligt förekommande varianter av parasiten. Dessa två varianter sprids på samma sätt och har jämförbara hälsoeffekter, men endast en av dem orsakar infertilitet. Resultaten visar att exponering för den variant som orsakar infertilitet leder till 20-40 procent högre sannolikhet att en kvinna är infertil. Dessutom innebär exponeringen för denna variant upp till 22 procent högre sannolikhet att en kvinna ingår sitt första äktenskap under barndomen. Jag finner också liknande resultat avseende sannolikheten att en kvinna föder sitt första barn före 15 års ålder. Om föräldrar räknar med att flickor gifts bort tidigt, kan det leda till lägre investeringar i flickors skolgång. Resultaten visar att exponering för den infertilitetsorsakande varianten av schistosomiasis ökar sannolikheten för att kvinnor helt saknar grundskoleutbildning.

Abstract

Infertility – the impaired ability to conceive or carry a pregnancy to term - is widespread in many low-income countries. Beyond the consequences suffered by those directly affected, high infertility rates can have broad societal impacts, as people may respond by marrying and having children at younger ages to achieve their fertility target. I study the link between infertility risk and marriage timing in Madagascar, focusing on child marriage. To study this I use spatial variation in infertility risk caused by the parasitic disease schistosomiasis and compare the effect of two endemic strains of this parasite. Both strains share key transmission mechanisms and have comparable health impacts, except that one leads to infertility while the other does not. I show that community-level exposure to the infertility-causing strain increases the probability that a woman is infertile by 20-40 percent. Exposure to this strain also increases the probability of child marriage by up to 22 percent, with similar effects on the probability of giving birth during adolescence. Parents may invest less in schooling for girls who are expected to marry young. I find that women exposed to the infertilitycausing strain are less likely to have any education.

Introduction

Finding a partner and having children are important life events. Economists have long been interested in understanding what shapes the timing of these events and how they matter for economic outcomes (Becker, 1960). While delaying family formation can have benefits, it also increases the risk of having fewer children than planned. When people face a high risk of infertility – a difficulty conceiving or carrying a pregnancy to term – they may respond by marrying and trying to conceive at a younger age to increase their chances of reaching their fertility target.

While some previous research has studied the hypothesis that infertility risk shapes marriage and fertility timing in high-income countries (Doepke, 2023), very little is known about the broader consequences of infertility risk in low-income countries. This omission is striking since women in low-income countries are exposed to a substantially higher risk of infertility that emerges earlier in their reproductive lives (Mascarenhas, 2012a).

In the first chapter of my thesis, "Essays on Fertility and Health", I set out to fill this gap by examining the relationship between infertility risk and early marriage and childbirth among women surveyed in Madagascar. In particular, I focus on child marriage. Child marriage remains widespread in many low-income countries and is associated with a range of adverse outcomes for girls subjected to the practice (Field and Ambrus, 2008) and their children (Chari, 2017). To document potential downstream effects of early marriage, I also include women's educational attainment as an outcome in this paper.

This paper is closely linked to goal 5.3 – to eliminate all harmful practices including child and forced marriage – of the 2030 Agenda for Sustainable Development. Designing effective policies to end harmful practices requires a nuanced understanding of their root causes. Existing work studying the root causes of child marriage has mainly focused on the role of cultural norms and

economic conditions (Corno et al., 2020; Corno and Voena, 2023; Jensen and Thornton, 2003). My research shows that a previously overlooked factor, infertility risk, may partly explain why this harmful practice persists.

This paper also relates to Sustainable Development Goal 5.6: to ensure universal access to sexual and reproductive health and rights. Family planning programs that target high-fertility, low-income populations have traditionally focused on providing tools and technologies to help individuals limit unwanted pregnancies and delay and space births. There are many examples of how such family planning programs have improved outcomes for women and children by empowering individuals to exercise greater control over their reproductive lives (see, for example, Miller 2004). However, the narrow focus on controlling the upper limit of fertility overlooks a critical issue that affects a significant number of people in these contexts: the inability to have children when they want to. My research highlights the importance of considering access to assisted reproductive technologies and treatment for diseases that cause infertility when designing family planning policies.

