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Fertility and contraceptive use in Latin America

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Declaration of authorship

I certify that the thesis I have presented for examination for the MPhil/PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

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Note on the data used in Chapter 3

The permission of the National Administrative Department of Statistics of Colombia (Departamento Administrativo Nacional de Estadística - DANE) to use the 2005 Population and Housing Census, as is the help provided by staff of DANE, is gratefully acknowledged. The author alone is responsible for the data analysis and the interpretation of the results.

Statement of co-authorship

This thesis conforms to the requirements of a doctoral thesis from the London School of Economics and Political Science. Guidelines state a minimum of three papers of publishable standard out of which at least one should be sole authored. Accordingly, this thesis presents an introductory chapter which gives an overview, the motivation and objectives. The second, third and fourth chapters are presented in the style of a journal article. Chapter 5 brings together the key findings of the thesis, discusses their implications and limitations, and makes recommendations for the future research agenda.

I confirm that my first and the second paper in chapters 2 and 3 are sole authored papers. I declare that the third paper presented in chapter 4 is jointly co-authored with my supervisors Dr. Tiziana Leone and Professor Mikko Myrskylä. For that chapter I led and carried out the majority of the work. The details of the contributions are provided in the table below.

Table of authorship contributions

Contribution	**Chapter 4**
Conception of the idea:	
a) Study of cohort fertility in Brazil	EB & TL
b) Study of educational differences in cohort fertility	EB
Research design:	
a) Reconstruction of fertility rates	EB
b) Forecasting approaches	EB & MM
Data management	EB
Analyses	EB
Interpretation of the results	EB
Writing of the manuscript	EB

EB: Ewa Batyra, TL: Tiziana Leone, MM: Mikko Myrskylä

Abstract

The rapid fertility declines and increases in contraceptive prevalence rates in the last decades in Latin America occurred concurrently with increases in teenage and unintended childbearing. The factors behind, as well as possible future demographic consequences of this unique pattern of fertility change are still poorly understood. This thesis advances knowledge of three aspects of reproductive behaviour in Latin America: dynamics of contraceptive use in relation to an unintended birth experience, educational disparities in motherhood-timing and possible future of cohort fertility. I explore an untapped potential of the Demographic and Health Surveys (DHS) and Population Censuses for Peru, Ecuador, Colombia and Brazil, and employ demographic and statistical modelling techniques that have not been previously fully exploited in the Latin American context.

First, I show how the longitudinal DHS reproductive "calendars" can be analysed using event-history models to advance the understanding of contraceptive choices of women who experience unintended pregnancies in Colombia and Peru. The study uncovers the importance of considering patterns of both pre- and after-birth contraceptive behaviour to inform the organization of postpartum family planning programmes in both countries. Second, using census data, I provide the first estimates of cohort first-birth age-specific schedules disaggregated by education level for Ecuador, Colombia and Peru. I document vastly increasing educational disparities in motherhood-timing during the fertility transition and discuss the potential factors behind this process. The analyses uncover a drastic increase in teenage fertility among women who drop-out of secondary school, indicating a need for an intervention. Lastly, using indirectly reconstructed fertility rates from censuses, cohort fertility is forecasted for total population and by education in Brazil. The study shows how a Bayesian model for fertility forecasting can be applied in the Latin American context where the childbearing pattern has been distinct from other world regions and where there is a scarcity of time-series of fertility rates. The study reveals the evolution of educational differences in completed fertility and shows that emerging low period fertility levels in Brazil might not necessarily correspond to women's equally low lifetime fertility in the future. Overall, the substantive findings improve the understanding of the reproductive behaviour disparities in Latin America and serve as inputs for the design of policies to alleviate them. The novel use of data and application of methods are important for the development of future research agendas on fertility change and for the collection of fertility data in the region.

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Table of content

List of tables

List of figures

List of abbreviations

ARIMA	Autoregressive Integrated Moving Average
ASFR	Age-Specific Fertility Rate
CDHS	Colombia Demographic and Health Survey
CEB	Children Ever Born
CFR	Cohort Fertility Rate
CPR	Contraceptive Prevalence Rate
DANE	Departamento Administrativo Nacional de Estadística
DHS	Demographic and Health Survey
ECLAC	Economic Commission for Latin America and the Caribbean
HICs	High-Income Countries
HFC	Human Fertility Collection
IBGE	Instituto Brasileiro de Geografia e Estatística
INEI	Instituto Nacional de Estadística e Informática
INEC	Instituto Nacional de Estadística y Censos
IPUMS	International Public Use Microdata Series
IUD	Intrauterine Device
LARCs	Long-Acting Reversible Contraceptives
LMICs	Low- and Middle-Income Countries
MICS	Multiple Indicator Cluster Survey
MPS	Ministerio de la Protección Social
OCM	Own-Children Method
PAHO	Pan American Health Organization
PDHS	Peru Demographic and Health Survey
TFR	Total Fertility Rate
USAID	United States Agency for International Development
WHO	World Health Organization

1. Introduction

1.1. Why study fertility and contraceptive use in Latin America?

During the last 50 years notable fertility declines occurred in Latin America and the Caribbean[1], where in the middle of the 20th century fertility was as high as 6 children per woman (United Nations 2017). Currently, the countries are reaching a stage of the fertility transition where total fertility rates (TFRs) decline close to the replacement level (i.e.: 2.1 children per woman). Moreover, contraceptive prevalence rates (CPRs) have substantially increased in the last decades and countries are "graduating" from the United States Agency for International Development (USAID) assistance for funding of family planning programmes and the collection of demographic and health surveys (Bertrand 2011). It is therefore "commonly believed that fertility and contraception are no longer crucial issues for Latin American families" (Cavenaghi 2009:14). Why is it still important to study fertility and contraceptive use in Latin America?

The main reason is that the patterns of change in the reproductive behaviour in Latin America continue to differ markedly from other world regions. First, in spite of high CPRs, the region is characterized by one of the highest levels of unintended motherhood in the world (Bearak et al. 2018; Sedgh, Singh, and Hussain 2014). In countries for which the estimates exist, around half the births are reported as unintended (Measure DHS 2018). This indicates that the family planning programmes' efforts did not eliminate the unmet need for contraception and that it is still important to identify areas for improvements in the provision of contraceptive services. Second, despite relatively low levels of fertility, Latin America is characterized by exceptionally high levels of teenage childbearing (Rodríguez 2013). While women with low socioeconomic status continue to enter motherhood very early in life, the signs of motherhood postponement have been emerging among higher socioeconomic strata in several countries (ECLAC 2005, 2011; Rosero-Bixby, Castro-Martín, and Martín-García 2009). This pattern of increasing polarization in motherhood timing between the population groups remains poorly understood. Lastly, the TFRs have recently declined to the below-replacement level in a number of countries in the region (United Nations 2017). Whether the continuation of this process can be expected remains unclear. This is particularly puzzling as the pattern of childbearing timing in Latin

[1] From here on referred to as Latin America

America, which is an important factor for fertility levels, did not conform to the patterns observed in any other world region.

Latin America is an exception on a global scale when it comes to these changes in reproductive behaviour, and yet it is a setting overlooked in the existing research. While the studies on contraceptive practices generally focus on investigating Sub-Saharan African countries where CPRs are low and fertility is high, the research on timing of childbearing and low fertility is mainly concentrated in settings such as Europe, East Asia and North America. In general, not a great deal of attention has been given to studying and understanding reproductive behaviour in the middle-income countries with low fertility (Bongaarts 2002). First, the factors behind the unique Latin American pattern of reproductive behaviour, as well as the possible future demographic consequences of it are not well understood. Moreover, the potential of the existing demographic data remains underexplored and the applications of the newest advancements in the methods designed to study fertility change are limited. It is an important gap, as knowledge about the fertility transition worldwide cannot be complete without the examination of reproductive behaviour in all of the world regions.

The aim of this thesis is to advance knowledge about three aspects of reproductive behaviour in Latin America, which pose challenges to public health, intergenerational inequalities and the age structure of the populations: (i) dynamics of contraceptive use in relation to an unintended birth experience in Colombia and Peru; (ii) educational disparities in motherhood timing in Colombia, Ecuador and Peru; and (iii) the possible future of fertility in Brazil. For that purpose I explore an untapped potential of the Demographic and Health Surveys (DHS) and Population and Housing Censuses, and employ demographic and statistical modelling techniques that have not been previously fully exploited in the Latin American context. The large part of this thesis explores the topics of interest in the cross-country comparative perspective, focusing on four countries which constitute almost half of Latin America's population. The cross-country comparative nature of this thesis allows for a greater generalizability of the results, in particular to other countries within the region, but also other middle-income settings.

The rest of this introduction consists of five sections. The aim of each of the first three sections is to critically review existing research on each of the three topics which this thesis examines: contraceptive use and unintended motherhood, timing of childbearing and

fertility levels. I identify gaps in knowledge and highlight the importance of addressing them. I discuss the data sources for the study of reproductive behaviour which have been publicly available for many years, but remain underused in the context of Latin American countries. The fourth section provides a justification for the focus of this thesis on Colombia, Peru, Ecuador or Brazil. The fifth section presents the detailed aims and the structure of the thesis.

1.2. Relationship between contraceptive use and unintended childbearing in Latin America

The first topic which this thesis focuses on is the dynamics of contraceptive use in relation to an unintended birth experience in Latin America.

1.2.1. Defining unintended childbearing

Studying pregnancy intentions is challenging. There is a large body of research about the measurement and meaning of unintended pregnancies (e.g. Bankole and Westoff 1998; Bachrach and Newcomer 1999; D'Angelo et al. 2004; Koenig et al. 2006; Rackin and Morgan 2018; Santelli et al. 2003, 2009; Trussell, Vaughan, and Stanford 1999; Zabin 1999). Unintended pregnancy might end in a live birth or termination -- abortion. Unintended pregnancy might be unplanned but once it occurs it might become wanted (Trussell, Vaughan, and Stanford 1999). Therefore, reporting of pregnancy intentions might differ depending on whether they are measured prospectively (before pregnancy) or retrospectively (after pregnancy). The retrospective reports aim to reflect the intention of women to have a child before they become pregnant. Such reports are commonly collected in surveys about pregnancies which ended in live births. Since women are asked after the pregnancy experience, the retrospective reporting tends to underestimate the levels of unintended births (e.g. Bankole and Westoff 1998; Koenig et al. 2006). On the other hand, prospective reports are known to be biased upwards as women might change their expectations between the time they are surveyed and conception (Rackin and Morgan 2018). There exists a strong association between the retrospective and the prospective reports of pregnancy intentions and there is no consensus on which measurement approach is superior (Rackin and Morgan 2018).

For Latin American countries, longitudinal surveys which can be used to study prospective pregnancy intentions are not available. The information about unintended pregnancies in the region can be derived from cross-sectional surveys which collect retrospective intention information only. In this thesis I focus on unintended pregnancies which ended in live births and I do not examine or discuss pregnancies which resulted in abortion. Abortions are usually severely underreported in surveys (Jones and Kost 2007). Detailed questions about abortions in settings where access to it is restricted, as in Latin America, are rarely part of the surveys. Usually, abortions are grouped together with other types of pregnancy terminations: miscarriages and stillbirths. The intentions of pregnancies which did not end in live births are not conventionally collected in surveys.

While keeping in mind the complexity of the concept of pregnancy intentions and the considerations discussed above, terms *unintended childbearing*, *unintended motherhood*, *unintended birth* and *unintended pregnancy* are often used interchangeably in this thesis.

1.2.2. Unintended childbearing and contraceptive use

Levels of unintended pregnancies tend to increase at the early stages of the fertility transition and subsequently decrease when total fertility rates reach intermediate levels and contraceptive prevalence rates increase (Adetunji 2001). In Latin America, high levels of unintended motherhood have remained and coexist with relatively low TFRs and high CPRs (Casterline and Mendoza 2009).

Distinctively high levels of unintended pregnancies in the region can be attributed to a number of cultural and access-related factors: (i) failure to use, or to correctly use, contraception due to insufficient access to reproductive health services, among the youngest women also due to stigma and limited power to negotiate the use of condoms (Ali, Cleland, and Shah 2003; Rodríguez Vignoli and Cavenaghi 2013); (ii) limited contraceptive method mixes[2] concentrated around one or two methods, often with either permanent methods such as female sterilization (e.g. in Brazil and Colombia) or traditional[3] methods (e.g. in Bolivia and Peru) being the main methods of family planning (Cavenaghi and Diniz Alves 2009); (iii) high percentage of the population being of

[2] Distribution of contraceptive methods used in the population (Sullivan et al. 2006)
[3] Usually referring to periodic abstinence, withdrawal and folk methods

indigenous origin, relying on the least effective contraceptive methods such as periodic abstinence or withdrawal, which have high failure rates (Wurtz 2012); (iv) importance of Catholicism in the region and the role of the Catholic Church in opposing the scaling of family planning programmes and in condemning contraceptive use (Necochea Lopez 2014); (v) relegation of the responsibility to control reproduction to females and limited acceptance of the male dependent methods such as condoms (Raguz 2009).

At the individual level, the research about the relationship between unintended motherhood and contraceptive use in Latin America has focused on examining and discussing the contraceptive practices which precede unintended pregnancies (Curtis, Evens, and Sambisa 2011; Eggleston 1999; Mensch et al. 1997; Prada, Biddlecom, and Singh 2011). Such studies have been deemed as important to understand better the meaning of unintended pregnancies and to identify potential barriers to effective contraceptive use. This in turn is relevant in order to design policies aiming at addressing these barriers and to reduce the high levels of unintended pregnancies. It is known that unintended births are associated with adverse health outcomes for mothers and their children (Gipson, Koenig, and Hindin 2008).

The study of contraceptive behaviour as a determinant of an unintended pregnancy is a dominant approach in the research on the relationship between contraceptive practices and unintended motherhood. This is evident in the studies on Latin America but can be also seen by looking at the literature on the topic more broadly. It has been widely explored and shown across various settings how the lack of use, or lack of effective use, of contraceptives can contribute to an unintended pregnancy (e.g. see literature review on the topic in Tsui, McDonald-Mosley, and Burke (2010)).

There is a small but growing body of research about women's contraceptive practices after an unintended birth, but only in the context of Sub-Saharan African countries and the United States (Bakibinga et al. 2016 for East Africa; Fotso et al. 2014 for Kenya; Matteson et al. 2006 for the United States). The need for such examinations has been justified by the importance of understanding whether women's contraceptive decision-making is influenced by their past pregnancy experiences.

Currently, there is a clear divide into studies which look at the contraceptive use as a behaviour which either precedes or follows an unintended pregnancy. Therefore, the relationship between these two processes is studied at one point in women's reproductive

lives only. Such approach can be seen as limited. From the research on contraceptive method switching it is known that women's contraceptive method choice might depend on the previous type of method used (Steele and Diamond 1999). Therefore, it is likely that the decision about what family planning method to initiate after an unintended pregnancy will depend on women's experience with contraception which led to that unintended pregnancy. On the other hand, whether the poorer contraceptive practices carry on or change after an unintended birth could potentially allow for a better understanding of the factors behind the occurrence of an unintended pregnancy in the first place.

While contraceptive switching in general has been studied across many settings, including Latin America (e.g. Blanc et al. 2009; Bradley, Schwandt, and Khan 2009; Curtis and Blanc 1997; DaVanzo et al. 1989; Steele, Curtis, and Choe 1999; Steele and Diamond 1999), contraceptive switching (or its lack) in relation to an unintended pregnancy experience is a topic which remains unexplored in any context. As a setting with distinctively high levels of unintended motherhood, the understanding of such contraceptive use dynamics in Latin America merits particular attention.

The study and the comparison of contraceptive behaviours before and after an unintended pregnancy can provide important information for the organisation and evaluation of the family planning programmes in the region. For example, if women tend to return after birth to the same method which discontinuation led to an unintended pregnancy, it might be an indication that in a given setting the choice of alternative methods of birth control is limited. Moreover, comparisons of the patterns of contraceptive behaviour change across countries with different accessibility to and acceptability of contraceptives might cast light on whether in a given context there exist barriers to the use of certain family planning methods. In Latin America such knowledge is particularly important as the contraceptive method mixes have been highlighted to be concentrated around the limited number of methods, as described in the previous paragraphs.

1.2.3. Data for the study of unintended childbearing and contraceptive use

The main difficulty in studying the dynamics of contraceptive use and unintended motherhood is that such examination requires detailed information about contraceptive practices and pregnancy intentions. Currently, the most commonly used source of information on the topic are survey data, such as the DHS for the low- and middle-income

countries (LMICs). Apart from a variety of indicators about women's "current" contraceptive use[4], DHSs include the reproductive "calendar" module. The DHS calendars are an unprecedented collection of nationally representative, longitudinal contraceptive histories. Latin American countries are the cradle of the DHS calendar as the first experimental surveys which included it were conducted in Peru and Dominican Republic in the 1980s (Goldman, Moreno, and Westoff 1989; Westoff, Goldman, and Moreno 1990). Since then, the calendar data have been part of numerous DHS rounds conducted across many countries in the region. However, beyond the cross-country comparative DHS reports on contraceptive switching and discontinuation (e.g. Bradley, Schwandt, and Khan 2009; Curtis and Blanc 1997; Gebreselassie, Rutstein, and Mishra 2008), there are only a few studies which use this module for the purpose of an in-depth examination of contraceptive behaviour in Latin America (Ali and Cleland 2005, Ali, Cleland, and Shah 2003 for cross-country; Kost 1990 for Peru; Leite and Gupta 2007, Leone and Hinde 2005 for Brazil; Barden-O'Fallon, Speizer, and White 2008 for Guatemala).

One of the key reasons why the use of reproductive calendars is rather limited in general is the calendar's complex format. The module not only requires a substantial level of data manipulation (USAID 2017), but also a careful consideration of the issues of left and right censoring. The potential of these longitudinal contraceptive histories for the study of the relationship between fertility intentions and contraceptive use in general, and Latin America in particular, remains underexplored. Making use of the Latin American calendar data is important because the efforts into collecting them has weakened in the recent years. The responsibility of the implementation of the surveys in the region is increasingly relegated from the USAID to the national bodies. Often, the calendar module is dropped from the surveys, as it has been in the case of for example Brazil, presumably as its collection is time consuming and costly. This means that calendars might be increasingly difficult to obtain for the region. Therefore, it is important to conduct investigations using this data source while it is still available and while it still has the potential to provide inputs for the organisations of the current family planning programmes. This is relevant as the initiatives such as Family Planning 2020 stress the need for generation of high quality data for decision-making in order to identify areas in which the family planning efforts should be reinforced in LMICs (FP2020 2015).

[4] Contraceptive use around the interview date

1.3. Educational disparities in the age at first birth in Latin America

The second topic which this thesis examines is the evolution of educational disparities in the age at first birth throughout the Latin American fertility transition.

1.3.1. Differentials in the age at first birth by education level

One of the most unique features of the Latin American pattern of fertility change has been the pronounced differences in the age at first birth by measures of socioeconomic status. The level of women's education has been widely acknowledged to be the most important determinant of the timing of transition to motherhood in the region (e.g. Bozon, Gayet, and Barrientos 2009; ECLAC 2011; Heaton and Forste 1998; Rodríguez 2013). There have been three prominent features of the changes in the age at first birth by education level in Latin America in the last decades.

First, the fertility transition has been characterized by the continuous TFR declines accompanied by increasing levels of teenage fertility in many countries, as well as stable or decreasing age at first birth (e.g. Bozon, Gayet, and Barrientos 2009; Chackiel and Schkolnik 1996; Esteve and Florez-Paredes 2014, 2018). This advancement of motherhood has been most pronounced among women with lower levels of schooling (e.g. Flórez and Núñez 2001; Rodríguez 2013). Since the 2000s, a reversal of the increases in the adolescent fertility at the population level has taken place (United Nations 2017). Nevertheless, very early motherhood remains prevalent among lower educated women (Rodríguez Vignoli and Cavenaghi 2013). There is a continued need to understand the factors behind the substantial levels of teenage fertility among women with low socioeconomic status in the region.

Second, the turn of the century has marked the beginnings of motherhood postponement in Latin America. Rosero-Bixby, Castro-Martín, and Martín-García (2009) identified that in the majority of countries the percentage of women who remained childless at age 25-29 increased between the 1990s and the 2000s. Their additional analysis for selected countries[5] showed the most pronounced change occurred among women with a college education, but in some settings this increase was observed also among lower educational strata. The authors suggested that the increases in the percentage of women

[5] Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, Nicaragua and Panama

still childless in their mid-20s at the population level in Latin America were driven by the increasing share of women with higher levels of schooling who transition to motherhood later in life. As a recent phenomenon, the examination of the first-birth postponement and its relationship with educational attainment has still attracted little attention. The evidence showing that highly educated women started to transition to first birth later in life in Latin America has nonetheless increased for a number of countries since the 2000s (Batyra 2016 for Colombia; Nathan 2015 for Uruguay; Miranda-Ribeiro and Garcia 2013, Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018 for Brazil).

Third, there have been growing signs of an emergence of a distinctive pattern of polarization in the first-birth age distribution since the 1990s in Latin American countries. This polarization has been characterized by the continuously high rates of the first births in the youngest age groups and concurrently emerging increases in the rates of first birth at older ages. In countries such as Uruguay, Brazil, Chile and Costa Rica this process has led to the appearance of the bimodal first-birth age-specific profiles (Lima et al. 2018; Nathan, Pardo, and Cabella 2016; Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018). This pattern has been attributed to the marked differences in the timing of transition to motherhood between women with the lowest and the highest levels of schooling in the region.

From the review of the existing literature it is evident that there exist larger differences than in any other part of the world in the pattern of the age at first birth by education level in Latin America. While low educated women continue to transition to motherhood very early in life, highly educated women have started to postpone motherhood in the highlighted countries. Consequently, the heterogeneity in the first-birth pattern between the population groups has been increasing. This peculiar pattern of motherhood timing still remains under-researched. There are a number of important aspects related to the topic of educational differences in the age at first birth, the examination of which has so far not attracted attention.

First, knowledge about how the educational disparities in the age at first birth evolved during the fertility transition across Latin America is limited. In particular, cross-country comparative studies about the long-term trends in the first-birth timing by education level are lacking. Such analyses are vital because the knowledge about the plausible factors behind the increasing differences in the age at first birth between the population groups in

the region is still limited. If the forces determining the growing disparities in motherhood timing are to be better understood, it is important to provide evidence about how they have evolved over long periods of time and across countries. For example, if the patterns of change have been similar between the countries and over time, then the search for the explanations of the processes of interest could focus on identifying factors common to these countries and time periods.

One of the suggested explanations for the substantial differences in motherhood timing by education level in Latin America has been the higher than elsewhere levels of social and economic inequalities. These inequalities can be reflected in the differences in educational opportunities, labour market opportunities or access to reproductive health services between the population strata. All of these factors can in turn be related to the differentiated patterns of first-birth timing between the educational groups (Azevedo et al. 2012; Lima et al. 2018; Rodríguez Vignoli and Cavenaghi 2013). The studies which touched upon this topic highlighted that there is a need for more analyses which could cast light on the interaction between these factors and the changes in the age at first birth in Latin America.

Second, the prominence of the differences in motherhood timing between the lowest and the highest educated women in the Latin American countries has been widely acknowledged. On the other hand, the understanding of the changes in the pattern of the age at first birth of women with intermediate levels of schooling, in particular women who enter secondary school is scant. This is an important limitation. With the secondary school expansion, women who reach intermediate educational levels have become the biggest population group in the majority of the countries in the region (Rios-Neto and Meireles Guimarães 2014). Yet, so far no attention has been paid to understanding the changes in the age at first birth, and its variation[6], among women who enter secondary school.

Third, the examinations of the pattern of the age at first birth in the region, both at the population level and by education level, have been so far conducted for a limited number of countries. Before the 2000s, the focus of research on motherhood timing in Latin America was on exploring changes in adolescent fertility, extensively studied across all countries in the region. The recent research about the changes in the age at first birth more

[6] Variation in the age at first birth both within that educational stratum and the variation in the age at first birth trends among women who enter secondary school between the countries in Latin America.

broadly has been however focused in settings with the lowest TFR levels -- repeatedly countries of the Southern Cone such as Uruguay and Chile, as well as Brazil (Lima et al. 2018; Miranda-Ribeiro and Garcia 2013; Nathan 2015; Nathan, Pardo, and Cabella 2016; Rios-Neto and Miranda-Ribeiro 2015; Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018), with some evidence for Colombia (Batyra 2016) and Costa Rica (Lima et al. 2018).

From the review of the existing literature it emerges that the changes in the age at first birth pattern outside of the context of these countries remain unexplored. In particular, the knowledge about motherhood timing in settings with still relatively higher TFRs is limited to the studies of teenage childbearing. This relates in particular to the Andean region, Central America and the Caribbean. With the emerging evidence about the first-birth postponement in the region this is an important gap in knowledge. This is because the changes in the timing of childbearing can be reflected in the increases or decreases in the rates of first birth not only at younger but also at older ages. The detailed study of the pattern of the timing of transition to motherhood requires examination of the first-birth rates at all ages.

1.3.2. Data for the study of trends in the age at first birth by education level

Estimates of the parity- and age-specific fertility schedules disaggregated by education level and their changes over long periods of time for Latin America are rare. There are two main sources of data which can be used for the purpose of such analysis – survey and census data. Both of these sources have their advantages and disadvantages.

Surveys such as DHS or Multiple Indicator Cluster Survey (MICS) often include full birth histories as well as information about women's education level. The advantage of surveys is that some of them also include additional information about the age at first union or age at first sexual intercourse which can provide additional insights into the events closely related to first-birth timing. On the other hand, the usefulness of survey data for the estimation of the fertility schedules disaggregated by parity, age groups and detailed educational groups might be limited due to small samples. For instance, the calculation of the first-birth age-specific rates of women who completed university from surveys is challenging. Due to particularly small sizes of the oldest surveys, estimating such measures for the earlier time periods or cohorts is not feasible. This is a limitation as the completion

of university is likely to be strongly related to the timing of transition to motherhood, in particular first-birth postponement (e.g. Berrington, Stone, and Beaujouan 2015).

Population and Housing Censuses could be more suitable for estimating the first-birth age-specific schedules since they either cover the whole population or a large population sample. For example, from a given census it is possible to indirectly estimate such schedules using the Own-Children Method (Cho, Retherford, and Choe 1986). Lima et al. (2018) calculated first-birth age-specific rates by education level from censuses for Chile for year 2002 and for Brazil for year 2010. Estimates of this kind can be however obtained for a year prior to the census date only. Consequently, the usefulness of this approach for the study of the long-term trends in the age at first birth can be limited. The indirect method of fertility estimation from census data based on a matching process developed by Miranda-Ribeiro, Rios-Neto, and Carvalho (2009), and so far applied to the case of Brazil, could be more suitable for such analysis. The method involves reconstructing women's birth histories for a period of 15 years prior to the census. This allows for a more detailed study of trends in the age at first birth. The advantage of this approach, for example as compared to the use of birth histories from survey data, is that due to the much larger size of the census, trends can be calculated in a more precise manner (Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018). The disadvantage is that since these birth histories are reconstructed for 15 years prior to the census, they do not include information about the age at first birth among women who gave birth before that period.

Census data can be used to derive estimates of the first-birth age-specific rates if additional retrospective information about the age or year of births is available. As part of the 2000 and 2010 census rounds in Latin America a number of countries included such information in the census questionnaires: Barbados, Colombia, Ecuador, Jamaica, Peru, Saint Lucia, Trinidad and Tobago and Uruguay. This variable has not been so far widely used. Only the study of Nathan (2015) for Uruguay provided estimates of the first-birth age-specific rates by education level using this piece of information for cohorts of women born between 1955 and 1980. Consequently, the potential of this source of birth histories for the study of motherhood timing in Latin American countries remains underexplored. Given the relevance of the age at first birth pattern in understanding the reproductive behaviour in the region, the lack of use of this data source is an important gap in research. A wider inclusion of the information about the age at first birth has been highlighted as important in upcoming 2020 Latin American census round. Since this information has been

available in a number of censuses for a decade, the fact that such already existing data are not used can be considered as an important oversight. The analysis of this piece of data can not only provide insights into the processes under study, it can also cast light on whether there might exist any issues, for example, with the quality of this information. Such knowledge can be relevant for the collection of this variable as part of the future census rounds in the region.

1.4. Emergence of low fertility and cohort fertility in Latin America

The third part of this thesis examines the recent emergence of low fertility in Latin America, focusing on cohort fertility forecasting.

1.4.1 Decline of fertility to low level

The TFR in Latin America reached the level of 2.1 in the 2010s, down from 5.9 in the 1950s (Chackiel and Schkolnik 1996; United Nations 2017). This fast decline has been attributed to a variety of factors, including: urbanization, women's increasing labour market participation, improvements in education, changing values and attitudes towards childbearing, secularization processes and development of family planning programmes (Guzmán et al. 1996). In the majority of the countries in Central and South America, the TFR fell from above 6 children per woman on average in the 1950s to below 3 around the 2010s (apart from Bolivia, Guatemala and French Guiana where TFR still remains higher)[7]. The exceptions to this pattern were Uruguay and Argentina where the TFRs were already around 3 children per woman in the 1950s, as well as Chile which had an intermediate-level TFR of around 5 in the mid-century. Since the 2000s, in an increasing number of countries fertility rates declined to the level of below replacement: first in Chile and Brazil (TFR of 1.8 in the 2010s), followed by Costa Rica, Colombia and Uruguay (TFR of 1.9 in the two former countries and TFR of 2 in the latter country in the 2010s) (United Nations 2017). It is evident that Latin American countries are entering a realm of low fertility.

[7] The levels of and the pace of change in TFRs in the Caribbean have been much more diverse. For example, in Cuba, the TFR has been already below the replacement level since the 1980s, falling from an intermediate level of 4 in 1950s. On the other hand, in countries like Dominican Republic, the TFR was as high as 7.6 in the 1950s, and remained above 2.5 children per women in the 2010s (United Nations 2017).

Compared to the European and North American countries which were the forerunners in the process of fertility decline, the TFRs in Latin American countries fell to below-replacement level at a much faster pace. The speed of the decline has been more similar to the experience of Eastern Asian countries such as South Korea or Taiwan (United Nations 2017). There exists a great variation in the levels of TFR at the advanced stages of the fertility transition. In many countries around the world the period fertility fell to the very low levels of below 1.5 (e.g. in East Asian countries and countries of Eastern Europe) (Goldstein, Sobotka, and Jasilioniene 2009; Kohler, Billari, and Ortega 2002). In the English speaking or Northern European countries the TFR change was less pronounced and the period fertility remained around the level of 2 children per woman (Bongaarts and Sobotka 2012; Cherlin 2010; Goldstein, Sobotka, and Jasilioniene 2009). Given the emergence of the sub-replacement TFRs in a number of Latin American countries, it is becoming important to consider what the possible future of fertility in the region could be. It is relevant to examine and discuss whether birth rates could further decline in Latin America as the continuation of this process will have an important bearing, for example, on the population age structure.

In order to explore what the future of fertility in Latin America could be, it is relevant to consider the possible factors behind the recent declines of the TFRs to the below-replacement level. The period fertility might fall to a low level because women have fewer children over their lifetime – the so-called "quantum" effect. Alternatively, the TFR might be temporarily depressed if women are postponing motherhood – the so-called "tempo" effect (Bongaarts and Feeney 1998). In Latin America the TFRs declined due to the strong pattern of birth limitation with a smaller contribution of birth spacing to the fertility change (Chackiel and Schkolnik 1996; Rodríguez 1996). As described in the previous section, motherhood postponement was absent for most of the fertility transition and the timing of childbearing pattern has been mainly characterized by stable or decreasing age at first birth over time. The falls of the TFRs to below-replacement levels in Latin America since the 2000s coincided however with the emergence of a trend towards later motherhood. Consequently, currently it is not known whether the emerging below-replacement fertility in the countries in the region means that women will in fact have fewer children over their lifetime as compared to the previous generations.

