CHILD MARRIAGE IN SUB-SAHARAN AFRICA:

TRENDS, EFFECTS ON HEALTH, AND EFFORTS TO LIMIT THE PRACTICE

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ABSTRACT

The marriage of any person below the age of eighteen, often referred to as child marriage, is widely considered a violation of human rights. Over the past decade the practice has garnered attention as a potential threat to women's health. Despite increasing discourse, estimates of trends in the prevalence of child marriage are dated and methodological challenges plague published studies of the relationship between child marriage and health. My thesis provides an updated examination of trends in sub-Saharan Africa, where rates of child marriage are highest, and aims to address some of the difficulties inherent in estimating the effects of child marriage on women's health.

The first manuscript in this thesis describes changes in the prevalence of child marriage in twenty-nine sub-Saharan African countries over a twenty-year period. I used a novel estimation technique to avoid biases that may have affected earlier studies. My results indicate that the prevalence of child marriage has declined over time but the rate of decline has stagnated in some countries.

Estimating the effects of child marriage on health is challenging for many reasons. The exposure is difficult to define and measure. Women married as children differ in many ways from their peers who married later in life, leading to concerns regarding confounding. I provide a critical evaluation of child marriage as a treatment within the potential outcomes framework and describe the challenge of approximating a causal contrast using observational data. The second manuscript included in this thesis makes the assumptions required for effect estimation more transparent through the use of matching techniques to estimate the effect of child marriage on the risk of domestic violence.

Improving educational opportunities for girls is a promising mechanism for delaying marriage. Since the 1990s many sub-Saharan African countries have adopted legislation that prohibits public primary schools from charging tuition fees.

Reducing financial barriers to schooling may result in greater educational attainment, particularly for girls. The third manuscript describes my evaluation of the effect of these legislative changes on the timing of reproductive events among girls in sixteen countries.

Child marriage remains a pervasive violation of human rights that disproportionately affects girls throughout the developing world. Upholding these rights requires knowledge of the geographic distribution of child marriage and the effectiveness of policies that aim to end the practice. This thesis represents my contribution to this effort.

RÉSUMÉ

Le mariage de toute personne de moins de 18 ans, souvent appelé le mariage d'enfants, est largement considéré comme une violation des droits de la personne. Dans la dernière décennie, cette pratique a retenu l'attention, car elle représenterait une menace pour la santé des femmes. Malgré une réflexion grandissante, les estimations des tendances de la prévalence du mariage d'enfants sont anciennes, et des difficultés méthodologiques omniprésentes compromettent les publications portant sur la relation entre le mariage d'enfants et la santé des femmes. Ma thèse fournit un examen actualisé des tendances en Afrique subsaharienne où les taux de mariage d'enfants sont les plus élevés. Elle vise également à aborder certaines des difficultés inhérentes à l'estimation des effets du mariage d'enfants sur la santé des femmes.

Le premier manuscrit de cette thèse décrit les variations observées de la prévalence du mariage d'enfants dans vingt-neuf pays d'Afrique subsaharienne sur une période de vingt ans. J'utilise une nouvelle approche afin d'éviter les biais ayant probablement affecté les estimations des études precedents. Mes résultats indiquent que la prévalence du mariage d'enfants décline avec le temps, mais que le taux de déclin stagne dans certains pays.

L'estimation des effets du mariage d'enfants sur la santé est difficile pour plusieurs raisons. Cette exposition est complexe à définir et à mesurer. Les femmes mariées pendant l'enfance se distinguent de maintes façons des femmes qui se marient plus tard, ce qui entraîne des biais de confusion. J'établis une évaluation critique du mariage d'enfants en tant que variable de traitement dans le cadre théorique « des résultats potentiels » (potential outcomes framework) et je décris la difficulté que constitue l'approximation d'un contraste causal à partir de données observationnelles dans ce cadre. Le deuxième manuscrit de cette thèse clarifie les hypothèses nécessaires pour estimer l'effet du mariage d'enfants sur le risque de violence domestique grâce à l'utilisation de techniques d'appariement.

L'amélioration des possibilités éducationnelles pour les filles est un mécanisme prometteur de retardement du mariage. Depuis les années 90, de nombreux pays subsahariens ont voté des lois interdisant aux écoles primaires publiques de facturer des frais de scolarité. La réduction des contraintes financières en éducation peut entraîner un meilleur niveau éducationnel, particulièrement chez les filles. Le troisième manuscrit décrit mon évaluation de l'effet de ces changements législatifs sur le calendrier des événements reproductifs des filles dans seize pays.

Le mariage d'enfants reste une violation persistante des droits de la personne affectant disproportionnément les filles des pays en développement. Le respect de ces droits nécessite une connaissance de la distribution géographique du mariage d'enfants et l'efficacité de politiques visant à éradiquer cette pratique. Cette thèse représente ma contribution à cet effort.

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The doctoral training I received in the Department of Epidemiology, Biostatistics, and Occupational Health at McGill University was of the highest order. I am deeply grateful to the faculty members who spend countless hours developing course material, lecturing, and engaging with students outside of the classroom in journal clubs and seminars. Their teaching has shaped my thinking and their commitment to learning has inspired me.

In particular, I thank my supervisor, Dr. Arijit Nandi, for volunteering his time and expertise over many years to review this work in its entirety. Dr. Nandi also generously provided tuition support throughout my studies, no small burden when taking on an international student, for which I am very thankful. My thesis committee members, Dr. Erin Strumpf and Dr. Jody Heymann, provided thoughtful advice and support throughout my pursuit of this degree.

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AUTHOR CONTRIBUTIONS

MANUSCRIPT 1

Koski A, Nandi A, and Clark S. Recent trends in child marriage in sub-Saharan Africa. [Under review by *Population and Development Review*]

I conceptualized the measurement techniques used in the study and was solely responsible for obtaining and analyzing data and interpreting results. I wrote the first draft of the manuscript. Drs. Arijit Nandi and Shelley Clark reviewed multiple drafts for important intellectual content and provided thoughtful advice on the framing of the paper.

MANUSCRIPT 2

Koski A and Nandi A. Child marriage and the risk of domestic violence in Kenya. [Being prepared for submission to *BMJ Global Health*]

I recognized the need for alternative methods of controlling for confounding of the relationship between child marriage and health. I decided upon the matching analysis described in this manuscript because in addition to controlling for confounding, it also makes some of the assumptions of causal inference transparent. I obtained Demographic and Health Survey data from Kenya, analyzed the data, interpreted the results, and wrote the first draft of the manuscript. Dr. Arijit Nandi reviewed the manuscript and provided constructive feedback that contributed to the current presentation of results.

MANUSCRIPT 3

Koski A, Strumpf EC, Kaufman JS, Frank J, Heymann J, and Nandi A. Eliminating primary school tuition fees delays age at marriage: Results of a quasi-experiment in 16 African countries. [Being prepared for submission to *Social Science & Medicine*]

All authors contributed to the conceptualization and design of this study. Drs. Strumpf, Kaufman, and Nandi provided guidance on the quantitative methods used. I obtained information on the structure of public education systems and changes to tuition fee policies in all countries as well as the Demographic and Health Survey data used to measure the outcomes. I analyzed the data, interpreted results, and wrote the first draft of the manuscript. All authors reviewed and improved the written work.

STATEMENT OF ORIGINALITY

The three studies that comprise this thesis all make original contributions to the existing literature on child marriage. The first manuscript presents an innovative method for measuring trends in the prevalence of child marriage using household survey data that avoids sources of bias known to affect previous measures. The second manuscript advances the quantitative rigor of studies that examine the relationship between child marriage and health. My use of matching methods to estimate the effect of child marriage on the risk of domestic violence in Kenya is the first study of child marriage that controls for confounding using a technique other than regression-based adjustment. Matching has the added benefit of highlighting the assumptions required for causal inference, which have not previously been discussed in this context. The third and final manuscript examines the effect of changes to national education policy on the timing of sexual debut, first marriage, and first birth among girls in sub-Saharan Africa. This is one of few studies to provide actionable evidence on the effectiveness of a policy to delay marriage across large populations.

This body of work is the realization of my own ideas and analyses.

CHAPTER 1: INTRODUCTION AND BACKGROUND INFORMATION

The United Nations defines child marriage as the marriage of any person before eighteen years of age. The practice has long been recognized as a violation of human rights, though the specific age cutoff was not defined until the adoption of the Convention on the Rights of the Child in 1989 and its complement, the African Charter on the Rights and Welfare of the Child, in 1990 (United Nations 1989; African Union 1990). Concern regarding child marriage as a potential threat to health is relatively recent. Researchers began exploring the association between age at marriage and risk of HIV infection in the early 2000s (Glynn et al. 2001; Clark 2004). Subsequent studies have evaluated the relationship between child marriage and a range of women's and children's health outcomes.

Child marriage has received increasing attention from international institutions and national governments yet estimates of change in the prevalence of the practice have not been updated for a decade. Empirical evidence linking child marriage to health outcomes is weak. My thesis addresses these issues in the context of sub-Saharan Africa, where rates of child marriage are highest.

My first objective was to update and improve the measurement of trends in child marriage over time. I used household survey data collected in twenty-nine countries to estimate trends over a twenty-year period. Chapter Three details the methods and results of this analysis.

My second objective was to critically examine child marriage as an exposure within the potential outcomes framework for causal inference. Measurement error and confounding are important threats to the validity of studies that aim to estimate the effects of child marriage on health. In Chapter Four I describe my use of matching

techniques to highlight the assumptions required for estimating the effect of child marriage on the experience of domestic violence in Kenya.

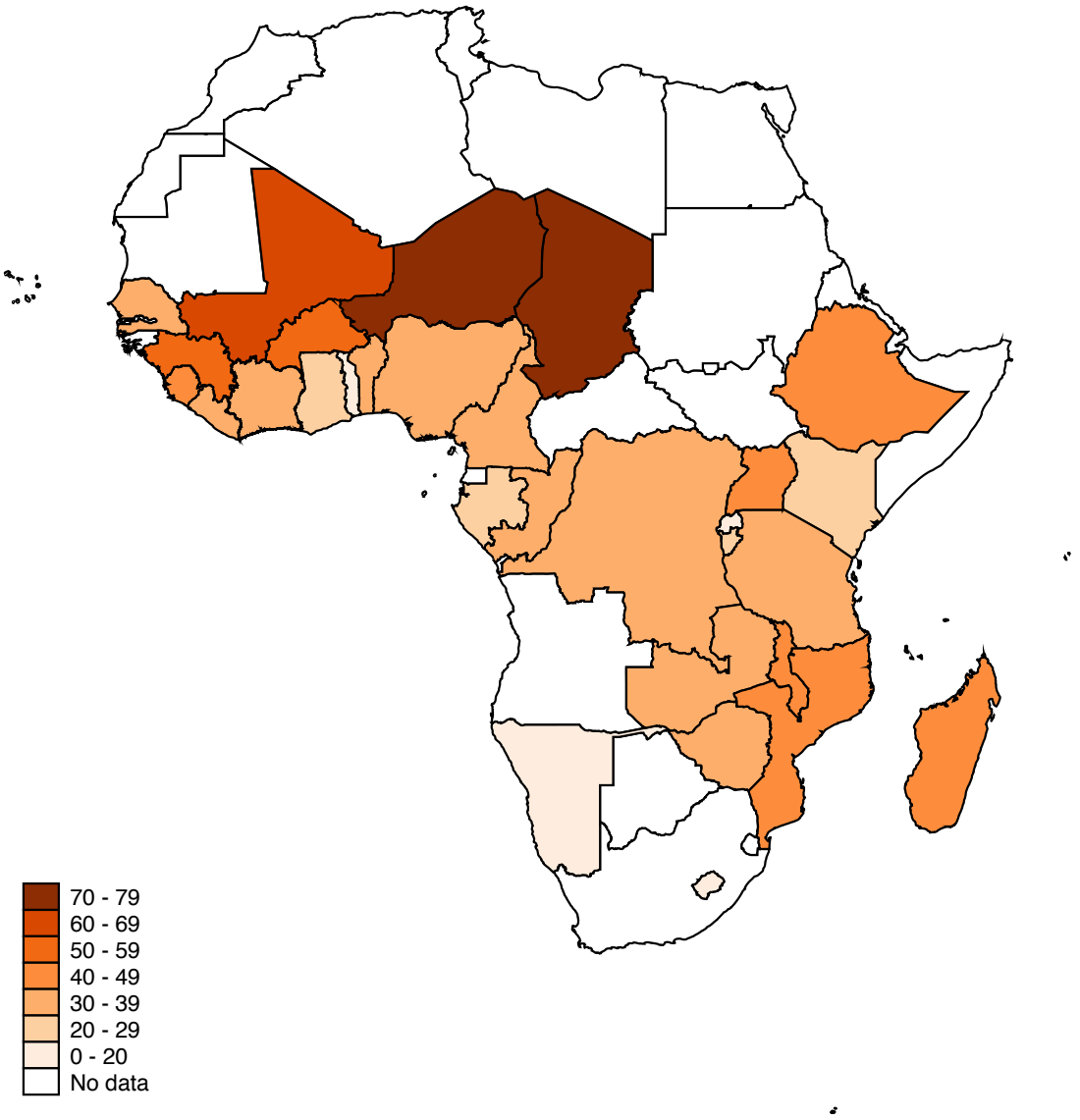
The thesis concludes with a discussion of mechanisms for delaying marriage. The World Health Organization recommends improving educational opportunities for girls as way to prevent early marriage and childbearing (World Health Organization 2011). Recent pilot programs have demonstrated that reducing the economic barriers to schooling effectively delayed marriage in Ethiopia and Malawi (Erulkar & Muthengi 2009; Baird et al. 2010). My final objective was to estimate the impact of sweeping changes to national education policy across sub-Saharan Africa on the timing of reproductive events among girls. This analysis is described in Chapter Five.

THE PREVALENCE OF CHILD MARRIAGE IN SUB-SAHARAN AFRICA

Child marriage occurs across the globe but is concentrated in low and middle-income countries. The highest rates are found in sub-Saharan Africa.

Figure 1-1 illustrates the proportion of women in sub-Saharan Africa aged 20-24 years and born between 1985-89 who reported being married before their eighteenth birthday. The prevalence of child marriage varies dramatically throughout the region, from less than 10% in Rwanda and Namibia to more than 70% in Niger and Chad.

FIGURE 1-1. PERCENTAGE OF 20-24 YEAR OLD WOMEN MARRIED AS CHILDREN IN SUB-SAHARAN AFRICA



Source: Author's estimates based on Demographic and Health Survey data on women born between 1985-89. Estimates from Chad based on women born between 1980-84.

A growing body of literature documents associations between child marriage and negative sexual and reproductive health outcomes among women. Marriage changes women's sexual behavior in ways that influence their health. Married girls have older partners and more frequent unprotected sex relative to their unmarried, sexually active peers (Clark 2004; Clark et al. 2006; Santhya et al. 2010). Young wives in many cultures face pressure to become pregnant shortly after marriage but even married women who do not want to become pregnant report having more frequent unprotected sex (Clark et al. 2006). For some women this inconsistency may stem from a limited capacity to assert themselves. Many women believe that husbands are justified in beating their wives if they refuse sex and may fear the threat of violence if they abstain (Kishor & Subaiya 2008). Moreover, marital rape is not recognized as a crime throughout much of sub-Saharan Africa which further diminishes women's ability to control the timing and frequency of sex (Horváth et al. 2007).

Married girls have higher rates of HIV infection, which may be partially explained by the greater age discrepancy between partners (Kelly et al. 2003; Clark 2004). Previous work based on data from Malawi has shown that men are more likely to be infected with HIV prior to marriage (Bracher et al. 2003). In sub-Saharan Africa young wives are also more likely to enter polygamous unions which further expand their sexual networks and their risk of acquiring sexually transmitted infections (Clark et al. 2006). Child marriage also places women at increased risk of developing cervical cancer, likely as a result of HPV infection (Zhang et al. 1989; Chaouki et al. 1998; Bayo et al. 2002).

Evidence suggests that women married as children face a high fertility burden early in their reproductive years. Studies of married South Asian women between 20 and 24 years of age found that those married before their eighteenth birthday were less likely to use any form of contraception prior to their first birth and had higher total

fertility relative to their peers married at later ages (Raj et al. 2009; Santhya et al. 2010; Godha et al. 2013). They also report more unwanted pregnancies, miscarriages, stillbirths, and abortions (Raj et al. 2009; Santhya et al. 2010; Godha et al. 2013). However, by their early twenties, the same women were more likely to be using a modern form of contraception or to have undergone sterilization (Raj et al. 2009; Godha et al. 2013).

Evidence from two studies indicates that women married as girls receive poorer maternal health care. They are less likely to receive adequate antenatal care, to give birth in a health care facility, or to have a skilled attendant present at delivery, all factors that may influence birth outcomes (Santhya et al. 2010; Godha et al. 2013). It is widely reported that women who give birth at young ages are at greater risk of experiencing obstetric complications but the empirical evidence is equivocal (Lawlor & Shaw 2002; Nove et al. 2014). The vast majority of births to adolescent girls occur within the context of marriage, making it exceedingly difficult to disentangle the effects of child marriage, young age at birth, and the socioeconomic characteristics that predispose girls to both.

Beyond sexual and reproductive concerns, child marriage has also been associated with increased risks of domestic violence and poor mental health. Women married as children report higher rates of physical violence, though evidence on sexual violence is mixed (Raj, Saggurti, Lawrence, et al. 2010; Santhya et al. 2010). A recent study conducted in Ethiopia found that girls under the age of eighteen who had received marriage requests, been promised in marriage, or had been married reported greater suicidal ideation relative to their peers who had never experienced any of these (Gage 2013). In the United States, women married as children are more likely to report substance use disorders as well as mood, anxiety, and psychotic disorders (Le Strat et al. 2011).

I am aware of a single study that examined the effect of maternal child marriage on children's health. Using data from India, this analysis found that children born to

mothers who were married before the age of eighteen were more likely to be malnourished. After controlling for confounding by indicators of socioeconomic status the investigators found no evidence that maternal age at marriage was associated with the incidence of acute respiratory infection or diarrhea, nor did they find an association with infant or child mortality (Raj, Saggurti, Winter, et al. 2010).