Method

The objective of the statistical method used in this paper is to establish a causal link between local infertility risk and the timing of marriage. Community infertility rates are likely to be correlated with observable and unobservable characteristics that also determine the timing of marriage and first birth. For example, the prevalence of unsafe abortions that cause infertility is likely to be higher in poor communities, and poverty can directly increase the risk that girls are subjected to child marriage.

My strategy to address this challenge is to compare the impact of exposure to two different strains of the parasitic disease schistosomiasis. Around 90 percent of the world's estimated 207 million annual schistosomiasis cases occur in subSaharan Africa (Rollingson et al., 2013). Two-thirds of these cases are caused by a strain of schistosomiasis called *S. haematobium*, and the remaining third is attributed to the strains *S. mansoni* and *S. intercalatum* (McManus et al., 2018). All of the endemic strains share key transmission mechanisms and cause comparable morbidity (Colley, 2014), with one important exception for the purposes of this study. Of the two strains endemic in Madagascar (S. mansoni and S. haematobium) only S. haematobium damages the reproductive organs, impairing women's ability to conceive and carry a pregnancy to term (Woodall and Kramer, 2018; King, 2018a, 2018b; Kjetland et al., 2010). The damage to the reproductive organs is progressive, and advanced forms of schistosomiasisrelated infertility may not be reversible with treatment (Kjetland et al., 2008; Miller, 2017).

I estimate a statistical model that includes exposure to both strains of schistosomiasis. From this model, I obtain estimates of the association between exposure and the timing of marriage and childbirth for each of the two strains of schistosomiasis. The key assumption of my empirical method is that the two strains share the same relationship with any other determinants of age at first marriage and childbirth. If this assumption holds, the *difference* between these two estimates identifies the causal impact of the infertility-causing strain on marriage and fertility timing.

Setting

Madagascar provides an ideal setting for this study for two reasons: first, schistosomiasis is highly endemic in large parts of the country, but with limited geographical overlap between the two strains. Second, although recent research suggests a link between HIV and the infertility-causing strain (Patel, 2021), this does not pose a concern for the validity of the research design, as HIV rates were exceptionally low in Madagascar during the study period (UNAIDS, 2023). Moreover, understanding the underlying causes of child marriage has high

relevance in Madagascar. The country has banned child marriage and committed to eliminating the practice by 2030, but progress has been slow: Over 40 percent of young Malagasy women were married before their 18th birthday in 2018 (UNICEF, 2021).

Childbearing carries significant cultural value in Malagasy culture. Ethnographers have connected the high value placed on women's ability to bear children to the central role of ancestor worship and the importance of the continuation of the lineage (Rajaonah, 2020). Early anthropological studies of Madagascar noted that premarital intercourse and infidelity ending in childbirth carried relatively little stigma in Madagascar and attributed these cultural norms to the high value placed on fertility (Gareme, 2004). In settings where fertility is highly valued, the consequences of infertility tend to be severe (Dyer, 2007). When a marriage does not produce a child the woman often carries the blame, and childlessness is commonly viewed as a legitimate reason for a husband to leave his wife (Rajaonah, 2020). The consequences of infertility for women are also evident in Madagascar's inheritance law: if a union is childless and the husband dies, the inheritance rights of the husband's relatives take precedence over those of the widow (Schwartz, 2011).

When considering these repercussions, it may not be surprising that a *fear of infertility* has been documented across other sub-Saharan African countries (Boivin et al., 2020) and in Madagascar (Klinger and Asgary 2017; Jansen, 2021). While fear of infertility is a complex issue affected by a myriad of factors (Sedlander et al., 2022), one potential explanation is that infertility is a commonly occurring health problem in this setting: one study estimated that up to 15 percent of Malagasy women suffered from primary or secondary infertility in 1990 (Mascarenhas, 2012a). Historically, access to reproductive health services in Madagascar has been limited but the country has seen significant improvements over the last three decades (United Nations, 2023). However, assisted reproductive technologies remain out of reach for the vast majority of

people in Madagascar, with one recent study documenting zero registered invitro fertilization units within Madagascar (Ombelet and Onofre, 2019).