1.4.2. Cohort fertility

The study of changes in cohort fertility rates (CFRs) which allows for the examination of the actual average number of children women have throughout their life has not attracted attention in Latin American countries. The evidence has started to emerge only very recently (Lima, Zeman, and Sobotka 2018). The main issue when studying cohort fertility in Latin America is that the examination of the CFRs of women who already finished childbearing cannot cast light on the recent changes in fertility levels. On the other hand, forecasting of cohort fertility which can provide insights into completed fertility of women who are still in their childbearing years is a topic largely overlooked in that context.

Forecasts of cohort fertility have been frequently performed for low-fertility countries in Europe, East Asia and North America and provided important insights into understanding the patterns of fertility change. Moreover, there have been growing discussions about the best methodological approaches to forecasting fertility in these settings (Bohk-Ewald, Peng, and Myrskylä 2017; Myrskylä and Goldstein 2013; Myrskylä, Goldstein, and Cheng 2013; Schmertmann et al. 2014). For example, in the United States the TFR declined from above 3 in the 1950s to 1.8 in the 1980s, experienced subsequent reversal to 2.1 around the 2000s and declined again to 1.9 around the 2010s (United Nations 2017). The CFR of women born between 1950 and 1970 on the other hand has been continuously around 2 children per woman, and in fact is likely to increase to 2.2 for cohorts born in 1980s. In sum, the CFR there has not declined and is unlikely to decline to the levels of the period fertility measures. This has been consistently documented across studies which used different methods of fertility forecasting (Myrskylä, Goldstein, and Cheng 2013; Schmertmann et al. 2014).

The knowledge about such relationship between the TFR and the CFR in the context of low-fertility Latin American countries is currently lacking. Few applications of the cohort fertility forecasting methods exist in the region (to the best of my knowledge only two studies on Brazil: Miranda-Ribeiro, Miranda-Ribeiro, and Rios-Neto (2017); Schmertmann et al. (2014)). The conclusions about the possible trends in cohort fertility markedly differ between these analyses. This raises several questions: What is the future of cohort fertility in Latin America? Which methods might be useful for forecasting of cohort fertility there? Answering these questions is important to cast light on the future course of fertility transition in the region. The knowledge about the relationship between

the TFR and the CFR is particularly relevant for Latin America as the changes in the age at motherhood did not conform to the pattern observed in any other setting, as explained in the previous sections. What consequences this distinct pattern of motherhood timing has had on the interaction between the period and the cohort fertility measures is an unexplored topic. Moreover, given the pronounced differences in fertility and timing of motherhood by education level, it is pertinent to make attempts to understand whether and how these processes have differed by women's level of education.

1.4.3. Data for forecasting cohort fertility

Forecasting of cohort fertility for Latin American countries is challenging as there is a scarcity of published estimates of the time-series of the age-specific fertility rates which are necessary for such analysis.

The main problems are that the long-term, complete series of age-specific fertility rates in the region are rarely available; the existing estimates are grouped into 5-year age groups. The grouping of fertility rates is often applied during the estimation process in contexts where fertility data might be affected by quality issues such as omission or age misreporting. To the best of my knowledge such estimates for Latin America are limited to two countries: Chile and Brazil. These are unpublished estimates of the individual researchers which were made available through the Human Fertility Collection (HFC) (HFC 2018).

The existing methods of fertility forecasting require fertility rates which are disaggregated by single-age groups. Such data can be obtained for example by splitting the existing 5-year age group estimates using interpolation techniques (Grigorieva et al. 2015; Schmertmann 2014). Alternatively, the rates could potentially be estimated directly into single-age groups for settings for which necessary data sources are available. Such an approach would need a careful assessment of the quality of the data. For example, the comparison of the reconstructed single-age group fertility rates' trends from multiple censuses could potentially allow us to explore and ascertain the reliability of the estimates (Cho, Retherford, and Choe 1986). Latin American countries have a long history of census data collection. The samples of the majority of these censuses have been harmonized and are publicly available through the International Public Use Microdata Series (IPUMS). To the best of my knowledge, there have been no attempts so far to examine the potential of

IPUMS data for the estimation of the detailed time-series of fertility rates in Latin America. Given that the need for such data is likely to increase due to the emergence of low fertility, it is important to explore ways which allow researchers to obtain detailed fertility rates' estimates in the region.

1.5. Colombia, Ecuador, Peru and Brazil within Latin America

1.5.1. Justification for the choice of the countries

This thesis examines three aspects of reproductive behaviour discussed in the previous sections in the context of Colombia, Ecuador, Peru and Brazil. I study the dynamics of contraceptive use in relation to an unintended birth experience in Colombia and Peru, and educational differences in motherhood timing in Ecuador, Peru and Colombia. I forecast cohort fertility in the context of Brazil. The choice of Colombia, Ecuador, Peru and Brazil as case studies is motivated by three factors.

First, I focus on Latin American countries in the context of which the examination of the considered processes can be seen as most relevant given the observed patterns of reproductive behaviour and given the potential importance of the findings for policies. I examine contraceptive use behaviour and unintended motherhood in the context of Colombia and Peru since these are settings with some of the highest percentages of births reported as unintended in Latin America (Casterline and Mendoza 2009; Measure DHS 2018). I forecast cohort fertility in the context of Brazil as it is a country with the lowest TFR out of those in Latin America which experienced rapid fertility transitions during the 2nd half of the 20th century (United Nations 2017). Therefore, understanding of whether fertility will continue to decline there is of particular importance.

Second, I study countries which so far have been largely overlooked in the research on certain aspects of reproductive behaviour. As explained in the section 1.3.1, the Andean region is one of the parts of the continent for which the evidence about the changes in the age at first birth is scarce. Consequently, in the study of the educational differences in motherhood timing I focus on Ecuador, Peru and Colombia. In addition to providing new insights into the topic of interest, this novel geographical focus expands the body of knowledge about the changes in the age at first birth in Latin America

Third, the focus on Colombia, Ecuador, Peru and Brazil considered together is important for the generalizability of the findings from this thesis. To the extent possible this study aims to go beyond the single-country analyses and to conduct comparisons across different settings. I examine closely connected aspects of reproductive behaviour in the context of four countries which share a substantial level of similarities with respect to changes in TFRs, CPRs and levels of unintended motherhood, similarities which are also shared with other countries in the region. At the same time Colombia, Ecuador, Peru and Brazil represent a variety of settings in Latin America with regard to other, related, aspects such as the patterns in the types of contraceptive methods commonly practiced. Although some of the examinations in this thesis are conducted in the context of different countries, the aim is to perform analyses which allow for a broader discussion about the relevance of the findings also for countries not considered in a given study. The objective is to provide evidence which enhances the understanding of the patterns of reproductive behaviour in the region more broadly.

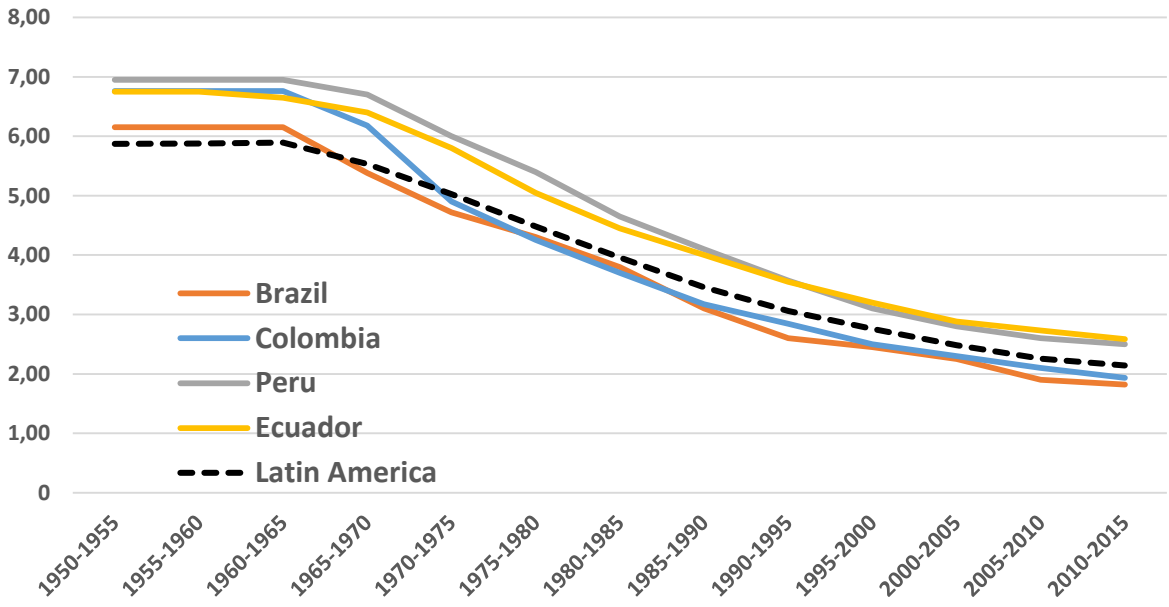
More specifically, I study contraceptive use in Colombia and Peru -- two countries which constitute distinct, yet typical of Latin American countries, contraceptive method mix settings. By means of such comparison I provide a more in-depth account of the relationship between contraceptive practices and unintended motherhood in the region. The consideration of the process of interest in two different settings allows me to explore whether the conclusions might be specific to a given context or whether they have the potential to be generalizable beyond one particular country or family planning setting. I forecast cohort fertility only for Brazil. Nevertheless, in a different part of the thesis I examine the pattern of change in the age at first birth in Colombia, Ecuador and Peru. The forecasting analysis for Brazil which looks into the interaction between the timing of childbearing, period and cohort fertility allows me to consider the potential implications of the findings for the future of fertility also in Colombia, Ecuador and Peru. Moreover, Brazil has been a forerunner in the process of fertility change among these four countries, and countries which experienced rapid fertility transitions since the 1950s. These “high” fertility settings in the middle of the century constitute the majority in the region (Chackiel and Schkolnik 1996). Given the marked similarities in the fertility changes and their determinants, it is plausible that the settings with still higher TFRs will follow the Brazilian pattern in the near future. Therefore, the focus on Brazil in the forecasting analyses can be seen as the first step to understating the future of fertility in Latin America more broadly.

In the following section I describe the trends in the patterns of reproductive behaviour across Colombia, Peru, Ecuador and Brazil in more detail.

1.5.2. Trends in fertility and contraceptive use in Colombia, Peru, Ecuador and Brazil

Colombia, Ecuador, Peru and Brazil belong to the group of Latin American countries in which the TFRs were as high as 6-7 children per woman in the 1950s (Figure 1.1). Although each country's fertility transition in Latin America had its unique features, the four countries represent settings with a TFR change pattern which can be seen as rather typical of the majority of the countries in the region (Chackiel and Schkolnik 1996). Brazil was the first of these countries to see a fall of the TFR to the below replacement level. The estimates from the 2010 Population and Housing Census data using the P/F Brass method suggested that the TFR there was at the level of 1.9 (IBGE 2010a). These estimates have been questioned by Castanheira and Kohler (2016) who have suggested that the P/F Brass might be overestimating the levels of TFR, which in 2010 was likely as low as 1.76. The TFRs in Ecuador and Peru remained at a higher level of around 2.5 in the latest time period. The TFR in Colombia is almost as low as in Brazil.

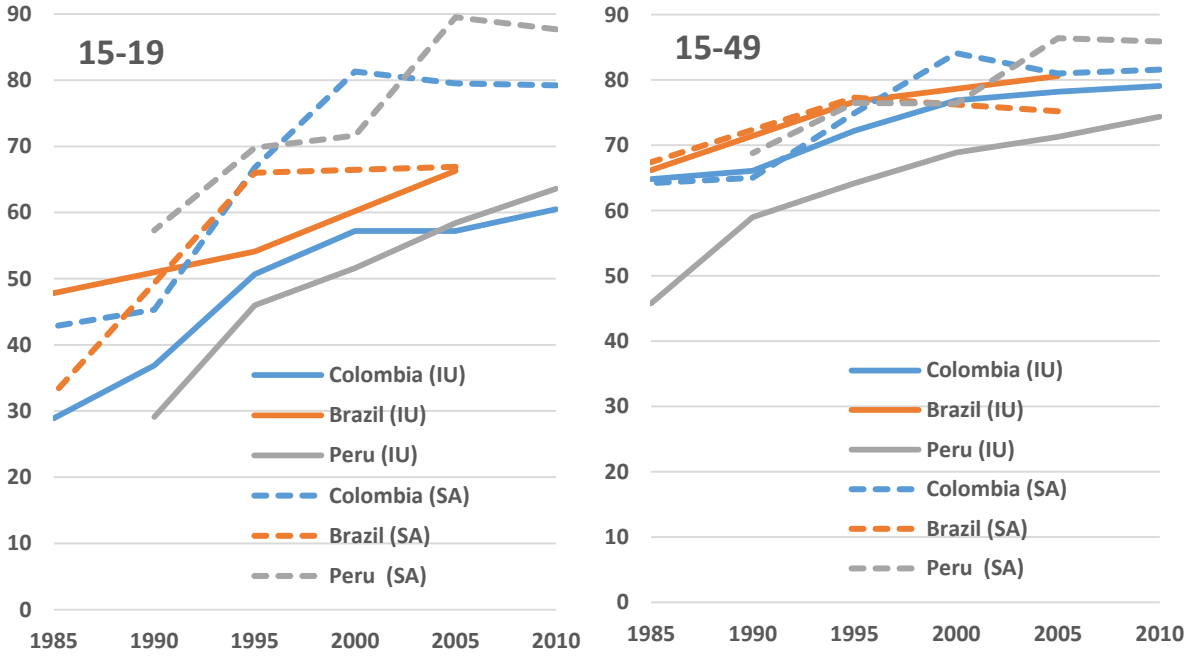
Figure 1.1. Trends in total fertility rate in Brazil, Colombia, Peru, Ecuador and Latin America, 1950-2015



Source: United Nations (2017)

As explained in section 1.4.1, many factors contributed to the fast fertility decline in the region. The developmental aspects related to changing social and economic circumstances as well as changing values and ideals regarding childbearing and family size were key in that process (Bongaarts and Watkins 1996; Guzmán 1996; Potter 1976, 1999; Potter, Schmertmann, and Cavenaghi 2002). The patterns of contraceptive use and the development of family planning programmes (or lack thereof) also played an important role in determining the course of fertility changes observed in Figure 1.1. The increases in contraceptive use are considered to be the most important proximate determinant of fertility decline in Latin America (Moreno and Singh 1996). Figure 1.2 shows trends in the percentage of women using contraception in Colombia, Peru and Brazil since the mid-1980s. I do not show the trends in contraceptive use or later on also in the level of unintended births for Ecuador since to the best of my knowledge there are no comparable surveys which allow for similar calculations. As in other parts of the continent, in Colombia, Peru and Brazil there occurred substantial increases in the percentage of women using contraception, both among all women of reproductive age and adolescents; women in union and women sexually active but not in union (Figure 1.2).

Figure 1.2. Percentage of women aged 15-19 (left) and 15-49 (right) in union (IU) and not in union but sexually active (SA) using any form of contraception in Colombia, Peru and Brazil, 1985-2010, (%)

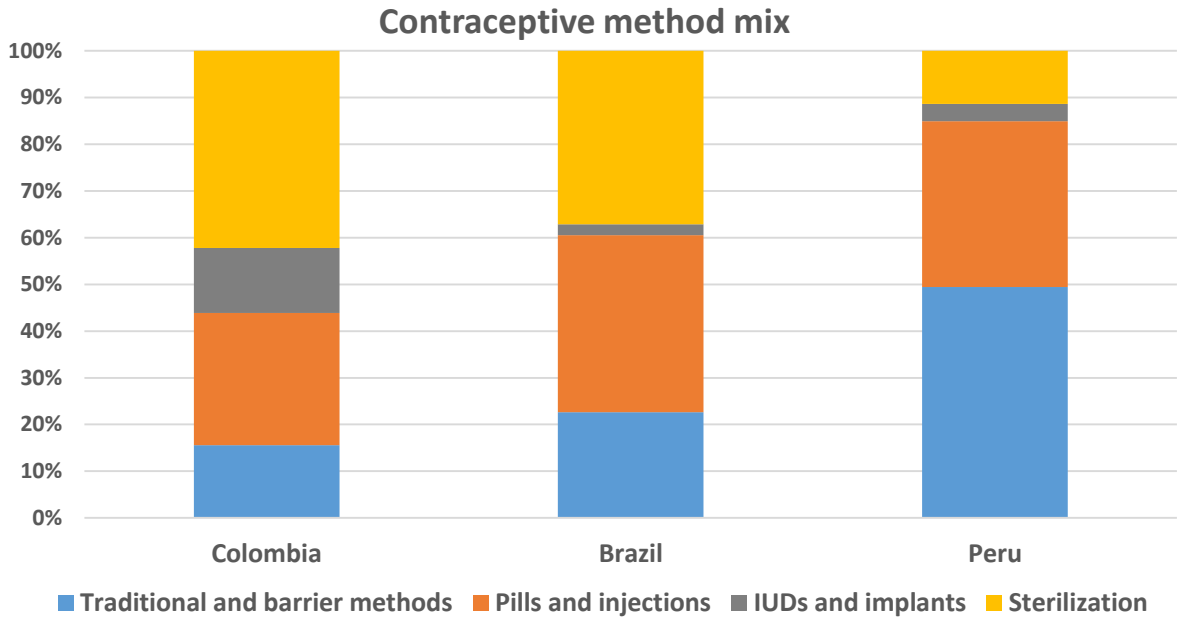


Source: Measure DHS (2018) for Colombia and Peru, Measure DHS (2018) and Ministério da Saúde (2009) for Brazil

In spite of the similarity in the CPRs' increases, the patterns of contraceptive method used differed across the countries, influencing the courses of fertility changes. The faster TFR declines in Colombia and Brazil than in the other parts of the continent have been attributed to the wide practice of sterilization. The high prevalence of this method of family planning contributed to a pattern of birth-stopping behaviour relatively early in women's reproductive lives in both countries (Bonneuil and Medina 2009; Goldani 2002; Parrado 2000; Potter 1999). In Brazil the prominence of sterilization in the method mix was driven by the limited availability of other contraceptive methods. Due to the lack of a governmental family planning programme, the contraceptive practices throughout the fertility transition concentrated around the use of sterilization and pills only (Martine 1996; Potter 1999). In Colombia on the other hand, the development during the 1960s of one of the most successful family planning programmes in Latin America played a key role in making a range of contraceptive methods available. The strong initiatives of Profamilia -- a private, non-profit family planning organization -- to promote contraception but in particular voluntary sterilization contributed to a substantial increase in the use of this method in the following decades (Miller 2010; Parrado 2000).

Figure 1.3 shows the contraceptive method mixes in Colombia and Brazil and compares them with Peru where the traditional and barrier methods are most commonly used. This pattern has been attributed to the substantial percentage of the population that is of indigenous origin. The high levels of use of traditional and barrier methods among indigenous women are reflecting preferences, but also their obstacles in accessing to the reproductive health services (language barriers, more difficult physical access and limited cultural sensitivity in terms of services provision) (Mendoza 2014). Although not shown here, the method mix in Peru is characteristic of other countries in the region as well, like for example Bolivia (Measure DHS 2018).

Figure 1.3. Contraceptive method mix among women aged 15-49 currently using contraception in Colombia (2010), Peru (2010) and Brazil (2006), (%)

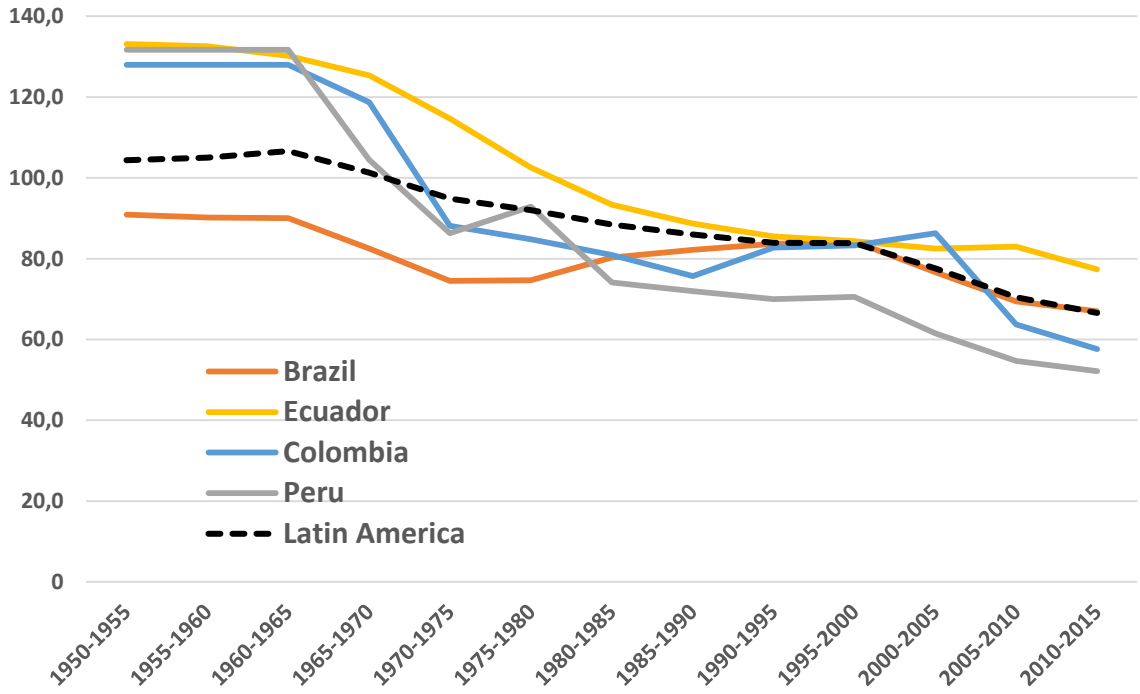


Source: Measure DHS (2018) for Colombia and Peru, Ministério da Saúde (2009) for Brazil

In spite of the increases in CPRs across the region, in particular among women aged 15-19, plateauing or increases in teenage fertility rates occurred during the 1990s (Figure 1.4). A number of explanations has been suggested for the coexistence of the increases in contraceptive use and the high levels of teenage pregnancies which are mainly unintended (Figure 1.5, left). It has been argued that although young women were increasingly using contraceptive methods, they were using them in a less effective manner. This has been reflected in either inconsistent contraceptive practices or high contraceptive failure rates, leading to substantial levels of early pregnancies (Flórez and Soto 2007). The issues around insufficient sexual education, a taboo culture around the sexuality of teenagers, limited access to reproductive health services as well as limited bargaining power to negotiate condom use among adolescents were also put forward as possible explanations (Rodríguez 2013; Rodríguez Vignoli 2017; Rodríguez Vignoli and Cavenaghi 2013; Verona 2018).

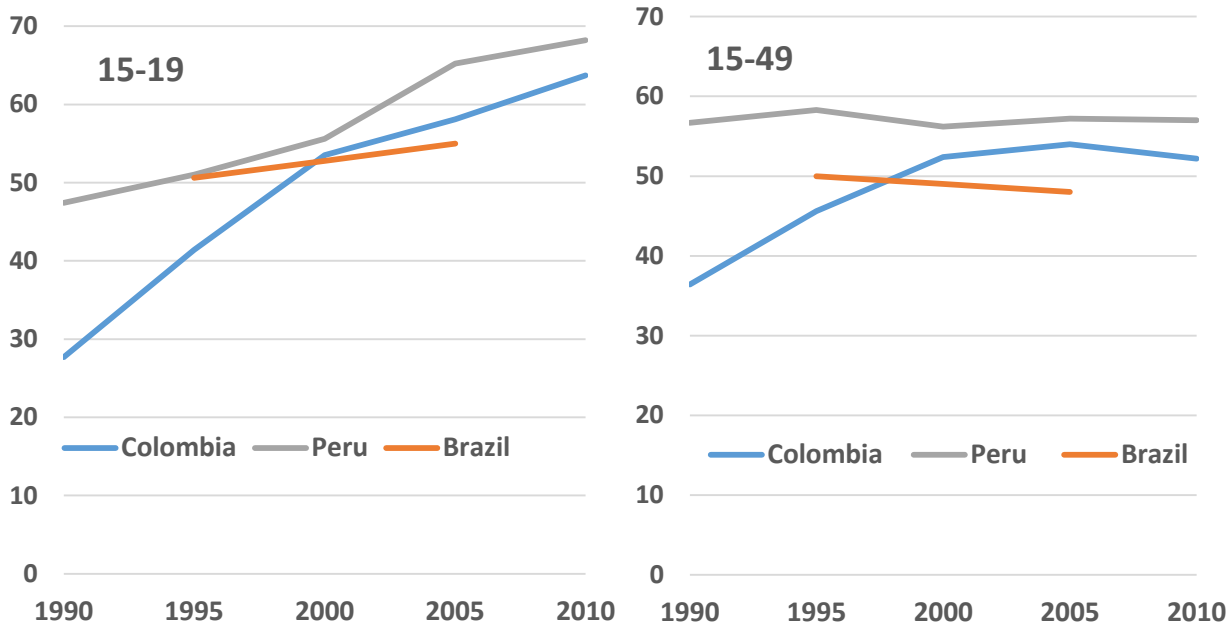
Figure 1.4 shows that since the 2000s there occurred a reversal in the teenage fertility increases in Brazil and Colombia; the rates started to decline again in Ecuador and Peru. This teenage fertility reversal coincided with the increases in the percentage of women still childless in their mid-20s at the population level across the region, as described in section 1.3.1. The cross-country comparative study of Rosero-Bixby, Castro-Martín, and Martín-García (2009) showed that this increase was particularly visible in Colombia and Peru, and a much smaller but visible change occurred in Brazil and Ecuador. The end of the rejuvenation of the first-birth timing pattern and the onset of motherhood postponement has been shown in subsequent research for Brazil (e.g. Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018; Verona 2018) and Colombia (Batyra 2016). Currently, there are no studies on the topic for Ecuador and Peru.

Figure 1.4. Trends in fertility rate at age 15-19 in Brazil, Colombia, Peru, Ecuador and Latin America, 1950-2015



Source: United Nations (2017)

Figure 1.5. Percentage of births reported as unintended[8] among women aged 15-19 (left) and 15-49 (right) in Colombia, Peru and Brazil, 1990-2010, (%)



Source: Measure DHS (2018) for Colombia and Peru, Measure DHS (2018) and Ministério da Saúde (2009) for Brazil

Figure 1.5 (right) shows that the levels of unintended motherhood have been high not only among teenagers but also among women of all reproductive ages. The rates increased during the 1990s in Colombia; in Peru they remained at a high level. Peru and Colombia generally stand out in the region in terms of levels of unintended motherhood (Casterline and Mendoza 2009). This can also be seen when comparing trends in these two countries with a trend observed in Brazil. In Peru, high levels of unintended childbearing have been attributed to a substantial reliance on the least effective contraceptive methods (as shown in Figure 1.3) which have high failure rates (Mendoza 2014; Wurtz 2012). It is not clear from the existing literature why Colombia is a setting with relatively high levels of unintended childbearing. The lack of evidence is surprising and there are no recent studies on the topic. One reason could be that there exists a strong association between intimate partner violence and unintended pregnancies in Colombia (Pallito and O`Campo 2004). Therefore, high levels of domestic violence (Garcia-Moreno et al. 2005) could be one of the factors contributing to the substantial levels of unintended pregnancies.

[8] Percentage of births reported as "unintended" ("mistimed" and "unwanted" grouped together) among births which occurred 5 years prior to the survey

1.6. Aims and structure of the thesis

The aim of this thesis is to address gaps in knowledge about contraceptive behaviour and unintended motherhood, changes in childbearing timing and fertility declines in Latin America identified in this introduction. The main contribution of this thesis is to provide new evidence about the reproductive behaviour in the region, focusing on the presented topics. An important aim of this research is also to bring attention to the unexplored potential of the publicly available data sources and the methodological approaches which can enhance the understanding of fertility change in Latin American. This thesis consists of three studies, each reported in separate chapters (2-4). The last chapter provides conclusions. In more detail, the rest of this thesis is structured as follows.

In Chapter 2, I examine whether an unintended pregnancy is associated with a change in contraceptive behaviour in Colombia and Peru. I study the dynamics of contraceptive use in relation to an unintended birth experience in two settings with similarly high levels of unintended motherhood and CPRs, but very different contraceptive method mixes. Such comparison allows not only for a greater generalizability of the findings but also for a discussion about the role of family planning policy and cultural factors in determining women's contraceptive choices. For that purpose, I use the 2010 and the 2012 DHS rounds for Colombia and Peru, respectively. I investigate the potential of the reproductive calendar data for these analyses employing transition matrices and competing risk hazard models. Thanks to the use of these longitudinal contraceptive histories, this is the first study to provide a comprehensive analysis on the topic for Latin America and most importantly in general as well. The results of this research are important for the understanding of the relationship between pregnancy intentions and contraceptive use, as well as for the organisation of the postpartum family programmes in both countries.

Chapter 3 examines the evolution of the educational disparities in the age at first birth during the fertility transition in Ecuador, Peru and Colombia. The study focuses on examining two aspects: the variation in the pattern of motherhood timing among women who enter secondary school and the changes in the educational composition of the population. These analyses aim to cast light on the possible factors behind the increasing educational differences in the age at first birth in Latin America. The findings provide important insights into the process of the increasing heterogeneity in the age at first birth pattern between the population strata observed in the region. The results allow to flag areas

in which interventions are needed in order to alleviate the pervasive disparities in motherhood timing in Latin America. The study shows the usefulness of the Population and Housing Censuses conducted in Colombia, Ecuador and Peru, previously unexploited for the study of the changes in the timing of childbearing. Thanks to the use of these datasets, this is the first study to provide estimates of the cohort first-birth age specific rates for total population and for educational groups for the Andean region countries.

Chapter 4 aims to forecast cohort fertility for total population and by education level in Brazil. The study explores whether the emerging low levels of TFR could correspond to equally low lifetime fertility of women who are still in their childbearing years. An in-depth analysis of the period and cohort fertility trends shows what consequences the changes in the motherhood timing in Brazil have had and are likely to have on the levels of fertility. The study provides evidence that it is possible to indirectly reconstruct detailed, consistent time-series of age-specific fertility rates from 1980-2010 IPUMS censuses. The core of the analysis involves the application of the newest methodological approaches of cohort fertility forecasting to the case of Brazil (Myrskylä, Goldstein, and Cheng 2013; Schmertmann et al. 2014). The emphasis is put on the discussion about how these methods can be used in the context of a country which represents a distinct pattern of fertility and motherhood timing. Both the substantive findings and the methodological conclusions from this research have important implications for the design of future studies on fertility decline in Latin America.

In Chapter 5 I conclude by summarizing the main findings of the thesis and their implications, discussing the limitations of the analyses and outlining the directions for future research on fertility and contraceptive use in Latin America.

The structure of this thesis presents the research "route" that I have undertaken during the course of my PhD and reflects the chronology of the development of my ideas. In the first instance, these ideas were based on the review of the literature which I conducted during the first year of my PhD and the identified gaps in knowledge. These ideas were further shaped by the research visits which I have undertaken over the course of the writing of the thesis. At the end of the process of writing of Chapter 2 I carried out a research visit in Colombia where I had a chance to present and to consult on the results of the study with experts working on reproductive health issues in the Ministry of Health and health practitioners. I reflect on these aspects in the conclusions. Also during the course of that

visit I accessed and conducted the analyses of the 2005 Colombian Population and Housing Census in the Colombian Statistical Office (DANE) in Bogota. These analyses were the basis for the writing of Chapter 3. Finally, I conducted a research visit in CEDEPLAR at the Federal University of Minas Gerais in Brazil where I further learnt about the methods of estimating fertility from censuses in LMICs. This experience formed the basis for the design of the analyses conducted in Chapter 4.