Women married as children are at increased risk for a range of adverse health outcomes but whether the relationships described above are causal remains unclear. The associations could also be attributed to poverty, which is one of the most important drivers of child marriage and is strongly associated with women's health. This and other challenges to estimating the causal effect of child marriage are discussed in the following chapters.

LEGISLATIVE AND PROGRAMMATIC EFFORTS TO DELAY MARRIAGE

Most countries have adopted laws that specify a minimum age at which persons can legally marry (United Nations 2011b). These minimum-age-at-marriage laws are the most common form of intervention aimed at curbing child marriage. To the extent of my knowledge no rigorous evaluation of the impact of minimum-age-at-marriage laws has been published to date but sustained high rates of child marriage suggest that such legislation is insufficient to end the practice. This is not surprising given that most countries permit exceptions to the minimum in cases of parental or judicial consent. Under these conditions the marriage of persons younger than 18 is legally permitted, effectively condoning human rights violations (United Nations 2011b; WORLD Policy Analysis Center n.d.). Moreover, the application of these laws is challenging in contexts where most marriages are not registered with any government authority. Calls for stronger enforcement have been made for more than a decade (Santhya & Jejeebhoy 2003; Hampton 2010).

Aside from national legislation a handful of programs aimed at delaying marriage among young girls have been piloted and evaluated. The Berhane Hewan program was designed to reduce the prevalence of child marriage in Amhara, Ethiopia. The program provided girls with mentorship, economic incentives to remain in school, and informal skills training and also facilitated community-wide discourse on the topic of child marriage. After a two-year pilot phase the rate of marriage had decreased among girls aged 10-19 years in villages where Berhane Hewane was implemented relative to control villages (Erulkar & Muthengi 2009).

Between 1994 and 1998 the government of Haryana, India ran a unique cash transfer program intended to improve sex ratios at birth and delay the marriage of young girls. Called Apni Beti Apna Dahn, or Our Daughters, Our Wealth, the program paid cash transfers to women who gave birth to a girl. In addition, a financial account was set up in the girl's name that paid a guaranteed amount upon her 18th birthday only if she was unmarried. A recent evaluation concluded that the program had no effect on the probability of child marriage but led to a significant increase in the proportion of girls married at exactly 18 years of age. According to interviews with program participants, many considered the payment upon the girl's 18th birthday a subsidy on marriage expenses (Nanda et al. 2015).

Another program in Zomba district, Malawi randomized young girls to receive payment of secondary school fees and cash transfers conditional on school attendance. After one year, girls in the treated areas were less likely than their peers in the control areas to report being married (Baird et al. 2010).

Continuing high rates of child marriage throughout much of sub-Saharan Africa indicate the need for broader efforts to prevent child marriage. Improving educational opportunities for young girls appears to be one promising mechanism based on the results of interventions in Malawi and Ethiopia. Chapter Five describes my evaluation of changes in national education policy in sixteen countries

throughout the region and their effects on the timing of reproductive events, including age at marriage.

CHAPTER 2: DATA SOURCES AND ANALYTIC METHODS

DEMOGRAPHIC AND HEALTH SURVEYS

Data collected via Demographic and Health Surveys (DHS) were used to conduct all of the analyses included in this thesis. The DHS Program has conducted nationally representative household surveys in 90 low and middle-income countries throughout the world since 1985, including 43 countries in sub-Saharan Africa. The surveys are primarily funded by the United States Agency for International Development (USAID) and administered in collaboration with national institutes in each country. Some countries have conducted a single survey. Many others conduct surveys approximately every five years, resulting in repeated nationally representative cross-sections of the population.

The DHS targets women of reproductive age, defined as 15-49 years, living in residential households. The core questionnaire includes items related to demographic traits including age, marital status, and education, as well as detailed items related to family planning and fertility behaviors. Women are also asked to provide a full reproductive history and to answer questions about all children below the age of five. In addition to the core questionnaire, countries may elect to include standardized supplemental modules on a variety to topics including domestic violence, alcohol consumption, and many others.

DHS samples are selected via a two-stage procedure and are typically stratified by region and urban/rural areas. The primary sampling units are selected using a probability-based procedure and usually correspond to census enumeration areas in countries that have conducted a recent census. Households are then randomly selected within each primary sampling unit and all eligible residents are invited to participate (ICF International 2012).

Data from the DHS are internationally comparable and the surveys have very high response rates. They are an important source of information on maternal and child mortality and other health related topics throughout the developing world. The DHS represent a vital source of information on marital trends in sub-Saharan Africa where civil registration of marriages is not systematic.

DHS data are publicly available from the DHS Program (http://dhsprogram.com). Users must register and provide a brief description of how the data will be used prior to being granted access.

OVERVIEW OF ANALYTIC METHODS

Different analytic methods were used in each of the studies that make up this thesis. The methods used to estimate trends in the prevalence of child marriage in sub-Saharan Africa are fully described in Chapter Three. Subsequent chapters describe my use of propensity score matching and difference-in-differences, an econometric technique commonly used to measure the impact of policy change. The discussion of these approaches within the manuscripts is concise in keeping with journal standards. The following paragraphs provide more detailed conceptual background on these two quantitative methods.

Randomized trials are the ideal study design for inferring causality. Many social exposures, including age at marriage, cannot ethically be randomized, leaving researchers to observe existing exposure patterns within populations. Under observational circumstances exposure status may not be independent of the outcomes of interest and as a result, inferring causality requires many strong assumptions (Holland 1986). Both of the quantitative techniques described below aim to approximate the conditions of a randomized trial using observational data.

PROPENSITY SCORE MATCHING

Matching is a non-parametric technique used to pair exposed and unexposed observations with regard to measured covariates that could potentially confound the relationship of interest. When effective, this ensures similar distribution of covariates between treatment groups. If one is willing to assume that all important confounders have been measured and matched upon, the resulting matched dataset can be analyzed as though it were obtained via a randomized trial.

It becomes more difficult to match exposed and unexposed observations as the number of measured confounders increases. Matching on the propensity score allows investigators to account for a large number of potential confounders using a single variable. The propensity score is the probability that an individual has the exposure of interest based on measured traits. Within epidemiology, the propensity score is most commonly predicted using a logistic regression model in which the dependent variable is a binary measure of exposure status and covariates are the independent variables. Rosenbaum and Rubin demonstrated that matching on the predicted propensity score can generate treatment groups that are conditionally exchangeable (Rosenbaum & Rubin 1983).

Matching on the propensity score has some important advantages over traditional regression-based adjustment for confounding. Comparing the distribution of propensity scores between treatment groups can readily identify positivity violations and allows investigators to restrict analysis to regions of common support. Differences in covariate distributions between treatment groups are likely to go undetected when using traditional regression methods as most statistical software packages simply extrapolate over covariate patterns for which there is little or no data (VanderWeele 2006). However, propensity score matching is only as

good as the available data and will not account for confounding by unmeasured covariates or residual confounding resulting from poorly measured covariates.

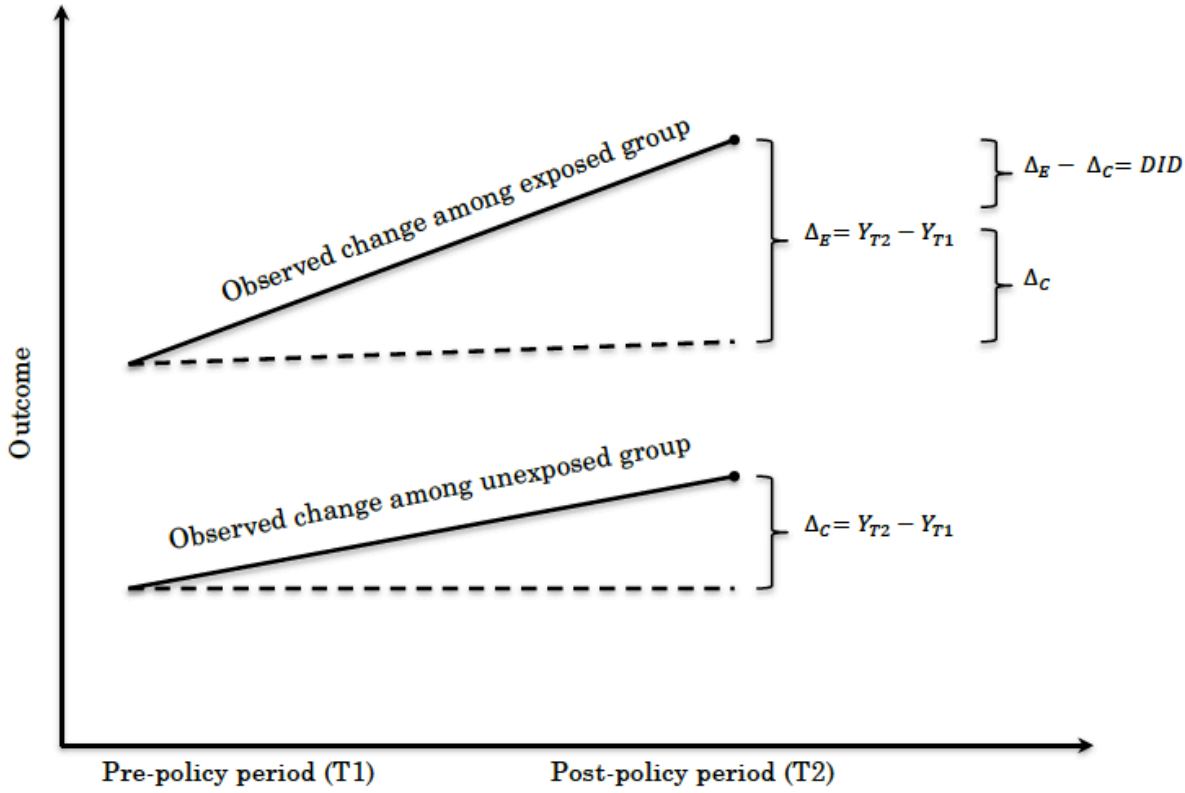
In Chapter Four I describe my use of propensity score matching to estimate the effect of child marriage on the experience of domestic violence among women in Kenya.

DIFFERENCE-IN-DIFFERENCES

Under certain assumptions, the timing of the implementation of a new law or policy can be considered a quasi-experiment. Although individual exposure to a new policy is not deliberately randomized, it is determined by an exogenous mechanism that can be considered independent of individual characteristics, much like the assignment of treatment status in a randomized trial.

The difference-in-differences approach is a quantitative method commonly used to estimate the effects of policy change. This method compares changes in outcomes over time between exposed and unexposed groups. The observed change over time among those exposed to the policy is attributable to both the true effect of the policy as well as any temporal trend in the outcome over the study period. The observed change in the control group over time is attributable only to the same temporal trend. Under certain assumptions, the effect of the policy can be estimated by subtracting changes in the control group from changes in the exposed group. The differences-in-differences effect identification strategy is illustrated in Figure 2-1.

FIGURE 2-1. CONCEPTUAL ILLUSTRATION OF EFFECT IDENTIFICATION USING THE DIFFERENCE-IN-DIFFERENCES METHOD



More specifically, the difference-in-differences estimate can be identified using regression models of the following form:

$$E(Y) = \beta_0 + \beta_1(exposure) + \beta_2(time) + \beta_3(exposure * time) + \Sigma\beta_j(covariate_j)$$

The model above includes fixed effects for exposure groups (β_1) and time period (β_2) that control for unmeasured, time-invariant differences across exposure groups and temporal trends in the outcome, respectively. The effect of the policy is represented by an interaction term between exposure status and time period (β_3).

In order for valid causal inference to be drawn from difference-in-differences estimates the trends in the outcome observed in the control group must be a good approximation of what would have happened to the exposed group had the policy not been implemented. The tenability of this assumption cannot be tested empirically, but demonstrating that trends in both groups are parallel prior to policy implementation lends credence to the assumption.

I used a difference-in-differences approach to estimate the effect of changes in education policy across sixteen countries. Further details on the method and my results are provided in Chapter Five.

CHAPTER 3: CHANGES IN THE PREVALENCE OF CHILD MARRIAGE IN SUB-SAHARAN AFRICA OVER A TWENTY-YEAR PERIOD

The elimination of child marriage is one of the targets for achieving United Nations Sustainable Development Goal number five: gender equality and the empowerment of all women and girls. Its inclusion on this list highlights the continuing importance of child marriage as a development issue and also ensures that the prevalence of child marriage will continue to be measured through 2030 and beyond.

Existing trend estimates are dated and potentially affected by well-recognized biases. The following manuscript introduces a novel technique for measuring changes in the prevalence of child marriage over time that avoids bias from some of these known sources. The results provide a more up-to-date picture of the prevalence of child marriage throughout sub-Saharan Africa and allow a more nuanced comparison of the patterns of decline in child marriage across countries.

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ABSTRACT

Child marriage has garnered increasing attention as a threat to development and health in low and middle-income countries over the past two decades. Sub-Saharan Africa has some of the highest levels of child marriage. Earlier studies measured the prevalence of child marriage across the region by comparing women of different ages, potentially introducing recall bias and other age-related inconsistencies in reporting into estimates of change over time. We used a novel measurement approach to estimate changes in the prevalence of marriage before 18 and 15 years of age among girls in 29 countries. Marriage before the age of 18 has become less common in most countries, though this decline has been concentrated among girls between 15 and 17 years of age. The proportion of girls who marry before 15 years of age has increased or remained unchanged throughout much of the region over a twenty-year period.

Child marriage is a violation of human rights that disproportionately affects girls in low and middle-income countries. These rights are alluded to in numerous human rights instruments including the United Nations Convention on the Consent to Marriage, Minimum Age for Marriage, and Registration of Marriage (1962), and the Convention on the Elimination of All Forms of Discrimination Against Women (1979) which required that member countries establish a legal minimum age at marriage in order to protect the rights of children. However, these documents did not recommend a specific minimum. It wasn't until the adoption of the Convention on the Rights of the Child in 1989 and its complement, the African Charter on the Rights and Welfare of the Child in 1990, that child marriage was defined as the marriage of any person below the age of 18 years. These two documents set the stage for current global efforts to eliminate the practice. Since their adoption child marriage has received increasing attention as a threat to development and health.

Child marriage has distressing implications for girls. Those who marry as children have fewer years of schooling than their peers who marry as adults leading to concerns regarding long-term social and economic opportunities. This relationship exists across the globe but the directionality of the association is uncertain and seems to vary across development contexts (Jejeebhoy 1995). Child marriage may limit girls' educational opportunities where public schooling systems are relatively strong (Field & Ambrus 2008) but in areas where schooling is unavailable the lack of educational opportunities may lead to child marriage. Such is the case in Niger where over 75% of women between 20-24 years of age had no formal schooling in 2012 (Institut National de la Statistique & ICF International 2013). It is unlikely that marriage prevents women who have never attended school from beginning their education.

More recently, child marriage is also considered a public health issue. Most of the health concerns regarding child marriage are related to women's reproductive and maternal health. This is unsurprising given the changes in sexual behavior that accompany marriage. Girls who marry as children have older partners and more frequent unprotected sex when compared to their sexually active, unmarried peers (Clark 2004). It follows that child marriage is strongly associated with the early onset of childbearing, short inter-pregnancy intervals, unwanted pregnancies, and high lifetime fertility (Raj et al. 2009). All of these are associated with poor obstetric outcomes, which are the leading cause of death among young women in low and middle-income countries (Patton et al. 2009). Young married women also have higher rates of HIV infection than their unmarried, sexually active peers (Glynn et al. 2001). This increased risk may stem from marrying older men who are already infected at the time of marriage, but is facilitated by frequent unprotected sex and limited agency to negotiate condom use (Bracher et al. 2003; Kelly et al. 2003; Clark 2004).

Sub-Saharan Africa has some of the highest rates of child marriage in the world. Half of girls marry before the age of 18 in many African countries despite programmatic and legislative efforts to prevent child marriage (Singh & Samara 1996; Mensch, Singh, et al. 2006). By 2010 nearly every country in the region had established a legal minimum age at marriage of 18 years in keeping with international standards for protecting human rights, though legislation in most countries allows multiple exceptions to the minimum (United Nations 2011b; United Nations 2011a; WORLD Policy Analysis Center n.d.).

Measuring the prevalence of child marriage is necessary for understanding where the practice is most common, the factors that drive it, and for evaluating the effectiveness of efforts to limit the practice. Reliable estimates also aid in the efficient targeting of programs related to child marriage. However, measuring age at marriage is a challenging task in sub-Saharan Africa. Unlike Western marriages,

which are often unambiguously dated by a ceremony, the signing of legal documents, and civil registration, marriage in sub-Saharan Africa is often described as a process consisting of multiple stages including legitimized sexual relations, cohabitation, and ceremonies. The process can be lengthy and the various stages occur in different sequence across ethnic and social groups (van de Walle & Meekers 1994; Locoh 1994; Arnaldo 2004). If several events are required to solidify a union it may be unclear when exactly the union was formalized. This raises profound difficulties for measuring age at marriage in the region.

MEASURES OF AGE AT MARRIAGE AVAILABLE IN THE DHS

The Demographic and Health Surveys (DHS) and their precursor, the World Fertility Surveys (WFS), were developed to measure fertility rates in a comparable manner across developing countries. The surveys aim to estimate the total number of women at risk of childbearing and therefore include broad questions intended to identify stable unions that may result in children. All female respondents are asked to self-report their marital status and the month and year they were first married or began cohabiting with a partner. Those who self-identify as married or indicate that they are living with a partner are considered in union. These questions result in imperfect data on age at marriage. Where union formation is a process consisting of multiple stages, it is unclear which point in the process corresponds to the reported month and year of marriage. Moreover, union formation processes differ across populations, potentially leading to systematically different reporting behaviors and biased estimates.