It has been estimated that over half of Madagascar's population is infected with schistosomiasis (Rollingson et al., 2013). Disease control primarily relies on mass administration of the drug praziquantel. Coverage of mass treatment programs has historically been uneven and low in Madagascar but has steadily increased since the end of the political crisis in 2009 (Rasoamanamihaja et al., 2023). However, recent studies have questioned the effectiveness of solely relying on mass treatment campaigns and to eradicate schistosomiasis, partly because of high reinfection rates (Zacharia et al., 2020).

A recent qualitative study from Madagascar documented that infertility was one of the main concerns reported by women with chronic S. haematobium infection, but their knowledge of how they acquired the disease was limited (Schuster et al., 2022). Survey evidence confirms that the general awareness of the consequences that schistosomiasis has on reproductive health remains low in Madagascar (Rausche et al., 2023). These findings suggest that while schistosomiasis-related infertility may be felt within communities, the public's knowledge of the link between the disease and infertility and how to avoid new infections is likely to be limited.

Data

Schistosomiasis exposure and main outcomes

To create a measure of exposure to the two strains of schistosomiasis, I digitize and geocode information from the Atlas of the Global Distribution of Schistosomiasis (Doumenge, 1987) for Madagascar. This document contains data on the community prevalence and spatial distribution of the two strains of schistosomiasis from nationwide epidemiological surveys. Individual-level survey data on women's outcomes, including their age at first marriage and their highest level of education, come from the Demographic and Health Surveys in Madagascar (DHS). I pool two waves of the DHS in Madagascar, conducted in 1997 and 2008–2009 respectively, resulting in a sample of 24,124 women. Both waves have information on the location of the community, which I use to construct the community-level exposure to the two strains of schistosomiasis and to merge environmental covariates.

Figure 1: Community-level exposure to S. haematobium and S. mansoni, constructed using community location and data from the Global Atlas of Schistosomiasis distribution



Source: Linnros (2024).

Finally, I construct measures of infertility. Infertility is commonly defined as an inability to conceive or carry a pregnancy to term after trying for a specific period. As the condition is unobservable unless someone is trying to conceive, infertility status is inherently challenging to measure. Moreover, I do not directly observe infertility status in the DHS data. Instead, I rely on women's self-reported birth histories to construct three measures of infertility.

First, I construct measures of primary infertility (involuntary childlessness) and secondary infertility (the inability to have another child after at least one successful pregnancy) following Mascarenhas et al (2012b). Both measures rely on the number of births a woman reports combined with measures of exposure to pregnancy (marital status, duration of marriage, contraceptive use and duration of contraceptive use) as well as fertility intentions. The advantages of these measures are that they will capture periods of infertility, both for women who have not yet given birth and for women who already have children. Moreover, these measures allow me to include the full sample in the analysis. However, they will not include infertile women who are divorced or who had an exposure time shorter than five years.

As a complement, I create an indicator for whether a woman is over 40 years old and has never given birth to a child. Assuming that the level of *voluntary* childlessness is low in this setting, this will be a credible measure for infertility for women who are nearing the end of their reproductive years. However, this measure has the disadvantage of substantially limiting the sample and will potentially overestimate infertility prevalence in this group by including women who are voluntarily childless or who have never had sexual intercourse. Moreover, this measure does not capture periods of infertility.

Secondary outcomes

In addition to the main outcomes in this paper, I study a set of secondary outcomes. As mentioned in the introduction, I include educational attainment in my analysis as this is an outcome that has been linked to child marriage by previous research.

Moreover, I include near-completed fertility (the total number of births to women over age 40) and fertility preferences (the number of children women report as their *ideal* number) to gain a deeper understanding of the mechanisms behind the main results. Lastly, I study men's fertility outcomes and marriage timing.

Conceptual framework

I construct a simple conceptual framework. The purpose of this framework is not to explicitly model all factors that may affect marriage timing. Rather, I seek to illustrate how the risk of infertility can affect the timing of marriage. For the purpose of this exercise, I make a number of simplifying assumptions about how marriage markets work and how fertility choices are made.