Although the structure of the thesis reflects the chronological order of the investigations, the writing of the papers has been an iterative process carried out over the four years of my PhD. In particular, within the last year of the writing of this thesis a substantial body of research has been published about timing of motherhood in Latin America. I aimed to continuously incorporate this new evidence into Chapter 3 of this thesis, which was already finished in October 2017. For example, one section of my study and the study of Esteve and Florez-Paredes (2018) provide a very similar account of changes in teenage first-birth rates' trends by education level in Colombia and Peru. Although the two studies aimed to answer different research questions, the overlapping analyses merit comparison and discussion. After this publication, I incorporated into Chapter 3 an additional discussion about the similarities and the differences in the results and the interpretation of these two analyses. These considerations further add to knowledge about the changes in motherhood timing in the region by showing how similar results can be interpreted in a different way and how similar approaches can be used to explore different research questions.

All three chapters of this thesis are of publishable quality and have been submitted to or will be submitted to peer-reviewed journals. The versions of the papers for publication differ however to some extent from the ones presented here. Some parts of text have been omitted from the papers for publication due to restrictions on length. This relates in particular to the in-depth discussions about the methods and data used in the studies, as well as certain tables and figures.

2. Contraceptive use behaviour change after an unintended birth in Colombia and Peru

Abstract

Context

The association between contraceptive behaviour and unintended childbearing has been primarily studied at one point in women's reproductive lives. Currently, there is a scarcity of research which investigates the dynamic of contraceptive use. This paper examines whether the experience of an unintended birth is associated with a change in contraceptive behaviour in Colombia and Peru, countries with persistently high levels of unintended fertility. This subject has not been previously studied using longitudinal contraceptive histories.

Methods

Monthly contraceptive use information was extracted from Demographic and Health Survey reproductive 'calendars'. Transition matrices and discrete-time event history models were used to examine the relationship between the last pre-pregnancy and the first postpartum contraceptive method used and to study how this relationship differs between women who reported an unintended and an intended birth.

Results

In both countries, compared to an intended pregnancy, after an unintended pregnancy resulting from a failure or an abandonment of less effective contraceptives women were more likely to initiate more effective methods than the one used before pregnancy. After an unintended pregnancy following the discontinuation of the most effective methods, women were less likely to return to using them postpartum, than after an intended pregnancy. Thus, unintended childbearing is an important determinant of a change in contraceptive practice.

Conclusions

The results from the study reveal and emphasize the importance of studying patterns of both pre- and postpartum contraceptive behaviour in order to gain a better understanding of contraceptive choices of women who experience unintended pregnancies. This study

highlights a need to implement more effective postpartum family planning programmes in Colombia and Peru.

2.1. Introduction

The study of the relationship between fertility intentions and contraceptive use is important to help understand persistently high levels of unintended pregnancies in many settings. The association between contraceptive behaviour and unintended childbearing has been primarily studied at one point in women's reproductive life course. Current literature describes contraceptive practices which precede the experience of an unintended pregnancy (Barden-O'Fallon et al. 2008; Curtis et al. 2011) or investigate how the history of an unintended birth is related to future contraceptive uptake (Bakibinga et al. 2016; Fotso et al. 2014; Matteson et al. 2006). However, there is a scarcity of studies which look at the dynamics of contraceptive use. For low- and middle-income countries there is no research on how contraceptive behaviour changes in relation to important reproductive events, such as unintended birth.

Latin America is a region with the replacement-level total fertility rate, high contraceptive prevalence rates but at the same time the highest percentage of pregnancies reported as unintended in the world (Sedgh, Singh, and Hussain 2014). Moreover, the funding for family planning in the region has been decreasing due to the "graduation" of the countries in the region from international assistance (Bertrand 2011). Yet still, the factors influencing contraceptive method choice and change in Latin America are poorly understood.

Unintended childbearing can be a disruptive and stressful event for a woman. It can adversely influence the mother's health as well as impact her behaviour during and after pregnancy (Gipson et al. 2008; Kost and Lindberg 2015). Important personal experiences resulting from reluctance or inability to implement self-protective practices were found to influence future behaviour (Weinstein 1989). Unintended pregnancy might, therefore, be related to a change in women's contraceptive decision-making to prevent future births more effectively. However, current studies examining determinants of postpartum contraceptive use largely ignore women's pre-pregnancy behaviour. It can be hypothesized

that the contraceptive method choice after birth will be related to a woman's past experience with contraception, particularly if it is followed by an unintended pregnancy.

Researching the relationship between contraceptive practices which precede and follow unintended pregnancy is important to extend the knowledge about the determinants of contraceptive use and to inform the organization of postpartum family planning programmes. Moreover, evidence shows that women who experienced one unintended birth are at higher risk of subsequent unintended births (Guzzo and Hayford 2011). Studying whether contraceptive practices change after an unintended birth could cast light on the proximate determinants of repeat unintended childbearing and short inter-pregnancy intervals.

This investigation used detailed, monthly, longitudinal contraceptive histories extracted from the calendar data of the Demographic and Health Survey (DHS) for Colombia (CDHS 2010) (Profamilia 2011) and Peru (PDHS 2012) (INEI 2012). It is the first study which comprehensively examines the association between an unintended birth experience and a contraceptive use behaviour change. No previous research used nationally representative data and encompassed women of all reproductive ages to study these processes. Moreover, given the importance of the availability and acceptability of contraceptives for method choice and switching (Kost 1990), this paper examined how the studied processes differed in two distinct contraceptive method mix and family planning settings. In Colombia the distribution of contraceptive methods used in the population is focused on limiting, permanent ones; in Peru the spacing, traditional and barrier methods dominate. The study of how the contraceptive use dynamic varies between countries with different method mix allows for the consideration of how the examined processes might be related to the country's family planning policy, as well as the cultural setting.

2.2. Unintended childbearing and contraceptive use behaviour change

Unintended pregnancy can be unwanted (when a woman did not want to have any children before becoming pregnant) or mistimed (when it occurred earlier than desired) (D'Angelo et al. 2004). Among women who are at risk of pregnancy, it can result from contraceptive non-use or discontinuation (method failure or abandonment) (Ali, Cleland, and Shah 2012; Bradley, Croft, and Rutstein 2011). Contraceptive failure can be preceded by the choice of

methods which have lower effectiveness or by inconsistent use. The non-use and abandonment of contraception can result from various barriers: (i) method's physical availability and cost, (ii) health concerns and side effects, (iii) misinformation and lack of knowledge about the methods, (iv) women's limited decision-making and (v) limited choice of methods (Black et al. 2010; Campbell, Sahin-Hodoglugil, and Potts 2006; Lemay et al. 2007).

Although some women might not desire or plan a pregnancy, their intentions to avoid childbearing might not be strong enough to motivate contraceptive use. The experience of pregnancy classified as unintended can be related to the presence of attitudes determining the ineffectiveness, or lack, of contraceptive practice. These can pertain to low self-perceived risk of pregnancy, low motivation to avoid pregnancy or ambivalence (conflicting attitudes towards pregnancy or lack of clearly specified fertility desires) (Curtis et al. 2011; Santelli et al. 2003; Trussell, Vaughan, and Stanford 1999).

Depending on the underlying reason and the meaning of the unintended pregnancy, the mechanisms through which it can lead to a contraceptive practice change might differ. Current evidence on the topic comes mainly from qualitative studies. Unintended pregnancy might increase the degree of women's contact with health care services and consequently create opportunities to acquire not only contraceptive methods but also information and counselling (Lemay et al. 2007). Therefore, unintended childbearing which resulted from inability or barriers to implementing effective contraceptive practice might improve access to means facilitating method uptake after birth. An unintended pregnancy which followed a strong desire to avoid childbearing might induce a feeling of distress and anxiety, resulting in an increased determination not to experience a similar event again. It might also worsen women's economic situation and create a need to avoid future pregnancy (Fotso et al. 2014). If unintended pregnancy followed the use of less effective methods which resulted in contraceptive failure, the experience might induce a desire to transition to more effective methods after birth. Similarly, the method abandonment due to side effects, health concerns or inconvenience of use leading to an unintended pregnancy might result in a switch to an alternative method after birth to better meet women's needs (Lemay et al. 2007).

The change in women's contraceptive decision-making after an unintended pregnancy which followed low self-perceived risk of pregnancy, low motivation to avoid

pregnancy or ambivalence might occur to adjust the behaviour to new fertility preferences resulting from a change in the family size. Unintended pregnancy might increase the perception of susceptibility to pregnancy and motivation to avoid future pregnancy (Lawson Smith, Skinner, and Fenwisk 2013). It might also serve as a learning experience referred to as a "teachable moment" (McBride, Emmons, and Lipkus 2003) or a "wake-up call" leading to a reassessment of contraceptive behaviour (Fotso et al. 2014).

Conversely, the experience of an unintended birth might not lead to the contraceptive behaviour change if barriers to the effective, or any, contraceptive practice which contributed to pregnancy persist. There might be no impact on the behaviour of an unintended pregnancy which followed ambivalence if the attitudes towards childbearing remain unchanged.

To the best of my knowledge, only one quantitative study -- conducted among 466 teenagers in 1990 in the city of Buffalo in the United States -- examined these processes (Orcutt and Cooper 1997). It found that adolescents who reported an unplanned pregnancy did not improve their contraceptive practice (both in terms of any method use and effectiveness), compared to teenagers without an unplanned pregnancy experience. Moreover, they were the poorest contraceptive users both before pregnancy, as well as afterwards. Therefore, that study provided no support for the evidence from existing qualitative investigations. Moreover, it focused on teenagers only and was not able to control for, for example, differences in socioeconomic profiles of adolescents who do and who do not experience unintended pregnancies. Other existing studies compared the method use after birth among women who reported an unintended and intended birth (Fotso et al. 2014; Matteson et al. 2006). Although attempting to examine whether unintended pregnancy might be related to a change in the contraceptive behaviour, they did not consider women's pre-pregnancy practices.

Compared to the previous research on the topic, the strength and novelty of this study in terms of research design is that: (i) I examined the relationship between the last pre-pregnancy and first postpartum contraceptive method used and (ii) I studied how this relationship differed between women who reported an unintended and an intended birth. By comparing the contraceptive use practice before pregnancy with that after birth, and the differences in that behaviour depending on the birth intention status, I was able to

explore whether the experience of unintended birth is associated with the contraceptive practice change. This is possible thanks to the use of the longitudinal contraceptive histories from DHS reproductive calendars which has not been previously used to examine these processes. This is the first study to provide a comprehensive analysis on the topic both for high as well as low- and middle-income settings.

Based on the evidence from the existing quantitative and qualitative research, this study examines the following hypotheses. If an unintended birth is associated with a contraceptive practice change through the described mechanisms, I expect women who reported an unintended birth to be more likely to switch, in particular to more effective methods after birth, compared to their pre-pregnancy use, than women who reported an intended birth. If there exist persistent barriers to contraceptive use or unintended birth experience does not change women's motivation to avoid future childbearing, I expect women to remain poorer contraceptive users after an unintended, than after an intended birth. This could be reflected in the lower level of use of any of the methods among them after birth or use of less effective methods.

2.3. Defining unintended childbearing

I used the DHS retrospective birth intention status definition. The information about the intention status of pregnancies resulting in terminations is not collected for Colombia and Peru and is not addressed here. I classify births as "intended" if a woman reported that she wanted to become pregnant at the time of the pregnancy. If a woman reported that she wanted to become pregnant later or not at all, I classified births as "unintended". Therefore, the measure used in this study aims to reflect the intention of women to have a child before they become pregnant. Such reporting can be subject to the ex-post rationalization, particularly of births which occurred in the more distant past (Bankole and Westoff 1998). This might be due to the reluctance to consider children born as unintended or to mothers` adaptation to the new reality (Koenig et al. 2006). I restricted the analysis to woman's last birth to diminish this problem. Moreover, in the multivariate analysis, I controlled for the time since birth to the interview to capture the fact that older children might be less likely to be reported as unintended. Due to the lack of available information, more nuanced measures capturing additional pregnancy intention dimensions could not be used in these analyses (Santelli et al. 2009). While

acknowledging the limitations, multiple researchers argue that the conventional measures of unintended childbearing, as used in this paper, are easily understandable by women, have high face validity and are useful analytically (Bradley, Croft, and Rutstein 2011; Joyce, Kaestner, and Korenman 2002; Marston and Cleland 2003; Rackin and Morgan 2018; Singh, Sedgh, and Hussain 2010).

2.4. Context of Colombia and Peru

In spite of steadily increasing contraceptive prevalence rates, the percentage of births reported as unintended rose in Colombia from 35% in 1990s to 55% in the 2010s; in Peru it has been stable at a high level of the 55% in the same time period (Measure DHS 2018). One of the proximate determinants of these changes has been the fact that a growing preference for smaller families and a trend towards earlier initiation of sexual activity in both countries have not been accompanied by the effective and consistent use of contraception (Ali, Cleland, and Shah 2003; Prada, Biddlecom, and Singh 2011). The discontinuation of contraceptive use has been the major factor for unintended childbearing in Colombia (Bonneuil and Medina 2009). Main reasons for discontinuation there are contraceptive failure and dissatisfaction with the method used (Bradley, Schwandt, and Khan 2009). In Peru, unintended pregnancies are predominantly the result of the failure of traditional methods (Mensch et al. 1997).

Despite many similarities, the two countries differ with respect to the contraceptive method mix. In Colombia the initial family planning programme efforts focused on the provision of oral contraception, barrier methods and intrauterine devices (IUDs); sterilization was introduced in the later phase. The organization by Profamilia of projects and mobile clinics to allow the provision of sterilization to all parts of the country made it widely available and practiced (Gómez and Seltzer 1998; Rizo and Roper 1986). Currently, sterilization is the most popular method of birth control. In Peru, the progress of family planning programmes during the 1990s stalled due to the opposition of the conservative government, resulting in the reduced access to services (Bertrand 2011; Chávez and Coe 2007; Coe 2004). The use of modern contraceptives decreased in the early 2000s, especially among the poorest. This was accompanied by the increase in the use of traditional methods which currently remain the most common family planning methods (Aramburú 2014; Gribble, Sharma, and Menotti 2007). The high level of use of periodic

abstinence and withdrawal is also related to its wide practice by indigenous groups which constitute a large percentage of Peru's population. In conclusion, in Colombia the limiting, permanent methods dominate within the method mix (43% of current users); in Peru the spacing, traditional and barrier methods are most common (50% of current users) (Measure DHS 2018). Moreover, the method mix is more diverse in Colombia than in Peru. This is particularly visible when comparing the use of long-acting reversible methods (LARCs) and sterilization between the two countries, with a low percentage of women using these methods in Peru (Measure DHS 2018).

In Colombia, the provision of contraceptives has been free of charge since 1993 and a wide range of methods is available as part of the social security system scheme *Plan Obligatorio de Salud* (MINSALUD 2015). The second biggest source of family planning methods is Profamilia which provides contraceptives for a charge. According to the Ministry of Health guidelines, during the antenatal visits women should be asked about the intendedness status of the pregnancy and the previous use of contraceptive methods. During the visits women should also obtain family planning counselling and methods should be provided to them after birth, before discharge (MPS 2007, 2008). Despite these regulations, there remain procedural challenges which might inhibit women's ability to obtain their preferred method after birth. While female sterilization can be obtained in all health facilities, in spite of the obligatory provision of other methods such as IUDs and implants, these contraceptives are provided only in the largest health facilities. Women delivering in smaller institutions are often referred to come back after six weeks to clinics where they can obtain these methods. This means a lost opportunity for family planning provision as the majority of women give birth in health facilities, but many might not return only to obtain contraception if they feel healthy and have no complications (Gómez Sánchez 2010; PAHO 1997).

In Peru, family planning methods have been available free of charge since 1995. Contraceptives are mostly acquired through the public health sector where they are provided as part of *Seguro Integral de Salud*. In particular, the use of injections increased substantially between the 1990s and 2000s due to their growing availability through the public health system (Aramburú 2014). This had a positive impact on access to contraception also after childbirth. The methods offered in Peru are, however, more limited than in Colombia: monthly injections and implants are not available as part of the health care system (Chávez and Távara 2010). According to national guidelines, during antenatal

visits in Peru, health professionals should provide information and promote the choice of a family planning method postpartum for the optimal birth spacing. Moreover, the postpartum health check between seven and thirty days after delivery should include family planning counselling (Toledo Manrique et al. 2004). However, due to the limited choice of LARCs and the evidence of stock-outs and shortages of methods included in the service provision, women might be referred from smaller health facilities to hospitals in order to obtain a preferred method (Chávez and Távara 2010; Ward, Santiso-Gálvez, and Bertrand 2015). This is an obstacle to the immediate provision of highly effective contraception in general, and after birth in particular.

2.5. Reproductive calendar data and sample selection

This study used data from DHS which collects detailed demographic and socioeconomic information about women aged 15-49. The sample sizes are: 53,521 women in the 2010 Colombian CDHS and 23,888 women in the 2012 Peruvian PDHS. These two surveys include the reproductive calendar module which provides individual, retrospectively reported, monthly, longitudinal data about reproductive events during five years prior to the survey: births, pregnancies and contraceptive use. The quality of the reproductive calendar in Latin America is recognized to be high (Leone 2002). I integrated the information about pregnancies, births and contraceptive use from the calendar with the maternity and birth histories which are part of the individual women's recode. The analysis is confined to women who gave birth during the five years prior to the survey date: 14,492 women in Colombia and 8,000 women in Peru.

In this study I specified the contraceptive use behaviour before the last pregnancy which ended in a live birth as the last episode of method use, if any, during five months before pregnancy. I justify this choice in the following paragraphs. Such defined last episode of method use might have ended in contraceptive failure or method abandonment before pregnancy. This study did not distinguish in the analysis between these two types of discontinuation, but aimed to capture both of them, as both might lead to an unintended pregnancy. The contraceptive use after birth is defined as the first method uptake, if any, during 12 months after birth. I examined the first method initiated after birth; method switching within the postpartum period is not considered in this study. I choose the 12 months period of observation of contraceptive use after birth following the World Health

Organization (WHO) classification of the postpartum period referring to a year after delivery (WHO 2013). I defined contraceptive use behaviour change between pre-pregnancy and after-birth as a switch between methods according to the effectiveness level or a change from the non-use to method use (or vice-versa).

The main issue when using the DHS reproductive calendar for the purpose of this study is left censoring. Due to the survey design, the contraceptive history before pregnancy is limited to that from the beginning of the calendar. If a woman became pregnant before that, no information about the contraceptive use before conception is available. For the rest of women, the length of the contraceptive history before pregnancy might differ depending on the timing of pregnancy with respect to the calendar coverage (the calendar spans the period of time which begins five years prior to the interview in both countries until the interview month). Therefore, for this study, the main challenge when using these data is defining the period for the contraceptive use before pregnancy to compare the individuals consistently.

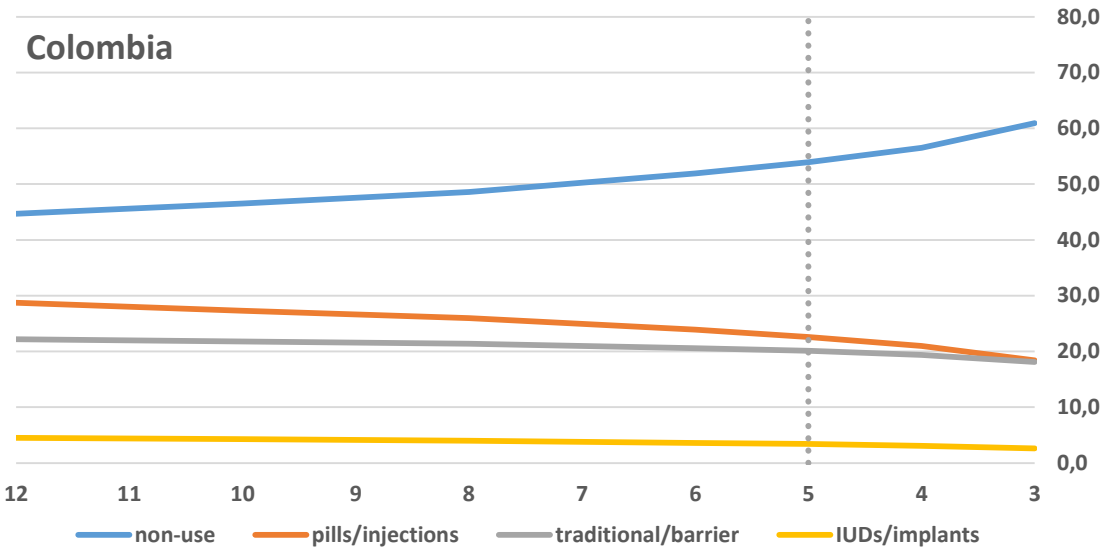
Following previous research which used the DHS reproductive calendar, I excluded the left-censored individuals with no reproductive history before conception (Leone and Hinde 2007). Handling the issue of a different length of histories before pregnancy is more complicated. Women might be non-users or discontinue a method before pregnancy. If a method failed, then the last episode of use is recorded one month before the first pregnancy month. If a woman abandoned a method, then the last episode of use is recorded a given number of months before conception; subsequent episodes show method non-use until pregnancy. Consequently, two issues need to be considered. First, the return to fecundity after discontinuation of more effective methods might take longer (for example, injections and pills). Thus, the shorter the chosen observation period before pregnancy, the more women who abandoned the use of such methods before the chosen cut-off would be classified as previous non-users. On the other hand, the choice of a longer cut-off, for example, 12 months, would result in a necessity to exclude an increasing number of women without sufficient information because of left censoring. Such exclusion could lead to a greater sample selection bias.

I chose a five-month cut-off and define the contraceptive behaviour as the last episode of method use, if any, during five months before pregnancy for two reasons. First, a literature review of the existing evidence identified that the median time from cessation of

contraception to pregnancy among women who conceive within a year of abandoning a method is no longer than five months for all method types (Mansour et al. 2011). Second, I examined the sample composition regarding the last contraceptive method used when different cut-offs were applied and compared it with the 12-month cut-off. In order to do that, I confined the survey samples to women for whom the whole 12-month period before pregnancy was observed. I calculated the distribution of the last pre-pregnancy method used in that sub-sample. Subsequently, I compared how this distribution would differ, if only 11 months of pre-pregnancy history was available for these women. I repeated the procedure for the shorter time periods. I considered 12 months to be a reasonable maximum cut-off, as studies show that the one-year pregnancy rates following cessation of pills, injections, implants and IUDs are similar to those following non-use (Mansour et al. 2011). Therefore, given no fertility problems, all women who abandoned a method are likely to become pregnant within a year.

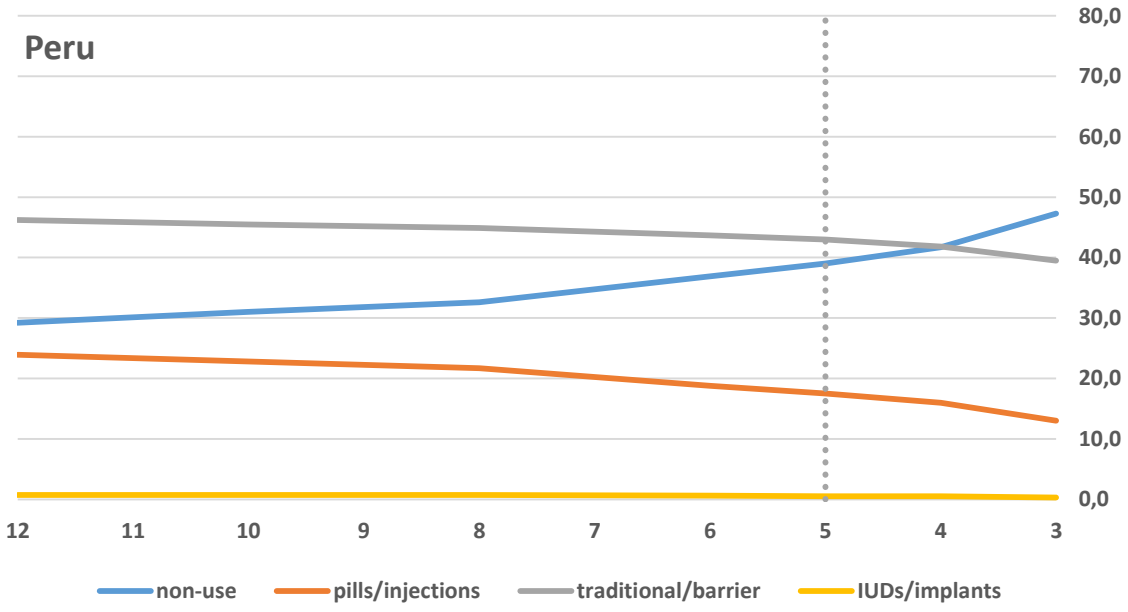
These checks show that up to the cut-off of five months, the distribution of methods used before pregnancy according to effectiveness in the samples does not substantially differ from that when a 12-month period is considered (Figure 2.1 and 2.2). In Colombia, for shorter periods, for example four months, the percentage of women who use pills and injections falls to the level of the use of traditional and barrier methods. In Peru, at four months the non-use becomes as frequent as the use of traditional and barrier methods. This confirms that the pre-pregnancy observation period of five months is a justified choice, and should not be shorter. Consequently, I confined the analysis to women for whom the period of at least five months of reproductive history before birth was observed.

Figure 2.1. Sample composition regarding the last contraceptive method used with different pre-pregnancy period cut-offs, Colombia (%)



Source: Author's calculations from CDHS 2010, PDHS 2012

Figure 2.2. Sample composition regarding the last contraceptive method used with different pre-pregnancy period cut-offs, Peru (%)



Source: Author's calculations from CDHS 2010, PDHS 2012

The aspect which needs to be considered when analysing the contraceptive behaviour within 12 months after birth using the calendar is that the reproductive histories are also right censored. This means that for women who gave birth within a year before the interview, the whole 12 months of contraceptive history after birth is not observed -- the information about their contraceptive practice is available only from birth to the interview month. In this study this aspect is accounted for using survival analysis, as further explained in the methods section. Nevertheless, I excluded individuals for whom no reproductive history at all after birth is available due to right censoring.

This sample selection procedure -- inclusion of women with at least five months of observation before pregnancy and at least one month of reproductive history after birth -- led to the exclusion of 7.8% women in Colombia and 7.2% women in Peru, out of those who gave birth during the five years prior to the survey. The final samples consist of 13,373 women in Colombia and 7,425 women in Peru. There are no discernible differences in socioeconomic and demographic characteristics between women selected for the study (sub-sample) and the total sample of women who gave birth during the five years prior to the survey (Table 2.1). Moreover, there are no obvious reasons why these subgroups of women should be systematically different. Therefore, the selection process should not cause any serious bias in the analysis.

Table 2.1. Comparison of the total sample of women who gave birth during five years prior to the survey date and women selected for the analysis (%), Colombia and Peru

%	Total sample Colombia	Sub-sample Colombia	Total sample Peru	Sub-sample Peru
Education				
no education	2.5	2.5	3.3	3.3
primary	28.4	28.3	30.6	30.7
secondary	52.2	52.4	44.2	44.1
higher	16.9	16.9	22.0	21.9
Wealth				
poorest	33.6	34.0	27.1	27.4
poorer	26.9	26.8	27.5	27.5
middle	19.5	19.4	21.1	21.2
richer	12.5	12.3	15.2	14.9
richest	7.6	7.5	9.1	9.0
Residence				
urban	66.1	65.8	59.4	59.0
rural	33.9	34.2	40.7	41.0
Ethnicity (Colombia/Peru)				
Native Colombian/Indigenous language speaker	13.5	13.6	12.2	12.3
Black/-	11.1	11.2	-	-
Other/Spanish speaker	75.5	75.2	87.8	87.7
Age at last birth				
>20	22.2	22.8	15.3	15.5
20-29	51.0	50.8	47.3	47.3
30-39	23.6	23.3	32.3	32.1
40-49	3.1	3.1	5.1	5.1
Union status				
never in union	10.6	10.7	6.1	6.2
married	17.9	17.6	25.5	25.4
cohabiting	56.0	56.5	59.9	60.2
formerly in union/not living together	15.4	15.2	8.5	8.3
Birth order				
1	37.0	37.4	32.0	32.1
2	28.7	28.5	26.7	26.7
3	16.2	16.2	17.4	17.3
4+	18.2	17.9	23.9	24.0
Birth intention status				
intended	45.3	45.4	43.2	42.8
unintended	54.7	54.7	56.8	57.2
Total	**14,492**	**13,373**	**8,000**	**7,425**

Source: Author's calculations from CDHS 2010, PDHS 2012

2.6. Methods

I classified contraceptive behaviour into non-use and three categories of contraceptive methods according to the increasing level of effectiveness: (i) traditional and barrier methods, (ii) pills and injections and (iii) IUDs and implants for pre-pregnancy use and IUDs, implants and sterilization for after-birth use. Traditional methods (withdrawal and periodic abstinence) and barrier methods (male and female condom, diaphragm) are least effective and coital dependent. Pills and injections are in the next effectiveness tier: although having very high perfect-use efficacy, their typical-use effectiveness is lower. Pills and injections are classified together also as these short-acting hormonal contraceptives might not be recommended immediately after childbirth for breastfeeding women. LARCs (IUDs and implants) and sterilization (female and male) have the lowest pregnancy rates. These methods, once initiated, do not require further action from the side of the user (Trussell 2011).

Using such defined contraceptive use categories, I conducted two sets of analysis. First, I calculated transition matrices to show the distribution of the first contraceptive methods used after birth, by the type of the last method used before pregnancy, if any, separately by birth intention status. Secondly, I used regression models to examine the relationship between the first method used after birth and the last method used before pregnancy, if any, and study how this relationship differed by birth intention status, controlling for covariates. As described in the data section, the reproductive calendar data are right censored. Below I describe how the right-censoring is handled and the details of the methods used in this study.

I followed women from their last birth at each month of the postpartum period until the moment they start using a contraceptive method or until the end of the postpartum period if they do not initiate any method. Women who gave birth within 12 months of the survey date are censored at the point at which the survey occurred, if they do not initiate any contraception by that time. In this analysis a “failure” (or an “event”) is considered to be the adoption of the first contraceptive method after birth by type, as grouped above. I treated the three contraceptive method groups as three possible transitions women might make from the state of non-use immediately after birth. I used a competing risk framework to consider and analyse these three types of possible transitions simulatenaously. The competing risks approach is used when there are multiple, mutually exclusive types of

events with which an episode of interest can end (Steele 2005). Therefore here, each type of the three possible contraceptive-related transitions serves as a competing risk, because adoption of a method from group (i) before adoption of any of the methods from group (ii) or (iii) precludes either of the two latter transitions from happening. The estimated quantity of interest is the risk of initiating a given type of contraceptive method, in the presence of all other types of possible contraceptive method related transitions.

First, in order to analyse the transitions women make between the pre- and postpartum contraceptive methods and to account for right censoring I used multiple-decrement life tables (Curtis and Hammerslough 1995; Steele and Diamond 1999). For women who used a given type of method before pregnancy, if any, I calculated the cumulative probabilities of starting using a contraceptive method by type within 12 months after birth. For that purpose, I used the *stcompet* command in Stata15 (Coviello and Boggess 2004; StataCorp 2015). I conducted the analysis separately by birth intention status and separately by country. I present the results in a form of tables which show a cumulative percentage of women who initiate a given type of method within 12 months postpartum, by the type of method used before pregnancy.

Second, I used the discrete-time competing risk hazard model to examine how the risk of initiating a given type of method after birth is associated with the contraceptive behaviour before pregnancy, and how this relationship differs by birth intention status, controlling for socioeconomic and demographic characteristics. The outcome in the model is a categorical variable with three categories representing the method-specific contraceptive choice postpartum, as defined above, and a fourth category denoting the non-use of contraception. In the model time is included as a dummy variable for each postpartum period month. I used the discrete-time approach because it allows for a straightforward inclusion of time-varying covariates which are important for the design of this study. I specified the model as the multinomial logistic regression (Steele 2005) and conducted the analysis in Stata 15 (StataCorp 2015). The main explanatory variables in the model are the contraceptive use before pregnancy (four-category variable: non-use and three groups of methods, as specified above), birth intention status (binary variable: unintended or intended) and an interaction term between these two variables.