Despite these limitations, the DHS are the most widely available, nationally representative source of information on age at marriage in sub-Saharan Africa and the most commonly used data source in studies of age at first marriage throughout the developing world. The DHS program's focus on international comparability has

facilitated multiple studies that compare change in age at marriage across developing regions as well as numerous studies that examine trends specific to sub-Saharan Africa (Singh & Samara 1996; Harwood-Lejeune 2001; Westoff 2003; Jensen & Thornton 2003; Garenne 2004; Mensch, Singh, et al. 2006; Mensch, Grant, et al. 2006; Shapiro & Gebreselassie 2013). Most of these studies have used the same method to estimate trends: using a single DHS wave, the authors compared the proportion of women who reported being married across different age groups (Singh & Samara 1996; Harwood-Lejeune 2001; Westoff 2003; Mensch, Grant, et al. 2006; Mensch, Singh, et al. 2006; Shapiro & Gebreselassie 2013). For example, Mensch et al. (2006) used the most recent survey wave available in 27 sub-Saharan African countries and estimated the proportion of women aged 20-24 and 40-44 who reported being married before the age of 18. A few studies have presented estimates of trends in age at marriage across birth cohorts rather than age groups. Jensen and Thornton (2003) reported trends in age at marriage over birth cohorts from 1950-1970 using a single DHS wave. Westoff (2003) and Garenne (2004) pooled data from WFS and DHS surveys within countries to estimate trends over birth cohorts between 1925-1979. Only a handful of studies have estimated trends in marriage before the age of 18 (Singh & Samara 1996; Jensen & Thornton 2003; Mensch, Singh, et al. 2006; Mensch, Grant, et al. 2006).

Measuring change in age at marriage by comparing reports from women of different ages leads to concerns regarding measurement error. Older DHS respondents report less complete information on age at marriage, meaning that their data is more frequently imputed than that for younger women (Gage 1995). Older women are also known to report that events occurred closer to the time of the survey than they actually did, a bias referred to as forward displacement and well recognized within studies using DHS data (Blanc & Rutenberg 1990; Gage 1995; Mensch, Grant, et al. 2006). If forward displacement of age at marriage affects DHS data we would expect measures of change over time based on the comparison of women of different ages to systematically underestimate the magnitude of change. For example, if women aged

40-44 years tend to report that their first union took place closer to the date of the interview than it actually did, this could plausibly result in fewer women in this age group being classified as married before the age of 18 than actually were. This would lead to artificially small estimates of change over time when compared with reports from 20-24 year old women. Moreover, child marriage is strongly associated with poverty and maternal mortality at a national level (Raj & Boehmer 2013). Concerns regarding the validity of age-based comparisons for estimating change over time deepen if women married as girls are more likely to die from maternal or poverty-related causes earlier than their peers married as adults. This differential probability of survival would also lead to underestimates of change in the prevalence of child marriage over time.

Recent work by Neal and Hosegood (2015) provides further reason to avoid using women of different ages to estimate trends over time. The authors documented significant inconsistencies in the reporting of reproductive events among women born in the same cohort but interviewed at different ages. They estimated the prevalence of marriage before the age of 15 among a sample of women interviewed between the ages of 15-19 and another sample of women born in the same cohort who were interviewed five years later when they were between the ages of 20-24. The estimated prevalence of marriage before the age of 15 differed markedly across these age groups. Examination of the estimated prevalence across survey waves in three sub-Saharan African countries (Mali, Uganda, and Senegal) led the authors to conclude that estimates among 20-24 year old women may be more consistent across survey waves relative to reports from younger women (Neal & Hosegood 2015).

In this analysis we use a novel estimation technique to measure trends in the prevalence of child marriage in sub-Saharan Africa. Our measurement approach builds upon previous studies that pooled DHS data within countries to obtain estimates of prevalence across birth cohorts and compares women who were of the

same age at the time they were interviewed. In this way, we avoid potential biases arising from forward displacement and selective survival. We compare our results with those obtained from estimates of women interviewed at different ages.

DATA AND STATISTICAL ANALYSES

We obtained DHS data from all sub-Saharan African countries that had conducted at least two standard survey waves and pooled data from all available waves within each country. We then limited our sample to women born between 1965 and 1989 and aged 20-24 years at the time they were interviewed. These limitations serve multiple purposes. First, including only women aged 20-24 years avoids the censoring of women below the age of 18 and is consistent with age cohorts used in previous studies. Second, our method avoids potential biases due to forward displacement of age at marriage and selective survival, as all women were in the same age range at the time they were interviewed. We limited our sample to women born between 1965 and 1989 because women between 20 and 24 years of age were represented in each of these birth cohorts. There is variation in the distribution of age across birth cohorts within countries but this is unlikely to affect our results because there is no right censoring in our data; all women in our sample were able to report on their experience over the full time period of risk for child marriage.

We estimate trends in the prevalence of child marriage among 20-24 year old women born in consecutive five-year birth cohorts beginning in 1965-69 and ending in 1985-89. Between two and six survey waves were available in each country and surveys were conducted between 4 and 26 years apart. Not all birth years are represented in each five-year cohort. We only estimated the prevalence of premarital birth within five-year cohorts that were represented by at least three single birth years in order to obtain estimates that are reasonably representative of the average within each five-year cohort. Four women who were missing data on

age at first marriage were dropped from the analysis. Our final sample included 156,281 women from 29 countries. Sample sizes by country are listed in Table 3-1.

TABLE 1-1. COUNTRIES AND DHS WAVES INCLUDED IN THE ANALYSIS. SAMPLE SIZE INCLUDES ONLY WOMEN BORN BETWEEN 1965-89 AND AGED 20-24 YEARS AT THE TIME THEY WERE INTERVIEWED.

Country	DHS survey waves included	Total sample size across all surveys
West Africa		
Benin	1996, 2001, 2006, 2011-12	6,844
Burkina Faso	1992-93, 1998-99, 2003, 2010	6,795
Cote d'Ivoire	1994, 1998-99, 2011-12	3,197
Ghana	1988, 1993-94, 1998-99, 2003, 2008, 2014	4,209
Guinea	1999, 2005, 2012	2,749
Liberia	2006-07, 2013	1,831
Mali	1995-96, 2001, 2006, 2012-13	7,229
Niger	1992, 1998, 2006, 2012	5,097
Nigeria	1990, 2003, 2008, 2013	10,087
Senegal	1986, 1992-93, 1997, 2005, 2010-14[a]	8,987
Togo	1988, 1998	1,558
East Africa		
Burundi	1987, 2010-11	1,775
Ethiopia	2000, 2005, 2011	7,388
Kenya	1988-89, 1993, 1998, 2003, 2008-09, 2014	8,218
Madagascar	1992, 1997, 2003-04, 2008-09	6,352
Malawi	1992, 2000, 2004-05, 2010	10,144
Mozambique	1997, 2003-04, 2011	5,817
Rwanda	1992, 2000, 2005, 2010-11	7,125
Tanzania	1991-92, 1996, 1999, 2004-05, 2009-10	8,024
Uganda	1988-89, 1995, 2000-01, 2006, 2011	6,586
Zambia	1992, 1996-97, 2001-02, 2007, 2013-14	6,839
Zimbabwe	1988-89, 1994, 1999, 2005-06, 2010-11	6,490
Central and Southern Africa		
Cameroon	1991, 1998, 2004, 2011	6,190
Chad	1996-97, 2004	2,463
Congo	2005, 2011-12	2,520
Dem. Rep. of Congo	2007, 2013-14	2,743
Gabon	2000, 2012	1,769
Lesotho	2004, 2009	2,988

Namibia	1992, 2000, 2006-07, 2013	4,267
Total		**156,281**

[a] Senegal began a continuous DHS in 2012.

We used logistic regression to estimate the marginal prevalence of child marriage within each of five consecutive five-year birth cohorts spanning a total of twenty-five years between 1965-1989. In countries that conducted a survey approximately every five years between the late 1980s and early 2000s we were able to obtain estimates within each birth cohort. In countries that had longer delays between surveys we were only able to obtain data for some of the birth cohorts. We plotted these estimates within each country to depict trends in the prevalence of child marriage over time. We also calculated prevalence differences to estimate the magnitude of change over time. Women born between 1970-74 were compared with those born between 1985-89 to estimate changes over a 20-year period.

We compared estimates of change in the prevalence of child marriage over a 20-year period obtained from our estimation technique with estimates obtained by using a single DHS wave in each country and comparing the proportion of women aged 20-24 and 35-39 who reported being married before the age of 18. This analysis was limited to a sample of 9 countries in which we were able to estimate the prevalence of child marriage among women born between 1970-74 and 1985-89 and that had conducted a DHS between 2008-2010 to ensure estimation over a similar time span. For example, women aged 35-39 years and interviewed in 2009 would have been born between 1970-74; those aged 20-24 would have been born between 1985-89. These birth cohorts are very similar to the comparisons we present using pooled data.

All of the estimates presented are weighted using de-normalized sampling weights. We de-normalized the sampling weights provided in each DHS recode dataset following guidelines for the use of pooled data published in the DHS Sampling and Household Listing Manual (ICF International 2012). The de-normalization procedure requires estimates of the target population in each country at the time of each survey. We obtained estimates of the population of women aged 15-49 years in

each survey year in each country from the United Nations World Population Prospects 2015 (United Nations 2015).

RESULTS

The prevalence of child marriage over time is presented by geographic region in Figures 3-1 through 3-3. There is striking heterogeneity between and within regions. West Africa has some of the highest rates of child marriage in the world. More than half of women born in the most recent cohort were married as children in 4 of the 12 countries in this region: Burkina Faso, Guinea, Mali, and Niger. In Niger, 75% of women in this birth cohort were married as children. Prevalence is lower in East Africa, where Malawi was the only country in which more than half of women born between 1985-89 were married as children. In Rwanda the prevalence drops below 10% in the same cohort. Data are sparse in Central and Southern Africa but prevalence estimates range from a high of 68% among women in Chad born between 1980-84 and 9% in Namibia among women born between 1985-89.

FIGURE 3-1. WEIGHTED ESTIMATES OF THE PREVALENCE OF CHILD MARRIAGE AMONG WOMEN AGED 20-24 YEARS IN WEST AFRICA. VERTICAL BARS REPRESENT 95% CONFIDENCE INTERVALS

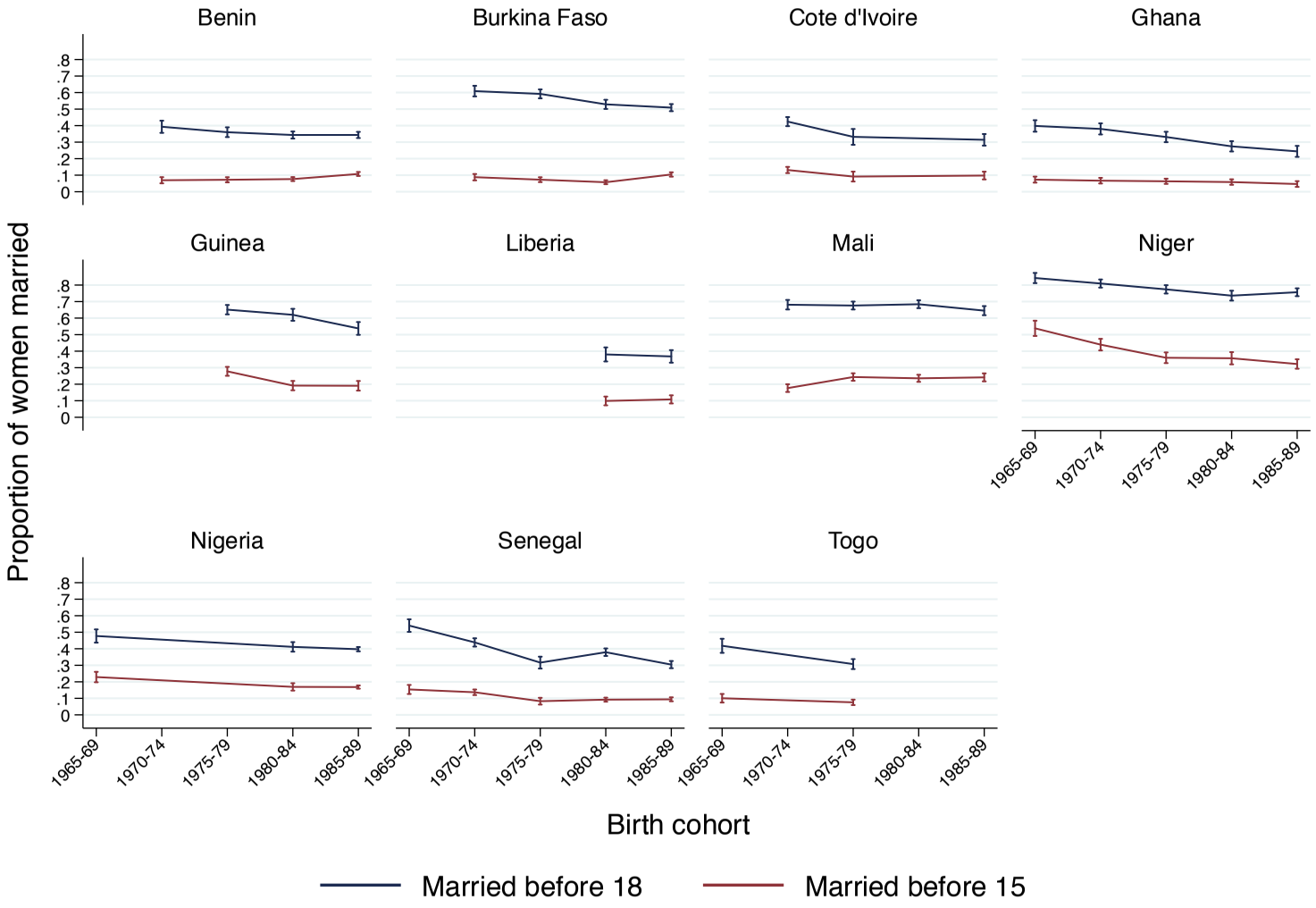


FIGURE 3-2. WEIGHTED ESTIMATES OF THE PREVALENCE OF CHILD MARRIAGE AMONG WOMEN AGED 20-24 YEARS IN EAST AFRICA. VERTICAL BARS REPRESENT 95% CONFIDENCE INTERVALS.

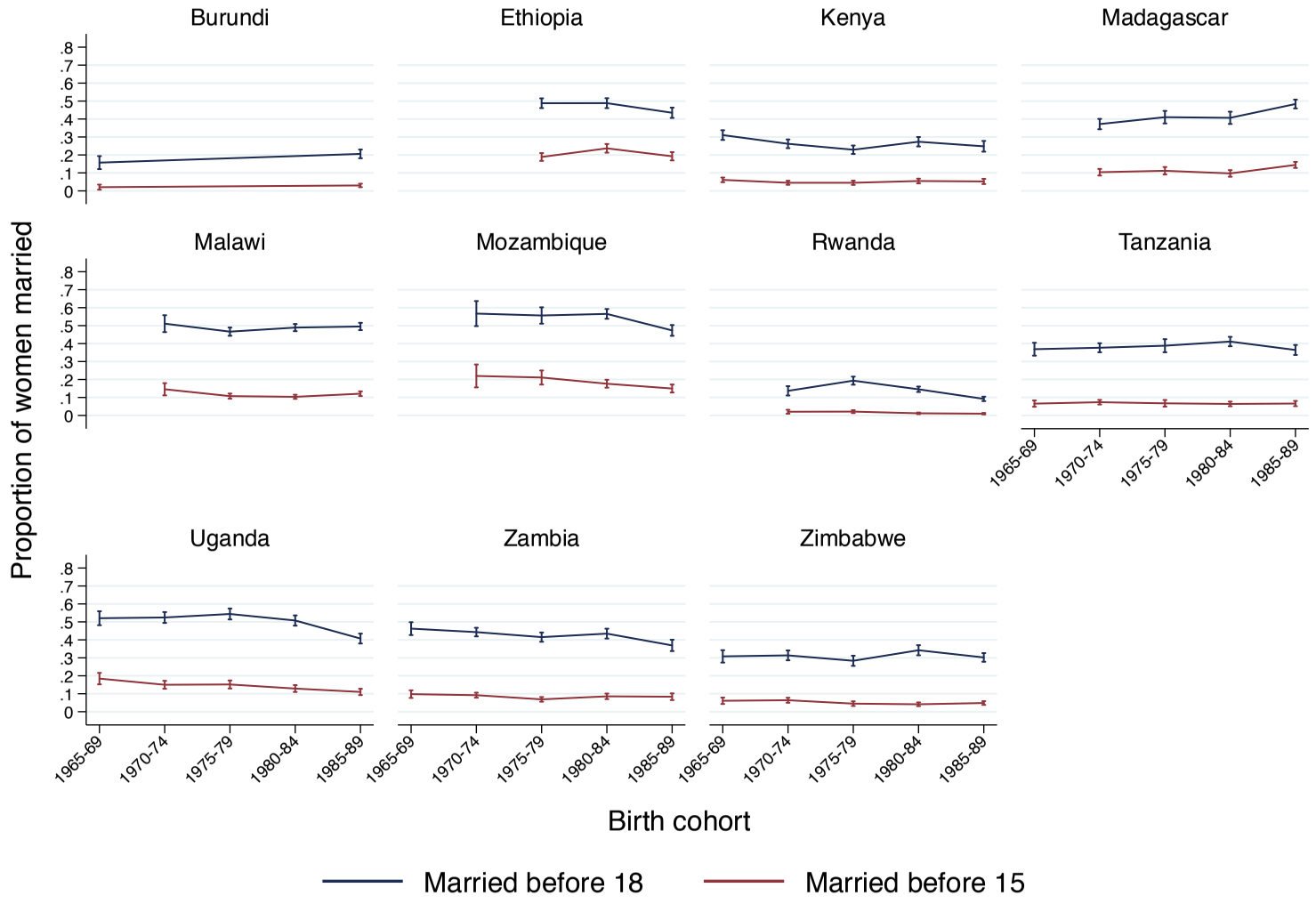
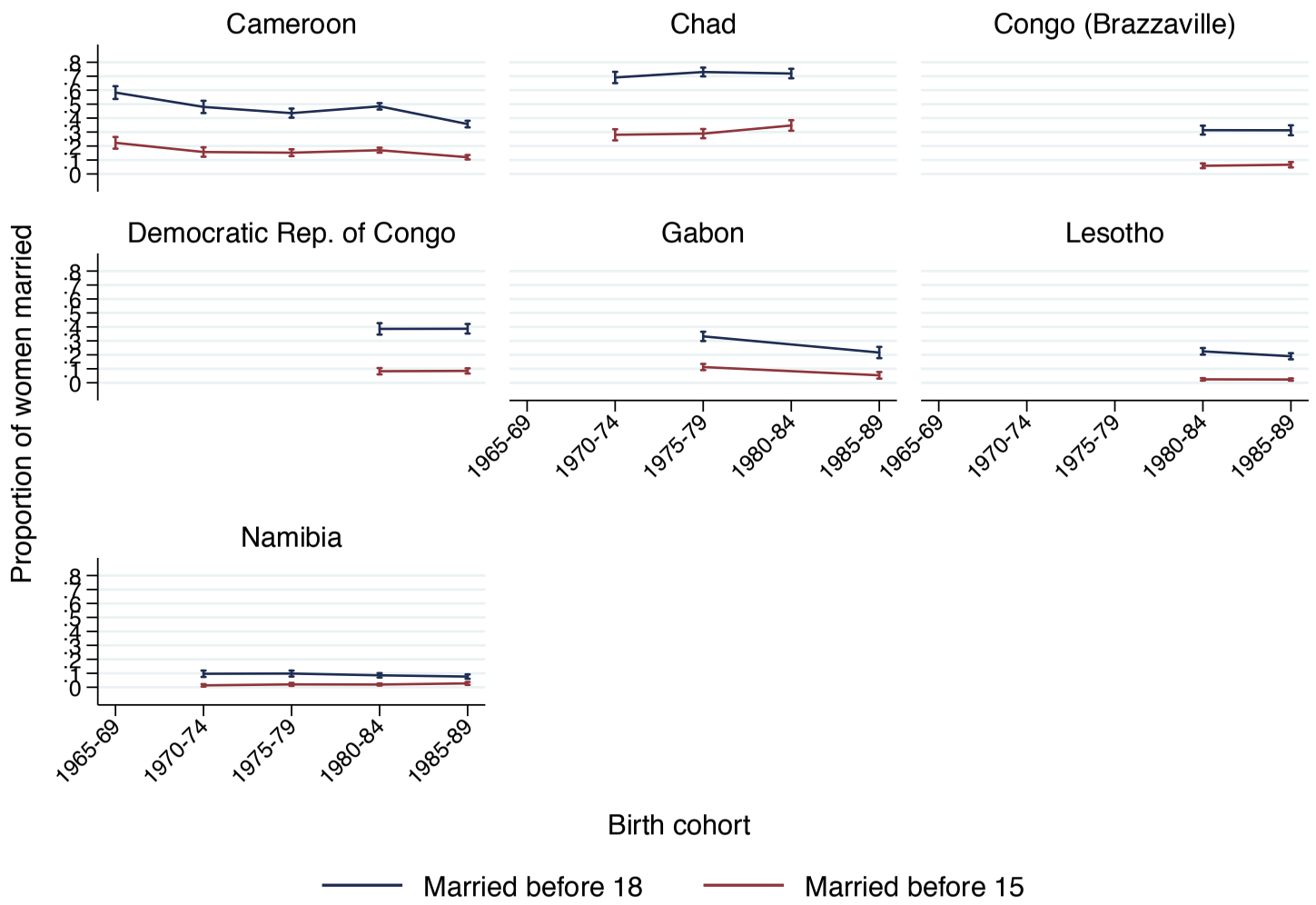