In the model, the choice between marrying young or old is made under a community-level risk of infertility. Some women have a lower probability of giving birth in each period than other women. However, women and girls cannot observe whether they are the low or the high fertility type before they attempt to have children, which they can only do within marriage. Before entering the marriage market, the risk of being the low fertility type is inferred by observing the fertility outcomes for older, already married women in a community. The model builds on the assumption that the share of infertile women is observable. I argue that this is not an unreasonable assumption, as a couple's infertility status often is public information (it is observable if a couple is childless after some time in marriage). In addition, information about

infertility problems may disseminate through kin and friendship networks. The decision of when to marry is based on the value placed on having children relative to delaying marriage, under the community level infertility risk.

The model illustrates that communities where the risk of being infertile is high will have higher rates of early marriage. An additional conclusion from the model is that the higher the valuation placed on having children relative to delaying marriage, the younger the age at first marriage.

Results

Main results

I first provide evidence in support of the assumption needed for a causal interpretation of my results, by demonstrating that the two strains of schistosomiasis share the same relationship with a range of other important determinants of marriage age.

I then estimate the effect of schistosomiasis on infertility. I find that exposure to the infertility-causing strain substantially increases infertility risk. The probability that a woman is infertile is 20–40 percent higher across the different measures of infertility, compared to baseline infertility rates between 1.5 and 6 percentage points.

I also find that women exposed to the infertility-causing strain have a higher probability of marrying and giving birth to their first child during early adolescence, compared to women exposed to the other strain. More specifically, a one standard deviation increase in the prevalence of the infertility-causing strain leads to a 7 percent higher probability that a woman married before her 18th birthday and a 22 percent higher probability she married before her 15th birthday. The relationship between the infertility-causing strain and

marriage timing emerges during early adolescence and lasts until age 20, implying a shift in the timing of marriage to childhood and early adolescence rather than a difference in the overall marriage rate.

Age at first birth is closely related to age at first marriage: at 11 percent schistosomiasis prevalence, I find an 8 percent higher probability that a woman gave birth to her first child before her 18th birthday. The likelihood that a woman gave birth to her first child before her 15th birthday is 22 percent higher.

Figure 2: The probability of first birth and marriage

(a) Probability of first marriage at age a (b) Probability of first birth at age a



Source: Linnros (2024). The outcome is the probability that a woman married (panel a) or had her first child (panel b) before or during a specific age (measured on the x-axis). The sample is restricted to women who are at least that age at the time of the survey. The dashed lines represent 95% confidence intervals applying clustered standard errors at the DHS community level. To make estimates easier to interpret, all point estimates and the upper and lower limits of the confidence intervals have been scaled by 11 percentage points, the median of schistosomiasis exposure in my data.

The findings that exposure to the infertility-causing strain increases the prevalence of infertility, early marriage and early childbirth are robust to controlling for a large set of covariates and accounting for the spatial structure of the data. Moreover, I rule out several alternative hypotheses that could explain my findings.

Completed fertility

Despite observing a higher probability of early childbearing for women who are exposed to the infertility-causing strain, these women are not more likely to have large families towards the end of their reproductive life. This pattern is unlikely to arise solely as a consequence of omitted variable bias, as early fertility is typically associated with high completed fertility (Bongaarts, 1984). This is also the case in my data: delaying marriage by one year is associated with a 0.3 decrease in the total number of births.

Fertility preferences

I also study the role of fertility preferences. This is important for two reasons. First, fertility preferences can be directly affected by exposure to infertility risk. For example, women who face a high infertility risk may adjust their fertility preferences to align with the expected or realized number of children.

Second, one conclusion from the conceptual framework discussed above is that the valuation of children may vary across individuals, and those who place a relatively high value on having children will have a stronger response to infertility risk. Fertility preferences can then be used to shed light on one of the mechanisms mediating the effect on early marriage. The Demographic and Health Survey asks women about how many children they consider to be ideal. I use the reported number of children as a measure of women's fertility preferences. I start by estimating the effect of exposure to the infertility-causing strain on women's fertility preferences. I do not detect any significant difference between the two strains, and the estimated differences are small in magnitude.

Having documented that there is no relationship between the infertility-causing strain and fertility preferences, I study how the effect of exposure to the infertility-causing strain of schistosomiasis on marriage age correlates with fertility preferences. The ideal number of children reported by a woman can be seen as an indication of how highly she values fertility, and the purpose of this exercise is to assess whether this valuation matters for the effect on early marriage. I find that the effect of the infertility-causing strain on a woman's probability of being married before her 15th birthday is concentrated among women who have a preference for large families.