The model is formulated as follows:

$$\log\left(\frac{h_{rti}}{h_{0ti}}\right) = \alpha_{rt} + \beta_r^{`} x_{ti} \quad , \quad r = 1,2,3$$

r - type of the first method initiated after birth: (1) traditional and barrier methods, (2) pills and injections, (3) IUDs, implants and sterilization

h_{rti} - hazard of adopting a method r at time t of women i after birth

h_{0ti} - hazard of continuing non-use of contraception after birth at time *t* of women *i*

α_{rt} - baseline hazard – a step function

$\beta_r^{`} x_{ti}$- vector of coefficients estimated separately for each method *r*, associated with set of explanatory variables (might be time-varying)

Such defined model consists of three equations, each contrasting the risk of initiation of one type of method with the risk of continued non-use of contraception after birth.

I included the following variables in the models: (i) socioeconomic: household wealth index, region and type of place of residence, education level; (ii) demographic: ethnicity, age at birth, birth order, union status, whether the birth was singleton or multiple, preceding birth interval, time since birth to interview; (iii) postpartum behaviour (time-varying covariates): breastfeeding status, return to sexual activity, postpartum amenorrhea. Factors in (i) and (ii) are known to be associated with the likelihood of an unintended pregnancy, contraceptive use and type of method choice (e.g. Adetunji 1998; Curtis and Blanc 1997; DaVanzo et al. 1989; Grady et al. 1989; Steele and Diamond 1999). Therefore, they might have a confounding effect on the main relationship of interest. Variables in (iii) are important for not only the uptake of contraception postpartum (return to sexual activity and postpartum amenorrhea) but also the type of contraceptive method adopted (breastfeeding status) (Becker and Ahmed 2001; Gebreselassie, Rutstein, and Mishra 2008).

I fitted separate models for Colombia and Peru. The models for both countries are the same, with one exception. As discussed in the previous sections and later shown in the results, the use of IUDs, implants and sterilization in Peru is very low. This restricts the possibility of including this group of methods in the competing risks model. Women who used these methods were included in the transition matrices analysis but excluded from the

multivariate analysis for Peru (5.9% of women). This entails omitting a group of the most effective method users there, who tend to be older, better educated, live in wealthier households and speak Spanish. How this affects the comparative nature of this study is explained in the discussion. Consequently, when describing the results of the multivariate analysis, I refer to IUDs, implants and sterilization as the most effective methods within the method mix for Colombia. For Peru, I considered pills and injections to be the most effective methods of the method mix.

When using the competing risk models, two additional aspects should be mentioned. First, using the multinomial logistic regression is only one way through which competing risk event history model might be specified. An alternative approach involves modelling the competing risks through a set of separate logistic models, one for each type of event. In such case, in a model for a given type of event other events are treated as censored. The estimates from such model describe the theoretical risk of an event of a given type, if all types of events other than the one modelled were absent (Steele 2005). In this study the multinomial logit model is preferred -- it allows me to estimate not the theoretical but the actual, observed rates of contraceptive method adoption in the sample, which is of main interest here. Nevertheless, to check the robustness of the analyses to the model choice, I examined whether the results would differ if the analysis was conducted using this alternative approach. The conclusions of interest remain unchanged.

The second important aspect to consider are the model's assumptions, in particular the independence assumption. The "independence of irrelevant alternatives" (IIA) assumption in the context of the competing risk models means that, conditional on covariates, the probability of one event happening, relative to no event happening is independent of the probability of each of the other events occurring, relative to the occurrence of no event (Hill et al. 1993). In the study of many demographic phenomena the IAA assumption is difficult to satisfy. Usually, the competing risks are likely to be correlated, such as in the case of for example study of deaths from different causes, transitions to different type of unions or, as done here, contraceptive-related transitions. In this study the IAA assumption means that the probability of use of a given type of contraceptive method relative to non-use is uncorrelated with a probability of using a different contraceptive method relative to non-use. Whether the IAA assumption is satisfied cannot be formally tested, but it is reasonable to think that the contraceptive use transitions will be correlated with each other.

Since this dependence is conditional on covariates, I control for a wide range of socioeconomic and demographic characteristics which might be associated with contraceptive method choice, as described above. I considered other model specifications, but there are no obvious alternatives which would allow me to examine the processes of interest. Although some modelling strategies to account for the correlation between the competing outcomes have been suggested, these have been developed in the context of two competing risks only (Box-Steffensmeier and Jones 2004).

2.7. Results

2.7.1. Descriptive analysis

In both countries, there is a strong association between unintended childbearing and demographic and socioeconomic characteristics (Table 2.2). For example, in Colombia, while 62.5 per cent of births among women with no education were unintended, this percentage was 41.6 among women with higher education. In both countries women who belong to indigenous groups, poorer households or live in rural areas are more likely to report an unintended birth. Unintended births occur more frequently among single women and those whose preceding birth interval was shorter. Youngest and oldest women are more likely to experience unintended births; unintended births occur more frequently at highest parities.

Table 2.2. Per cent of births reported as unintended by demographic and socioeconomic characteristics (%), Colombia and Peru

	Colombia	Peru		Colombia	Peru
Education* **			**Preceding birth interval*** **[9]		
no education	62.5	73.0	<18 months	73.7	72.8
primary	60.4	62.5	18-36 months	69.5	68.3
secondary	55.4	57.4	>36 months	43.4	49.2
higher	41.6	46.8			
Ethnicity (Colombia/Peru)* **			**Age at last birth*** **		
Native Colombian / Indigenous language speaker	61.7	68.9	<20	66.1	69.0
Black / -	59.0	-	20-29	52.4	54.7
Other / Spanish speaker	52.7	55.5	30-39	47.5	53.3
			40-49	61.2	67.9
Wealth index* **			**Birth order*** **		
poorest	61.1	65.6	1	49.7	52.0
poorer	54.5	60.2	2	47.2	47.6
middle	53.5	51.4	3	61.5	57.4
richer	46.9	50.9	4+	70.7	74.5
richest	41.6	46.3			
Union status* **			**Residence*** **		
never in union	72.5	75.8	urban	52.1	53.4
married	40.1	54.3	rural	59.5	62.6
cohabiting	53.7	55.7			
formerly in union/not living together	62.3	62.9			
			Total % unintended	**54.7**	**57.2**

*** p <0.001, association between the birth intention status and a given characteristic significant in the chi-square test

Source: Author's calculations from CDHS 2010, PDHS 2012

In both countries, more women used contraception before unintended, than before intended pregnancy (Tables 2.3 and 2.4, last columns). In Peru, women were more likely than in Colombia to use a method before unintended pregnancy. Almost half of those who reported an unintended birth there used traditional and barrier methods. This pattern reflects the specificity of the method mix in Peru, where more women use family planning methods before unintended pregnancy, but due to the use of the least effective methods, the contraceptive failure levels are also higher. Greater traditional and barrier methods use in Peru is also observed after birth. The main difference between the two countries is in

[9] For women whose birth of interest was of order 1, the preceding birth intervals denotes the time from first sex to first birth.

the postpartum use of IUDs, implants and sterilization. In Colombia, after pills and injections, these are the most popular methods; in Peru, their use both before and after pregnancy is low.

The method distribution postpartum differs by birth intention status in both countries (Tables 2.3 and 2.4, last rows). Compared to an intended birth, after an unintended birth, more women remain non-users, but fewer of them initiate traditional and barrier methods. Moreover, they are slightly more likely to start using methods of highest effectiveness (IUDs, implants and sterilization in both countries and pills and injections in Peru). This indicates a reversal of the pattern observed regarding the contraceptive behaviour before pregnancy.

Table 2.3. Transition matrices – percentage distribution of the first method used within 12 months of birth (destination method), given the last method used before pregnancy (origin method), Colombia (%)

origin method	**destination method**				
intended	non-use	traditional/ barrier	pills/ injections	IUDs/implants /sterilization	Total (% origin method)
non-use	**20.9**	18.7	36.1	24.2	100.0 (59.6)
traditional/barrier	12.7	**43.3**	22.4	21.5	100.0 (15.9)
pills/injections	9.6	14.7	**50.6**	25.2	100.0 (20.2)
IUDs/implants	8.5	10.4	23.1	**58.0**	100.0 (4.3)
Total	16.8	21.4	36.4	25.4	100.0 (100.0)
unintended	non-use	traditional/ barrier	pills/ injections	IUDs/implants/ sterilization	Total (% origin method)
non-use	**30.3**	13.7	32.1	24.0	100.0 (49.3)
traditional/barrier	14.5	**32.8**	27.8	24.9	100.0 (22.6)
pills/injections	11.8	14.4	**41.0**	32.8	100.0 (25.3)
IUDs/implants	11.7	14.4	24.5	**49.3**	100.0 (2.9)
Total	21.5	18.1	33.2	27.1	100.0 (100.0)

Note: The row percentages are obtained from the multiple-decrement life tables. The percentages in the last column in parentheses relate to the percentage of women in the sample using a given type of contraceptive method before pregnancy

Source: Author's calculations from CDHS 2010, PDHS 2012

Table 2.4. Transition matrices – percentage distribution of the first method used within 12 months of birth (destination method), given the last method used before pregnancy (origin method), Peru (%)

origin method	**destination method**				
intended	non-use	traditional/ barrier	pills/ injections	IUDs/implants/ sterilization	Total (% origin method)
non-use	**18.6**	32.2	44.5	4.8	100.0 (52.8)
traditional/barrier	12.9	**59.3**	23.3	4.4	100.0 (31.6)
pills/injections	6.7	21.1	**67.5**	4.7	100.0 (14.9)
IUDs/implants	8.3	25.0	41.7	**25.0**	100.0 (0.8)
Total	15.0	38.8	41.4	4.8	100.0 (100.0)

unintended	non-use	traditional/ barrier	pills/ injections	IUDs/implants/ sterilization	Total (% origin method)
non-use	**26.3**	21.5	46.5	5.7	100.0 (30.3)
traditional/barrier	16.2	**43.0**	35.8	5.0	100.0 (49.3)
pills/injections	10.6	22.5	**58.4**	8.4	100.0 (20.1)
IUDs/implants	8.3	41.7	50.0	**0.0**	100.0 (0.4)
Total	18.2	32.3	43.7	5.9	100.0 (100.0)

Note: The row percentages are obtained from the multiple-decrement life tables. The percentages in the last column in parentheses relate to the percentage of women in the sample using a given type of contraceptive method before pregnancy.

Source: Author's calculations from CDHS 2010, PDHS 2012

In both countries, compared to an intended birth, after an unintended birth a smaller percentage of women who discontinued contraception before pregnancy returns to the same method postpartum (bolded in the tables). For both birth intention status groups, previous users of traditional and barrier methods in both countries and pills and injections in Colombia are more likely to switch to a more effective, rather than less effective methods. This pattern is however more pronounced after an unintended birth in both countries. For example, in Colombia, 22% of previous traditional and barrier users initiated pills and injections after an intended birth; among women who reported an unintended birth it was 28%. In Peru, the corresponding percentages were 23% vs. 36%, respectively.

The switching to a more effective practice after an unintended birth occurs to a larger extent in Colombia than in Peru. After an unintended pregnancy resulting from discontinuation of pills and injections in Peru a higher percentage of women initiates IUDs, implants and sterilization than after an intended pregnancy. However, in general, more women use methods of lower effectiveness.

A distinct pattern is observed among women who before pregnancy discontinued IUDs and implants in both countries. After an unintended birth, more women change their contraceptive practice to a less effective one than after an intended birth. As IUDs and implants have very low failure rates, women most likely abandoned these methods and subsequently experienced an unintended pregnancy. Particularly striking is that none of the women who discontinued these methods before unintended pregnancy in Peru used these methods or sterilization postpartum. For both birth intention status groups, the shift to a less effective practice after the use of these methods is more pronounced there than in Colombia. These results should be interpreted while keeping in mind the small percentage of women who used the most effective methods in Peru.

Transition matrices show that there exists a more distinct pattern of contraceptive behaviour change for women who reported an unintended birth, except for previous non-users. In Colombia, women who experienced an unintended pregnancy following method non-use are less likely to adopt any type of contraceptive methods, compared to women who had an intended pregnancy. In Peru, they are substantially less likely to use traditional and barrier methods.

2.7.2. Multivariate analysis

There exists a strong association between the type of method used before pregnancy and after birth (Table 2.5). In both countries, the risk of initiating postpartum the same method as used before pregnancy is the highest. When tested with the likelihood ratio test, the interaction term between the variables describing the contraceptive use before pregnancy and birth intention status is statistically significant[10]. This means that the association between preconception and postpartum contraceptive use differs depending on whether a birth was intended or not.

[10] p-value < 0.001 for the comparison of the nested models with and without the interaction term. Throughout this study I consider the associations to be statistically significant at the conventional level of < 0.05.

Table 2.5. Competing risk hazard models: relative risk ratios for the initiation of a given type of method after birth, Colombia and Peru

	Type of method initiated after birth					
Variables	**Traditional/ barrier vs. non-use**		**Pills/injections vs. non-use**		**IUDs/implants/ sterilization vs. non-use**	
	Colombia RRR	**Peru RRR**	**Colombia RRR**	**Peru RRR**	**Colombia RRR**	**Peru RRR**
Birth intention status (BIS)						
Intended	1.00	1.00	1.00	1.00	1.00	-
Unintended	0.82**	0.73**	0.91†	1.03	1.06	-
Method before pregnancy (MBP)						
none	1.00	1.00	1.00	1.00	1.00	-
traditional/barrier	3.12***	2.17***	0.74***	0.60***	1.00	-
pills/injections	1.09	1.08	1.82***	2.12***	1.12	-
IUDs/Implants	0.91	-	1.19	-	2.33***	-
Interaction: BIS*MBP						
unintended*none	1.00	1.00	1.00	1.00	1.00	-
unintended*traditional/barrier	1.05	1.12	1.45***	1.57***	1.14	-
unintended*pills/injections	1.23†	1.31	0.88	0.78*	1.15	-
unintended*IUDs/implants	1.54	-	1.06	-	0.65*	-
Region (Colombia / Peru)						
Atlantica / Lima Metropolitana	1.00	1.00	1.00	1.00	1.00	-
Oriental / Resto Costa	1.38***	0.87†	1.53***	0.75**	1.22**	-
Central / Sierra	1.36***	0.64***	2.35***	0.58***	0.97	-
Pacifica / Selva	1.40***	0.76*	1.90***	0.70**	1.27***	-
Bogota / -	1.21†	-	1.54***	-	1.45***	-
Territorios / - Nactionales	1.20*	-	1.91***	-	0.90†	-
Residence						
Urban	1.00	1.00	1.00	1.00	1.00	-
Rural	0.89†	0.87†	1.18***	0.95	0.93	-
Education						
No Education	1.00	1.00	1.00	1.00	1.00	-
Primary	1.04	1.24	1.85***	0.88	1.29†	-
Secondary	1.09	1.39*	2.15***	1.00	1.62***	-
Higher	1.25	1.71**	2.29***	0.83	1.90***	-
Ethnicity (Colombia / Peru)						
Other / Spanish speaker	1.00	1.00	1.00	1.00	1.00	-
Native Colombian / Indigenous lang. speak.	0.73***	0.89	0.49***	0.61***	0.52***	-
Black / -	0.79**	-	0.77***	-	0.70***	-

Wealth index						
Poorest	1.00	1.00	1.00	1.00	1.00	-
Poorer	1.07	1.09	1.16**	1.17*	1.49***	-
Middle	1.12	1.21†	1.20**	1.17†	1.48***	-
Richer	1.11	1.14	1.16†	0.97	1.76***	-
Richest	1.04	1.28†	1.20†	0.89	1.77***	-
Age at last birth						
>20	1.00	1.00	1.00	1.00	1.00	-
20-29	0.99	1.11	0.82***	0.72***	1.04	-
30-39	1.18†	1.36**	0.64***	0.56***	1.52***	-
40-49	1.23	1.36†	0.54***	0.36***	1.62***	-
Birth order						
1	1.00	1.00	1.00	1.00	1.00	-
2	1.05	0.85*	0.86***	0.99	3.58***	-
3	1.00	0.80*	0.83**	0.88	5.31***	-
4+	0.93	0.68***	0.82**	0.83*	4.31***	-
Multiple birth						-
No	1.00	1.00	1.00	1.00	1.00	-
Yes	1.01	1.57†	1.32	1.23	2.66***	-
Union status						
Never in union	1.00	1.00	1.00	1.00	1.00	-
Married	2.96***	2.60***	2.44***	2.59***	1.64***	-
Cohabiting	2.35***	2.42***	2.34***	2.88***	1.43***	-
Other	1.07	1.40†	1.36***	2.03***	1.03	-
Time since birth	0.99***	0.99***	0.99***	1.00	1.00*	
Preceding birth interval						
<18 months	1.00	1.00	1.00	1.00	1.00	-
18-36 months	0.99	0.76**	0.96	0.79**	0.94	-
>36 months	1.13	0.80*	1.01	0.79**	0.96	-
Breastfeeding (TVC)	1.15†	1.39*	1.09	1.12	0.97	-
Sexually active (TVC)	3.44***	18.38***	2.54***	10.04***	2.00***	-
Amenorrheic (TVC)	0.83***	0.37***	0.64***	0.31***	0.66***	-

[a] Reference category has a relative risk ratio of 1.00
[b] -outcome not considered for Peru
[c] Dummy variables for each month postpartum month (duration since birth) omitted from the output
[d] TVC – time varying covariate
†p<0.10; *p<0.05; **p<0.01; ***p<0.001

Source: Author's calculations from CDHS 2010, PDHS 2012

The relative risk ratios in Table 2.6 show the difference between the birth intentions status groups in the risk of initiating a given type of method, compared to not initiating any method postpartum, by the type of method used before pregnancy. These are obtained from the models presented in the Table 2.5. The inclusion of the interaction term allows for the calcualtion of these relative risk ratios for all categories of the variable describing the pre-pregnancy contraceptive use.

Table 2.6. Competing risk hazard models: relative risk ratios for the initiation of a given type of method after birth, Colombia and Peru

		Type of method initiated after birth					
Method before pregnancy	**Birth intention status**	**traditional/ barrier vs. non-use**		**pills/injections vs. non-use**		**IUDs/implants/ sterilization vs. non-use**	
		Colombia RRR	**Peru RRR**	**Colombia RRR**	**Peru RRR**	**Colombia RRR**	**Peru RRR**
non-use	intended	1.00	1.00	1.00	1.00	1.00	-
	unintended	0.82**	0.73***	0.91†	1.03	1.06	-
traditional/ barrier	intended	1.00	1.00	1.00	1.00	1.00	-
	unintended	0.86†	0.82**	1.32**	1.63***	1.21†	-
pills/injections	intended	1.00	1.00	1.00	1.00	1.00	-
	unintended	1.01	0.96	0.81**	0.81*	1.22*	-
IUDs/implants	intended	1.00	-	1.00	-	1.00	-
	unintended	1.27	-	0.97	-	0.69*	-

[a] Based on the models in Table 2.5
[b] Reference category has a relative risk ratio of 1.00
[c] -outcome not considered for Peru
†p<0.10; *p<0.05; **p<0.01; ***p<0.001

Source: Author's calculations from CDHS 2010, PDHS 2012

The results are consistent with the patterns observed in the transition matrices for women who used contraception before pregnancy. In Colombia, after an unintended pregnancy which resulted from the discontinuation of traditional and barrier methods women have a higher risk of initiating pills and injections, than after an intended pregnancy. After an unintended pregnancy following the use of pills and injections women are less likely to start using these methods postpartum than after intended pregnancy; they are more likely to adopt IUDs, implants and sterilization. In Peru women who discontinued traditional and barrier methods before unintended pregnancy have a lower risk of initiating

them after birth than those who had an intended pregnancy; they have a higher risk of initiating pills and injections. These results confirm that unintended pregnancy which occurred after the discontinuation of the methods of lower effectiveness is associated with a higher uptake of more effective methods postpartum, compared to an intended pregnancy.

Women who before unintended pregnancy used methods of the highest effectiveness within each country's method mix are less likely to return to using them, than after intended pregnancy. In Colombia, the odds of the risk of initiating IUDs, implants and sterilization for previous IUD and implant users are 31% lower after an unintended birth. In Peru, the odds of the risk of using pills and injections for previous users of these methods are lower by 19% after unintended birth. These results confirm that after an unintended birth women are less likely to re-initiate the highly effective methods which they used before pregnancy, compared to women who reported an intended birth.

Controlling for covariates, women who did not use any method before an unintended pregnancy are as likely to start using pills and injections, IUDs, implants and sterilization after birth, as women who reported an intended birth. This means that after an unintended pregnancy following the non-use women are similarly likely to initiate methods of higher and highest effectiveness, as women who reported an intended birth. Women who did not use contraception before unintended pregnancy are however less likely to start using traditional and barrier methods in both countries. The lower uptake of traditional and barrier methods' practice might be related to the fact that the use of these methods depends on both women and their partners. Consequently, this pattern might reflect the fact that some women might not be able to negotiate, for example, the use of condoms or withdrawal (Raguz 2009; Wurtz 2012). Alternatively, it might reflect a preference against the use of the coital dependent methods.

2.8. Discussion

This study sheds light on the factors associated with contraceptive method choice and change, as well as the determinants of postpartum contraceptive uptake, and consequently contributes to the body of knowledge about contraceptive use dynamics. The strength of the analysis is the use of detailed, longitudinal contraceptive histories

from the DHS calendar. The results show the importance of going beyond the study of the contraceptive behaviour at one point in women's reproductive lives in order to gain a better understanding of contraceptive practices. This paper demonstrates that when studying method choices postpartum it is important to take into account women's past contraceptive use. Moreover, in spite of their known and unquestionable limitations, the retrospective pregnancy intentions are an important determinant of postpartum contraceptive use. These two factors, but in particular the past contraceptive use, have been largely ignored in previous studies. I show the utility of the DHS calendar which is well suited for such analyses, yet remains an underused source of reproductive histories.

There are four key findings from this study. First, there exists a strong pattern of staying postpartum with the same method as used before pregnancy, but this association is weaker among women who reported an unintended birth. Among users of less effective methods before unintended pregnancy, the method switching occurs towards a more effective contraceptive practice postpartum. Moreover, controlling for socioeconomic and demographic characteristics, women who did not use contraception before an unintended pregnancy are similarly likely to initiate methods of high effectiveness after birth, as women who reported an intended pregnancy. This study supports the hypothesis that an unintended birth experience is associated with contraceptive behaviour change in Colombia and Peru. These results differ from the conclusions of the previous study conducted in the US which found no association between the unplanned pregnancy and contraceptive practice change (Orcutt and Cooper 1997). This finding is important as it means that the results of studies conducted for high-income countries might not necessarily be generalizable to other settings. The results for Colombia and Peru suggest that after an unintended pregnancy resulting from a less effective contraceptive practice women seek more effective means to prevent future pregnancies and are able to obtain them.

The second important finding from this study is worrisome. The results suggest that women who used the most effective methods within each country's method mix before unintended pregnancy were less likely to re-initiate them postpartum. This study uncovers that the previous dissatisfaction not only with less effective, but also more effective contraceptives might discourage their use after birth. The past use of methods of higher effectiveness might indicate that already before unintended pregnancy these women showed a higher motivation to avoid pregnancy, but they discontinued use for

some reason other than to become pregnant. Previous studies found that the short-acting hormonal methods and LARCs are mainly discontinued due to side effects and health concerns (Bradley, Schwandt, and Khan 2009). Unintended pregnancies resulting from such discontinuation might indicate an unmet need for more information about the concerns related to the specific method use or a wider choice of methods (Barden-O'Fallon, Speizer, and White 2008). Consequently, a lower uptake of these methods after an unintended, than after an intended pregnancy, is concerning. It suggests that women who want to use highly effective means to prevent pregnancy might not be receiving enough information about the possible side effects they might experience and this leads to the abandonment of these methods altogether.

In both countries, antenatal visits and postpartum check-ups could be used as an opportunity to provide information to address the problems which led to the discontinuation of these highly effective methods, in particular among women who report unintended pregnancies. The use of services during which these methods can be discussed and potentially obtained for free as part of national health systems is almost universal in Colombia and Peru. At the same time, however, there remain barriers which might impede women's access to these methods after birth in both countries. As discussed in the Context section 2.4, a limited number of health facilities provides LARCs in Colombia and Peru; in Peru not all LARCs are available as part of the health system's contraceptive method offer (Chávez and Távara 2010; Ward, Santiso-Gálvez, and Bertrand 2015). It is likely that if the highly effective methods are not readily available in health facilities, the opportunities for contraceptive counselling are also limited. The results from this study highlight a need to strengthen the postpartum family planning programmes in both countries.

Third, the comparison of Colombia and Peru provides insights into how contraceptive use dynamics can share similarities, but can also differ in two distinct contraceptive method mix, family planning and cultural settings. Transition matrices showed a higher level of method switching after an unintended birth in Colombia than in Peru, in particular to a more effective practice. In settings without a broad method availability, in case of discontinuation the possibilities of switching to an alternative method might be limited (Kost 1990). Therefore, this pattern likely reflects a wider range of methods available and practiced in Colombia. A small number of women in Peru used LARCs and permanent methods. Because of this, it was not possible to study in the multivariate analysis whether after

unintended pregnancy due to discontinuation of pills and injections women are more likely to start using LARCs and sterilization. This cannot be ruled out given the results from transition matrices and is a limitation for the comparative nature of this analysis. Nevertheless, according to transition matrices overwhelmingly more women who discontinued pills and injections before unintended pregnancy in Peru start using less effective methods postpartum. This is contrary to the findings for Colombia. The low use of methods at the highest end of effectiveness in Peru might be related not only to availability and access, but also contraceptive preferences and acceptability of these methods. This could be related to two factors: the large percentage of the population of indigenous origin and the history of sterilization programme in the country, with accusations that the procedure was performed without informed consent during the 1990s (Aramburú 2014). Nevertheless, an important point to make is that none of the women in Peru who discontinued IUDs and implants before unintended pregnancy returned to using them postpartum. This suggests that there exists a broader problem with the provision, accessibility or information about these methods in Peru.

The results presented in this paper underline the need for more studies investigating and disentangling the mechanisms through which unintended pregnancies could be associated with a change in contraceptive behaviour. In order to better meet the contraceptive needs of women who experience unintended pregnancies, it is imperative to further understand what factors determine method switching, both to a more and to a less effective practice, across various low- and middle-income settings with differentiated accessibility and acceptability of contraceptive methods.

Lastly, the transition matrices showed that in spite of a higher level of method switching after an unintended birth, many women go back to the same method postpartum. This highlights the importance of understanding and addressing the reasons for discontinuation of these methods when providing family planning information pre- and postpartum to facilitate their future consistent and continued use. This could help to ensure that these methods are not discontinued for the same reason again, which would expose women to the risk of subsequent unintended pregnancy or short inter-pregnancy intervals. It is also important to understand in greater depth why women who did not use contraception before unintended pregnancy are less likely to adopt coital dependent methods. The results from this study might mean that some women might find the use of these methods difficult, for example because of the lack of bargaining power, or simply

inconvenient. These barriers or preferences might have persisted, in spite of the unintended pregnancy experience.

This study has limitations. I could not address the causal relationship between the unintended birth experience and the contraceptive use behaviour change - the focus here has been on exploring the association between these two processes. This fact does not compromise the objectives of this study and, in particular, the discussed importance of its findings. Moreover, I used the simplest definition of unintended childbearing and could not address the issue of the intensity of the pregnancy intentions. The complexity of the analysis and limited sample sizes did not allow for disaggregating unintended births into more detailed categories, for example, mistimed and unwanted or those resulting from contraceptive failure and method abandonment. Moreover, due to the lack of longitudinal information, the socioeconomic variables used in the study are recorded at the time of the survey, not pregnancy. This has to be kept in mind while interpreting the results, but it is not very likely that the values of these variables changed substantially during the short period of observation used in this study. Lastly, the improved contraceptive practice might be related to simply a more consistent and effective use of the same method. This aspect could not be studied with existing contraceptive histories.

In spite of these limitations, the study extends knowledge about contraceptive use dynamics in Latin America. As a direction for further research, more analyses for other countries in the region with available calendar data could be conducted. Colombia and Peru are two examples of very different contraceptive settings, both of which are however characteristic of other countries in Latin America. For example, the contraceptive method mix in Peru is very similar to that observed in Bolivia. The distribution of contraceptive methods used in Colombia on the other hand is very similar to that of Brazil or Dominican Republic. Future research could explore whether the patterns of contraceptive behaviour observed in Colombia and Peru could be generalized to other settings in the region with similar features related to women's contraceptive practices.

3. Increasing educational disparities in the timing of motherhood in the Andean region: A cohort perspective[11]

Abstract

In spite of a peculiar pattern of the age at first birth in Latin America, there is a lack of research about the long-term trends in the timing of transition to motherhood at all stages of women's reproductive lives and across countries in the region. This paper examines the evolution of educational disparities in the age at first birth during the fertility transition in three Andean-region countries: Ecuador, Colombia and Peru. Using birth history information available for the first time in the latest Population and Housing Censuses, I estimate the first-birth age-specific probabilities disaggregated by various measures of education level, for cohorts born between 1945 and 1980. In all countries, educational expansion was accompanied by the increasing probability of first birth before the age of 20 among women with below completed higher education, but the most drastic change occurred among women who drop-out of secondary school. Concurrently, the first-birth rates at the age of 20-29 decreased for women who achieved higher education; an evidence of an increase in the rates above the age of 30 among them has emerged. A pronounced divergence in the first-birth timing between the educational groups occurred during the fertility transition. Comparison of a relative and an absolute educational level classification shows that the increasing disparities between the lowest and the highest educated women were equally pronounced even when accounting for the changes in educational composition across cohorts. This paper discusses the potential factors behind the polarization in the age at first birth in the region. It argues that there is a need for policies encouraging not only secondary school entrance but also secondary school completion in the context of substantial educational expansion and high levels of school drop-out observed in the region.

[11] The microdata from the Population and Housing Censuses used in this study were provided by the statistical offices of the respective countries. I gratefully acknowledge Departamento Administrativo Nacional de Estadística (DANE), Instituto Nacional de Estadística e Informática (INEI) and Instituto Nacional de Estadística y Censos (INEC) for making the data available for this project. The author alone is responsible for the data analysis and the interpretation of the results.

3.1. Introduction

The changes in the timing of motherhood in Latin America received considerable attention due to increases in teenage fertility in the region (e.g. Rodríguez 2013; Rodriguez Vignoli 2014, 2017; Rodríguez Vignoli and Cavenaghi 2013). However, beyond changes in adolescent motherhood, little is known about the long-term cohort trends in the age of first birth. In particular, the variation in these trends by measures of socioeconomic status, between the countries in the region and throughout the fertility transition remains unexplored.

Examining these processes is particularly relevant in the Latin American context. The region has long been characterized by stark inequalities in economies, labour markets and between social strata. These inequalities are reflected in very different patterns of reproductive behaviour between population groups (ECLAC 2011). Moreover, there has been growing evidence of an increasing polarization in the motherhood timing within Latin American countries, attributed to the substantial differences in the age at first birth between the educational strata (Lima et al. 2018; Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018). However, compared to other global regions (e.g. McLanahan 2004; Rendall et al. 2009, 2010), little evidence exists about the evolution of the differences in the timing of motherhood over women's reproductive lives and by measures of socioeconomic status for Latin America. The existing studies which looked at the long-term trends in the age at first birth disaggregated by education level are single-country studies, covering different time periods, using different education level classifications and measuring age at first birth in a different way (Batyra 2016 for Colombia; Miranda-Ribeiro and Garcia 2013 for Brazil; Nathan 2015 for Uruguay). There is currently no research which looks at how the educational disparities in the age at first birth changed across Latin American countries throughout the fertility transition. Moreover, the geographical scope of the existing studies about the age at first birth in general in the region is limited to the countries with the lowest levels of total fertility rate (TFR).

The study of the long-term changes in the age at first birth by education can help us understand the extent to which motherhood, and its social and economic costs, have been shifting between the social strata throughout the fertility transition in the region. Moreover, a better understanding of whether the processes share similarities between countries, can shed light on their determinants.