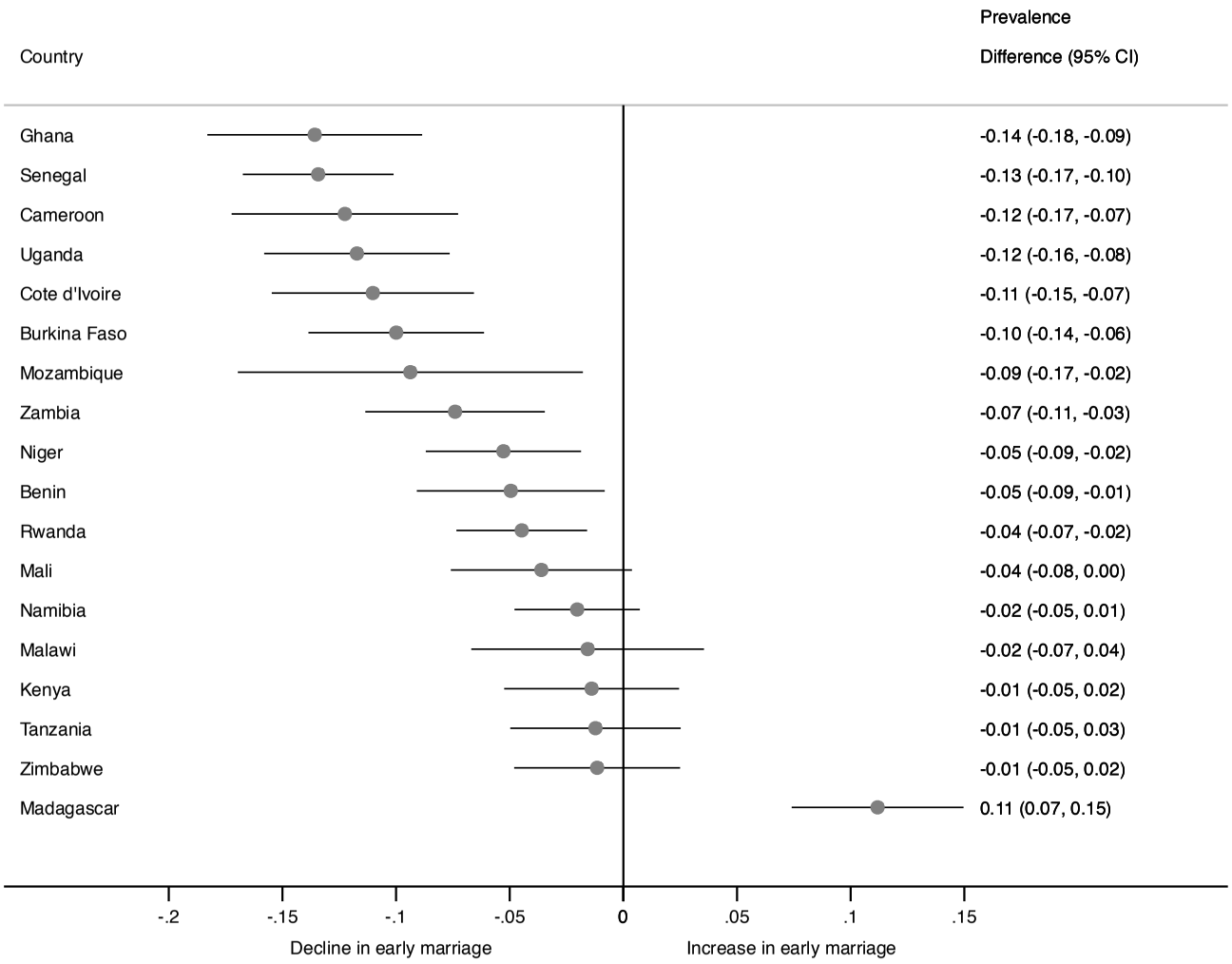
FIGURE 3-3. WEIGHTED ESTIMATES OF THE PREVALENCE OF CHILD MARRIAGE AMONG WOMEN AGED 20-24 YEARS IN CENTRAL AND SOUTHERN AFRICA. VERTICAL BARS REPRESENT 95% CONFIDENCE INTERVALS.



There is clear visual evidence of a decline in the prevalence of child marriage over time in many countries but the pattern of decline differs markedly. In Niger, Senegal, Malawi, and Kenya early declines in child marriage appear to have stagnated among recent birth cohorts while Burkina Faso and Ghana show evidence of slow but steady decline over time. Child marriage appears to have declined only recently in Mozambique, Rwanda, Uganda, and Zambia. The prevalence of child marriage doesn't appear to have changed in Tanzania, Zimbabwe, or Namibia over this period, though the prevalence in Namibia is relatively low compared to the rest of sub-Saharan Africa.

Results presented in Figure 3-4 support these conclusions. Figure 3-4 illustrates the magnitude of change in the prevalence of child marriage over a 20-year period in 18 countries for which we were able to estimate the prevalence among women born in 1970-74 and 1985-89. The prevalence of child marriage declined in 17 of these countries, though the estimated magnitude of the decline was very small and not statistically significant in six of them: Kenya, Malawi, Mali, Namibia, Tanzania, and Zimbabwe. The prevalence of child marriage in Madagascar increased by 11 percentage points over this period.

FIGURE 3-4. WEIGHTED PREVALENCE DIFFERENCE ESTIMATES COMPARING THE PREVALENCE OF CHILD MARRIAGE AMONG WOMEN BORN BETWEEN 1970-74 TO THE PREVALENCE AMONG WOMEN BORN BETWEEN 1985-89.



Trends in the prevalence of marriage before the age of 15 are shown in red in Figures 3-1 through 3-3. Mali and Niger have the highest prevalence of very early marriage among women born in the most recent cohort with 25% and 28% married before the age of 15, respectively. Very few girls were married this young in Rwanda or Namibia and less than 5% of women born between 1985-89 were married before 15 years of age in Ghana, Burundi, and Lesotho.

These figures indicate that the vast majority of women married as children get married between the ages of 15 and 17. Although marriage before the age of 15 is less common, there is little evidence of a decline in the prevalence of marriage among very young girls. The prevalence of marriage before the age of 15 and the magnitude of change over time is presented in Table 3-2. More than 10% of girls born between 1985-89 reported being married before their 15th birthday in 9 of these 18 countries. Only 12 of the countries examined show any indication of a decline in the prevalence of very early marriage, and only five of these countries have experienced a statistically significant decline. The prevalence of marriage before the age of 15 has increased significantly in Benin, Mali, Madagascar, and Namibia.

As a result of the relatively small decreases in marriage before the age of 15 compared to marriage before the age of 18, the proportion of child marriages that occur to very young girls has increased in many countries. For example, the prevalence of marriage below the age of 18 has declined substantially in Burkina Faso while the prevalence of marriage below the age of 15 has remained relatively stable. Among women born between 1970-74 and married as children, 14% were married before their fifteenth birthday. This percentage rose to 20% among women born between 1985-89.

TABLE 3-2. PREVALENCE OF MARRIAGE BEFORE THE AGE OF 15 AMONG WOMEN BORN BETWEEN 1970-74 AND 1985-89 AND THE MAGNITUDE OF CHANGE OVER TIME.

Country	Prevalence 1970-74	Prevalence 1985-89	Prevalence difference (95% CI)
West Africa			
Benin	6.9	10.7	3.8 (1.6, 6.0)
Burkina Faso	8.8	10.4	1.6 (-0.7, 4.0)
Cote d'Ivoire	13.1	9.8	-3.4 (-6.4, -0.4)
Ghana	6.7	4.7	-2.0 (-4.5, 0.4)
Mali	17.6	24.2	6.5 (3.2, 9.9)
Niger	44.0	32.2	-11.7 (-16.3, -7.2)
Senegal	13.7	9.4	-4.3 (-6.3, -2.2)
East Africa			
Kenya	4.5	5.3	0.7 (-1.1, 2.6)
Madagascar	10.4	14.4	4.1 (1.6, 6.6)
Malawi	14.6	12.1	-2.5 (-6.1, 1.2)
Mozambique	22.0	15.0	-7.0 (-13.8, -0.2)
Rwanda	2.1	1.0	-1.1 (-2.2, 0.1)
Tanzania	7.4	6.6	-0.8 (-2.7, 1.2)
Uganda	15.0	11.0	-4.0 (-6.8, -1.2)
Zambia	9.2	8.3	-0.9 (-3.2, 1.4)
Zimbabwe	6.4	4.8	-1.6 (-3.3, 0.2)
Central and Southern Africa			
Cameroon	15.7	12.0	-3.7 (-7.5, 0.0)
Namibia	1.4	2.7	1.4 (0.0, 2.7)

Madagascar stands out in our analysis as the only country in which we found significant increases in the prevalence of marriage before the ages of 18 and 15. All provinces in the country were represented in each of the survey waves used in this analysis, making it unlikely that the increase is attributable to differences in the sample of women interviewed across survey waves. An examination of sub-national trends over time showed that the prevalence has increased steadily in some provinces over this twenty-year period (see Appendix). Notably, the legal minimum age at marriage in Madagascar was 14 years for girls until 2007 when it was raised to 18 years in keeping with international human rights standards (Repoblikan'i Madagasikara 2007).

The increase in the prevalence of very early marriage in Mali occurred between women born in 1970-74 and 1975-79; no further change has been observed among more recent birth cohorts. One district, Kidal, was not represented in the 1970-74 birth cohort. Though sample sizes from this district are small, it has the highest estimated prevalence of very early marriage in the country. We assessed the robustness of our estimates by dropping all data from Kidal district and found that the prevalence of very early marriage still increased significantly over this twenty-year period.

Changes in geographical subdivisions recorded in surveys from Benin and Namibia over the time period examined in this analysis prevented us from examining sub-national trends in these countries.

COMPARISON WITH AGE GROUP METHOD

We compared the results from our method to those obtained by using a single DHS wave and comparing the proportion of women who reported being married before 18 years of age among different age groups, as done in earlier studies. For the age-group comparison we subtracted the proportion of 35-39 year old women who

reported being married before age 18 from the proportion of 20-24 year old women who reported the same. We compared these figures to estimates obtained by subtracting the same proportion among 20-24 year old women born between 1965-69 from that among women born between 1985-89.

The estimates obtained from both measurement techniques are remarkably similar as shown in Table 3-3. Estimates of change in the prevalence of child marriage over this 20-year period differed by more than 5 percentage points in only two countries: Burkina Faso and Senegal. We estimated a modest 1-percentage point decrease in the prevalence of child marriage in Burkina Faso when comparing women of different ages. When we compared the prevalence of child marriage among 20-24 year old women born in different cohorts we estimated a 10-percentage point decline. Differences in the estimates of change in Burkina Faso result from different estimates of prevalence among 35-39 year old women interviewed in 2010 (52.6%) and 20-24 year old women born between 1970-74 (60.9%) and are consistent with concerns regarding forward displacement bias.

TABLE 3-3. PERCENTAGE OF WOMEN MARRIED BEFORE THE AGE OF 18 AS ESTIMATED BY COMPARING CHANGE ACROSS AGE GROUPS USING A SINGLE DHS WAVE AND BY COMPARING CHANGE ACROSS BIRTH COHORTS USING POOLED DHS DATA

Country	% Women married before 18 by age at interview				% Women married before 18 by birth cohort		
	DHS year	20-24 (n)	35-39 (n)	Δ	1985-89 (n)	1970-74 (n)	Δ
West Africa							
Burkina Faso	2010	51.6 (3242)	52.6 (1984)	-1.0	50.9 (2537)	60.9 (1030)	-10.0
Ghana	2008	24.6 (869)	35.8 (637)	-11.2	24.4 (729)	38.0 (821)	-13.6
Senegal	2010	28.8 (1302)	33.8 (773)	-5.0	30.4 (3300)	43.8 (1707)	-13.4
East Africa							
Kenya	2008-09	26.4 (1744)	29.9 (930)	-3.5	24.8 (1814)	26.2 (1616)	-1.4
Madagascar	2008-09	48.2 (2901)	35.5 (2077)	12.7	48.4 (2413)	37.2 (1224)	11.2
Malawi	2010	49.6 (4392)	51.3 (2575)	-1.7	49.5 (3778)	51.1 (565)	-1.6
Rwanda	2010	8.1 (2692)	17.1 (1442)	-9.0	9.2 (2383)	13.7 (740)	-4.5
Tanzania	2009-10	36.9 (1860)	42.4 (1249)	-5.5	36.5 (1774)	37.7 (1907)	-1.2
Zimbabwe	2010	30.5 (1815)	29.9 (1034)	0.6	30.2 (1767)	31.4 (1231)	-1.2

DISCUSSION

We found that the prevalence of child marriage has fallen over time throughout most of sub-Saharan Africa, a result consistent with earlier studies that have concluded age at marriage is rising in the region. However, early declines have not been sustained in a number of countries including Niger, which as the highest prevalence of child marriage in the region. There is no evidence that the prevalence of child marriage has decreased meaningfully over this twenty-year period in Kenya, Malawi, Mali, Namibia, Tanzania, or Zimbabwe.

Decreases in the prevalence of child marriage have been concentrated among 15-17 year old girls. Half of the countries we examined have made no significant progress in reducing the prevalence of marriage among girls younger than 15. There is evidence of a substantial decrease in only five countries: Cote d'Ivoire, Niger, Senegal, Mozambique, and Uganda. Distressingly, the prevalence of marriage among girls younger than 15 has risen in four countries: Benin, Mali, Madagascar, and Namibia. Although the proportion of women who report being married before the age of 15 is relatively low, ranging between 8% and 15% in most countries, this represents a large number of girls. The marriage of very young girls warrants greater concern from a public health perspective because their physiological immaturity may put them at increased risk for HIV and other sexually transmitted infections (Moss et al. 1991). Giving birth at such a young age may also increase the risk of obstetric complications, though the empirical evidence is mixed (Lawlor & Shaw 2002; Nove et al. 2014). Regardless of whether young age increases the risk of complications relative to older women, obstetric complications are the leading cause of death among 15-19 year old girls in developing countries (Patton et al. 2009).