School enrolment

Early marriage and childbirth can directly cause girls to drop out of school (Field and Ambrus, 2008), but may also decrease parental investments in girls' education if parents expect girls to leave the educational system at a young age. I investigate if exposure to infertility risk impacts educational attainment. I find suggestive evidence that women exposed to the infertility-causing strain are less likely to have any primary school education. Although the difference between the two strains is not statistically significant, the point estimate indicates that a one standard deviation increase in the infertility-causing strain leads to a 3.4 percent lower probability of having any primary school education.

Men's outcomes

I also studied men's outcomes as changes in women's marriage outcomes naturally suggest changes to local marriage markets and potential consequences for men. As infertility risk may affect both the supply of and the demand for young brides, the effect on men's age at first marriage is not obvious. On the one hand, if exposure to the infertility-causing strain affects both men's and women's ability to have children, or if men have a preference for similar-aged spouses, men may also marry younger. Moreover, even if only women's ability to have children is affected, higher infertility rates may lead to more divorces, which would induce men to marry younger if they have preferences over fertility timing and anticipate going through a larger number of unions before finding a fertile partner. On the other hand, if older, divorced men also have a preference for very young brides when looking for a new spouse, and these men are more competitive in the marriage market, men's age at first marriage could increase. Finally, a third alternative is that men's age at first marriage is not affected by infertility risk.

I find that men exposed to the infertility-causing strain are also more likely to be childless at old ages, which could be driven either by a direct effect of exposure¹, or a history of matches to infertile women. In equilibrium, men's marriage age could also be affected, but I find that the effects on marriage timing and educational attainment are limited to women. I also document that, as a natural consequence of exposed women marrying young while exposed men do not, there is a larger age gap between exposed women and their husbands. Finally, I investigate the consequences of exposure to the infertilitycausing strain for marriage turnover and find that exposed women are more likely to have had multiple partnerships.

¹ While there is no clear evidence linking schistosomiasis infection to male infertility, the medical literature has not ruled out the existence of this link (King, 2018).

Conclusions

Infertility associated with infections and diseases of the reproductive system is widespread in low-income countries. My research demonstrates that the high infertility rates observed in many low-income countries can have broad societal consequences by influencing marriage and childbearing patterns of entire communities, leading to higher rates of child marriage and teenage pregnancies. Moreover, I provide suggestive evidence that girls exposed to high infertility risk are less likely to enroll in primary school.

These findings carry important policy implications. Family planning programs in low-income contexts have traditionally focused on offering tools and technologies to delay, space and limit births. My research highlights the importance of reducing the risk of infertility and assuring people that they will be able to start a family when they are ready to do so.

Improving access to assisted reproductive technologies and scaling up treatment and prevention programs for diseases that cause infertility in lowincome countries not only has the potential to help the vast number of people who are currently struggling with infertility. This paper shows that in addition, these investments may also come with positive externalities as they can contribute to the advancement within other critical policy areas such as reducing teenage birth rates and ending child marriage. In the case of schistosomiasis, this would mean investing in infrastructure that provides people with clean water sources as well as scaling up mass treatment programs and eradication campaigns.

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What does the link between infertility risk and marriage timing look like? This study investigates whether exposure to an infertility-causing strain of the parasitic disease schistosomiasis affects the probability of child marriage in Madagascar. Findings reveal that exposure to the infertility-causing strain increases infertility risk by up to 20–40 percent and raises the likelihood of child marriage by up to 22 percent. Similar impact has been found on adolescent births. The results also indicate that women exposed to this strain are less likely to have any education at all.

Hur ser sambandet ut mellan infertilitetsrisk och ålder för ingående av äktenskap? Denna studie undersöker om exponering för en infertilitetsorsakande variant av parasitsjukdomen schistosomiasis påverkar sannolikheten för barnäktenskap i Madagaskar. Resultaten visar att exponering för denna variant ökar risken för infertilitet med 20–40 procent och ökar sannolikheten för barnäktenskap med upp till 22 procent, med liknande effekter på tonårsfödslar. Exponering för den infertilitetsorsakande varianten ökar också sannolikheten för att kvinnor helt saknar grundskoleutbildning.

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