The objective of this paper is to examine the cohort trends in the educational disparities in the age at first birth during the fertility transition in Latin America, in a cross-country comparative perspective. Using census data, I estimate the first-birth age-specific probabilities, disaggregated by various measures of educational level, for cohorts of women born between 1945 and 1980 in three countries of the Andean region: Ecuador, Peru and Colombia. The study uses a question about the age at first birth, available for the first time in the latest census for each of these three countries. The use of the birth history information from these censuses allows for the estimation of the first- birth age-specific schedules and a detailed examination of the long-term trends in the age at first birth. This piece of information has not been previously utilized to explore the timing of childbearing in Colombia, Peru and Ecuador. Using these censuses, I investigate three understudied aspects of changes in the age at first birth in Latin America.

First, I analysed these processes from a cohort perspective and encompassed women starting from those who entered their reproductive life at the time of the beginning of the fertility transition in the three countries. The cohort approach is particularly suited to study the changes in the timing of childbearing by education level and throughout the fertility transition in the region. The rapid fertility decline in the region since the 1960s has been accompanied by a vast educational expansion (Rios-Neto and Meireles Guimarães 2014). Such expansion means that the consecutive cohorts of women entering school could have been exposed to different educational systems and different levels of quality of teaching. These aspects as well as the size of the population entering and finishing a given educational level influence labour market opportunities (Ryder 1965). This factor is known to be closely related to the timing of motherhood. Therefore, the cohort approach to the analysis of the age at first birth can facilitate the search for explanations of the observed changes in reproductive behaviour in the region.

The second contribution of this research is the comparison in the analysis of various measures of education level. First, I study in detail the variation in the patterns of first birth among women with intermediate levels of education - I compare women who complete and drop-out of secondary school. Second, I classify women according to their educational attainment as well as a measure which takes into account the changes in the educational composition across cohorts, and I compare the results. These analyses cast light on the factors behind the changing educational disparities in the timing of motherhood in the

context of high levels of school drop-out and substantial educational expansion observed in the region (Kattan and Székely 2015).

The third novelty of this research is the focus on the countries of the Andean region, which remains an understudied geographical area within the research about the age at first birth in Latin America. The studies on the topic in general for the region have been so far concentrated on countries such as Brazil, Uruguay and Chile (e.g. Lima et al. 2018; Nathan, Pardo, and Cabella 2016; Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018). Consequently, this paper advances the understanding of the regional variation in the age at first birth in Latin America.

3.2. Context of the Andean region: the cases of Ecuador, Peru and Colombia

The TFRs in Ecuador, Peru and Colombia declined in the last half of the century to the level close to replacement (from the level of almost 7 in 1950 to 2.1 in Colombia, 2.5 in Peru and 2.6 in Ecuador in 2010) (United Nations 2017). The TFR change in the three countries started later and from a higher level than in the countries of the Southern Cone. Although the initial levels were similar to those of Brazil, the change proceeded there at a slower rate (Chackiel and Schkolnik 1996).

The three countries are characterized by high levels of social and economic inequalities. The Gini coefficients there in 2010 were above the Latin American average (Cornia 2014a). Between the 1950s and 2000s, these countries experienced periods of increasing income inequalities, in particular during the recession of the 1980s (Adsera and Menendez 2011; Cornia 2014b). What distinguishes the Andean region from the other parts of Latin America is a substantial percentage of the population of indigenous origin who are more likely to belong to poorer households, receive less schooling and live in the rural and more remote parts of the countries. Moreover, a distinct characteristic of the three countries is a challenging geography which determines substantial social and economic inequalities between regions and urban-rural areas (Casterline and Mendoza 2009; Davis, Bilsborrow, and Gray 2015; Larrea and Freire 2002). These marked inequalities in Ecuador, Peru and Colombia are reflected in the very different patterns of reproductive behaviour between the population strata.

Education has been found to be one of the most important markers of the differences in fertility and timing of motherhood in the Andean region and Latin America more broadly (e.g. Castro-Martín and Juarez 1995; ECLAC 2011; Heaton and Forste 2009; Weinberger, Lloyd, and Blanc 1989), but these processes have also been differentiated by household income, ethnicity and place of residence (ECLAC 2005, 2011). There exists a strong association between all of these socioeconomic characteristics in Colombia, Ecuador and Peru. In particular, the income, regional and ethnic inequalities are reflected in inequalities in access to education and student performance. In order to understand the changing differences in the timing of motherhood by educational level, it is important to consider the factors behind the educational inequalities observed in these countries.

First, due to increasing coverage since the 1950s, the children from poorer households who were previously excluded from the educational system have been increasingly entering and completing primary and secondary school education (Bassi, Busso, and Muñoz 2013b; ECLAC 2010). However, this educational expansion put a strain on the educational systems and influenced the quality of teaching which varies largely by school and by place of residence. Consequently, the schools tend to be highly segregated by socioeconomic class (Murillo and Martínez-Garrido 2017), which has been suggested as related to the problem of the perpetuation of inequality in the region (Daude 2013; ECLAC 2010).

Second, although children from the more disadvantaged backgrounds have been increasingly starting secondary school, the completion rates among them are lower than those among wealthier socioeconomic groups. The educational expansion resulted in virtually universal primary school coverage in the three countries, but the secondary school attendance and completion rates have been lower (ECLAC 2010). The problem of secondary school grade repetition and drop-out in the region has been particularly pronounced (Kattan and Székely 2015), and is most common among the poorer, those living in rural areas and indigenous populations (ECLAC 2002, 2010). Moreover, completing university in that context is still something that is reserved for more privileged groups (ECLAC 2010; Hopenhayn 2012). In all three countries there is a wide range of private and public universities. These have varying tuition fees which at some institutions depend on the income of students' parents. However, the completion of a low quality secondary school education often limits the chances of students from poorer backgrounds to attend university (Carlson 2001; ECLAC 2010). The poor quality of secondary schools

among lower socioeconomic strata can contribute not only to lower chances of attending university, but also lower aspirations and incentives to complete secondary school at all (Kattan and Székely 2015).

3.3. Education and timing of motherhood in Ecuador, Peru and Colombia

Studies about the timing of childbearing by education level in Ecuador, Peru and Colombia have concentrated on examining changes in adolescent fertility. Teenage motherhood increased in the last decades and that change was most pronounced among women with lower and middle levels of education in all three countries (Bozon, Gayet, and Barrientos 2009; ECLAC 2011; Esteve and Florez-Paredes 2014, 2018; Rodríguez 2013; Rodriguez Vignoli 2014; Rodríguez Vignoli and Cavenaghi 2013).

One group of studies argues that these changes were driven by poverty and the low opportunity cost of early motherhood among less-educated women. That is, those who completed fewer years at school advanced motherhood due to their limited social mobility perspectives and future employment prospects (Azevedo et al. 2012; Flórez 2005; Flórez and Soto 2007; Gaviria 2000; Rodríguez Vignoli and Cavenaghi 2013). In particular, the high inequalities which characterize Latin America were suggested to contribute to the higher rates of adolescent motherhood compared to other regions of the world (Azevedo et al. 2012). Becoming a mother among the teenagers from more disadvantaged backgrounds and with lower levels of education has been suggested as a source of personal realization, a way to acquire social status and an alternative strategy in the face of a low likelihood of other important transitions in life (Ehrenfeld Lenkiewicz 2013; Flórez 2005; Gaviria 2000; Rosa et al. 2016; Steele 2011).

Other researchers pointed to the increasing levels of unintended childbearing among teenagers and the importance of the continued barriers to fertility regulation they face (Rodriguez Vignoli 2014, 2017). The authors argue that the less advantaged adolescents have limited access to contraception and sexual and reproductive health services and this results in high levels of early motherhood among them. Although the availability of the methods of family planning has been increasing, women in lower socioeconomic strata have continued to experience access-related difficulties (Kulczycki 2011).

There is only scant evidence about motherhood timing by education level beyond teenage fertility changes for Ecuador, Colombia and Peru. With the exception of the case of Colombia discussed in the next section, there is no research about how the pattern of the age at first birth changed over time within educational groups in the Andean countries.

This is an important gap in the knowledge. Ecuador, Peru and Colombia were part of the analyses of Rosero-Bixby et al. (2009) which identified increasing levels of childlessness among women aged 25-29 at the population level across Latin America between the 1990s and the 2000s The change was most pronounced in Colombia and Peru, but the evidence of an increase emerged in Ecuador as well. The authors argued that this processes reflected a weakening of the social imperative of early motherhood in the region more broadly. Therefore, the examination of the timing of childbearing in a more holistic way and beyond adolescent motherhood is important to understand the changes in the age at first birth in these three countries.

3.4. Changes in the educational disparities in the age at first birth in Latin America

Few studies examined the long-term changes in the educational differences in the age at first birth in Latin America. For Colombia a study showed that for the cohorts born after 1960, these disparities widened due to increasing risk of first birth among women who attended primary and secondary school and decreasing risk of first birth among women who entered higher education (Batyra 2016). For Brazil, Miranda-Ribeiro and Garcia (2013) documented a similar divergence between 1980 and 2010. While the mean age at first birth among women with less than 7 years of education decreased, it increased among those who had spent more than 12 years at school. For women with 8-11 years of education, there was a stability in the first birth pattern over time. Increasing disparities were also observed in Uruguay, where for women born after 1955 with the low education level the median age at first birth decreased. The corresponding median for women in the middle and high educational groups increased (Nathan 2015).

Two conclusions can be drawn on the basis of these studies. First, the trend towards earlier motherhood among the lowest educated women and the emerging motherhood postponement among the highest educated resulted in the divergence in the first-birth timing between these two educational strata. However, apart from documenting these

trends, the existing studies provide little discussion about what factors might be responsible for this divergence. Second, the results of these studies suggest that there hasn't been one pattern of change among women in the middle educational categories: in Brazil the age at first birth was stable, it increased in Uruguay and it decreased in Colombia. Nevertheless, these studies looked at different time periods, used different measures to study the changes in the age at first birth and classified education levels in a different way, which does not allow for their direct comparison. Consequently, it is not clear whether women with intermediate levels of schooling have been following the behaviour of higher educated ones or have continued to enter motherhood early in life, as women in the lower educational groups have.

3.5. Aims and contributions of this study

The aim of this paper is to examine the cohort trends in the educational disparities in the age at first birth in Latin America, focusing on three Andean region countries: Colombia, Ecuador and Peru. The specific research questions are: How have the educational disparities in the age at first birth changed during the fertility transition? Have these processes shared similarities between the countries? What could be the possible factors behind these changes?

To answer the first two research questions, I study cohorts of women born starting from 1945 who were entering their reproductive life at the beginning of the fertility transition in the 1960s. I examine how the probability of first birth has been changing among these cohorts across all stages of women's reproductive lives and disaggregate the trends by education level. By examining Ecuador, Colombia and Peru, this is the first study to compare the experiences of different countries with respect to the evolution of the educational differences in the patterns of the age at first birth and to examine these processes over the course of the fertility transition for Latin America. This contributes to the body of knowledge about motherhood timing not only in the Andean region, but in Latin America more broadly. Moreover, this study is the first to provide estimates of the first-birth age-specific schedules for the Andean region countries.

Answering of the third research question aims to shed light on the possible factors behind these changes. It should be noted that this study neither can, nor even attempt to,

disentangle the underlying causes of the changing disparities in the age at first birth in the region. By examining and discussing two aspects, (i) secondary school drop-out and (ii) changes in the educational composition of the population, this paper aims to cast light on some of the plausible determinants of these disparities.

First, I examine trends in the first-birth rates of women with intermediate level of schooling, focusing on secondary completion and drop-out. As described in the Context section 3.2, the non-completion of secondary school is a crucial problem in Latin America. However, no previous study has looked specifically at the changes in the timing of motherhood of women who enter but do not finish secondary school. Due to educational expansion, the secondary school entrants have become the biggest population strata in Latin American countries (Rios-Neto and Meireles Guimarães 2014). Therefore, it is increasingly important to understand the changes in the timing of childbearing among them. Moreover, it can be anticipated that due to the increase in the percentage of women who enter secondary school, this population group has been becoming more heterogeneous. While the prominence of the differences in motherhood timing between the lowest and the highest educated has been widely acknowledged, so far no attention has been paid to understanding the patterns of change in the age at first birth among women who enter secondary school. This aspect is also important since, as discussed in the previous section, the course of change in the motherhood timing among intermediate educated women in Latin America is not clear from the existing evidence.

Second, I cast light on the role of the changes in the educational composition of the cohorts in the process of increasing differences in the motherhood timing between the highest and the lowest educated women. From the existing evidence, it is clear that the reproductive behaviour of the lowest and the highest educated diverged in Latin America. It is also evident that a vast educational expansion occurred in the region. However, it is not known what role the changing educational composition of the population played in the changing differences in the age at first birth between these two population groups. Specifically, due to the educational expansion, women with few years of schooling in younger cohorts in Latin America have become a shrinking and an increasingly disadvantaged group (Rodríguez Vignoli and Cavenaghi 2013). Therefore, it is possible that the observed advancement of motherhood among women with the lowest educational attainment in the younger cohorts is to some extent driven by the fact that they have become an adversely select group. Consequently, the changing educational composition of

cohorts might be responsible to a certain degree for the increasing disparities in the age at first birth between the lowest and the highest educated women.

In order to explore this aspect, I use and compare two measures describing the level of education: (i) women's educational attainment and (ii) women's relative position within a cohort in terms of educational achievement -- a measure which varies depending on the educational composition of a given cohort.

Previous research has shown that the changes over time within educational groups in various demographic processes such as life expectancy (Bound et al. 2015) or teenage fertility (Esteve and Florez-Paredes 2018) might be attenuated when using a relative education classification, as compared to the fixed educational categories. In particular, the study of Esteve and Florez-Paredes (2018) concluded that changes in the rates of adolescent first-births within educational groups across cohorts have been more stable in Latin American countries when examined using the relative education classification. The results of the analyses for Colombia, Peru and Dominican Republic using Demographic and Health Surveys showed that this indeed has been the case for the middle educational groups. The findings for the most and the least educated women have been however inconclusive. First, the use of the relative education classification did not seem to result in the attenuation of the magnitude in the teenage first-birth rates' increases across cohorts among the least educated women. Nonetheless, the authors concluded that when the relative educational classification is used, women with the lowest and the medium levels of schooling had similar rates of transition to motherhood below the age of 18 across cohorts. Second, the patterns of change among the highest educated women differed between the countries. Since the focus of the study was to identify a broad pattern of differences in teenage first-birth rates' trends between the relative and the absolute educational measures, the results pertaining to the changes among the lowest and the highest educated women were not discussed. Moreover, in general the study was confined to the analysis of transition to motherhood by the age of 18; therefore, it did not examine the changes in the age at first birth more broadly.

In this study, I use census data to examine and to discuss in depth the extent to which the trends in the disparities in the rates of first birth between the lowest and the highest educated strata will differ when using the relative educational classification and the classifications describing women's educational attainment, at all ages. If these are of a

similar direction and magnitude, it will be an indication that the diverging first-birth pathways between the lowest and the highest educated have not been driven by the changing educational composition of the population.

The use of the information about the age at first birth from censuses allows for an examination of the changes in the timing of motherhood, without a problem of small sample sizes which accompanies the use of survey data. This is relevant if the aim is to disaggregate the long-term trends by age groups, cohorts and, in particular, detailed education-level measures. Importantly, the use of census data allows for the estimation of the first-birth age-specific schedules, providing a complete picture of the changes in the timing of childbearing. It also permits to conduct analyses for settings for which DHS survey data are not available, such as Ecuador.

3.6. Data

This study uses the Population and Housing Censuses for Ecuador (2010), Peru (2007) and Colombia (2005). I study countries of the Andean region for which the information about the timing of first birth is available in the latest census. The census for Ecuador has been obtained from the webpage database of the country's statistical office Instituto Nacional de Estadística y Censos (INEC 2010). The access to the censuses for Colombia and Peru has been obtained through personal communication with the respective statistical offices: Instituto Nacional de Estadística e Informática in Peru (INEI) and the Departamento Administrativo Nacional de Estadística in Colombia (DANE). The relatively more restrictive nature of the censuses for the countries covered by this research is presumably one of the reasons why they have not been previously used for the study of motherhood timing. Although the samples of these censuses are available through the Integrated Public Use Microdata Series (IPUMS), the main variable of interest for this study -- the age or year in which women had their first birth -- is not part of these samples.

The main advantage of using census data is that they cover the whole population of countries or a large population sample. For Ecuador and Peru all enumerated women aged 12+ were asked about their fertility history. For Colombia, the detailed fertility questions were part of the extended census questionnaire and were asked of a random sample of households. As a result around 21% of the population of women aged 12+ was interviewed.

The results in this study for Colombia are weighted estimates using the weights provided by DANE. The three censuses allow for a study of the long-term trends in the age at first birth since they are not restricted to women below the age of 49. Although using these data one could encompass women without age restriction, in this paper I confine the analysis to individuals up to the age of 65. The limitation of the use of retrospective information about fertility from any source is that women in a given cohort who died or migrated before the census date are not enumerated. Therefore, it needs to be assumed that mortality and migration are not selective by for example the number of children ever born and the age at first birth. For the oldest women these assumptions would most likely be increasingly violated. I restrict the analysis to women aged up to 65 as in all countries these women were born around the year 1945. This allows me to encompass with the analysis cohorts of women who were entering their reproductive life at that beginning of the fertility transition in the 1960s.

In the censuses for Ecuador and Peru, women were asked about their age at first birth; in Colombia, the question was about the year of first birth. In order to obtain the information about the age at first birth, I subtracted the year of each woman's first birth from the year of the census. I classified women into yearly birth cohorts using the variable describing women's year of birth for Ecuador and Colombia. Due to the unavailability of this information for Peru, I calculated women's year of birth by subtracting their age from the year of the census. I studied cohorts born between 1945 and 1980. I confined the analysis to women born until 1980, since in all of the countries they were at least 25 years old. It is reasonable to assume that the level of education does not considerably change beyond that age, since the typical age of graduation from university in all three countries is below the age of 25. This allows for the consistent comparison of the trends by education level between the cohorts and countries.

The final number of women in this analysis is 2,967,335 in Ecuador, 6,138,615 in Peru and 1,980,203 in Colombia.

3.7. Methods

To study the changes in the age at first birth, from each census I calculated the first-birth age-specific probabilities separately for each birth cohort. I divided the number of first births which occurred in a given age interval by the number of women who were still

childless at the beginning of that age interval and the length of the interval. These rates correspond to the hazard of first birth, which is the probability of first birth in a given age group among women at risk of first birth (Cleves et al. 2010). This approach allows for a study of the changes in the rates of transition to motherhood over women's reproductive lives and across cohorts. For each cohort I presented the final rates as the local average of the estimate for that cohort and the four nearest birth cohorts. For example, the rate of first birth at age 20-24 for the 1950 cohort is the average of the rates for that age group for cohorts of women born between 1948 and 1952. The analyses for this paper were conducted in Stata 15 (StataCorp 2015).

I calculated these rates for the total population and for educational groups. I classified women according to the stages of each country's educational system. This allows for the examination of how the timing of transition to motherhood has been changing within the actual educational strata. This is important in order to interpret the findings within the context of the educational expansions observed in the three countries. The main analysis in this paper entails dividing women into four categories: (i) up to completed primary school, (ii) incomplete secondary school, (iii) completed secondary school and (iv) completed higher education. Primary school lasts 5 years in Colombia and Peru, 6 years in Ecuador. It takes 6 years to complete secondary school in Colombia; 5 years in Peru and Ecuador. I divided women who entered secondary school into those who completed it and those who did not. Women who entered secondary school but completed fewer years than equivalent to the length of the secondary school, are referred as women who dropped-out out of secondary school. I classified women as having attained higher education if they completed a number of years necessary to obtain the qualification known as *Superior*. In these countries it usually amounts to between 3 to 5 years, depending on the type of the programme.

In the next step I conducted the analysis using the educational classification which describes women's relative position within a cohort in terms of educational achievement. I calculated the top and the bottom quartiles of the educational attainment distribution for each cohort. I used a variable describing the level of education attained and the number of years of schooling completed.

Table 1 shows the number of years of schooling which fall into each of the relative educational level categories across the three countries for the oldest (1945) and youngest

(1980) cohort. This shows that the educational composition of the population shifted substantially upwards. Broadly speaking, for the youngest cohort, having achieved a number of years of schooling equivalent to the completion of primary education (5 or 6 years depending on the country) meant being at the bottom of the educational distribution. For the older cohorts, it was enough to complete just beyond 1 or 2 years at school to belong to the population strata with a more advanced educational level. In fact in Ecuador and Colombia it was enough to complete primary school to be at the top of the educational distribution. This shows that, in all countries, women who do not go beyond primary education in the younger cohorts are becoming a shrinking population group, likely from the lowest socioeconomic strata.

Table 3.1. Relative educational level classification for the 1945 and the 1980 cohort, number of years of schooling, first quartile (Q1) and fourth quartile (Q4), Ecuador, Colombia and Peru

	Ecuador		**Colombia**		**Peru**	
Cohort/Quartile	**Q1**	**Q4**	**Q1**	**Q4**	**Q1**	**Q4**
1980	0-6	14+	0-6	13+	0-7	15+
1945	0-1	6+	0-2	7+	0-1	11+

Source: Author's calculations from Population and Housing Censuses Colombia 2005, Peru 2007, Ecuador 2010

Two additional issues need to be considered when interpreting the results of the analysis conducted in this study for Peru. First of all, for that country for women who entered higher education there was no information about the number of years completed at that level. It could only be identified whether these women completed or did not complete the level *Superior*. This has no consequences for the analysis conducted using the absolute education level classification, but has to be considered in the analysis which uses the relative classification. For women who entered, but did not complete higher education, I assumed that they completed only one year at that level. I make this assumption on the basis of the evidence that usually the higher education drop-out in Latin American countries occurs at the very beginning of the degree (Marta Ferreyra et al. 2017). In order to check whether the obtained quartiles are an accurate depiction of the educational distribution across cohorts, I compared them with the quartiles calculated from the available Demographic and Health Surveys for Peru. The similarity of the results gives

confidence that the quartiles calculated from the census approximate well the measure of interest.

Second, there is a high level of missing values for the variable describing the age at first birth in Peru. A thorough examination of this issue revealed that the information about the age at first birth in all countries in the census has been recorded only for women with a valid response to the question about the number of children ever born (CEB). For Colombia and Ecuador, the missingness level for the "age at first birth" variable was small (3.3% in Ecuador and 4.5% in Colombia). Moreover, there were no substantial differences in the distribution of the missing values for the variable "age at first birth" and "number of children ever born", depending on women's year of birth and education level. I consequently excluded women for whom the information about the age at first birth was not recorded. For Peru, the problem was more pronounced (11.7% responses missing). For that country, I assumed that women for whom the response to the question about the CEB was missing had zero children, for the following reasons. A commonly observed problem in the censuses regarding the CEB information is the misclassification of childless women as having a missing value on that variable (El-Badry 1961). An in-depth examination of the profile of women with missing values on CEB in Peru showed that it was very similar to the profile of nulliparous women. Second, I compared the percentage of childless women by year of birth in the 2007 census with the 2007/8 Demographic and Health Survey (INEI 2008). The percentage of nulliparous women in the census was substantially lower than in the DHS. When women with missing values on CEB in the census were assumed to have 0 children, the percentage of childless women in DHS and census was very similar.

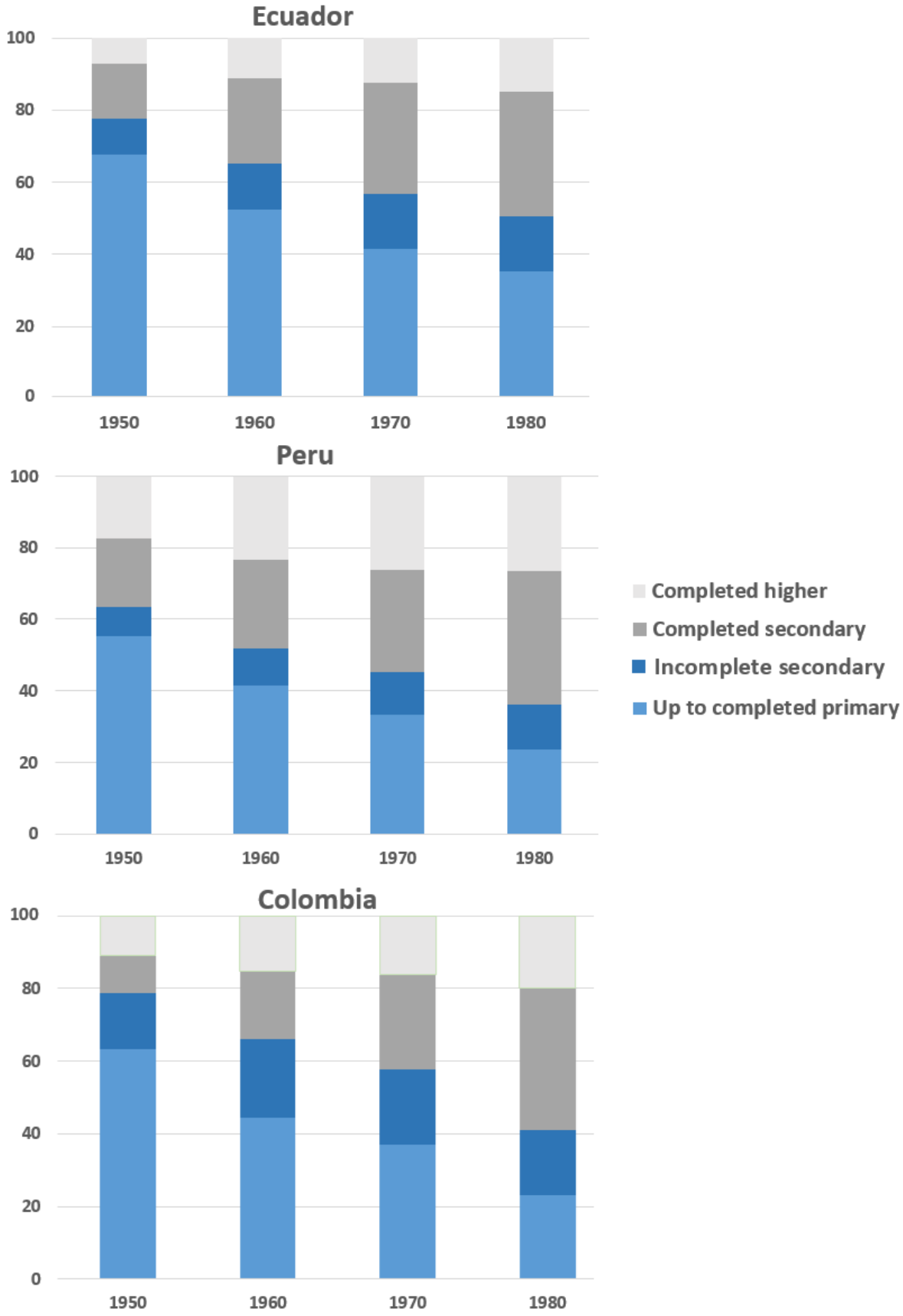
As a sensitivity check, I conducted an additional set of analyses which are the main purpose of this paper for Peru. Instead of assuming that women with missing values on CEB had 0 children, I excluded them from the analysis. The main conclusions of interest in this study regarding the changes in the disparities in the age at first birth by education level remained unchanged. Nevertheless, the poorer data quality should be kept in mind when interpreting the fertility patterns for that country. First, the applied assumption might have resulted in the overestimation of the number of childless women, as some women with missing values were probably not nulliparous. It is likely that the first-birth probabilities will be more sensitive to that problem the higher the age group considered. This is because the denominator of the first-birth rate will be influenced by the assumption

to an increasing extent, the smaller the number of women who are still childless becomes. Second, even when women with a missing value are assumed to have 0 children, the information about the age at first birth remains missing for 6% of women. Further details and the results of the sensitivity analyses for Peru are in the Appendix.

3.8. Results

Figure 3.1 shows the changes in educational composition across four chosen cohorts. During the last half century, an increasing percentage of women has been entering and completing more advanced levels, in particular secondary school. While the percentage of women in the lowest educational category more than halved, the highest educational level completion almost doubled. Moreover, the drop-out rate from secondary educational institutions increased. In Ecuador and Peru, there was a change by more than 50% in the percentage of women who entered, but completed fewer years than necessary to finish secondary school between the 1950 and 1980 cohort. In Colombia the increase was less pronounced but the level of secondary school drop-out in the youngest cohort was the highest of all three countries.

Figure 3.1. Educational composition of the birth cohorts 1950-1980, Ecuador, Peru and Colombia (% of the total female population)



The total population first-birth age-specific schedules changed little across cohorts (Figure 3.2). There does not seem to be a consistent pattern of change in these schedules across the three countries. In all however the peak of the curves remained in the age group 20-24. On the other hand, the changes in the pattern of the timing of motherhood within the educational strata have been similar across the three countries and are shown in Figures 3.3 and 3.4. The schedules as well as changes in these schedules differed substantially between the educational groups.

Figure 3.3 shows a stark contrast between the first-birth age-specific profiles of women with the lowest and the highest educational attainment. A common feature of all of the countries has been an increase in the probability of first birth at age 15-19 among women with up to completed primary education. The rejuvenation of the first-birth pattern was most pronounced in Colombia: the hazard of first birth at age 15-19 more than doubled there between the 1950 and 1980 cohort. The schedule for women with a low level of education in Peru shows a plateauing of the first birth probability above age 30. It is possible that the lower quality of fertility data for Peru, as described in the previous section, might be contributing to that pattern.

The first births for women who completed university remained concentrated at older ages. The peak of the schedule in Peru and Colombia has been slowly shifting from the age group 25-29 to 30-34, while in Ecuador it remained at age 25-29. In all countries, the intensity of first birth decreased in women's 20s. One the other hand, the intensity of first birth above the age of 30 started to increase across the cohorts. Consequently, the first-birth schedules started to shift to older ages in all countries. These results point to the emerging postponement of motherhood among highly educated women, visible already when comparing the 1950 and the 1960 cohort.

Figure 3.4 shows that in all three countries the first-birth age-specific schedules differed vastly also between women with intermediate levels of schooling: those who entered secondary school and completed it and those who did not complete it. Women who dropped-out of secondary school substantially advanced transition to motherhood. The change in the first-birth schedules among women who completed secondary school has been much less pronounced. There does not seem to be a consistent pattern of change within that educational strata across the three countries, an aspect discussed further below.