We attempted to avoid known sources of bias in the measurement of trends in age at marriage by comparing women interviewed at the same age across birth cohorts. Even so, the processional nature of marriage in the African context poses many

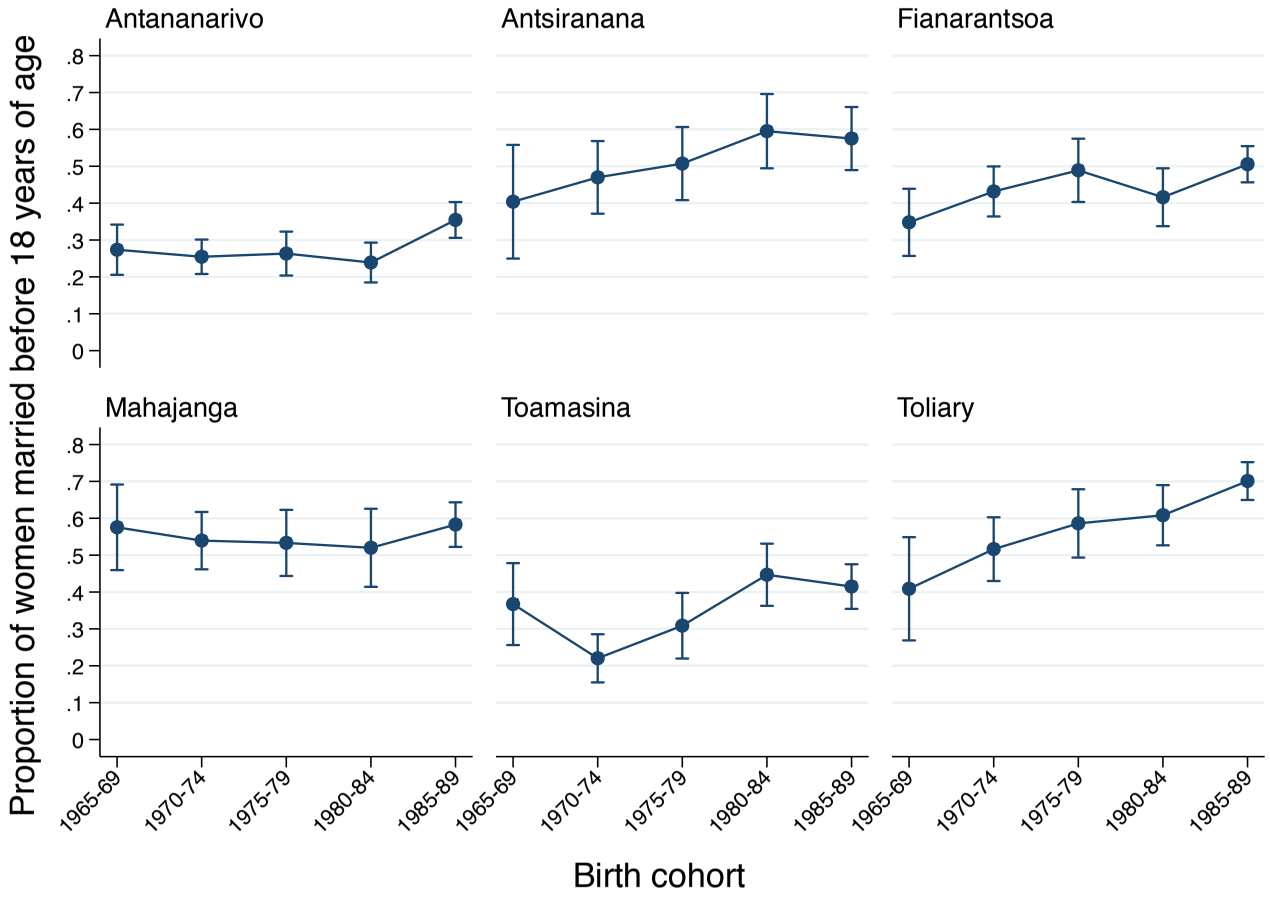
challenges for the measurement of trends over time. Perceptions of marriage have likely changed over the time period examined in this study. Rapid social change has taken place: national economies are growing, schooling opportunities for girls have increased in many areas, and minimum age at marriage laws have been adopted or updated. Additional legislative changes increasingly protect women's rights within marriage and have been covered in the media (Mwesigwa 2015). Both estimation techniques discussed in this analysis may be affected by changes in the perception of marriage over time. If marriage is a process that includes many distinct stages, it is plausible that the point in the process at which women consider themselves in union has changed. Women interviewed at the same age but born in different years may have systematically different reporting behaviors. The same bias is likely present among women of different ages surveyed at the same point in time. In order to conclude that the bias is greater in the birth cohort comparison one would have to believe that all women surveyed at a given point in time consider the same stage in the marriage process to be the point at which they were first in union, regardless of age. In other words, one would have to believe that older women adjust their views of marriage over time and apply these updated perceptions to their own self-reported date of marriage.

Child marriage is a pervasive human rights violation in sub-Saharan Africa that may hinder progress toward development and public health goals. During the time period examined here, 23 of the 29 countries in our analysis had sent the minimum legal age at marriage at 18 years or older (United Nations 2011b). Exceptions are Guinea (17), Niger (15), Togo (17), Chad (15), the Democratic Republic of Congo (15) and Zimbabwe (16), which set the minimum age between 15 and 17 years. Our estimates suggest that such laws are insufficient to stop the practice of child marriage. Calls for stronger enforcement of minimum age at marriage laws have been made for at least a decade (Singh & Samara 1996; Santhya & Jejeebhoy 2003). Though such laws represent an important precedent for the protection of human

rights, given the numerous exceptions to the minimums even enforcement of existing laws is unlikely to eliminate child marriage.

Intervening on the drivers of child marriage such as poverty and lack of educational opportunities effectively delays marriage. Randomized studies in Kenya and Malawi have shown that reducing the cost of schooling by providing school uniforms or cash transfers conditional on attendance reduced the incidence of child marriage (Duflo et al. 2006; Baird et al. 2010). Another study in Turkey found that lengthening the duration of compulsory schooling led to delayed marriage and reduced fertility (Güneș 2013). Improving educational opportunities for girls has the potential to bring about benefits far beyond delayed entry into marriage and should be strongly considered by governments serious about addressing the issue of child marriage.

FIGURE 3-5. TRENDS IN THE PREVALENCE OF CHILD MARRIAGE BY PROVINCE IN MADAGASCAR



CHAPTER 4: ESTIMATING THE CAUSAL EFFECTS OF CHILD MARRIAGE

Estimating the causal effects of child marriage is challenging for many reasons. The exposure is difficult to measure as discussed in the previous chapter. Child marriage is also a poorly defined exposure from the counterfactual perspective because the distribution of child marriage in the population is determined by many different mechanisms, a violation of the consistency assumption (Hernán & Taubman 2008). For example, the existence of minimum age at marriage laws and their level of enforcement, the level of poverty in the population, and the status of women in society all determine the prevalence and social patterning of child marriage. Each of these factors could plausibly be intervened upon to prevent child marriage.

The existence of a plausible mechanism of intervention is implicit in observational studies. Consider a hypothetical observational study that found 100 instances of domestic violence were attributable to being married before the age of 18. An alternative interpretation would be that 100 instances of domestic violence could be prevented if we intervened to delay marriage until 18 years of age or later. When there are multiple plausible interventions, as is the case for observational studies of child marriage, the precise causal contrast in question becomes impossible to define (Hernán & Taubman 2008). What, exactly, should we intervene upon to achieve the reduction of 100 instances of violence estimated in our hypothetical study? Each of the factors listed above contributed to the distribution of child marriage observed in the study sample and the effect on domestic violence would likely differ depending on which of these factors we intervened upon. The presence of multiple treatment mechanisms means that the causal contrast being measured is imprecise, which makes it impossible to answer the question definitively (Hernán & Taubman 2008).

Beyond the challenges of measuring child marriage and the lack of treatment consistency there are two additional assumptions required for valid causal inference: conditional exchangeability, or the absence of confounding, and positivity, which requires that exposed and unexposed observations be present within each strata of measured covariates (Westreich & Cole 2010). The following manuscript describes the lack of exchangeability between women married as children and women married as adults in a sample from Kenya. There are also a small number of women married as children in the sample who had covariate patterns so distinct that they could not be matched to women married as adults. The use of matching techniques allows these violations of conditional exchangeability and positivity to be identified and the analysis conducted accordingly to limit their impact on the estimated results.

MANUSCRIPT 2: CHILD MARRIAGE AND THE RISK OF DOMESTIC VIOLENCE IN KENYA

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ABSTRACT

Child marriage, defined as the marriage of any person before the age of 18, is a violation of human rights and a threat to women's health. The practice has been associated with a range of negative sexual and reproductive health outcomes for women but these associations may be confounded.

We pooled DHS data collected in Kenya in 2003 and 2008-09 and limited our sample to 9348 ever-married women. We matched women married as children and women married as adults based on their propensity score to create treatment groups that were exchangeable with regard to measured confounders. We estimated the effect of child marriage on the risk of domestic violence within this matched sample using regression models.

Women married as children had a 6% excess risk of experiencing physical violence relative to women who married later and a 3% excess risk of experiencing severe violence, such as being choked, burned, or attacked with a weapon. We found no evidence that child marriage increased women's risk of sexual violence. Our results are the first to quantify the magnitude of the association between child marriage and domestic violence in the African context while controlling for confounding.

Marriage before the age of 18 years, commonly referred to as child marriage, is widely considered a violation of human rights (United Nations 1989; African Union 1990). More recently, the practice has also been perceived as a threat to women's health. Research results document associations between child marriage and a range of negative health outcomes for women including short inter-pregnancy intervals, unwanted pregnancies, and maternal mortality, as well as increased risks of HIV infection and domestic violence (Clark 2004; Raj et al. 2009; Raj, Saggurti, Lawrence, et al. 2010; Raj & Boehmer 2013).

Whether these associations are causal remains unclear. In order to determine whether child marriage causes poor health outcomes, ideally we would measure the outcome of interest among a target population of women first married at any point before the age of 18 and the same group of women if they were first married after the age of 18, i.e. under both treatment and control conditions. Clearly, we can only observe one of these conditions. The other remains unobservable, or counterfactual. Therein lies the fundamental problem of causal inference: we are unable to observe what would have happened if a woman who first married as a child instead married as an adult and vice versa (Holland 1986; Maldonado & Greenland 2002).

To get around this problem, we must estimate outcomes under the counterfactual condition by substituting a different group of women. In the case of child marriage, we compare outcomes among one group of women who married as children and a different group of women who married as adults (aged 18 or older). The validity of causal inference depends on how closely the substituted population mirrors the target population. In other words, the substituted group of women who married as adults should be indistinguishable from the women who married as children with regard to all relevant covariates in order to estimate the causal effect of child marriage.

Estimating the causal effect of child marriage is challenging for a number of reasons. First, we know that women who marry as children are markedly different from their peers who marry as adults. Across the globe, women married as children have fewer years of schooling and more often live in poor, rural households than women married later (Singh & Samara 1996; Jensen & Thornton 2003; Clark 2004; Raj et al. 2009; Raj 2010; Santhya et al. 2010; Le Strat et al. 2011; Shapiro & Gebreselassie 2013). Observed associations between child marriage and health outcomes may be confounded by these differences. Second, child marriage occurs early in life and most widely available data sources from developing countries include few measures of early life conditions that could be used to control for confounding. Childhood poverty is an important driver of child marriage in sub-Saharan Africa. In Kenya and other countries in the region a bridewealth is often paid from the groom's family to the bride's family to secure a marriage (North 2010; Raitala 2015). Poorer families have greater incentive to marry daughters early in order to collect the bridewealth, which can be substantial. However, few data sources include variables that characterize early-life socioeconomic status. For example, the Demographic and Health Surveys (DHS), the most widely available internationally comparable data source from low and middle-income countries, include measures of current socioeconomic status for women aged 15-49 years but few indicators of early life conditions. Child marriage plausibly affects many subsequent indicators of socioeconomic status including educational attainment and household wealth in adulthood. It is therefore inappropriate to adjust for these measures of later life circumstances.

Despite these challenges to estimating the causal effects of child marriage, many sources state that women married as girls are at increased risk of domestic violence (Population Council n.d.; United Nations Fund for Population Activities UNFPA 2012; Jain & Kurz 2007; World Health Organization 2013). Empirical evidence to support this claim is limited. Jensen and Thornton (2003) examined the unadjusted bivariate association between age at marriage and the experience of violence in

Columbia and India and found that women married below the age of 18 were more likely to report experiencing violence. In a report published by the DHS Program, Kishor and Johnson (2004) reported the unadjusted bivariate association between age at marriage and the experience of violence in nine countries. Though they did not look at child marriage specifically, the authors found that women married at younger ages were more likely to report ever experiencing violence and to have experienced violence in the 12 months prior to the date they were surveyed. Three studies based on household survey data from India reported an association between age at marriage and the experience of spousal violence (Raj, Saggurti, Lawrence, et al. 2010; Raj 2010; Santhya et al. 2010). Two of these attempted to control for potential confounding using basic regression adjustment but did so using variables that were likely affected by the exposure (Raj, Saggurti, Lawrence, et al. 2010; Santhya et al. 2010). Aside from the inclusion of data from Zambia in the study by Kishor and Johnson (2004) we are unaware of any published work that examines the relationship between child marriage and domestic violence in the African context.

In this study we estimate the effect of child marriage on the experience of domestic violence in Kenya. We highlight the assumptions required for this analysis by using propensity score matching techniques to obtain a sample of women married as children and women married as adults that are similar with regard to measured covariates. We also measure the potential influence of unmeasured confounding on our estimates.

DATA

We used data from two consecutive waves of the Demographic and Health Survey (DHS) conducted in Kenya in 2003 and 2008-09. The DHS are internationally comparable household surveys that collect demographic and fertility-related information from nationally representative samples of women aged 15-49 years in low and middle-income countries. Sampling strategies and methodology have been described previously (Corsi et al. 2013). Kenya conducted a total of six standard DHS surveys between 1989 and 2014. The 2003 and 2008-09 waves were selected for this analysis because they included a variable indicating childhood place of residence, one of a very limited set of variables indicating childhood socioeconomic status, and because both surveys included a panel of questions on domestic violence.

All respondents to the DHS are asked to report the month and year they were first married or began living with a partner. We subtracted the date of birth reported by the respondent from the date of first marriage or cohabitation to estimate age at first union. Women in union before their 18th birthday were considered married as children.

The surveys used in this analysis included a module of questions regarding women's experience of physical and sexual violence at the hands of their current husband or partner, or their previous partner in the case of divorce or widowhood. In households that included multiple eligible women the domestic violence module was only administered to one randomly selected woman in accordance with ethical guidelines for research on domestic violence (World Health Organization 2001). The following questions were asked of this sub-sample of women: Does your husband/partner ever push you, shake you, or throw something at you? Slap you? Twist your arm or pull your hair? Punch you with his fist or with something that could hurt you? Kick you, drag you, or beat you up? Try to choke or burn you on

purpose? Threaten or attack you with a knife, gun, or any other type of weapon? Women were asked about specific acts of violence because this type of inquiry is thought to improve the validity of reporting relative to more subjective lines of questioning (Ellsberg et al. 2001; World Health Organization 2001). Respondents to the domestic violence module were also asked whether their husband or partner ever physically forced them to have sexual intercourse or to perform other sex acts when they did not want to.

We created three separate outcome variables based on these questions. We categorized physical violence as severe or less severe. Less severe violence includes pushing, shaking, throwing objects, slapping, twisting, punching, kicking or dragging. Severe violence includes choking, burning, or being threatened or attacked with a weapon. These categories correspond to those used by the DHS. Women who reported that their husband or partner had forced any type of sexual contact were considered to have experienced sexual violence.

Our initial sample was composed of 9348 ever-married women aged 18-49 years interviewed as part of the 2003 or 2008-09 DHS and who were selected to respond to the domestic violence questions.

STATISTICAL ANALYSES

We began our analysis by using a logistic regression model to estimate the propensity score, or the probability that each woman was married as a child, conditional on measured characteristics (Rosenbaum & Rubin 1983; VanderWeele 2006). We predicted the propensity for child marriage as a function of age, childhood residence (urban/rural), ethnicity, religious identity, and a binary indicator of whether the respondent had any formal schooling. Children in Kenya are expected to begin primary school at six years of age (International Bureau of Education 2010). Although overall educational attainment may be affected by age at marriage

and would be inappropriate to include in the propensity score model, this marker of whether or not girls ever attended school is unlikely to be a consequence of child marriage. The youngest age at marriage reported in our sample was nine years, substantially later than the recommended entry age of six years even if girls enroll in primary school late. We believe that whether or not girls received any formal schooling may be a crude measure of women's status as it indicates families' ability and/or willingness to educate girls.

The propensity score model also included variables that are associated with domestic violence but unlikely to confound the relationship of interest because the inclusion of such variables may improve the precision of effect estimates (Brookhart et al. 2006). We included variables indicating the husband or partner's educational attainment, the age discrepancy between partners (in years), and a binary measure of whether the respondent's husband drank alcohol as this is associated with domestic violence in Kenya (Jaoko 2010). Six variables measuring the respondent's acceptance of domestic violence were also included. All female respondents to the DHS were asked whether they felt a husband was justified in beating his wife if she goes out without telling him, neglects the children, argues with him, refuses to have sex with him, or burns the food. We included a binary indicator of women's response to these individual questions, as well as an indicator for women who responded that they felt husbands were justified in beating their wives under all of the circumstances described above. We included interaction terms between variables if they improved covariate balance.

After estimating the propensity score for each respondent we matched women married as children (treated women) to women married as adults (control women) within each survey year (2003 or 2008-09) based on their score. Matches were determined using a nearest neighbor technique with replacement and a tight caliper of 0.01. More than one control was matched to each treated observation in the event that propensity scores matched exactly. We frequency weighted all effect

estimates to account for the fact that some control observations were used more than once. We quantified covariate balance between treatment groups before and after matching by calculating the standardized difference (Austin 2009).

We estimated the effect of child marriage on each of the domestic violence outcomes within the matched dataset using regression models. Effect estimates represent the average treatment effect among the treated (ATT) because unmatched observations were dropped from the analysis.

BIAS ANALYSIS

There are a limited number of variables available in the DHS to characterize early-life socioeconomic status and the status of women in Kenyan society, two of the most important confounders of the association between child marriage and domestic violence. Residual confounding may affect our estimates even after matching on the available variables. We conducted a simple bias analysis to determine whether our effect estimates could be completely attributed to unmeasured confounding (Lash et al. 2009). We assumed the presence of an unmeasured, binary indicator of childhood poverty status and posited a range of plausible values for the difference in the prevalence of childhood poverty between treatment groups and the strength of the association between childhood poverty and domestic violence. We then calculated bias-adjusted effect estimates using the simplified formula presented by VanderWeele and Arah (2011).