Figure 3.2. First-birth age-specific probabilities, birth cohorts 1950-1980, Ecuador, Peru and Colombia

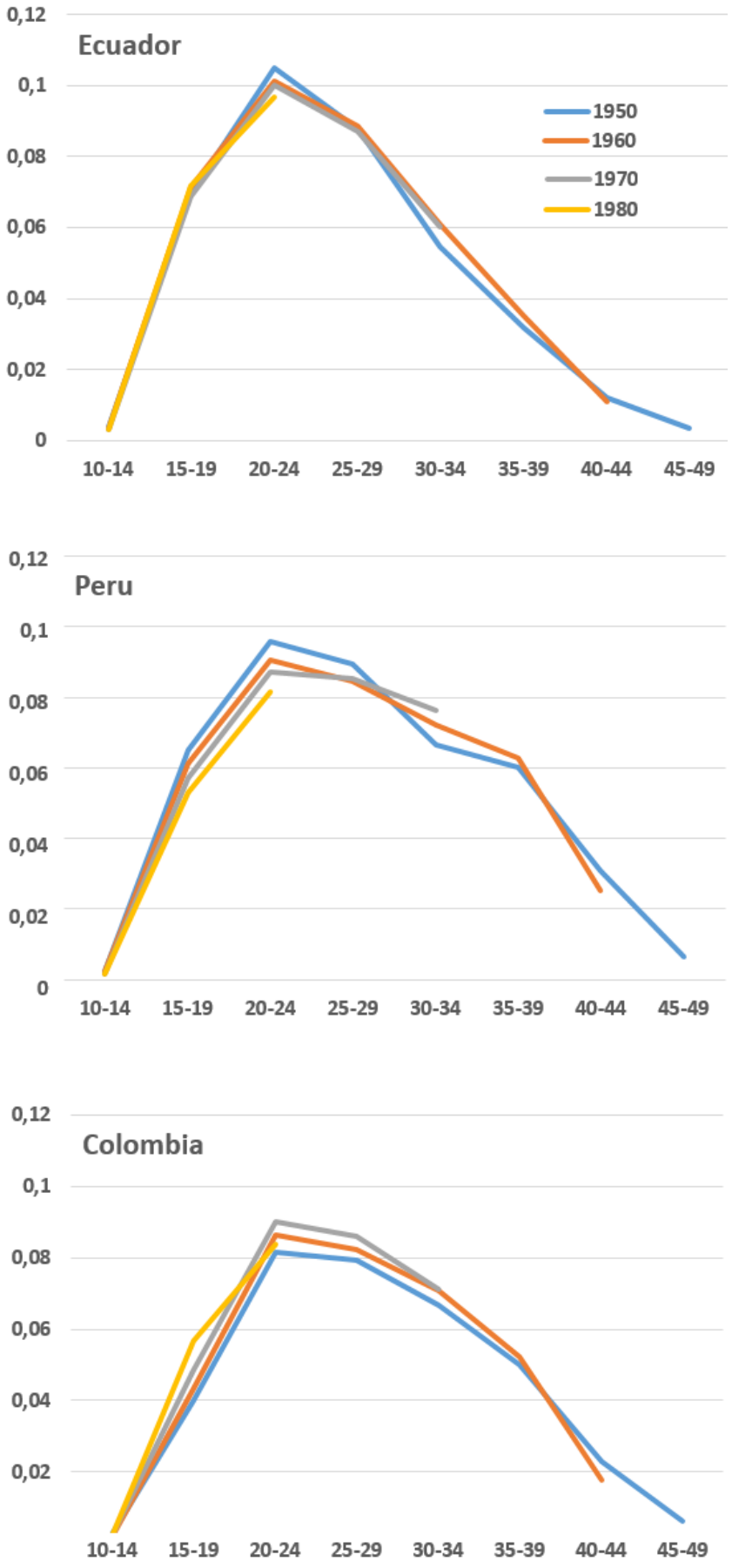


Figure 3.3. First-birth age-specific probabilities, birth cohorts 1950-1980, the lowest and the highest level of educational attainment, Ecuador, Peru and Colombia

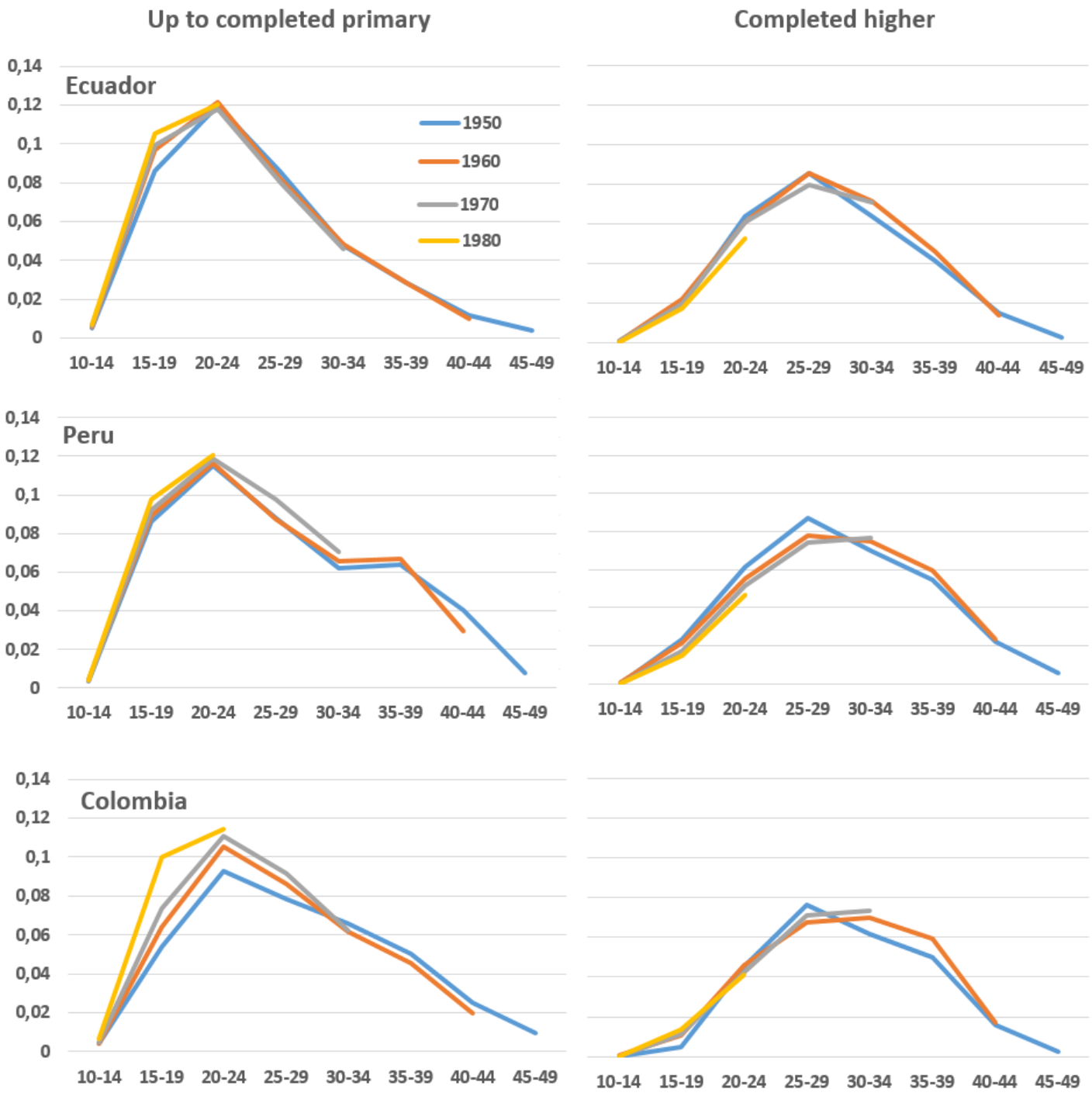
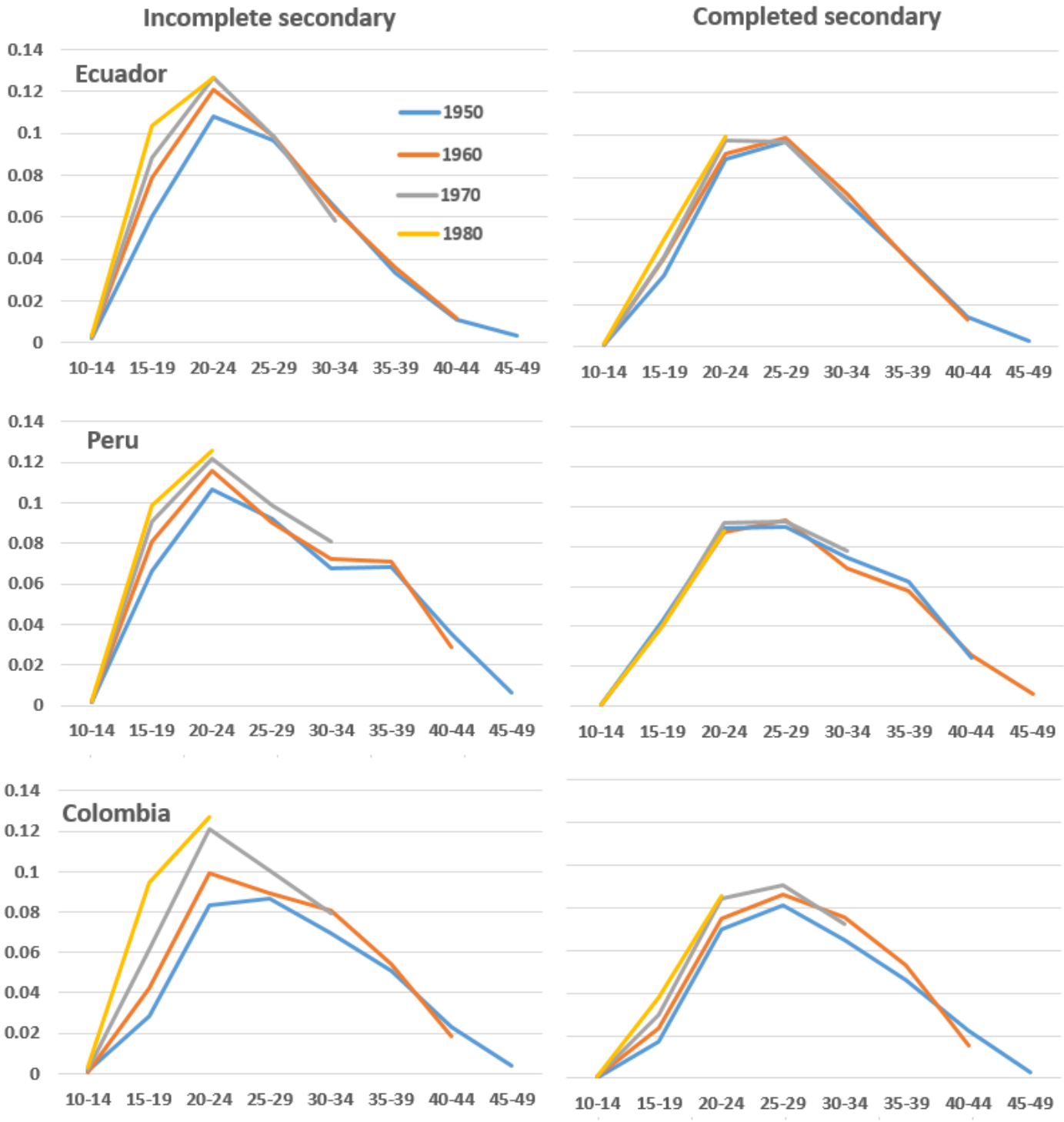


Figure 3.4. First-birth age-specific probabilities, birth cohorts 1950-1980, middle educational attainment groups, Ecuador, Peru and Colombia



To examine in detail the changing disparities in the timing of motherhood between the educational groups throughout the fertility transition, I show the trends in the first-birth probabilities in three age intervals: 10-19, 20-29 and 30-39 (Figure 3.5, 3.6 and 3.7 respectively). I present these results for all cohorts of women born between 1945 and 1980. I show the estimates for the four educational groups representing educational attainment (solid lines). In each figure I also include the first-birth probabilities for the lowest and the highest educational quartiles (dotted lines).

The increase in very early motherhood (below age 20) was mainly associated with low levels of education (Figure 3.5). Nevertheless, it can be seen that in all countries it was among women who dropped-out of secondary school that the advancement of motherhood was most pronounced. A convergence of the first-birth rates occurred between women with up to primary education and women who entered but did not complete secondary school. The differences in the intensity of first birth below the age of 20 between the two lowest educational groups, while substantial for the oldest cohort, virtually disappeared for the youngest one.

In Ecuador and Colombia teenage fertility increased also among women who completed secondary school. Nevertheless, the rates of teenage first births among them have been much lower than among those who dropped-out of secondary school. Moreover, in all countries the difference in the probability of early first birth increased substantially between women who complete and do not complete secondary school. This means that the association between secondary school drop-out and teenage pregnancy considerably strengthened across cohorts.

In all countries, the difference in the rate of very early first birth increased between women who completed secondary school only and those who completed higher education. In Ecuador and Colombia this was due to the advancement of motherhood among women who completed secondary school. In Peru this is also observed but there it was due to the decrease in the risk of adolescent first births among women with university education.

The results of the trends in the first-birth rates of women in the bottom (Q1) and the top (Q4) quartiles cast light on the changing disparities between the least and the most educated. The increasing difference in the intensity of first birth between these two population groups below the age of 20 is clearly visible. The increase in the first birth probability is only slightly less pronounced among women in the bottom of the educational

distribution, as compared to women in the lowest, fixed educational attainment group. The direction of the difference between the educational classifications is as expected, but the magnitude of this difference is small. For Peru and Colombia the difference is only subtle. This provides evidence that women in the least educated strata of the population have been advancing transition to motherhood across cohorts in the three countries and that was not driven by the fact they have become an increasingly select group. Moreover, the results reveal that among the top educated 25% of the population, teenage fertility decreased in all three countries between the oldest and the youngest cohort.

Consequently, the extent of the divergence between the lowest and the highest educated in very early motherhood is similar when the analysis is conducted using the two educational classifications. These findings mean that the first-birth timing has been increasingly varying between these two populations groups, and that the changing educational composition of cohorts had a limited contribution to that pattern.

The increasing differentials in the probability of first birth are also observed in the age interval 20-29, with clearly visible widening gaps between the educational groups (Figure 3.6). The intensity of first birth among women with completed higher education is markedly lower than among the rest of the population. This means that these women had lower progression rates to motherhood of all educational strata not only in teenage years, but also in their 20s. Women with the highest educational attainment were the only ones among whom there is an evidence of a decrease in the probability of first birth at that age, starting from cohorts born around the 1950s. The relative educational level classification shows a clear decrease in the intensity of first birth among the top educated women across these cohorts in the three countries. The reduction of the probability of first birth signals that highly educated women were retreating from childbearing during their 20s. Consequently, the disparities widened between women with the highest levels of schooling and everyone else in all three countries.

Figure 3.5. First-birth probabilities, age group 10-19, cohorts 1945-1980, by educational attainment (solid) and educational quartiles (first Q1 and fourth Q4 quartile, dotted), Ecuador, Peru and Colombia

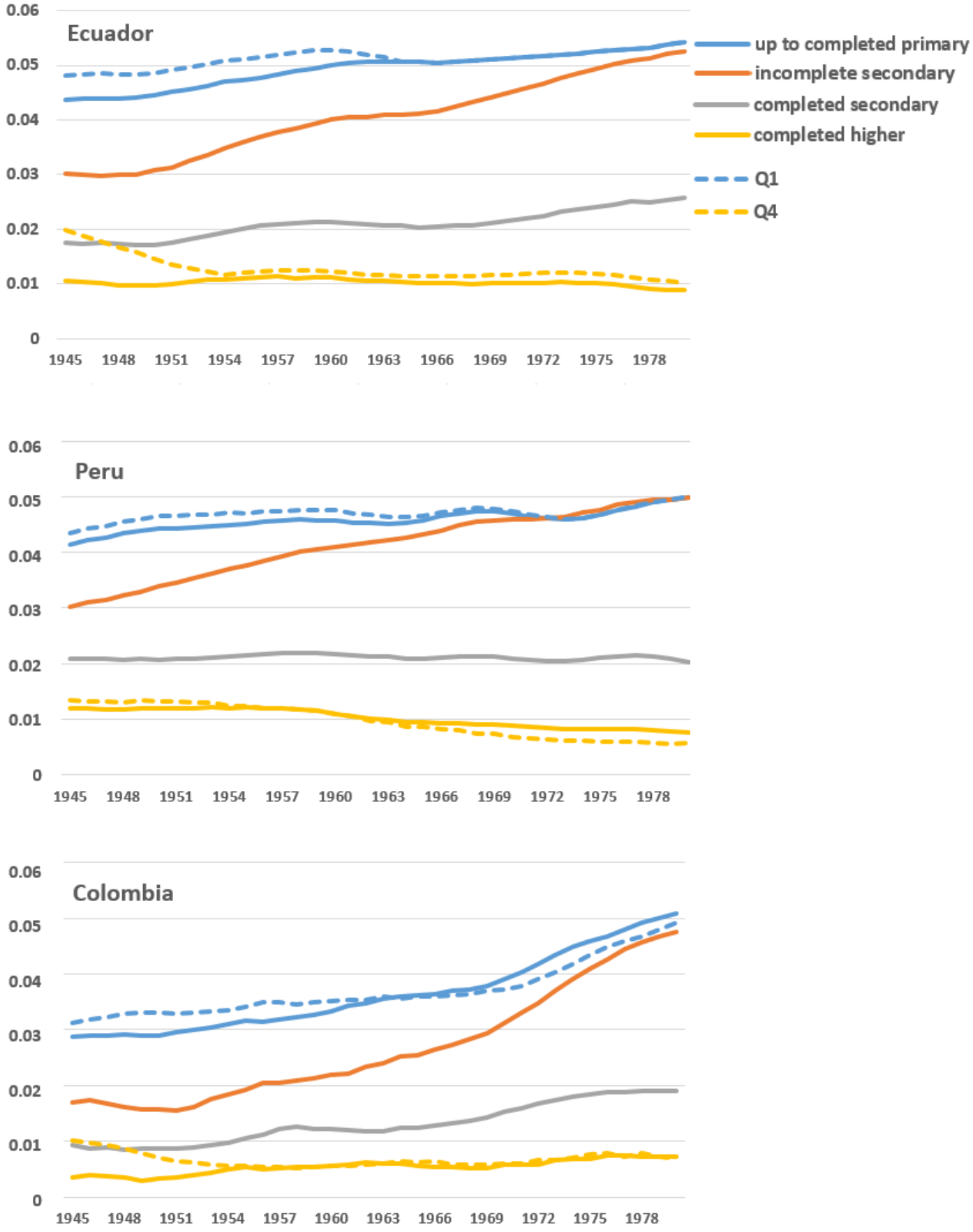
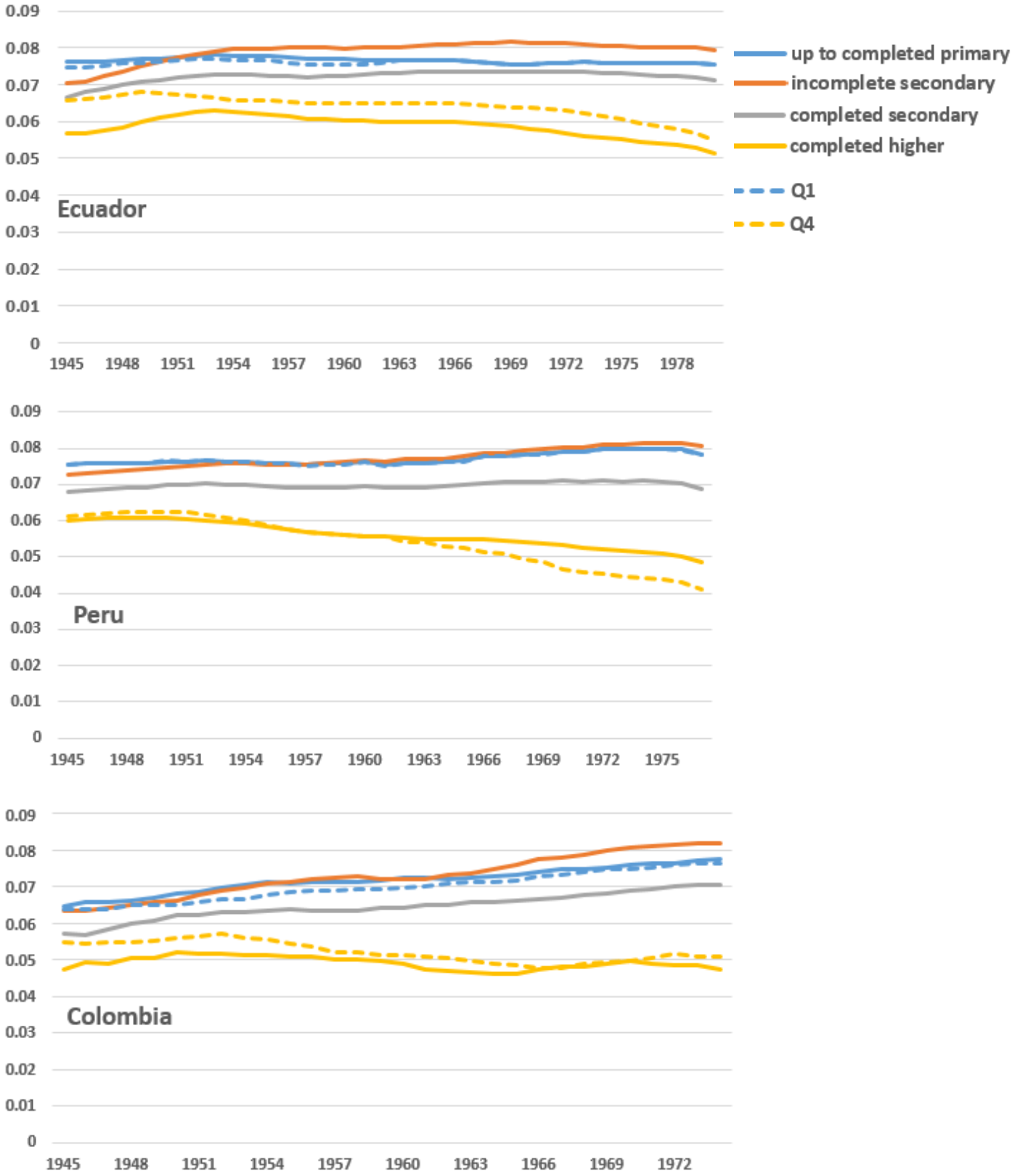


Figure 3.6. First-birth probabilities, age group 20-29, cohorts 1945-1980, by educational attainment (solid) and educational quartiles (first Q1 and fourth Q4 quartile, dotted), Ecuador, Peru and Colombia



The decrease in the motherhood rate below the age of 30 among the most educated women might mean lower levels of childbearing across cohorts or a shift of motherhood to older ages. Looking at whether the rates of first birth were increasing or not above the age of 30 gives further insights into these processes (Figure 3.7). It should be noted that these trends encompass only women born up to the years 1970, 1966 and 1964 in Ecuador, Peru and Colombia, respectively. These are the cohorts which reached the age of 39 at the time of the census.

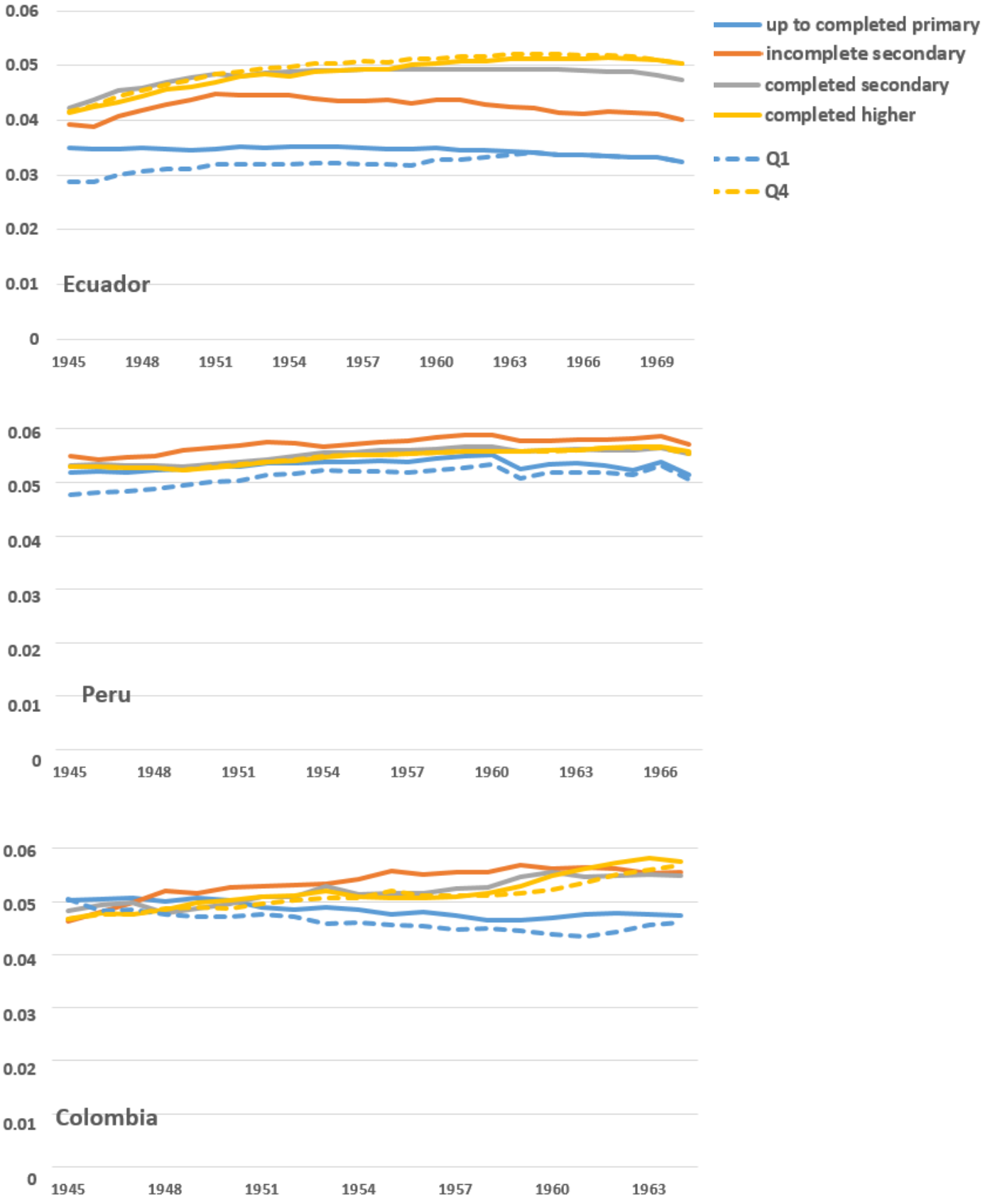
The intensity of first birth at older ages increased to the largest extent among women with completed higher education in Ecuador and Colombia, while a smaller but visible change occurred in Peru. This emerging trend and the decrease in the probability of first birth below the age of 30 suggests the beginnings of realization at older ages of the postponed births among women with the highest levels of schooling. This process has been more clearly visible from the changes in the first-birth age-specific schedules shown in Figure 3.3. For a few cohorts which reached the end of their childbearing years, I examined the extent of childlessness in the three countries. So far, no change either at the population level or for the distinct educational groups can be observed. This confirms that the observed changes in the first-birth pattern so far are a reflection of the shifts across age groups in the timing of motherhood and not changes in the levels of first births across cohorts.

An increase in the intensity of first birth above age 30 occurred also among women who completed secondary education. This happened in spite of the rising or stable probability of first birth among them at younger ages. It is likely that due to the substantial increase in the percentage of women who complete secondary school, this subgroup of women became more diverse. This might be reflected in the elevated intensity of first birth among them both at the younger and older ages. The trends in the hazard of first birth in the age interval 30-39 for women in the two lowest educational groups are less consistent across the three countries, but they are relatively more stable compared to the two highest educational strata.

In Ecuador and Colombia, these processes resulted in slightly widening differences in the probability of first birth at older age between women who completed at least secondary school and those who completed up to primary school. This change is observed when looking both at the relative and absolute level classifications, but the pattern is much less

consistent than in the younger age groups. Very little change in these disparities is observed in Peru. Again, the poorer quality of data regarding the fertility information there should be kept in mind when looking at the presented patterns. This is particularly important for the interpretation of the disparities at older ages given the previously presented plateauing of the first-birth probabilities above age 30 among women with lower levels of education. In general, the changes in the rates and the degree of the divergence in the patterns of first birth in the age group 30-39 have been the smallest of all age intervals. This is related to the fact that with the available data the rates cannot be yet calculated for the more recently born women, which does not allow for a more detailed examination of these trends.

Figure 3.7. First-birth probabilities, age group 30-39, cohorts 1945-1970, by educational attainment (solid) and educational quartiles (first Q1 and fourth Q4 quartile, dotted), Ecuador, Peru and Colombia



3.9. Discussion

This paper examined the long-term cohort trends in the educational differences in the age at first birth for Ecuador, Peru and Colombia. For the three countries, the existing disparities in the age at first birth between the educational groups are the results of a long process of divergence in reproductive behaviour throughout the fertility transition. The increasing disparities in the rates of first birth are observed both at the younger and the older ages. Although not without differences, the broad patterns of change have been similar in the three countries. There are three main findings from this study which cast light on the possible factors behind the identified increasing disparities in the timing of motherhood.

First, this study provides new insights into the process of teenage fertility increase and highlights the importance of looking at the variation in the first-birth timing among women with intermediate levels of schooling. Consistently across the three countries, the intensity of very early first birth increased to the largest extent among women who dropped-out of secondary school. Among the youngest cohorts, abandoning secondary school is much more likely to be associated with teenage fertility than it was in the past. The disparities in the probability of first birth in adolescent years increased substantially between those who dropped-out of and those who completed secondary school. This process has been likely driven by the increasing share of relatively poorer girls entering secondary school over time who enrol, but do not complete their education. This can be inferred from the convergence of the rates of first birth between those who drop-out of secondary school and those who finish their education at the primary level.

The knowledge about whether teenage pregnancies follow or precede school abandonment would be vital to make conclusions about the reasons behind the increase in the rates of first births among women who drop-out of school as well as generally the reasons behind the rise of adolescent motherhood in these countries. The association between school abandonment and teenage pregnancy might be however very complex and establishing causality between the two processes needs a separate inquiry, as well as longitudinal data. Nevertheless, a few existing studies about the sequencing of these events in the region can shed light on the factors behind this increase.

In Colombia, among young women from poorer backgrounds pregnancy was found to mainly follow school abandonment. Moreover, school withdrawal before becoming

pregnant was more prevalent among teenagers from lower socioeconomic strata (Flórez and Soto 2007). The authors argue that it is likely that these pregnancies to a large extent are not unintended and are driven by the same factors as school drop-out, namely disadvantage and poverty. Moreover, the study of Näslund-Hadley and Binstock (2011) showed that one quarter of young women they interviewed in Peru and half in Paraguay dropped-out before becoming pregnant and this was due to lack of interest in continuing education or a need to enter the labour market. Those who were still in school at the time of pregnancy, decided to leave due to their already poor academic performance, low quality of schooling and low expectations regarding the benefits of continuing education. Their qualitative investigation did not support the common assumption that unintended pregnancy is a leading factor for school-drop among young mothers who discontinue education. Rather it is the educational underachievement that precedes adolescent childbearing.

There is no doubt that the levels of unintended motherhood among teenagers are high and have increased in Latin America (Rodríguez Vignoli 2017, also shown in Chapter 1 of this thesis). This factor could be behind the steep rise in the rates of first birth among secondary school drop-outs identified in this study. Nevertheless, given the evidence from the above presented studies, it is likely that the observed rise in teenage first births was only to some extent driven by the increasing levels of unintended childbearing which lead to school abandonment. The limited opportunities determining both school withdrawal and subsequent adolescent motherhood are an equally plausible explanation for that pattern.

Such reasoning is in line with research arguing that becoming a mother among teenagers from more disadvantaged backgrounds and with lower levels of education is a result of limited social mobility and employment prospects in the region (Azevedo et al. 2012; Flórez 2005; Flórez and Soto 2007; Gaviria 2000). Moreover, studies attributed the high level of teenage fertility and the increasing polarization in the pattern of the age at first birth in the region to the high levels of social and economic inequalities (Azevedo et al. 2012; Lima et al. 2018; Rodríguez Vignoli and Cavenaghi 2013). As described in the Context section 3.2, such inequalities can be reflected in the inequalities in the educational opportunities and in students' school performance, which are strongly related to drop-out. Although children from more disadvantaged groups have been increasingly entering secondary school across generations in Latin America, the quality of the institutions they attend and their school completion rates are lower than among those in the more

advantaged groups (Bassi, Busso, and Muñoz 2013a; Daude 2013; Kattan and Székely 2015). Quality of school can influence educational aspirations, prospects of attending university and consequently school completion rates (ECLAC 2010; Jensen 2010a; Kattan and Székely 2015). These in turn determine labour market opportunities which have a potential to influence the motivation to avoid early motherhood (Azevedo et al. 2012). The disparities in access to quality educational opportunities as well as substantial levels of social segregation of schools are known barriers which contribute to high levels of school drop-out in the region. They are also one of the probable factors behind the strengthening association between school abandonment and the early pregnancy alongside educational expansion identified in this study. From a policy perspective, these results indicate there is a need to create conditions not only for the entrance but also the continuity of school attendance, in particular among the least advantaged young women, in the context of increasing school coverage in the region.

Second, this study shows that the changing educational composition of the population was not a contributing factor in the divergence in motherhood timing between the lowest and the highest educated. When using a measure which takes into account changing educational composition of the cohorts, the magnitude of the disparities was equally pronounced in the three countries. The analyses shows that the 25% of least educated women was transitioning to motherhood earlier over time. Contrary to expectations, increasing intensity of adolescent childbearing among women with the lowest levels of schooling was attenuated little when the relative and the absolute educational classifications were compared. The interpretation of the findings from this study for Colombia and Peru differs from those of the study of Esteve and Florez-Paredes (2018). The authors concluded that when the relative education level classification is used, the lowest and the medium educated women across cohorts have been transitioning to motherhood at similar ages. This study shows that women with the lowest levels of schooling have been transitioning to motherhood earlier over time and this has happened to a similar extent irrespectively of how educational level was classified. This interpretation of findings is important, as it suggests that teenage fertility increases among the least educated women have been driven to only a small extent, if any, by the fact that they have become an adversely select group. This means that women in the lowest socioeconomic strata continue to fail to benefit from the expansion of the educational

systems or increasing access to contraception as compared to women in the higher socioeconomic groups.

At the same time, this study shows that the highest educated women (both 25% top educated women and those completing university) started to postpone motherhood to older ages in the three countries. This is mainly visible in the reductions of the probability of first birth in women's 20s, but the evidence of increases in the probability of first birth above the age of 30 is emerging. The analyses revealed that the first-birth age-specific schedules among women who completed university have started to shift to older ages, interestingly, already among women born around the 1960s. These findings cast new light on the patterns of motherhood timing in the Andean region. The results highlight that important insights about the changes in the timing of motherhood in these contexts can be gained from looking at the evolution of the full first-birth age-specific schedules. Such schedules have not been previously estimated for these countries. In general, the Andean region countries have not been part of the recent discourse about the association between education level and changes in the age at first birth more broadly in Latin America. The fact that the first-birth age specific schedules among highly educated women in Colombia, Peru and Ecuador have slowly started shifting to older ages means that it is likely that these countries in the future might also see the emergence of bimodal pattern in the age at first birth, as identified in countries such as Brazil, Uruguay, Chile and Costa Rica (Lima et al. 2018; Nathan, Pardo, and Cabella 2016; Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018). This is a likely scenario if the process of motherhood postponement intensifies among younger, most educated women. This study shows that in order to understand better what the future of fertility and motherhood timing could be in Latin America it is important to broaden the geographical scope of the analyses on the topic in the region.

The last finding from this study is that the disparities in the intensity of first birth increased also between women who completed secondary school only and those who completed higher education in all three countries. In Ecuador and Colombia the rates of first birth below the age of 20 increased also among women finishing secondary school. Consequently, the disparities in the intensity of first birth between them and women who completed university grew across cohorts. The same process was visible in Peru and was driven by the reduction of first births in teenage years among the most educated. Moreover, consistent across the three countries, the gaps in the timing of motherhood increased

between these two educational strata in the age group 20-30, due to much lower rates of progression to first birth among highly educated women. These findings suggest that women who completed secondary school only have not been following the behaviour of women who completed university throughout the fertility transition in the three countries covered by this analysis.

These results could point to the importance of the decreasing power of obtaining a secondary school degree in ensuring employment due to the substantial expansion of secondary schooling observed in the last decades across cohorts (ECLAC 2010). It is known that the size of the population entering and finishing a given educational level influences labour market opportunities (Ryder 1965). For Latin American countries, the evidence shows that the wages of secondary school graduates decreased relative to those who obtain lower levels of education (Manacorda, Sanchez-Paramo, and Schady 2010). Currently, it is the completion of higher education that increases the rates of return in terms of income in the labour market there (ECLAC 2010; Hopenhayn 2012). The changing differences in the labour market opportunities between the highly educated and all other population groups due to educational expansion are a plausible explanation for the increasing first-birth disparities between them. This interpretation is consistent with research which argues that the meaning of completion of secondary school changed over time in the region and obtaining a secondary school degree might not be translating into enhanced employment opportunities (Rodríguez Vignoli and Cavenaghi 2013).

Given the substantial increase in the secondary school graduates across cohorts in the region, the role of this educational stratum in determining the pattern of the age at first birth is likely to grow. Therefore, future research should pay more attention to the changes in motherhood timing of women who complete secondary school. How the pattern of motherhood timing has been changing over time among them and how it varies across countries in the region is a particularly understudied topic.

Following the theory of "diverging destinies" (McLanahan 2004), the findings from this study related to the increasing disparities in the age at first birth between the educational groups are worrisome. Given the strong link between the income and educational inequalities in Ecuador, Colombia and Peru, polarization of this kind might be associated with increasing disparities in the parental resources which can be allocated to children depending on social class. Women in the Andean region who have their first birth

very early are more likely to be employed in lower-class jobs and are more likely to experience domestic violence (Urdinola and Ospino 2015). These aspects can have further consequences on the development of their children and contribute to the intergenerational transmission of poverty (Azevedo et al. 2012). The persistence of stark disparities in the timing of motherhood can therefore contribute to the persistence or worsening of intergenerational inequalities between the socioeconomic strata in the region.

This study shows that the use of census data can improve understanding of the long-term developments in the timing of motherhood. The retrospective birth history data collected in the censuses are a valuable source of information. The collection of this retrospective fertility information should be sustained. This is particularly important since the efforts to collect survey data in Latin America are weakening, among other reasons due to the "graduation" of these countries from international assistance from USAID (Bertrand 2011). For example, the last Demographic and Health Survey for Ecuador was conducted in 1987 and no study has so far looked into the patterns of change in the age at first birth in that country. Moreover, attempts should be made to ensure the quality of fertility data in censuses. As extensively discussed in this study, the issues around the reporting on fertility information, as in Peru, are a barrier to exploiting the full potential of this data source.

3.10. Appendix: Sensitivity analysis of the assumption about variable "children ever born" in Peru

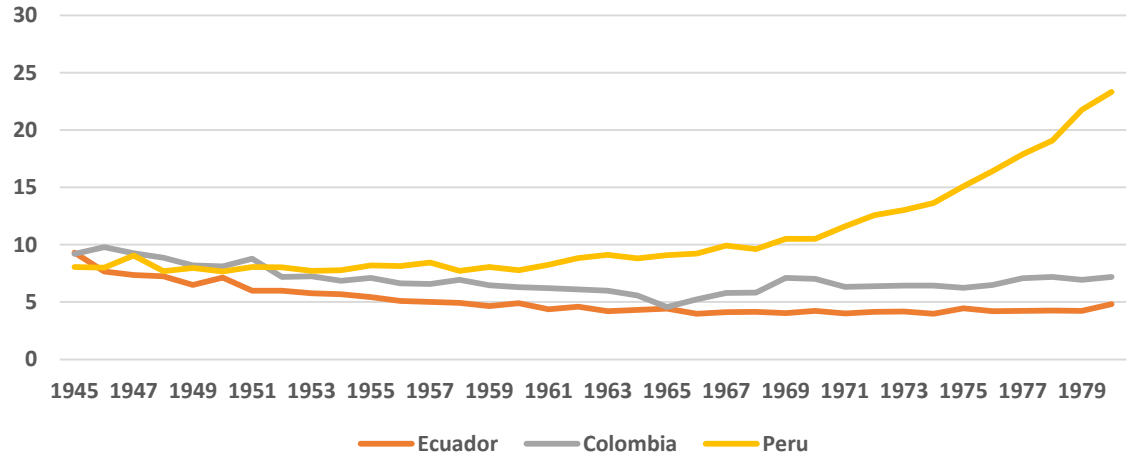
The level of missing values for the "age at first birth" variable is highest in Peru (12% of responses not recorded). The missingness there increases the younger the women are; it also increases with educational attainment (Figure A3.8 and Table A3.2). The missing values for the variable describing the number of children ever born (CEB) exhibit a similar pattern (Figure A3.9 and A3.3). A commonly observed problem in the censuses regarding the CEB information is the misclassification of childless women as having a missing value on that variable (El-Badry 1961; United Nations 1983). The distribution of missing values for the CEB variable by education level and woman's year of birth suggests that this could be the case in Peru. Consequently, this issue could have resulted in a substantial level of missingness for the variable "age at first birth". I explore this as a potential explanation. First, I compare the characteristics of women for whom the CEB response is missing and women who reported 0 children. Next, I compare the percentage of childless women by year of birth from the 2007 census with the estimates from the Demographic and Health Survey conducted in years 2007-08. If there exists a substantial problem of nulliparous women being misclassified as having a missing value on CEB in the census then the percentage of childless women between the two sources should differ to a large extent.

Table A3.4 shows that women with missing values on the CEB variable have a similar profile in terms of their education attainment as women who never had children. Their profile regarding their year of birth is also more similar to nulliparous women, compared to women with at least 1 child (Table A3.5). Graph A3.10 shows that beginning with the 1965 cohort, DHS gives consistently higher levels of childlessness than census (DHS vs. Census). When the missing values for the variable CEB in the census are assumed to mean "0" (category "Census, assuming missing means nulliparous"), census and DHS give similar estimates. These two checks suggest that in the Peruvian census, there might exist a substantial problem of childless women being classified as having a missing value on CEB variable. Based on that, in the analysis for this paper I assumed that women who have a missing value on CEB in the census for Peru, have in fact 0 children, across all cohorts.

This assumption might result in the overestimation of the number of childless women, as some women who did not answer the question about CEB were not nulliparous. To examine how the applied assumption could influence the results, I conducted the sensitivity

analysis. Instead of assuming that women with missing values on CEB had 0 children, I excluded them from the analysis conducted in this paper. This means assuming that women with the missing values on CEB have the average parity and age at first birth as women whose parity is known. As explained above, it is an unlikely scenario. Nevertheless, even when this assumption is made, the main interpretation of the results of interest remains the same. Graphs A3.11, A3.12, A3.13 show the evolution of the educational disparities in the first-birth rates across all cohorts for the age intervals 10-19, 20-29 and 30-39 when all women with missing values are excluded from the analysis. The main finding of interest – the divergence in the rates of first birth between educational strata at ages 10-19 and 20-29 – is still visible.

Figure A3.8. Missing values on age at first birth by woman's year of birth, cohorts 1945-1980, Ecuador, Peru and Colombia, (%)



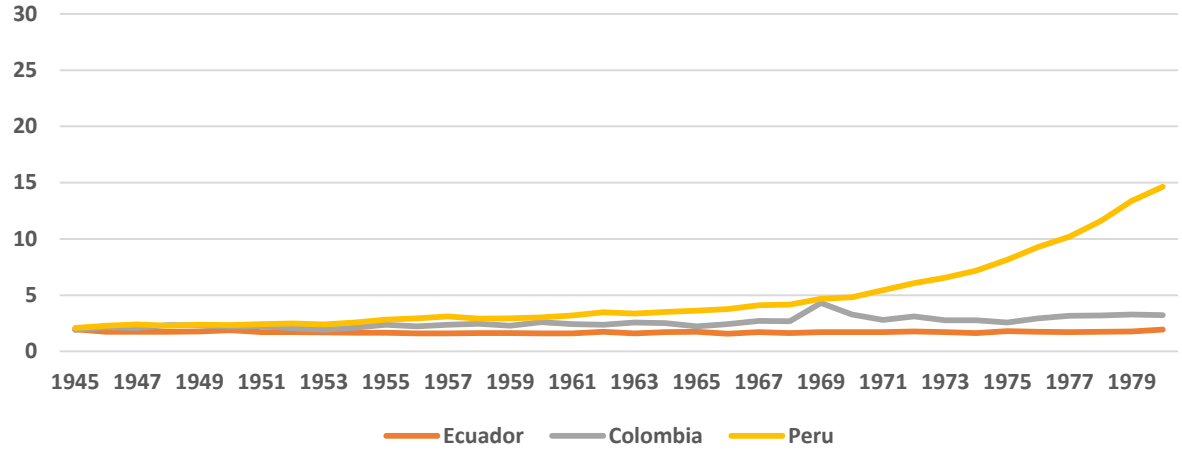
Source: Author's calculations from Population and Housing Censuses Colombia 2005, Peru 2007, Ecuador 2010

Table A3.2. Missing values on age at first birth by woman's education level, cohorts 1945-1980, Ecuador, Peru and Colombia, (%)

By education level	**Ecuador**	**Peru**	**Colombia**
Up to completed primary	4.93	8.01	5.63
Incomplete secondary	1.72	8.18	3.76
Completed secondary	1.84	12.88	3.63
Completed higher education	2.18	18.25	3.53
Total	**3.35**	**11.67**	**4.53**

Source: Author's calculations from Population and Housing Censuses Colombia 2005, Peru 2007, Ecuador 2010

Figure A3.9. Missing values on CEB, by woman's year of birth, cohorts 1945-1980, Ecuador, Peru and Colombia, (%)



Source: Author's calculations from Population and Housing Censuses Colombia 2005, Peru 2007, Ecuador 2010

Table A3.3. Missing values on CEB, by education level, cohorts 1945-1980, Ecuador, Peru and Colombia, (%)

Education level	**Ecuador**	**Peru**	**Colombia**
Up to completed primary	0.45	2.28	1.93
Incomplete secondary	0.30	2.63	1.43
Completed secondary	0.45	6.61	1.35
Completed higher education	0.69	11.20	1.12
Total	**0.46**	**5.68**	**1.57**

Source: Author's calculations from Population and Housing Censuses Colombia 2005, Peru 2007, Ecuador 2010

Table A3.4. Comparison of women with missing values on CEB with nulliparous women, cohorts 1945-1980, Peru, (%)

Education level	**0 children**	**Missing value**	**1+ children**
Up to completed primary	19.6	15.2	40.6
Incomplete secondary	5.2	5.0	11.6
Completed secondary	28.6	31.8	26.8
Completed higher education	46.6	48.1	21.0
Total	**100.0**	**100.0**	**100.0**

Source: Author's calculations from 2007 Peru Population and Housing Census

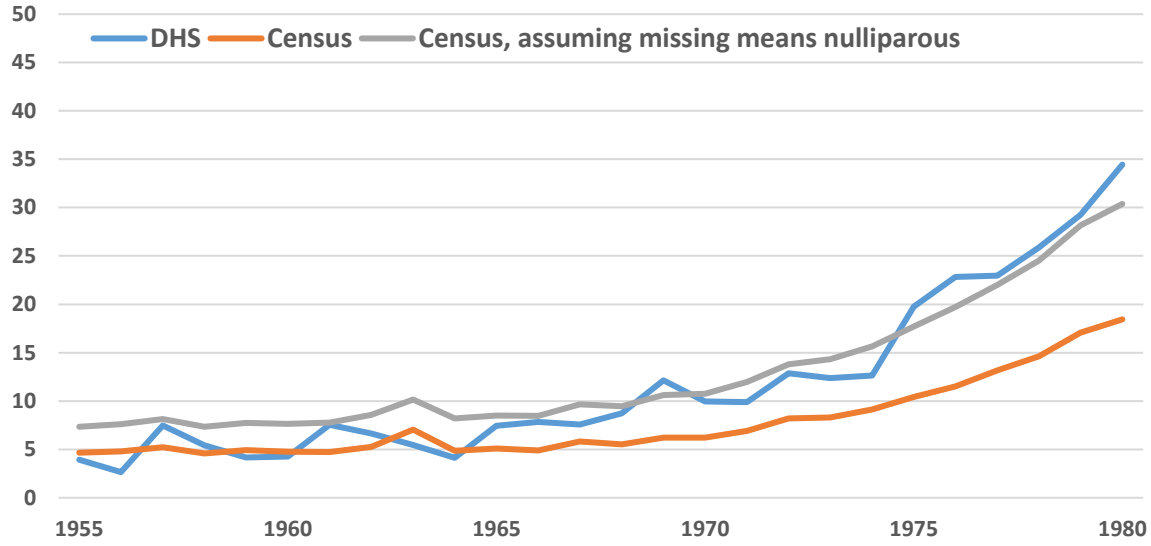
Table A3.5. Comparison of women with missing values on CEB with nulliparous women, cohorts 1945-1980, Peru, (%)

Year of birth	0 children	Missing value	1+ children
1945	0.91	0.50	1.45
...	...	...	...
1960	1.74	1.46	2.90
1961	1.53	1.37	2.57
1962	1.96	1.73	2.95
1963	2.48	1.57	2.73
1964	1.84	1.75	2.99
1965	2.24	2.11	3.49
1966	1.65	1.69	2.68
1967	2.88	2.71	3.89
1968	2.32	2.33	3.31
1969	2.85	2.88	3.58
1970	3.05	3.17	3.82
1971	3.06	3.26	3.44
1972	3.91	3.94	3.64
1973	3.72	4.02	3.42
1974	4.37	4.73	3.63
1975	5.22	5.69	3.75
1976	4.87	5.53	3.12
1977	7.51	8.25	4.12
1978	6.80	7.78	3.31
1979	8.42	9.75	3.41
1980	9.62	11.45	3.55
Total	**100.0**	**100.0**	**100.0**

Source: Author's calculations from 2007 Peru Population and Housing Census

Comparison of the information from the 2007 Census and 2007-08 DHS for Peru

Figure A3.10. Percentage of childless women by year of birth, cohorts 1955-1980, Peru, (%)



Source: Author's calculations from 2007 Peru Population and Housing Census and 2007-08 Peru Demographic and Health Survey

Sensitivity analysis of the results for Peru: analysis excluding women with missing values on age at first birth

Figure A3.11. First-birth probabilities, age group 10-19, cohorts 1945-1980, by education level, Peru

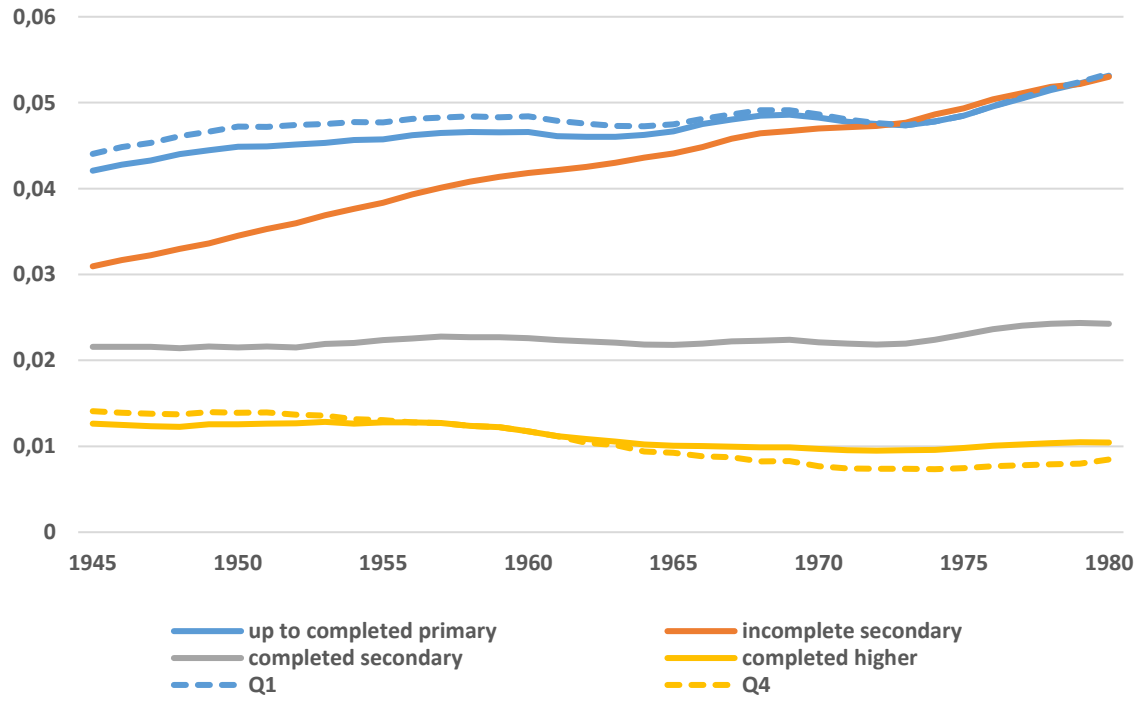


Figure A3.12. First-birth probabilities, age group 20-29, cohorts 1945-1980, by education level, Peru

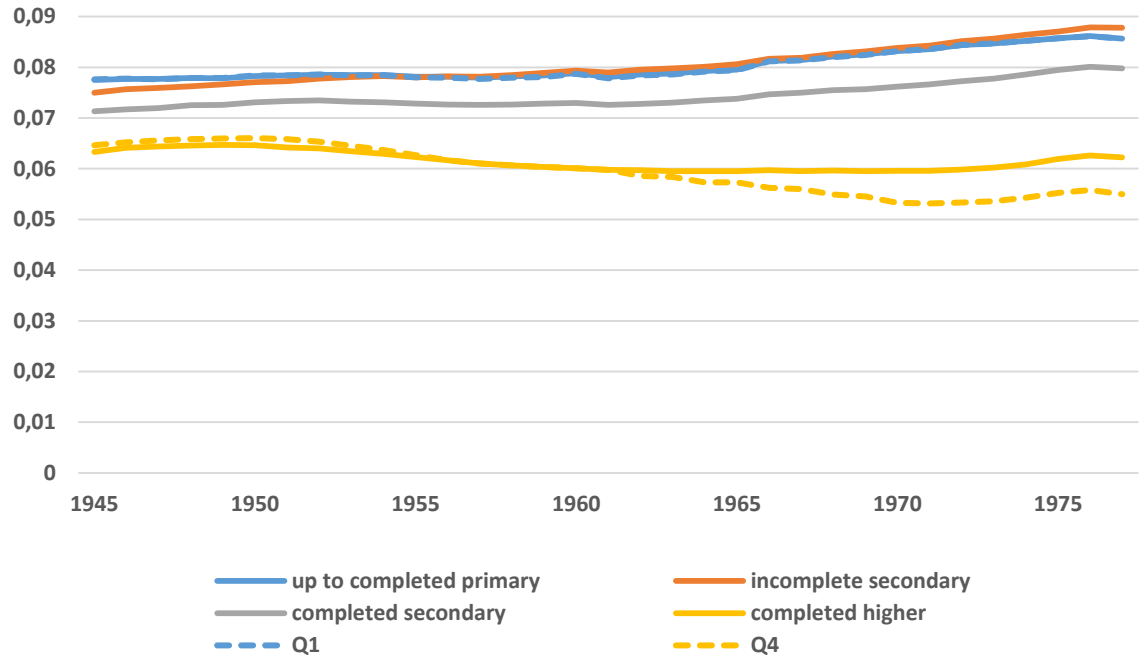
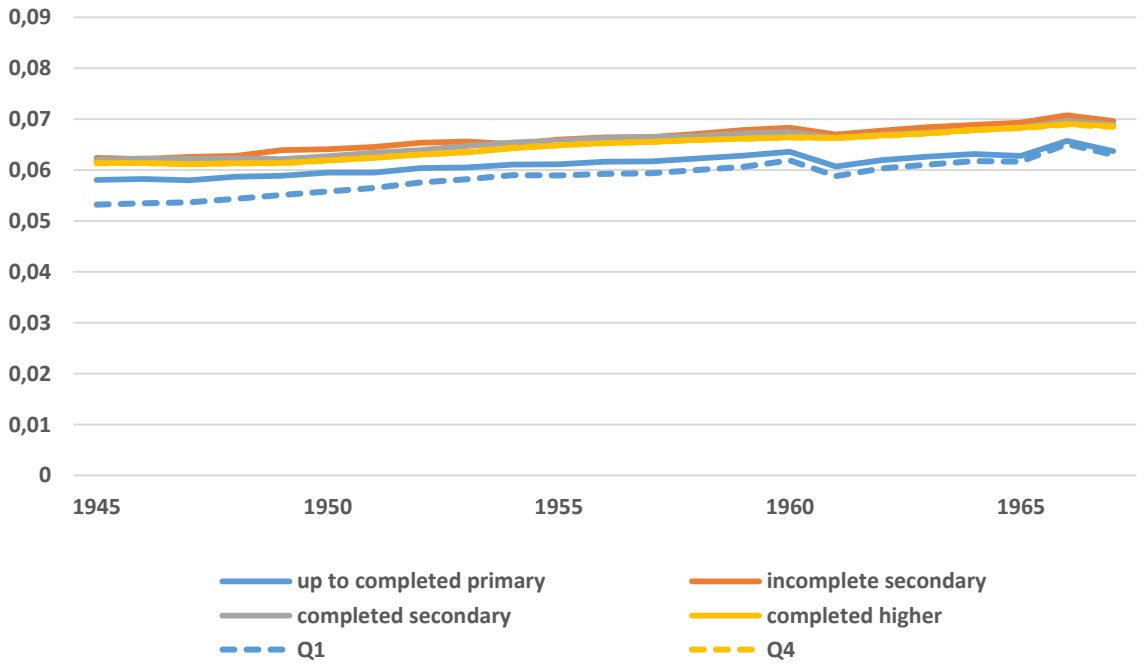


Figure A3.13. First-birth probabilities, age group 30-39, cohorts 1945-1970, by education level, Peru



4. How low is fertility in Brazil? Forecasting of cohort fertility in Latin America

Abstract

The total fertility rate (TFR) in Brazil dropped from above 6 in 1950 to 1.76 in 2010. Due to the recent shift in the timing of motherhood, the decline of the TFR to low values might be providing a misleading picture of the changes in fertility levels. The knowledge about cohort fertility -- a measure free from the impact of tempo-changes -- is currently lacking for Latin American countries. The aim of this study is to forecast cohort fertility of women born up to 1985 in Brazil. The time-series of age-specific fertility rates are indirectly reconstructed from 1980-2010 IPUMS censuses. A Bayesian model of Schmertmann et al. (2014) is modified and used to forecast cohort fertility for total population and by education level, and to quantify uncertainty around the estimates. With high probability, the lifetime fertility of women born after 1975 will be higher than the recent, low levels of TFR for the total population and among highly educated strata. Younger cohorts started to postpone motherhood and the emerging low levels of period fertility in Brazil will not necessarily correspond to equally low lifetime fertility of women who are still in their childbearing years. Nevertheless, the cohort fertility of women with higher levels of schooling is likely to remain at a very low level. This study shows how existing methods can be used to forecast cohort fertility in Latin American countries where the pattern of fertility and motherhood timing differed substantially from other world regions, where there is scarcity of published time-series of fertility rates and where in order to fully understand the fertility change, it is necessary to take into account the variation in this process by measures of socioeconomic status.

4.1. Introduction

The total fertility rate (TFR) in Brazil plummeted from above 6 children per woman on average in the 1950s to 1.76 in 2010 (Castanheira and Kohler 2016; United Nations 2017). As a result, Brazil became the first country to reach low fertility levels of all the countries in Latin America which experienced rapid fertility declines since the 1950s (Chackiel and Schkolnik 1996). This has led to growing concerns about the potential implications of the below-replacement fertility for the age structure of the population, as well as sustainability of intergenerational relations.

It is well known that period fertility measures such as TFR can be subject to fluctuations due to changes in fertility timing -- the so-called tempo-effects (Bongaarts and Feeney 1998; Cooper 1991). If women are advancing or postponing motherhood, the TFR can be temporarily inflated or depressed, even if the number of children women have over their lifespan is not changing. In many European and East Asian countries, parenthood postponement has been one of the drivers of very low period fertility levels during the 1990s, and the subsequent TFR rebounds during the 2000s (Goldstein, Sobotka, and Jasilioniene 2009; Kohler, Billari, and Ortega 2002). Due to the shifts to later childbearing, the cohort fertility indicators in these settings have been higher than the period fertility indicators (Myrskylä, Goldstein, and Cheng 2013). This is because cohort fertility is a measure of the average number of children women actually have during their lifetime and is free from the impact of the tempo-distortions.

Despite increasing debates about the future of fertility in Brazil and the concerns about the possibility of the low fertility "trap" (Goldani 2002), the research in the Brazilian context has thus far been dominated by the studies of TFR change. Due to the recent changes in motherhood timing, it is increasingly important to consider the limitations of this period fertility measure. Starting in the 2000s, a reversal of the pervasive teenage fertility increases took place and the evidence of motherhood postponement emerged in Brazil and Latin America more broadly (Miranda-Ribeiro and Garcia 2013; Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018; Rosero-Bixby, Castro-Martín, and Martín-García 2009; Verona 2018). This shift in the timing of motherhood opens a question of whether the emerging below-replacement fertility will mean that women will in fact have fewer children over their lifetime across generations. The understanding of the evolution of cohort fertility in that context is however lacking. Not only is the evidence about the

possible future course of cohort fertility scarce, but the results from the two studies which examined this topic are contradictory (Miranda-Ribeiro, Miranda-Ribeiro, and Rios-Neto 2017; Schmertmann et al. 2014). Currently there is no research which comprehensively examines the extent to which the emerging low levels of TFR in Brazil could correspond to equally low lifetime fertility of women who are still in their childbearing years.

The aim of this study is to address this gap in knowledge by first forecasting cohort fertility and subsequently by comparing the trends in the period and the cohort fertility measures in Brazil. This research delivers a key contribution to the subject by examining these processes also disaggregated by women's education level. Some of the most notable features of reproductive behaviour in all Latin American countries have been wide disparities in fertility and timing of childbearing by education level (ECLAC 2011; Rodríguez 2013). In order to understand the relationship between the period and cohort fertility in that setting, it is important to examine the variation in this process by women's level of schooling. No previous study has attempted to forecast cohort fertility disaggregated by measures of education level in a Latin American country or any other setting.

There are two main challenges to forecasting cohort fertility in countries like Brazil. This study further contributes to the body of knowledge about cohort fertility in Latin America and other low- and middle-income settings by addressing these challenges. First, there is a scarcity of published estimates of fertility rates disaggregated by single groups of age and year which are the necessary inputs for methods of fertility forecasting. There are no such series disaggregated by measures of education level. This study uses International Public Use Microdata Series (IPUMS) in order to indirectly reconstruct the long-term series of detailed fertility rates. Secondly, the existing methods of fertility forecasting have thus far been applied primarily in the context of Europe, Asia and the United States. Compared to the countries which were the forerunners in fertility transition, birth rates declined in Latin America at a much faster pace. Moreover, the pattern of motherhood timing has been distinct from other parts of the world. The application of the existing methods to such setting has been so far limited. In this study a Bayesian model of Schmertmann et al. (2014) is modified and used in order to forecast cohort fertility in Brazil, both for the total population and by education level.

The focus of this paper on Brazil is important for understanding the future of fertility not only in that country but in Latin America more broadly. Brazil is the biggest country in the region and consists of more than 30% of its population (United Nations 2017). Moreover, Brazil has been a forerunner in the process of fertility change among countries which experienced rapid fertility transitions since the 1950s in Latin America (Chackiel and Schkolnik 1996; United Nations 2017). Considering the marked similarities in the reproductive behaviour within the region, it is possible that other countries might follow the Brazilian low-TFR pattern in the future. This is the first study of the past and the possible future trends in cohort fertility for total population and by education level for a Latin American country.

4.2. Fertility and timing of childbearing in Brazil

The rapid decline in TFR since the 1950s in Brazil has been attributed to a number of factors: social and economic transformation, industrial development, modernization, urbanization, women's increasing labour market participation (Carvalho and Rodríguez Wong 1996; Martine 1996); changing values and attitudes due to, among other factors, spread of mass communication and TV, including the popularity of soap operas (Ferrara, Chong, and Duryea 2012; Rios-Neto, Miranda-Ribeiro, and Potter 1998); specificity of the contraceptive method mix with "limiting" methods such as sterilization being the main method of birth control (Potter 1999; Leone 2002; Caetano 2001; Caetano and Potter 2004; Goldani 2002).

Brazil is a clear example of a fertility decline driven by the spread of new ideas: the fertility change was seen first among the most privileged, urban social groups of the most developed parts of the country. Since the 1970s the decline has spread across the whole population (Carvalho and Rodríguez Wong 1996). The TFRs have been falling among all social classes, both urban and rural and across all of the states, with the highest socioeconomic strata leading the trend. Nevertheless, differences in reproductive behaviour between the population groups persisted. The TFR was below the replacement level already in the 1990s among women who enter secondary school and those earning above-minimum wages (Cavenaghi and Berquó 2005). Among women with less than secondary school and living in poorer households, the period fertility remained above 2 children per woman on average in 2010 (Berquó and Cavenaghi 2014).