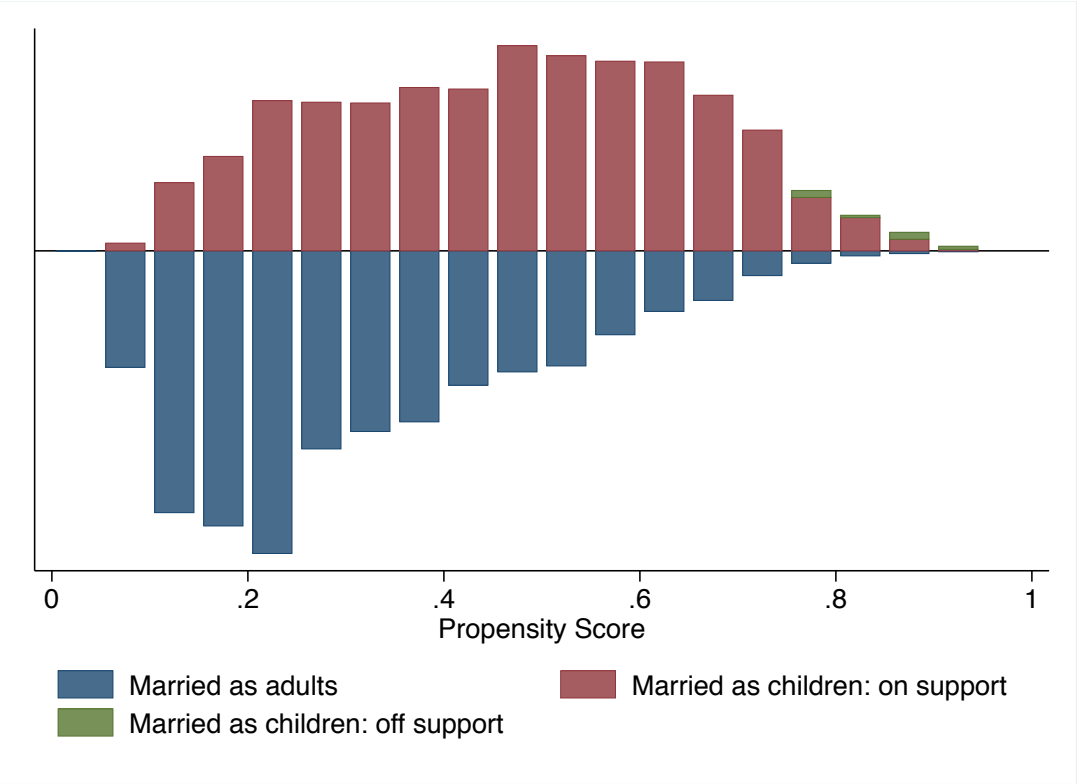
RESULTS

We were able to estimate a propensity score for 7350 of the 9348 women included in our initial unmatched sample. The remaining 1998 women were missing data for one or more of the variables used to estimate the propensity score and were dropped from the analysis. A total of 25 exposed observations with propensity scores between 0.781 and 0.934 were off support, meaning that there were no control

observations with covariate patterns that produced propensity scores this high. These were dropped from the analysis, along with 374 control observations that were unmatched. The distribution of propensity scores among women married as children and women married as adults is shown in Figure 4-1. Our final matched dataset included 6951 women between the ages of 18 and 49 in 2709 matched sets. Many observations had exactly the same propensity scores and as a result women married as children were matched with up to 22 control observations. This indicates that the limited number of pre-treatment variables available in the DHS were not sufficient to finely differentiate the probability of being married as a child.

More than 38% of the women in this sample reported being married as children. Domestic violence was also common: more than 36% of women had experienced less severe violence, 10% had experienced severe violence, and 13% reported that their husband or partner had physically forced intercourse or other sex acts against their will.

FIGURE 4-1. DISTRIBUTION OF PROPENSITY SCORES AMONG WOMEN MARRIED AS CHILDREN AND WOMEN MARRIED AS ADULTS IN THE UNMATCHED SAMPLE



Matching substantially improved covariate balance between treatment groups as shown in Figure 4-2. No set value of the standardized difference indicates important residual imbalance and if the covariate is a strong confounder any residual confounding could affect estimates. However, absolute differences of less than 0.10 are an often cited guideline for indicating reasonable covariate balance (Austin 2009). Standardized differences were greater than 0.10 for many variables in the unmatched sample, indicating that women who married as children and those who married as adults differed substantially with regard to the measured covariates. For example, in our unmatched sample 31% of women married as children reported that they had no formal schooling while only 13% of women married as adults reported the same. Table 4-1 presents covariate values among treated and control women in the matched sample and shows that these groups are very similar after matching on the propensity score.

FIGURE 4-2. ABSOLUTE STANDARDIZED DIFFERENCES FOR PRE-TREATMENT VARIABLES IN THE UNMATCHED AND MATCHED SAMPLES

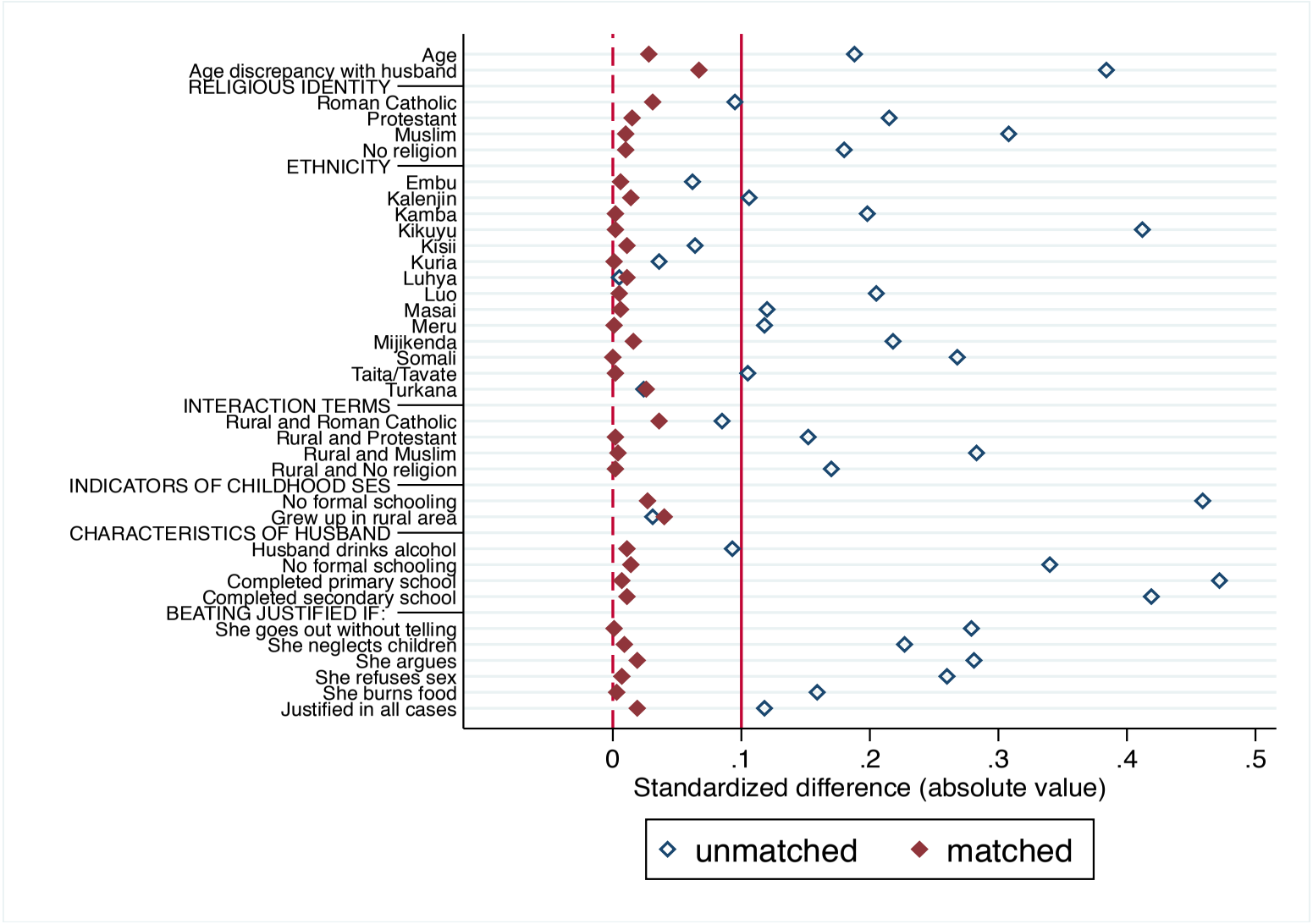


TABLE 4-1. COMPARISON OF PRE-TREATMENT CHARACTERISTICS BETWEEN WOMEN MARRIED AS CHILDREN AND WOMEN MARRIED AS ADULTS WITHIN THE MATCHED SAMPLE. VALUES FOR AGE ARE MEANS, ALL OTHERS ARE PROPORTIONS.

Variable	Married as a child (<18)	Married as an adult (18+)	Standardized difference (absolute)
Woman's age	29.81	30.03	0.03
Age difference with husband	8.95	9.40	0.07
Religious identity			
Roman Catholic	0.18	0.19	0.03
Protestant / Other Christian	0.55	0.55	0.02
Muslim	0.22	0.22	0.01
No religion	0.04	0.04	0.01
Ethnicity			
Embu	0.01	0.01	0.01
Kalenjin	0.10	0.10	0.01
Kamba	0.05	0.05	<0.01
Kikuyu	0.11	0.11	<0.01
Kisii	0.05	0.05	0.01
Kuria	<0.01	<0.01	<0.01
Luhya	0.15	0.15	0.01
Luo	0.16	0.16	0.01
Masai	0.03	0.03	0.01
Meru	0.03	0.03	<0.01
Mijikenda/Swahili	0.11	0.10	0.02
Somali	0.13	0.13	<0.01
Taita/Tavate	0.01	0.01	<0.01
Turkana	0.01	0.01	0.03
Interaction terms			
Grew up rural and Catholic	0.15	0.16	0.04
Grew up rural and Protestant	0.45	0.45	<0.01
Grew up rural and Muslim	0.17	0.17	<0.01
Grew up rural and no religion	0.04	0.04	<0.01
Indicators of early-life socioeconomic status			
Grew up in rural area	0.80	0.82	0.04
Never attended school	0.29	0.28	0.03

Husband's traits			
Drinks alcohol	0.32	0.32	0.01
Never attended school	0.21	0.21	0.01
Completed primary school	0.44	0.44	0.01
Completed secondary school	0.12	0.12	0.01
Justification of domestic violence			
She goes out without telling	0.46	0.46	<0.01
She neglects children	0.56	0.56	0.01
She argues with him	0.49	0.50	0.02
She refuses sex	0.37	0.37	0.01
She burns the food	0.19	0.19	<0.01
Justified in all cases	0.11	0.11	0.02

Our estimates of the effect of child marriage on each of the domestic violence outcomes are presented in Table 4-2. The first column contains regression-adjusted associations between child marriage and each of the outcomes among the unmatched sample. These estimates are adjusted for the respondent's age, the age discrepancy between partners, religious identity, ethnicity, the year of interview, a binary indicator of childhood residence (urban/rural), a binary indicator of any schooling, husband's educational attainment and alcohol consumption, and the respondent's attitudes regarding domestic violence. Estimates in the second column represent the average treatment effect among women who were married as children (ATT), calculated among the matched sample. Kenyan women married as children are at increased risk of experiencing domestic violence. Their excess risks of less severe and severe physical violence were 6% (95% CI 3%, 9%) and 3% (95% CI 0%, 5%) greater, respectively, than their peers who were married as adults. The excess risk of sexual violence among women married as children is approximately 1% but this is not significantly different from zero. Effect estimates for physical violence obtained from the matched sample are slightly smaller but not significantly different from the regression-adjusted estimates obtained from the unmatched sample. Further regression-based adjustment to account for small residual

imbalances remaining within the matched sample did not change our results. We found no evidence that the magnitude of the effects differed depending on whether the child was married before the age of 15 or between 15 and 17 years of age.

TABLE 4-2. ESTIMATED DIFFERENCES IN THE RISK OF DOMESTIC VIOLENCE AMONG WOMEN MARRIED AS CHILDREN RELATIVE TO WOMEN MARRIED AS ADULTS

Outcome	n	Unmatched sample RD (95% CI)	n	Matched sample RD (95% CI)[a]
Less severe physical violence	7351	0.074 (0.050, 0.097)	6949	0.059 (0.027, 0.091)
Severe physical violence	7348	0.036 (0.021, 0.051)	6947	0.026 (0.004, 0.047)
Sexual violence	7350	0.002 (-0.015, 0.018)	6949	0.010 (-0.010, 0.030)

[a] Standard errors were bootstrapped. RD: risk difference CI: confidence interval

Results of our bias analysis are detailed in Table 4-3. As described above, we assessed the sensitivity of our estimated treatment effects to the presence of an unmeasured binary indicator of childhood poverty. We allowed the prevalence of the confounder to take values between 10% and 50% greater among treated women relative to control women and allowed the hypothetical risk difference between the confounder and the outcomes to vary between 5% and 20%. These bias parameters are based on informed assumptions. We estimated the association between a current-status measure of household wealth included in the DHS and each of the violence outcomes. Household wealth is estimated using an asset-based index that includes factors such as ownership of appliances (television, motorcycle, etc.), household construction (roofing materials, floor coverings), and the proximity of water sources, among others. We then made informed assumptions about whether the magnitude of the associations between childhood poverty and violence would be greater or smaller than those between current-status household wealth and violence.

More than 31% of women married as children in our unmatched sample were living in households categorized in the poorest wealth quintile at the time they were interviewed while only 15% of women married as adults were living in such poor households. This indicates a prevalence difference of more than 15% in current-status poverty. Poor families may have a greater need for the bridewealth obtained from marrying their daughters at a young age and men who are capable of paying the bridewealth are often older and from wealthier households, suggesting that young girls' household socioeconomic status may rise after marriage. In light of this, we hypothesized that the difference in the prevalence of childhood poverty between treatment groups may be even greater than the difference in adult household socioeconomic status. Based on this hypothesis we allowed the prevalence difference to increase up to 50%.

We are unaware of any published studies that have estimated the association between childhood poverty and the experience of domestic violence in adulthood. With no published literature to draw our estimates from, we once again began by estimating the association between household wealth at the time of the survey and each of the domestic violence outcomes. When comparing women residing in households in the wealthiest and poorest quintiles we found that women in the poorest quintile had 14% greater risk of less severe physical violence, 6% greater risk of severe physical violence, and 3% greater risk of sexual violence. These estimates are in line with a previous study that found poor Kenyan women to be at greater risk of domestic violence (Bamiwuye & Odimegwu 2014). We allowed the magnitude of the hypothesized association between childhood poverty and each of these outcomes to be slightly less and slightly greater than the estimated association between household wealth in adulthood and each of the outcomes.

TABLE 4-3. BIAS PARAMETERS AND THE RESULTING RANGE OF BIAS-ADJUSTED RISK DIFFERENCE ESTIMATES

Prevalence difference	Association between child poverty and violence (RD)	Bias term	Bias-adjusted RD estimate (95% CI)
Less severe physical violence			
0.00	0.00	0.00	0.059 (0.027, 0.091)
0.10	0.10	0.01	0.049 (0.017, 0.081)
0.20	0.10	0.02	0.039 (0.007, 0.071)
0.30	0.10	0.03	0.029 (-0.003, 0.061)
0.50	0.10	0.05	0.009 (-0.023, 0.041)
0.10	0.20	0.02	0.039 (0.007, 0.071)
0.20	0.20	0.04	0.019 (-0.013, 0.051)
0.30	0.20	0.06	-0.001 (-0.033, 0.031)
0.50	0.20	0.10	-0.041 (-0.073, -0.009)
Severe physical violence			
0.00	0.00	0.00	0.026 (0.004, 0.047)
0.10	0.05	0.005	0.021 (-0.001, 0.042)
0.20	0.05	0.01	0.016 (-0.006, 0.037)
0.30	0.05	0.015	0.011 (-0.011, 0.032)
0.50	0.05	0.025	0.001 (-0.021, 0.022)
0.10	0.10	0.01	0.016 (-0.006, 0.037)
0.20	0.10	0.02	0.006 (-0.016, 0.027)
0.30	0.10	0.03	-0.004 (-0.026, 0.017)
0.50	0.10	0.05	-0.024 (-0.046, -0.003)
Sexual violence			
0.00	0.00	0.00	0.010 (-0.010, 0.030)
0.10	0.05	0.005	0.005 (-0.015, 0.025)
0.20	0.05	0.01	0.000 (-0.020, 0.020)
0.30	0.05	0.015	-0.005 (-0.025, 0.015)
0.50	0.05	0.025	-0.015 (-0.035, 0.005)
0.10	0.10	0.01	0.000 (-0.020, 0.020)
0.20	0.10	0.02	-0.010 (-0.030, 0.010)
0.30	0.10	0.03	-0.020 (-0.040, 0.000)
0.50	0.10	0.05	-0.040 (-0.060, -0.020)

RD: risk difference, CI: confidence interval

The effect of child marriage on the risk of less severe physical violence is reasonably robust to unmeasured confounding. Point estimates remain positive under all but the most extreme combination of bias parameters. The positive effect could be entirely explained by unmeasured confounding only if the prevalence of child poverty was at least 30 percentage points greater among women married as children relative to those married as adults and if the association between childhood poverty and physical violence was stronger than that between adult poverty status and violence. The estimated effect of child marriage on severe violence is less robust; a modest degree of confounding would reduce the excess risk to less than 1%.

We estimated that the risk of sexual violence was very slightly elevated among women married as children but this result could plausibly be explained by the presence of any residual or unmeasured confounding. Even a small degree of confounding would render this result not statistically different from zero and could result in a negative point estimate (Table 4-3).

DISCUSSION

Our results indicate that women married before the age of 18 are more likely to experience physical violence at the hands of their husbands or partners relative to women married after their 18th birthday. Domestic violence of any severity can lead to serious health concerns (Campbell 2002). The excess risk of being threatened or attacked with a potentially deadly weapon is 3% among women married as children. This may be an underestimate as some women attacked in such a violent manner may have been killed and unable to report on their experiences.

We found no evidence of an excess risk of sexual violence among women married as children. Although the DHS questions on sexual violence ask women to report any unwanted contact, marital rape is not recognized as a crime in Kenya and women may not feel their desire is relevant to sexual contact in the context of marriage (Republic of Kenya 2006). A recent effort to quantify the association between child marriage and sexual violence in India also found that the association was not robust to control for confounding (Raj, Saggurti, Lawrence, et al. 2010). This contradicts the results of qualitative studies in India that report early sexual encounters among newly married adolescents are often accompanied by coercion and force (Santhya & Jejeebhoy 2003). We know of no comparable studies from sub-Saharan Africa.

In order to infer that child marriage causes increases in the risk of domestic violence of the magnitude presented in Table 4-2 one would have to assume that age at first marriage is effectively randomized within our sample of married Kenyan women, conditional on the pre-treatment variables we were able to included in our propensity score model. In other words, that the effect estimates presented in Table 4-2 are free of confounding. This is unlikely given the limited number of pre-treatment variables available in the DHS (Shadish et al. 2008). We would have preferred to include a wider range of predictors in our propensity score model but in the absence of better data we assessed the sensitivity of our estimates to the presence of unmeasured confounding. Values of the bias parameters used to adjust our estimates were based on informed assumptions and may not represent the true parameters but our efforts to quantify the impact of unmeasured confounding on our estimates is likely an improvement over the assumption of no confounding (Lash et al. 2009). We found that estimates of the effect on less severe physical violence are reasonably robust.

Our analysis is subject to additional limitations beyond the potential effects of unmeasured confounding. Both exposure status and the outcomes are measured with error. Older women are known to report that events occurred closer to the date

of they survey than they actually did, a phenomenon known as forward displacement bias. This may result in fewer older women reporting that they were married as children and would likely bias our estimates toward the null. Domestic violence may be underreported despite efforts to ensure privacy during the interview and the objective nature of the questions. We have no a priori reason to believe that reporting of domestic violence would be differential by exposure status. Non-differential misclassification of the outcomes would likely lead to bias toward the null. Finally, we did not account for survey weights when calculating our estimates and as a result, our findings are generalizable only to the survey sample and are not nationally representative.

Estimating the causal effects of child marriage will continue to be challenging in the absence of richer data sources that include measures of early life conditions. Our aim was to more accurately quantify the magnitude of harm attributable to child marriage in Kenya using the available DHS data. To the extent of our knowledge, this is the first study to quantify the effect of child marriage in Kenya and the first to do so using methods that control for confounding in all of Africa.

Child marriage is widely condemned as a violation of human rights and has been prohibited under Kenyan law since 2014 (Republic of Kenya 2014). Further evidence that child marriage leads to poor health outcomes for girls, including domestic violence, may strengthen community resolve to end the practice. Such evidence may also serve to sensitize health care practitioners to the heightened risks faced by married adolescents, a group often neglected in existing public health programs focused on unmarried, sexually active adolescents.

CHAPTER 5: EFFORTS TO DELAY MARRIAGE

As discussed in Chapter One, minimum-age-at-marriage laws are the most commonly adopted intervention aimed at limiting child marriage. Such laws have thus far been insufficient to curb the practice in sub-Saharan Africa. Broader efforts that act on the drivers of child marriage are needed. Improving educational opportunities for girls could provide an alternative to early marriage and may influence long-term economic and health outcomes.

Over the past two decades many sub-Saharan African countries adopted legislation that abolished tuition fees for public primary schooling. Enrollment and primary school completion rates rose in every country following fee removal (The World Bank 2009; Iscan et al. 2015). These increases were larger among girls and children from low-income households in Uganda, but there is little evidence on the socio-demographic patterning of enrollment increases in other countries (Deininger 2003; Nishimura et al. 2008; Morgan et al. 2014). Regardless of whether the policies improved gender ratios at enrollment, some portion of the increase must be attributable to a larger number of girls attending school after tuition fees were eliminated.

Previous pilot projects in Ethiopia and Malawi demonstrated that reducing financial barriers to schooling for girls effectively delayed age at marriage (Erulkar & Muthengi 2009; Baird et al. 2010). Tuition elimination policies could potentially influence the timing of reproductive events on a larger geographic scale. The following manuscript describes my evaluation of the effect of tuition elimination policies on the timing of sexual debut, first marriage, and first birth in sixteen sub-Saharan African countries.

MANUSCRIPT 3: TUITION-ELIMINATION POLICIES DELAY AGE AT MARRIAGE: A QUASI-EXPERIMENTAL EVALUATION IN SIXTEEN AFRICAN COUNTRIES

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ABSTRACT

Education is strongly associated with reproductive behaviors. Women with more schooling marry later and have fewer, healthier children. Many African countries eliminated primary school tuition fees in the 1990s in an effort to make education more accessible, particularly for girls. We evaluated the effect of these policy changes on the timing of reproductive events.

We used data from Demographic and Health Surveys to assemble a panel of women born between 1950 and 1998 in 16 sub-Saharan African countries. These data were merged with longitudinal information on the timing of tuition fee elimination in each country. We estimated the effect of eliminating fees on age at sexual debut, first marriage, and first birth using a difference-in-differences approach. Fixed effects for country and year of birth were included to control for unobserved country-level confounders and for temporal trends in the outcomes.

The adoption of tuition-elimination policies led to average increases of 0.32 years in the age at sexual debut (95% CI -0.15, 0.78), 0.73 years in the age at first marriage (95% CI 0.21, 1.24), and 0.35 years in the age at first birth (95% CI -0.03, 0.73).

This is the first study to estimate the effects of legislative efforts to eliminate tuition fees on reproductive behaviors across many countries in sub-Saharan Africa, providing results that are generalizable across much of the region.

Early marriage and childbearing are detrimental to girls' health and development. Getting married at a young age limits girls' ability to control the timing and frequency of sex and may hinder their ability to negotiate contraceptive use, leading to early childbearing, high fertility, and increased risk of HIV infection (Clark 2004; Raj et al. 2009). Complications of pregnancy are estimated to be the leading cause of death for girls aged 15-19 in low and middle-income countries (Patton et al. 2009).

Education is strongly associated with women's reproductive behavior. Women with more schooling marry later and have fewer, healthier children (Jejeebhoy 1995). These associations persist across varying economic and cultural contexts but whether they are causal remains unclear. Variation in the duration of schooling between individuals is closely tied to other individual and household-level characteristics that are challenging to measure, raising concerns that unmeasured confounding may bias the observed associations (Bledsoe et al. 1999; Cutler & Lleras-Muney 2006; The World Bank 2009). Early studies of the relationship between education and reproductive behaviors relied on cross-sectional data and were unable to eliminate the possibility of reverse causality that could arise if girls marry early due to limited educational opportunities (Jejeebhoy 1995; Kattan 2006; The World Bank 2009).

A growing body of evidence from experimental and quasi-experimental studies avoids some of the problems inherent in earlier studies by examining changes in national education policy. These policy changes can be considered exogenous sources of variation in the duration of schooling that are plausibly unrelated to individual-level traits. Günes evaluated a change in the duration of compulsory schooling in Turkey and found that a one-year increase in schooling resulted in a decrease in fertility before 22 years of age, likely through a delay in the age at marriage (Güneş 2013). Another study used a school construction program in Indonesia as an instrument for schooling and found that each additional year was

associated with an average increase of 0.38 years in the age at marriage (Breierova & Duflo 2004). Reducing the cost of attending primary school in Kenya by providing free school uniforms led to delays in the age at sexual debut, marriage, and childbearing (Duflo et al. 2006). A conditional cash transfer program that reduced the cost of secondary school enrollment in Malawi also led to delays in these three outcomes (Baird et al. 2012). A nationwide program that removed primary school tuition fees and improved educational infrastructure in Nigeria in 1976 was associated with a decrease in fertility before age 25 (Osili & Long 2008). All of these studies examined the effect of policy changes within a single country. Our analysis examines the effect of tuition elimination policies across a sample of 16 sub-Saharan African countries, expanding the generalizability of our results to a much larger geographic region.

Studies that evaluate the impact of policy changes provide actionable information on the effectiveness of legislative interventions. Their results contribute to the development of evidence-based policy by providing information that legislators can use to select courses of action. Policy-relevant evidence on the social determinants of health is scarce and evaluations of specific interventions in this realm have been called for (Harper & Strumpf 2012; Galea 2013; Nandi & Harper 2014).

Over the last three decades many sub-Saharan African countries adopted legislation that eliminated tuition fees for public primary schooling. These interventions were intended to improve access for children in poverty, particularly girls (The World Bank 2009). Dramatic increases in primary school enrollment followed tuition fee elimination in every country (Kattan 2006; The World Bank 2009). Given the strong correlation between schooling and reproductive behaviors and the potential for tuition-elimination policies to increase educational opportunities for girls, we were interested in whether these policies led to population-level shifts in the timing of reproductive events. We estimated the effect

of these policy changes on the timing of sexual debut, first marriage, and first birth across sixteen sub-Saharan African countries.

METHODS

DATA

We identified sixteen sub-Saharan African countries that adopted similar legislation aimed at eliminating primary school tuition fees and for which we were able to reliably establish the timing of legislative implementation (Table 5-1). This information was obtained from the International Bureau of Education's World Education Data and reports from the World Bank. The same sources provided information on the structure of the public education system in each country, including the expected age at enrollment in primary school. This information was compared with documents from national Ministries of Education when possible.

Exposure to tuition-elimination policies was defined as a function of birth year and country of residence. Women were considered exposed to the policy change if born in a year that allowed them to reach the expected age of entry to primary school in the same year the legislation was implemented or later, as detailed in Table 5-1. For example, Uganda eliminated primary school tuition fees in 1997. Children in Uganda are expected to begin primary school at 6 years of age. Therefore, respondents born in 1991 or later were considered exposed to the legislation because they were expected to have entered primary school in the year the legislation was adopted (or later) and to have received the entire duration of their primary schooling tuition-free. Portions of the women sampled in five of the sixteen countries included in this analysis were considered exposed. These five countries are referred to as intervention countries in Tables 5-1 and 5-2. With the exception of Zimbabwe, all of the control countries included in the analysis eventually

eliminated primary school tuition fees as well but they did so too recently for any exposed women to be included in available DHS data. The number of exposed women in Rwanda and Tanzania is so small that they are considered to be functionally control countries.

TABLE 5-1. YEAR TUITION FEES ELIMINATED IN EACH COUNTRY AND THE EARLIEST BIRTH COHORT EXPOSED TO TUITION-FREE PRIMARY SCHOOLING

Country	DHS surveys used	Year legislation implemented	Expected age at enrollment	Earliest cohort exposed
Intervention countries				
Cameroon	1991, 1998, 2004, 2011	2000	6	1994
Ethiopia	2000, 2005, 2010-11	1995	7	1988
Ghana	1988, 1993-94, 1998 2003, 2008	1996	6	1990
Malawi	1992, 2000, 2004-05 2010	1994	6	1988
Uganda	1988-89, 1995, 2000 2006, 2011	1997	6	1991
Control countries				
Benin	1996, 2001, 2006, 2011-12	2006	6	2000[a]
Burkina Faso	1992, 1998, 2003, 2010	2007	6	2001[a]
Burundi	1987,2010-11	2005	7	1998[a]
Kenya	1988-89, 1993, 1998, 2003, 2008-09	2003	6	1997[a]
Lesotho[b]	2004-05, 2009-10	2006	6	2000[a]
Mozambique	1997, 2003-04, 2011	2005	6	1999[a]
Namibia	1992, 2000, 2006-07 2013	2013	6	2007[a]
Rwanda	1992, 2000, 2005, 2010-11	2003	7	1996
Tanzania	1991-92, 1996, 1999 2004-05, 2009-10	2002	7	1995
Zambia	1992, 1996, 2001-02 2007	2002	7	1995[a]
Zimbabwe	1988-89, 1994, 1999 2005-06, 2010-11	-	7	none

[a] Data from women born in this year or later not included in available standard DHS data

[b] Lesotho's Free Primary Education program began in 2000 and was phased in until 2006. We considered Lesotho to be tuition free from 2006 onward.

We were interested in three outcomes: age at sexual debut, age at first marriage or cohabitation with an intimate partner, and age at first birth. Data on each of these outcomes were obtained from standard Demographic and Health Surveys (DHS) conducted in each of the countries between 1987 and 2013. The DHS are nationally representative household surveys conducted in low and middle-income countries that collect detailed information on reproductive experiences throughout the life course. The design and sampling methodology have been summarized elsewhere (Corsi et al. 2013). We pooled all of the available survey data across countries. Women who reported that they had not experienced any of the events of interest were excluded. Estimation samples for effects on age at sexual debut, first marriage, and first birth included 436508, 403614, and 398388 women aged 15-49 years, respectively. The country-specific breakdown of these samples is detailed in Table 5-2.

TABLE 5-2. SAMPLE SIZE BY COUNTRY AND EXPOSURE STATUS

Country	Age at first sex		Age at first marriage		Age at first birth	
	Affected by legislation (n)	Born too early to be affected by legislation (n)	Affected by legislation (n)	Born too early to be affected by legislation (n)	Affected by legislation (n)	Born too early to be affected by legislation (n)
Intervention countries						
Cameroon	559	28646	247	25,628	158	24636
Ethiopia	2699	30612	2575	31155	1584	28794
Ghana	245	18924	54	17170	54	16372
Malawi	4489	35252	3360	39373	2999	37896
Uganda	1167	27863	661	26468	560	25851
Control countries						
Benin		37806		36198		34905
Burkina Faso		34582		33952		31818
Burundi		8542		8302		8007
Kenya		8991		25714		26675
Lesotho		11862		9807		10023
Mozambique		31156		28018		26897
Namibia		23683		13825		21039
Rwanda[a]	7	27973		25746		25782
Tanzania[a]	14	32453	1	30165		29481
Zambia		24031		21295		21389
Zimbabwe		24952		23900		23468
Total	**9180**	**427328**	**6898**	**396716**	**5355**	**393033**

[a] So few women from Rwanda and Tanzania were affected by tuition elimination legislation that these countries are considered functionally control countries.

Less than 5% of women were missing data on age at sexual debut and less than 1% were missing data on age at first marriage or first birth. These women were dropped from the analysis.

STATISTICAL ANALYSES

We used a difference-in-differences approach to estimate the effect of these legislative changes on the timing of reproductive events. This method compares trends in each of the outcomes between intervention and control countries before and after the legislative change. We identify the effect of the policy change by using fixed effects for year and country, which control for temporal trends in the outcomes shared between countries and for fixed, unmeasured differences between countries, respectively (Angrist & Pischke 2009). Specifically, we used linear regression models of the following form:

$$Y_{i,c,t} = \beta_0 + \beta_1(policy_{c,t}) + \gamma_c + \delta_t + e_{i,c,t}$$

In the model above $Y_{i,c,t}$ represents the age at first sex, first marriage, or first birth for woman i residing in country c and born in year t. The variable $policy_{c,t}$ represents an indicator equal to one if tuition fees had been eliminated in country c and affected women born in year t. The coefficient β_1 is an estimate of the effect of being exposed to tuition-free primary schooling. γ_c represents a fixed effect for country that controls for unmeasured, time-invariant confounders that vary across countries. δ_t represents a fixed effect for year of birth that controls for temporal trends in the outcomes of interest shared across countries, and $e_{i,c,t}$ is the error term. Standard errors accounted for clustering by country. All analyses were conducted using Stata version 12 (StataCorp, College Station, Texas).

The validity of our estimates rests upon the assumption that temporal trends observed among control countries are a reasonable representation of the trends that would have been observed in the five intervention countries had they not eliminated

tuition fees or had they done so at a later point in time (Angrist & Pischke 2009). We evaluated the tenability of this assumption by calculating the average annual rate of change in each of the outcomes during the pre-policy period (1950-1987) in all of the countries and assessing the similarity in rates between intervention and control countries. We also tested for differences in trends between intervention and control countries by including a product term for treatment status and year of birth in linear regression models estimating the effect of treatment status on each of the outcomes.

SENSITIVITY ANALYSES

Some girls would have already begun primary school at the time tuition fees were eliminated. Presumably these students would have had to pay tuition fees for some, but not all years of their primary schooling. Our analysis considered these girls unexposed and thus yielded a conservative estimate of effect. In order to address this partial misclassification of exposure status we conducted a sensitivity analysis in which all women who would have received any portion of their primary schooling free of tuition were considered exposed to the policy.

Zimbabwe was the only country included in our analysis that did not eventually legislate the removal of primary school tuition fees. We estimated treatment effects after excluding data from Zimbabwe to test the robustness of our results to the inclusion of this potential outlier.

RESULTS

Average ages at sexual debut, first marriage, and first birth in our sample were 16.8, 18.1, and 19.0 years, respectively. Table 5-3 presents mean values of the three outcomes among women born between 1950 and 1987, the period before any women were exposed to the legislative change, along with average annual rates of change

in each of the outcomes over the same period. Average rates of change are similar across countries, indicating that pre-treatment trends in the outcomes are comparable between intervention and control countries. The assumption of comparable pre-treatment trends is further supported by the results of hypothesis testing for differences in trends between intervention and control countries (Table 5-3).

TABLE 5-3. MEAN VALUES OF THE OUTCOME AND AVERAGE ANNUAL RATES OF CHANGE AMONG WOMEN BORN BETWEEN 1950-1987 IN EACH COUNTRY

Country	Age at first sex		Age at first marriage		Age at first birth	
	Mean (SE)	Ann. change (95% CI)	Mean (SE)	Ann. change (95%CI)	Mean (SE)	Ann. change (95%CI)
Intervention countries						
Cameroon	15.97 (0.02)	0.01 (0.01, 0.01)	17.75 (0.03)	-0.02 (-0.02, -0.02)	18.65 (0.02)	-0.03 (-0.03, -0.03)
Ethiopia	16.31 (0.02)	0.02 (0.02, 0.02)	16.44 (0.02)	0.00 (0.00, 0.00)	18.83 (0.02)	-0.04 (-0.04, -0.04)
Ghana	17.02 (0.02)	0.00 (0.00, 0.00)	18.55 (0.03)	-0.04 (-0.04, -0.04)	19.61 (0.03)	-0.04 (-0.04, -0.04)
Malawi	16.44 (0.01)	-0.01 (-0.01, -0.01)	17.47 (0.02)	-0.03 (-0.03, -0.03)	18.45 (0.02)	-0.04 (-0.04, -0.04)
Uganda	16.05 (0.02)	0.01 (0.01, 0.01)	17.44 (0.02)	-0.02 (-0.02, -0.02)	18.24 (0.02)	-0.02 (-0.02, -0.02)
Control countries						
Benin	16.98 (0.02)	-0.02 (-0.03, -0.02)	18.54 (0.02)	-0.05 (-0.05, -0.05)	19.56 (0.02)	-0.05 (-0.05, -0.05)
Burkina Faso	16.96 (0.01)	-0.01 (-0.01, -0.01)	17.50 (0.02)	-0.02 (-0.02, -0.02)	19.01 (0.02)	-0.04 (-0.04, -0.04)
Burundi	19.37 (0.04)	0.00 (0.00, 0.00)	19.73 (0.04)	0.01 (0.01, 0.01)	20.85 (0.04)	-0.01 (-0.01, -0.01)
Kenya	16.54 (0.02)	0.01 (0.01, 0.01)	18.50 (0.02)	-0.01 (-0.01, -0.01)	18.84 (0.02)	-0.02 (-0.02, -0.02)
Lesotho	17.89 (0.03)	-0.03 (-0.03, -0.03)	18.92 (0.04)	-0.01 (-0.01, -0.01)	20.05 (0.03)	-0.06 (-0.06, -0.06)
Mozambique	15.78 (0.02)	-0.03 (-0.03, -0.03)	17.82 (0.03)	-0.04 (-0.04, -0.04)	18.67 (0.02)	-0.07 (-0.07, -0.07)
Namibia	18.08 (0.02)	-0.05 (-0.05, -0.05)	22.56 (0.05)	-0.13 (-0.13, -0.13)	20.34 (0.03)	-0.06 (-0.06, -0.06)
Rwanda	19.54 (0.02)	-0.04 (-0.04, -0.04)	20.15 (0.02)	-0.02 (-0.02, -0.02)	21.26 (0.02)	-0.05 (-0.05, -0.05)
Tanzania	16.57 (0.02)	0.01 (0.01, 0.01)	17.95 (0.02)	-0.00 (-0.00, -0.00)	18.74 (0.02)	-0.01 (-0.01, -0.01)
Zambia	16.02 (0.02)	-0.01 (-0.01, -0.01)	17.52 (0.02)	-0.01 (-0.01, -0.01)	18.21 (0.02)	-0.02 (-0.02, -0.02)
Zimbabwe	17.72 (0.02)	0.02 (0.02, 0.02)	18.83 (0.03)	-0.02 (-0.02, -0.02)	19.26 (0.02)	-0.01 (-0.02, -0.01)

Intervention countries	16.33 (0.01)	-0.01 (-0.01, 0.01)	17.41 (0.01)	-0.03 (-0.03, -0.03)	18.67 (0.01)	-0.04 (-0.04, -0.04)
Control countries	17.19 (0.01)	-0.01 (-0.01, -0.01)	18.63 (0.01)	-0.03 (-0.03, -0.03)	19.38 (0.01)	-0.04 (-0.04, -0.04)
P		$p^a = 0.26$		$p^a = 0.93$		$p^a = 0.44$

[a] Interaction p-values obtained from linear regression models of the effect of exposure to policy change on each of the outcomes that included an interaction term between birth year and country-level treatment status.

A total of 9497 women between 15 and 23 years of age were considered exposed to tuition-elimination policies. Estimates of the effect of these legislative interventions on the timing of sexual debut, first marriage, and first birth are presented in Table 5-4. The difference-in-differences estimates shown should be interpreted as the change in the average age at each event after elimination of tuition fees among exposed women relative to unexposed women. Tuition-elimination policies led to an increase of approximately 4 months in the average age at sexual debut and first birth and an increase of nearly 9 months in the average age at first marriage.

TABLE 5-4. ESTIMATED EFFECT OF ADOPTING LEGISLATION THAT PROHIBITS TUITION FEES FOR PRIMARY SCHOOLING ON THE TIMING OF REPRODUCTIVE EVENTS

	Age at sexual debut (95% CI)* (n = 436508)	Age at first marriage (n = 403614)	Age at first birth (n = 398388)
tuition-free primary schooling	0.32 (-0.15, 0.78)	0.73 (0.21, 1.24)	0.35 (-0.03, 0.73)

* Cluster robust 95% CIs, with clustering at the country level

The magnitude of our effect estimates decreased when we expanded the definition of exposure to include all women eligible for any portion of their primary schooling under tuition-free policies but the point estimates remain positive, indicating an increase in the average age at each event (Table 5-5). The exclusion of data from Zimbabwe did not meaningfully influence our results.

TABLE 5-5. ESTIMATED EFFECT OF ADOPTING LEGISLATION THAT PROHIBITS TUITION FEES FOR PRIMARY SCHOOLING ON THE TIMING OF REPRODUCTIVE EVENTS, USING EXPANDED DEFINITION OF EXPOSURE THAT INCLUDES GIRLS WHO BEGAN SCHOOL UP TO 7 YEARS LATE

	Age at sexual debut (95% CI)* (n = 436508)	Age at first marriage (n = 403614)	Age at first birth (n = 398388)
tuition-free primary schooling	0.27 (0.00, 0.54)	0.38 (-0.06, 0.81)	0.19 (-0.06, 0.44)

* Cluster robust 95% CI, with clustering at the country level

DISCUSSION

We found that the adoption of tuition-elimination policies led to a delay of between 8 and 9 months in the average age at marriage among women in our sample, a 4% increase relative to the sample mean. Estimates of effects on age at sexual debut and first birth were inconclusive: point estimates indicate that eliminating tuition fees may have resulted in delays of between 3 and 4 months in the average age at both events though we could not rule out chance explanations.

The World Health Organization strongly recommends increasing educational opportunities for girls as a mechanism for delaying marriage and the onset of childbearing but provides no specific policy guidance to governments that aim to do so (World Health Organization 2011). Many potential interventions exist: governments could invest in education infrastructure, train more qualified teachers, extend the duration of compulsory schooling, or implement one of many possible cost reduction measures. Our study provides further evidence that reducing the cost of schooling can delay marriage and evaluates a specific intervention through which educational opportunities can be advanced.

Our estimates do not address variation in the extent or effectiveness of policy implementation within or between countries. Challenges associated with the

removal of school fees are common and well documented (Deininger 2003; Chimombo 2005; Kattan 2006). Anecdotal evidence indicates that in many areas fees are still being charged informally despite legislative efforts to eliminate them. Though dramatic increases in enrollment were reported following removal of tuition fees, enrollment statistics tell us nothing about whether students remained in school or their level of learning (Pritchett 2013). Furthermore, in many countries the quality of primary education suffered as a result of rapid increases in enrollment that were not accompanied by investments in infrastructure or the training of qualified teachers (Kattan 2006; The World Bank 2009). Despite these challenges, our results indicate that legislative action to reduce the cost of schooling had a measureable effect on women's lives by delaying the average age at marriage. The effect of these legislative efforts may grow if enforcement improves over time and additional investments are made to enhance the quality of education.

Our analysis relies on a number of assumptions that warrant careful consideration. First, our definition of exposure assumes that girls enrolled in primary school at the expected age of entry. Some children begin primary school at a later age though little data is available to quantify the extent of delayed entry in most low-income countries. We were unable to determine the age at which respondents began primary school using DHS data. Older girls who enrolled in primary school following the removal of tuition fees would have been considered unexposed in our primary analysis, potentially leading to an underestimate of the effect of removing tuition fees. However, girls that enrolled in primary school up to seven years late would have been considered exposed under the expanded definition used in our sensitivity analysis.

Second, all three of the outcome measures were self-reported. The question about timing of sexual debut is particularly sensitive and some evidence suggests that as women age they may report being older at the time of each event (Gage 1995; Bledsoe et al. 1999; Gersovitz 2005). In order for this bias to affect our reported

results the degree of measurement error would have to be different between intervention and control countries. We have no a priori reason to believe that this is the case.

Although we controlled for confounding by fixed, unmeasured country-level variables and for temporal trends in the outcomes shared across countries, our estimates could plausibly be confounded by other policies implemented concurrently that affected the outcomes measured in this analysis. The inclusion of 16 countries that removed tuition fees at different points in time as well as outcome data from multiple pre- and post-intervention time periods limits the likelihood that concurrent policy implementation in any single country impacted our estimates (Meyer 1995; Angrist & Pischke 2009).

Most developing countries aim to improve educational attainment among their citizens. The question is not whether governments should make education more accessible, but how. Strong quantitative evidence indicates that legislative interventions at the primary school level can be effective mechanisms for advancing population health goals. Previous studies have demonstrated that reducing the costs of primary schooling mitigates risk factors for HIV infection in Kenya and that increasing the duration of compulsory schooling in Turkey improved infant health (Baird et al. 2012; Günes 2013). We add to this evidence by showing that the elimination of primary school tuition fees led to a delay in the average age at marriage across 16 sub-Saharan African countries.

The United Nations Millennium Development Goals focused global attention on achieving universal primary schooling by 2015. Low and middle-income countries have seen dramatic increases in primary school enrollment over the past two decades, which have produced more students eligible to advance to secondary school. The United Nations Sustainable Development Goals aim to ensure universal access to secondary schooling as well. It will be important for future studies to evaluate the effectiveness of efforts to improve access to secondary education. The

average ages at marriage and first birth found in many of the countries included in this analysis fall within the period during which girls are expected to be completing their secondary education, suggesting that improvements in accessibility could further delay these events.

CHAPTER 6: SUMMARY AND CONCLUSIONS

Child marriage is a complex social construct defined in part by human rights instruments, national legislation, and societal norms. Although the United Nations definition of child marriage as the marriage of any person before the age of 18 provides an objective age-based cut-point for measuring the incidence and prevalence of the practice, the definition remains imprecise because the concept of marital union varies across cultures and with time. This thesis provides an empirical examination of child marriage with a particular focus on its implications for women's health and highlights the challenges to quantitative studies of the issue that stem from the lack of a universally applicable definition.

The first manuscript describes a novel method for measuring trends in child marriage over time using household survey data. Estimating the prevalence of child marriage among women interviewed at the same age allowed me to avoid recognized sources of bias that affect earlier studies. Calculating the prevalence within consecutive birth cohorts allowed me to examine a larger number of data points than previous studies, which facilitated an examination of heterogeneity in trends between countries. Previous studies that examined change over a twenty-year period using only two data points, for example, rates among 20-24 and 40-44 year old women, were unable to assess these differences in patterns of decline. I found that the prevalence of child marriage has declined throughout much of sub-Saharan Africa over a twenty-year period. However, my results also demonstrate that this decline has been concentrated among 15-17 year old girls. The prevalence of marriage among girls less than 15 years of age has remained unchanged over this period in many countries. Between 8% and 15% of women interviewed reported being married before their 15th birthday in most countries. Though this proportion

is small in comparison with the proportion married before 18, it represents a large absolute number of girls.

In addition to providing a more detailed picture of changes in the prevalence of child marriage, the first manuscript also highlights challenges to measuring the practice. Although the novel measurement technique I used avoids some sources of bias it cannot overcome the more profound difficulty of defining union in the sub-Saharan African context. Anthropological research described in Chapter 3 provides evidence that union formation processes vary widely across cultures and socioeconomic groups within the region. The Demographic and Health Surveys (DHS) ask women to report the month and year in which they were first married or began cohabiting with a partner, though we cannot be sure that the dates reported by survey respondents correspond to the same point in union formation processes within similar cultural groups, let alone across political boundaries. Moreover, it is difficult to conceive of any validation study that would allow us to measure the prevalence of child marriage more accurately. This difficulty in imagining a validation study leads to questions regarding the notion of child marriage: comparative studies such as this demand a definition of union that can be applied uniformly across cultures and countries. Such a definition doesn't currently exist.

Despite these measurement difficulties, estimates based on available DHS data are useful for documenting the extent of child marriage as a violation of human rights, which is concerned with a broader range of potentially harmful consequences that may or may not include threats to health. Advocacy groups focus on the potential for child marriage to affect less tangible outcomes such as girls' personal development, capacity for independent thinking, and friendship formation, as well as their educational and economic opportunities. A woman's self-reported date of marriage corresponds with a perceived life transition that may affect her well being with regard to all of the factors listed above and more.

DHS data may be less useful for measuring the magnitude of health-related consequences because the self-reported date of marriage may or may not correspond with other behaviors that threaten women's health. For example, the definition of child marriage used in this and previous studies does not differentiate between a woman who reported that she was married at 6 years of age but did not reside or have sexual contact with her partner for another decade, a woman who reported being married at 19 but began having regular sexual relations with her partner three years prior which resulted in a child born at 17, or a woman who reported being married at 13 and began having regular sexual relations with her husband at that age. All three of these hypothetical scenarios are likely associated with different health-related risk profiles.

Over the past decade numerous studies documenting an association between child marriage and women's health have been published in leading biomedical journals (Raj et al. 2009; Hampton 2010; Raj, Saggurti, Winter, et al. 2010). Nearly all have relied upon DHS data. The analysis presented in Chapter 4 represents an attempt to give the issue rigorous quantitative treatment and to be clear about the limitations to causal inference when using DHS data. I estimated the magnitude of the association between child marriage and the experience of domestic violence among women in Kenya using DHS data collected in 2003 and 2008-09. I used matching techniques to draw attention to the strong potential for confounding that arises from stark differences between women married as children and women married as adults. Limiting my analysis to a propensity score matched sample of women, I found that those married before the age of 18 were at increased risk of experiencing physical violence from their husbands or partners relative to their peers who married at later ages. I also described the limited ability to control for important sources of confounding of the relationship using DHS data and conducted a bias analysis to quantify the potential effect of unmeasured confounding on my estimates. This analysis showed that the association was reasonably robust. To the extent of my knowledge, this was the first study of the effect of child marriage on

health to make any attempt to control for confounding beyond regression-based adjustment.

Although our analysis aims to more accurately estimate the magnitude of the harms attributable to child marriage, this type of research question may be of limited use to policy makers. Knowing that there is an association between child marriage and domestic violence may help to support existing goals to reduce child marriage but doesn't provide any information on how to achieve that goal (Harper & Strumpf 2012). Policy makers are more likely to be interested in the effectiveness of specific interventions to limit or eliminate child marriage.

Improving educational opportunities for girls is a promising mechanism for delaying marriage. Pilot studies in Malawi and Ethiopia demonstrated that reducing financial barriers to schooling led to later ages at first marriage and the WHO recommends this avenue of intervention for delaying early marriage and childbearing (Erulkar & Muthengi 2009; Baird et al. 2010; World Health Organization 2011). The final manuscript included in this thesis describes my evaluation of the impact of changes to national education policies across sub-Saharan Africa on the timing of girls' reproductive events. Specifically, I examined whether adopting legislation that prohibits public primary schools from charging tuition fees led to delays in sexual debut, marriage, and childbearing. I used a difference-in-differences approach to estimate the effect of the legislation while controlling for temporal trends in each of the outcomes. We estimated that the adoption of these policies delayed marriage by an average of 9 months but found no conclusive evidence that they led to postponement of sexual debut or the onset of childbearing.

The provision of free primary schooling is an intervention that acts on two of the strongest drivers of child marriage: poverty and gender inequality. Improving educational attainment is a desirable end in itself; it's unlikely that policy makers who supported the elimination of tuition fees were motivated primarily by the

potential for the policy to reduce the incidence of child marriage. Our analysis highlights the fact that policies that improve gender equality can have far reaching and unanticipated benefits.

DIRECTIONS FOR FUTURE RESEARCH

The United Nations lists the elimination of child marriage as a target for measuring progress toward achieving Sustainable Development Goal 5: gender quality and the empowerment of all women and girls. This ensures ongoing interest in measuring trends in the prevalence of child marriage over time. Surveillance of progress toward eliminating child marriage should not be limited to developing countries. Child marriage occurs across the globe and is no less a violation of children's human rights when it occurs in high-income countries. For example, thousands of children are married in the United States every year (Reiss 2015). It would be useful for future studies to quantify trends in child marriage in high-income countries and to identify factors that drive the practice in different economic contexts.

Minimum-age-at-marriage laws in North America are very similar to those found throughout much of sub-Saharan Africa. The United States and Canada have set the minimum legal age for marriage at 18 years but both permit exceptions to these laws in the case of parental or judicial consent. It would be interesting to use simulation studies to examine the potential reduction in child marriage and the potential effects on women's health that could be achieved if exceptions to minimum-age-at-marriage laws were removed.

The potential mechanisms through which child marriage may affect health have not been clearly described. Clark (2004) examined the changes in sexual behavior that accompany marriage and influence the risk of HIV infection among married girls in Kenya and Zambia but beyond this, few hypothesized pathways between age at marriage and other poor health outcomes have been discussed in the literature. The

use of directed acyclic graphs (DAGs) to describe relationships between age at marriage and health outcomes has the potential to strengthen analyses by identifying pathways through which the exposure may act on the outcomes in question and differentiating these pathways from relationships that confound the association of interest (Shrier & Platt 2008). By learning more about the mechanisms through which early marriage affects health we may identify points of intervention that could mitigate harm. This is especially important for providing health care services to girls who are already married, a group often neglected by public health programming focused largely on unmarried, sexually active adolescents (Santhya & Jejeebhoy 2003).

Perhaps most importantly, it will continue to be important to measure the impact of programs and policies intended to reduce the incidence of child marriage. This can best be achieved at a population level using quasi-experimental designs (Meyer 1995; Angrist & Pischke 2009). Rigorous evaluations can determine which interventions are effective and facilitate evidence-based policy making.

CONCLUSION

Child marriage remains a pervasive violation of human rights that hinders progress toward public health and development goals. Though the prevalence of child marriage has fallen over time throughout much of sub-Saharan Africa the decline has slowed or stopped in some of the countries that have the highest rates of child marriage in the world. Many girls continue to be married before their eighteenth birthday despite the existence of minimum-age-at-marriage laws. These laws set important precedents but are unlikely to eliminate the practice given numerous exceptions to the minimum and the challenge of enforcement in contexts where civil registration of marriages is uncommon. Additional interventions on the drivers of child marriage, deep-seated poverty and gender inequality, are needed. Improving

educational opportunities for girls is one such intervention that effectively prevents child marriage and may lead to many additional benefits throughout the life course.

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