The uninterrupted fertility decline in Brazil took place in the context of increasing teenage fertility and decreasing age at first birth during the 1990s. The trend towards earlier motherhood was observed among all population groups, but it was most prominent among women with lower levels of schooling and belonging to the poorer population groups (Martins 2016; Rodríguez 2013). Although there is no clear cut explanation of this unique phenomenon on the global scale, the reasons for the rejuvenation of the fertility pattern in Brazil and Latin America more broadly have been extensively discussed in the literature (e.g. Azevedo et al. 2012; Marteleto and Dondero 2013; Rodríguez Vignoli and Cavenaghi 2013; Rodriguez Vignoli 2014, 2017).

A number of studies have shown that the trend towards earlier motherhood reversed during the 2000s. Teenage fertility decreased for the first time in Brazil between 2000 and 2010 (Verona 2018). Miranda-Ribeiro and Garcia (2013) showed that after a steady decline since the 1980s, the mean age of childbearing and the mean age at first birth increased at the population level between 2000 and 2010 in Brazil. They also found that the mean age at first birth of women who entered university has been increasing already since the 1980s. This onset of the postponement transition in Brazil has been suggested in the subsequent study of Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro (2018). Moreover, Cavenaghi and Berquó (2014) showed that the age-specific fertility rates of women with at least 9 years of schooling increased above the age of 30 between 2000 and 2010. It is evident that women, in particular those with more years of schooling, started to postpone motherhood in Brazil. Consequently, the following questions emerged: How will the reductions in fertility at younger ages be related to women's future fertility? Will the decreases of fertility at younger ages be recuperated? Thus far there is a gap in knowledge on these issues.

4.3. Impact of changes in motherhood timing on period fertility and cohort fertility in Brazil

Attempts to understand the effect of the changes in the timing of childbearing on fertility levels in Brazil have focused on applying methods of TFR tempo-adjustments (Miranda-Ribeiro, Rios-Neto, and Ortega 2008; Rios-Neto and Miranda-Ribeiro 2015). These studies found that the decreasing age at childbearing was responsible for the inflating (negative) TFR tempo-effect between the late 1980s and the 2000s. The subsequent shift

towards later motherhood resulted in the emergence of the deflating (positive) TFR tempo-effects between the second half of the 2000s and 2010. These analyses show that the tempo-effects have been distorting the TFR values in Brazil since the 1980s and they cast light on the possible direction of the impact of these changes on the TFR. A well-known limitation of the tempo-adjusted TFRs is that they are synthetic indicators and they do not allow for the examination of the possible levels of fertility of real cohorts of women who are still in their childbearing years. Cohort fertility measures on the other hand correspond to the actual fertility experiences of women, they have a straightforward interpretation and they allow for the examination of whether women are having more or fewer children over their lifespan.

There have been only a few studies about the future of cohort fertility in Brazil. Two papers consistently showed that the cohort fertility rate (CFR) decreased among women born between 1950 and 1970 from above 3.6 to around 2.3 (Miranda-Ribeiro, Miranda-Ribeiro, and Rios-Neto 2017; Schmertmann et al. 2014). The Bayesian forecast of Schmertmann et al. (2014) suggest that the CFR for women born between 1975 and 1985 was likely to range between 2 and 2.5 children per woman. Brazil was one of the 37 countries included in this forecasting model, hence the specific results pertaining to that country were not discussed in detail. The forecast suggested a substantial increase in fertility rates at older ages among the youngest cohorts, resulting in the likely plateauing and even a temporary increase in cohort fertility rate. It is possible that this forecasted increase in fertility rates at older ages reflects the future realization of postponed motherhood among the youngest cohorts in Brazil. The magnitude of this recuperation shown by the forecast is however unexpected, given that the motherhood postponement process in Brazil is only at the very early stage. These results are in contrast with the forecast of Miranda-Ribeiro, Miranda-Ribeiro, and Rios-Neto (2017). Using Autoregressive Integrated Moving Average (ARIMA) models their findings suggested a continuation of the CFR decline to 1.7 and the lowest-low of 1.3 for women born in 1980 and 1985, respectively. Such ARIMA models are a form of extrapolation of the time series into the future based on the past trend, which in the case of Brazil results in the forecast anticipating the continuation of the CFR decline to very low values. Consequently, currently there is no consensus as to what the plausible course of the cohort fertility could be in the future in Brazil.

In this study we re-apply the Bayesian method of Schmertmann et al. (2014) to the case of Brazil. Specifically, two versions of the model are implemented and the results are compared: the original version of the model and a modified version which differs in the use of prior information from the original model. Moreover, the results are compared with an alternative method of cohort fertility forecasting: a method based on the limited extrapolation of the age-specific fertility trend (Myrskylä, Goldstein, and Cheng 2013). These analyses aim to cast light on which method might be suitable to forecast cohort fertility in the context of a country such as Brazil.

The remaining of this paper is organized as follows. First we describe the data used and the process of reconstructing the time-series of age-specific fertility rates. Next, we describe and justify the choice of the methods. Subsequently, the trends in the period and cohort fertility rates for total population and for educational groups are presented and compared. These analyses aim to explore the extent to which the emerging low levels of TFR in Brazil could correspond to equally low lifetime fertility of women who are still in their childbearing years. The findings are discussed in the last section.

4.4. Data

This study uses microdata from four rounds of the Population and Housing Censuses conducted in Brazil in 1980, 1991, 2000 and 2010. These data come from IPUMS (Minnesota Population Center 2017). IPUMS provides harmonized and comparable census samples which are well suited for the analysis of demographic phenomena over time. We reconstruct the time series of period age-specific fertility rates (ASFRs) by single age and year, as well as by the level of education. The rates are calculated for women of reproductive age 15-49 and years 1966-2010, using the information about women aged 15-64 from each of the censuses. The details about the census samples used in this study are in Table 4.1.

Table 4.1. The IPUMS census sample sizes and the number of women aged 15-64 in each sample; time period for which ASFRs are reconstructed from each census, Brazil

Census date	IPUMS census sample size (% of the total population)	Number of women aged 15-64	Time period for which ASFRs are reconstructed
2010	9,693,058 (5.0%)	3,292,648	1996-2010
2000	10,136,022 (6.0%)	3,275,351	1986-2000
1991	8,522,740 (5.8%)	2,579,371	1977-1991
1980	5,870,467 (5.0%)	1,738,469	1966-1980

Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

4.4.1. Estimation of the time-series of ASFRs for total population

We estimate the time series of ASFRs using the Own-Children Method (OCM) (Cho, Retherford, and Choe 1986). The OCM is an indirect, reverse-survival technique which can be applied to estimate fertility rates in settings where vital registration data or detailed birth histories from censuses or surveys are not available. This method has been previously applied to the Brazilian censuses in order to reconstruct the fertility rates for the 5-year age groups (Lima 2013). These data were used as inputs in the forecast of cohort fertility for that country in the study of Schmertmann et al. (2014), after the estimates were split into one-year age groups using the calibrated spline method (Schmertmann 2014). For the purpose of this paper the age-specific fertility rates are reconstructed by single age and year groups and such raw data are used for the analysis. This is preferred for two reasons. First, when using such approach no additional data manipulation such as interpolation to single-age groups is necessary. This allows us to avoid the risk that data might be over-adjusted or over-smoothed due to the initial grouping and subsequent disaggregation of the rates. What influence such data manipulation can have on the fertility trends cannot be assessed if the original single-age group estimates are not available. Secondly, such approach allows for the assessment of the quality of the raw, single-age group estimates, as discussed in the next sections.

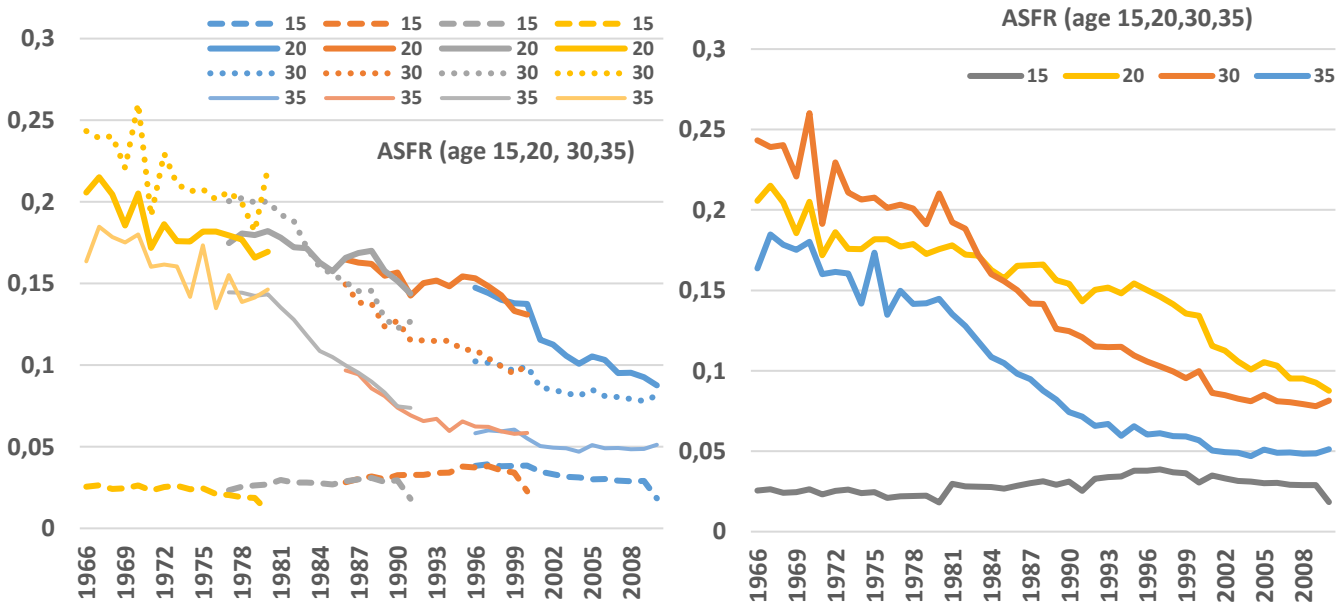
The details of the implementation of the OCM and its limitations have been extensively described in the existing literature and are not repeated here (Brass 1975; Cho, Retherford, and Choe 1986; Retherford et al. 1979; United Nations 1983). In this section, the input data which are necessary to reconstruct fertility trends using the OCM for Brazil are described. The analysis is performed in two stages.

In the first stage, the method involves matching the enumerated children (aged 0-14) in the census to their mothers (women aged 15-64), if they live in the same household. The method allows for the estimation of the fertility trends for the time period of 15 years prior to the census for women aged 15-49. It is conventionally assumed that up to the age of 15 a large percentage of children will still be living in the same household as their mother (Cho, Retherford, and Choe 1986). The IPUMS data are well suited for the OCM estimation because they include the Constructed Family Interrelationship module. We use two variables which together allow us to easily and consistently identify biological and step mothers of children: (i) "momloc" (mother's location in the household) and (ii) "stepmom" (probable stepmother). The matched children ("own" children) are then classified according to their age and the age of their mother in order to generate a mother-child matrix. This matrix includes also the number of children which were not matched to any women ("not-own" children), by their age. This part of the analysis was conducted in Stata 15 (StataCorp 2015).

In the second stage, the "non-own" children of a given age are redistributed proportionally between women, according to the distribution of the "own" children by age of women. We make adjustments for the census under enumeration based on the information published by the Brazilian Statistical Office (IBGE 2008). Next, both children and mothers are reverse-survived to estimate two quantities for each of the 15 years prior to the census: (i) the number of births by women's age and (ii) the number of women by age. For the reverse-survival we use the information about life expectancy at birth for each year between 1966 and 2010 published by the World Bank (World Bank 2018). These estimates are based on the estimates of the United Nations Population Division and are interpolated annual data from 5-year period data. We compare these estimates with those published by the Brazilian Statistical Office for periods for which they are available (IBGE 2010b). The estimates are consistent between the two sources. We discuss the possible impact of the mortality assumptions on the estimates in more detail in the next sections. To obtain a mortality pattern from the information about life expectancy at birth for each year preceding the census we use the "West" Coale - Demeny model life table, which is typically used for Brazil. Finally, the age-specific fertility rates for each year are calculated by dividing the number of reverse-survived births by the number of reverse-survived women. For this step of the analysis a programme written by Lwendo and Levin (2017) is used.

Since censuses in Brazil were conducted every 10 years, it is possible to compare the overlapping retrospective estimates from two census rounds to check for internal consistency. This check is important and it is recommended in order to identify potential problems which might accompany the estimation of fertility from censuses in LMICs, for example women's or children's age misreporting (Cho, Retherford, and Choe 1986). If the data are affected by age misreporting or other sources of bias, the trends between the censuses will overlap poorly (Cho, Retherford, and Choe 1986). For Brazil, the agreement between the rates from each of the two pairs of censuses is very good (Figure 4.1 left). This check makes sure that the age-specific trends do not reveal any pattern of systematic distortions or inconsistencies which could affect the results of the further analysis. For the years for which overlapping estimates exist, we combine them as follows. We sum the number of the reverse-survived births to women aged *x* in year *t* from two censuses and divide them by the sum of the number of reverse-survived women aged *x* exposed to the risk of birth in year *t* from two censuses (Figure 4.1 right). This approach has been previously used to combine overlapping estimates from survey data (Cetorelli 2014).

Figure 4.1. Selected age-specific fertility rates trends (age 15, 20, 30, 35), censuses: 1980, 1991, 2000 and 2010 for time period 1966-2010, raw (left) and combined (right), total population, Brazil



Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010, Own-Children Method estimates

4.4.2. Estimation of the time-series of ASFRs for subgroups according to education level

The procedure for reconstructing the ASFRs by education level using the OCM is the same as described in the previous section but three additional aspects need to be considered. First, there is no information about whether census under enumeration varies for different population groups. Consequently, we do not make adjustments for under enumeration when reconstructing the education level specific trends. Second, the detailed life tables or estimates of life expectancy at birth are not available for Brazil for subpopulations for the time period covered by this analysis. In this study it is assumed that the mortality pattern is the same among all individuals. We conduct a sensitivity analysis to examine how the results would change if differentiated patterns of mortality between educational groups were assumed (results with description in the Appendix). The differences in the reconstructed trends in fertility are not substantial and the main conclusions of this study remain unchanged. This is consistent with the numerous analyses which show that OCM is not sensitive to mortality assumptions (Cho, Retherford, and Choe 1986; Retherford, Chamratrithirong, and Wanglee 1980; Scalone and Dribe 2017).

Third, when the OCM is used to estimate fertility trends by socioeconomic characteristics, the method is based on the assumption that a value of a given characteristic at the time of the census applies to the time period for which the rates are reconstructed (Rindfuss and Sweet 1977). It needs to be used with caution when disaggregating trends by characteristics which might change over the reproductive life. In the case of education, women might still progress to higher educational levels after the beginning of the reproductive period (age 15). For that reason, we group women into two educational groups which are not very likely to change after the age of 15, but still provide an informative division into women with the lower and the higher levels of schooling. The first group encompasses women who completed up to primary school (8 years of schooling). The second group consists of those who completed at least the first year of secondary school (9+ years of schooling). Throughout this study these groups are referred to as the low and the high educational groups, respectively. The rationale for this division is that students start primary school at the age of 7 and graduate at the age of 15 in Brazil. This classification aims to minimize the problem of the subsequent progression to higher educational levels among the youngest women. This means that it is not possible to disaggregate the trends by more detailed education groups, for example into women who

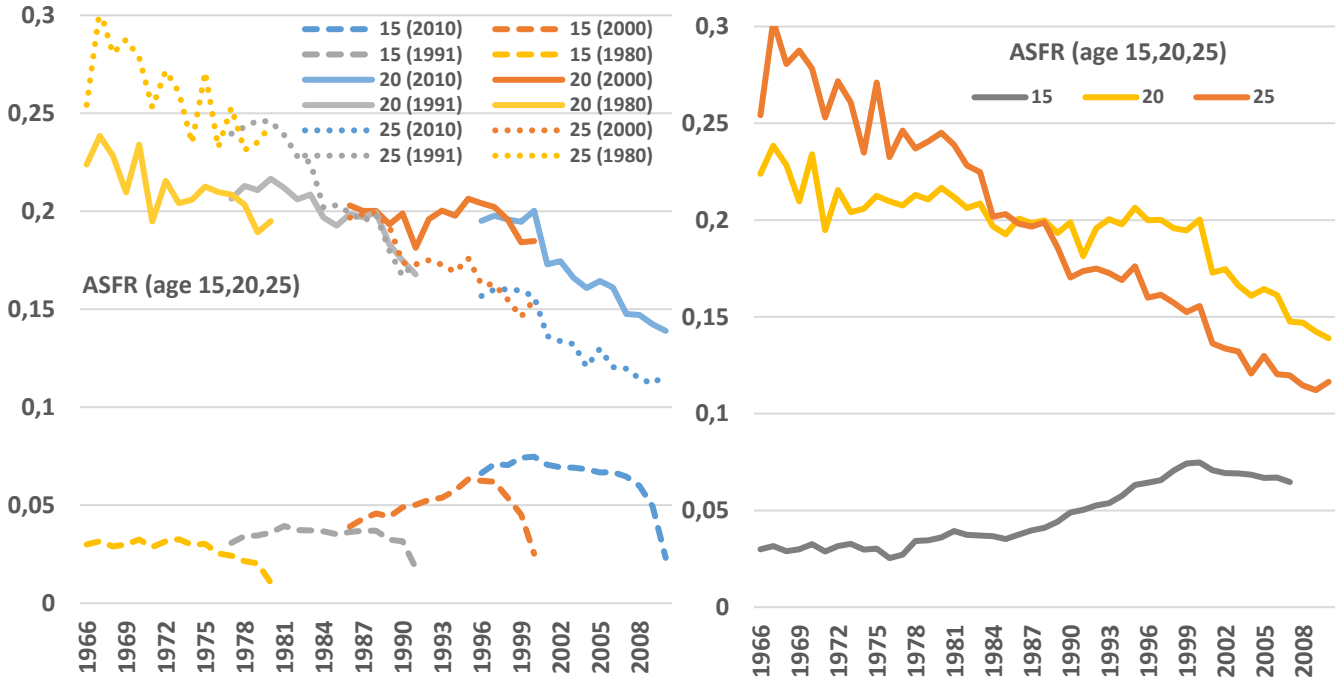
entered or completed university. This is the main limitation of this study when it comes to the examination of the fertility changes by women's level of education. This division used here is however very relevant for the examination of the TFR and CFR change in Brazil. As described in the Section 4.2, while the TFR remains above the replacement level among women with below secondary education, it has been below the replacement level among those who completed some secondary school since the 1990s.

The potential problem of incomplete educational trajectories in this study relates mainly to women in the age group 15-19 since secondary school entrance typically occurs before the age of 20. This issue is known to result in the underestimation of fertility rates for the youngest age groups in the years just before the census date among women with the low levels of schooling (Rindfuss and Sweet 1977). Figure 4.2 shows that this is the case for Brazil as well. For women with the low level of education, there is evidence of the underestimation of the fertility rate at the age of 15 for around 3 years prior to the census. This problem diminished the higher the age group considered and although still visible at the age of 20, it disappears for the older ages (for example, age 25). To minimize the bias resulting from this problem we use an approach suggested in previous research (Rindfuss and Sweet 1977). We exclude the estimates 3 years before each census for the ages from 15 to 20. The two remaining overlapping years from the two censuses are combined using the same procedure as for the total population. This results in the truncation of the rates in year 2007 for the age group 15-20. Consequently, for the low educated women, it is not possible to calculate the total fertility rate beyond that time point. The cohort analysis is however not affected, since these rates correspond to the fertility experiences of women born after 1985.

The extent of the possible bias resulting from this problem is less clear for women who already completed some secondary school. The retrospective estimates close to the census date are based on the subset of women who already entered that educational category. If these women are representative of those who will eventually end up in that group, the bias should not be severe. The extent of it however cannot be assessed. Figure 4.3 shows that the problem of the sharp decline in fertility rates at younger ages is not recorded for women with the higher level of education. The overlap of the estimates below the age of 25 in general is however less consistent for this educational group. The most pronounced differences exist for the estimates obtained from the 2000 and 2010 censuses. Beyond the age of 25, the agreement in the rates is very good between all of the censuses

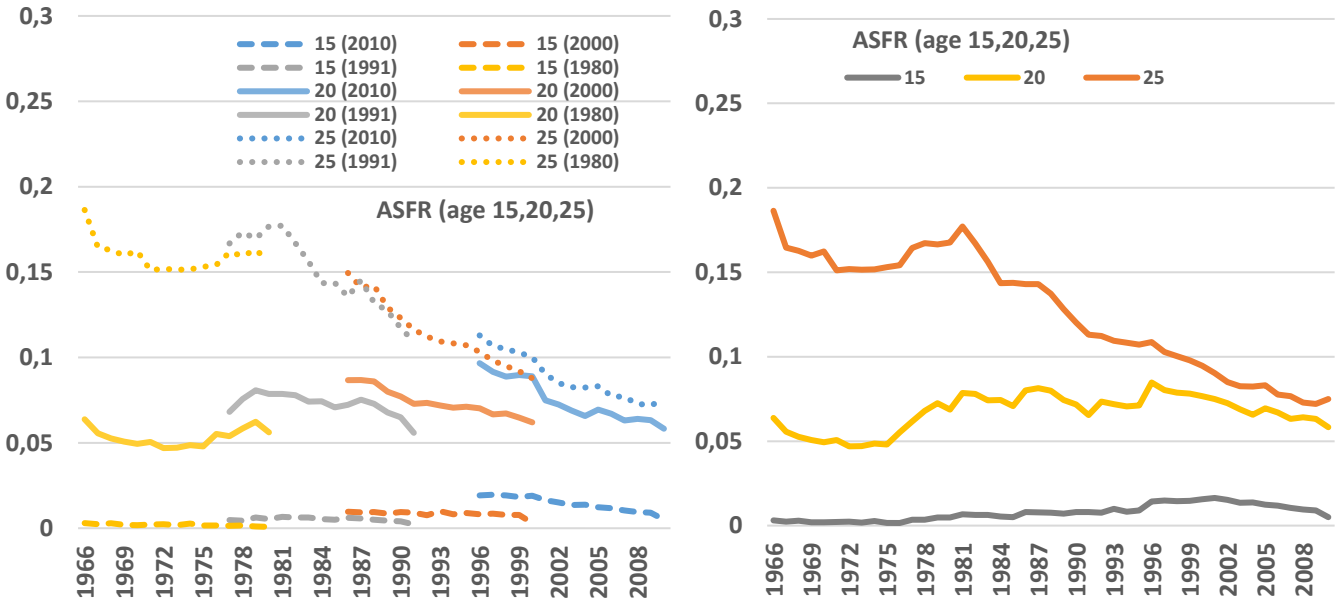
(not shown). We combine the rates for women in this educational group in a similar manner as for the total population at all ages. The possible implications of the lower level of agreement between the estimates for this educational group are further discussed in the results section.

Figure 4.2. Selected age-specific fertility rates trends (age 15, 20, 25) censuses: 1980, 1991, 2000 and 2010 for time period 1966-2010, raw (left) and combined (right), low education level, Brazil



Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010, Own-Children Method estimates

Figure 4.3. Selected age-specific fertility rates trends (age 15, 20, 25), censuses: 1980, 1991, 2000 and 2010 for time period 1966-2010, raw (left) and combined (right), high education level, Brazil



Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010, Own-Children Method estimates

The distribution of women by the educational groups for years in which the censuses were conducted, as well as for chosen birth cohorts is presented in Table 4.2.

Table 4.2. Educational composition: (i) women aged 15-49, years 1980-2010, (ii) women by birth year 1955-1985 (%), Brazil

(i)Year	**Low education**	**High education**	**(ii)Birth year**	**Low education**	**High education**
2010	44.61	55.39	**1985**	32.50	67.49
2000	62.15	37.85	**1975**	55.87	44.13
1991	74.80	25.20	**1965**	66.43	33.57
1980	84.57	15.43	**1955**	78.30	21.70

Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

4.5. Methods

4.5.1. Choice of the forecasting method

The main analysis of this paper involves using a Bayesian model of cohort fertility forecasting (Schmfertmann et al. 2014). It is a flexible approach which does not involve making ad-hoc assumptions in the process of model specification. The advantage of the method is that it allows for the evaluation of forecast uncertainty. This method originally combines information about the age patterns in cohort fertility schedules and the patterns in time-series of age-specific fertility rates from 37 countries. It uses both contemporary fertility information (of cohorts born after 1949) and historical fertility information (of cohorts born between 1900-49). The contemporary data provide information about the recent trends in the age-specific fertility rates. The historical data are used as a source of prior information about the cohort fertility schedules ("shape prior") and the fertility rates at each age ("time-series prior"). The strength of this approach is the use of the information about the plausible patterns of fertility and their change over time across many countries to produce a probabilistic fertility forecast.

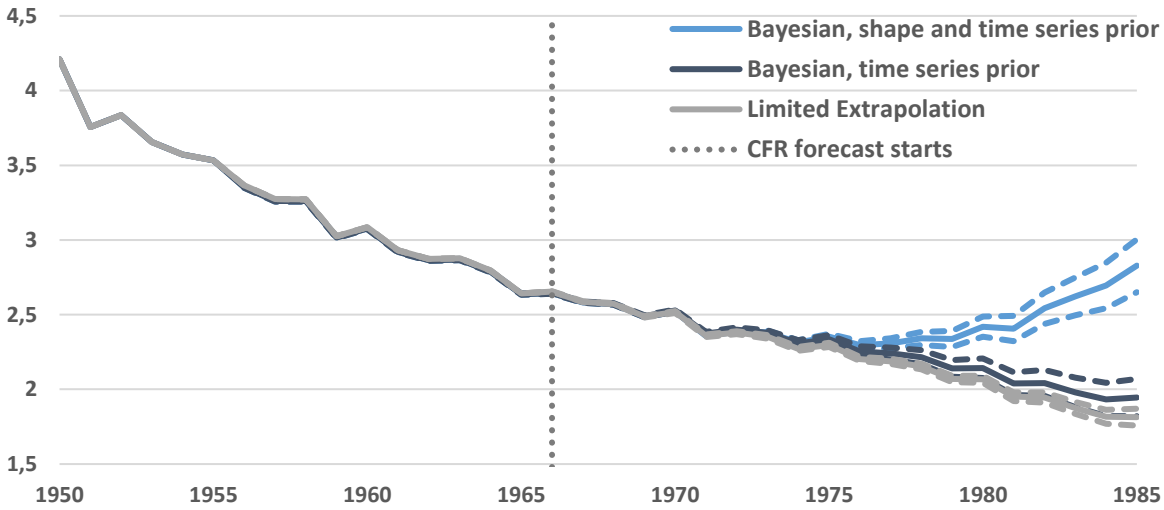
As described in Section 4.3, the results for Brazil from the Bayesian model suggested a substantial increase in fertlity at older ages among the youngest cohorts. In order to explore this aspect further we re-implement the original Bayesian model using the estimated ASFRs and also implement a modified variant of this model. The modification involves using only the time-series prior, without inclusion of the shape prior in the model. This decision is dictated by the fact that the Brazilian cohort fertility schedule is not well represented by the historical cohort schedules which are part of the model. The historical schedules which are the source of the prior information come only from high-income countries in Europe, Asia and the US. In most of these settings the biggest share of the fertlity decline occurred already before the 1900s and during the 20th century the age-specific fertility schedules where shifting to older ages. This historical information does not include examples of fertility profiles from settings similar to Brazil. There, fertility transition started in the 1960s, fertility declined from a higher level and across all ages, and this process was not accompanied by motherhood postponement at the population level. These features of fertility change: (i) the overall cohort fertility level, (ii) the mean age of childbearing and (iii) the variance of childbearing ages describe the likeliness of a given age pattern of fertility in the Bayesian model. Based on the knowledge from the

historical fertility schedules, the less a given fertlity schedule can be approximated by these three components, the higher the shape penalty, i.e. the more the forecast for a given cohort is based on the model's prior assumptions regarding the fertility change. Given that the changes in these components in Brazil differed as compared to the countries included in the model, in this study a variant of the Bayesian model without the shape penalty is explored.

Subsequently, these results are comapred with the results from an alternative forecasting method – a method involving a limited extrapolation of the age-specific fertility trends (Myrskylä, Goldstein, and Cheng 2013). A recent study has shown that this method and the Bayesian model (Schmertmann et al. 2014) performed best, and similarly well, in terms of forecast accuracy out of the existing methods of fertility forecasting in the context of high income countries (Bohk-Ewald, Peng, and Myrskylä 2017). The Bayesian method however was found to outperform the latter method in terms of quantification of uncertainty. The comparison of the two variants of the Bayesian model and an alternative method of fertility forecasting allows us to cast light on which approach might be more suitable to study cohort fertility in a context of Brazil. The analyses for this study were conducted in Stata 15 and R 3.4.0 (R Core Team 2017; StataCorp 2015).

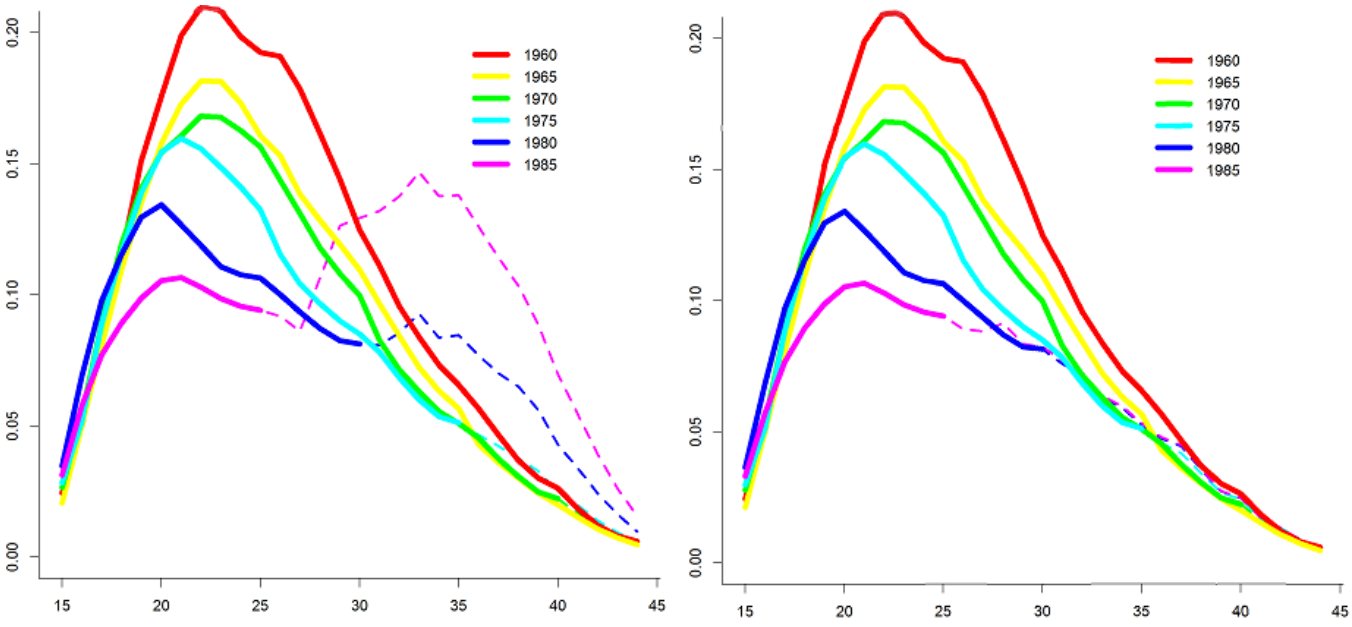
Figure 4.4 shows the result of the CFR forecast for the total population produced using two variants of the Bayesian model and the limited extrapolation method. The forecast from the Bayesian model with the shape prior diverges from the Bayesian model without the shape prior and the limited extrapolation method. The first approach suggests a plateauing and a subsequent reversal of the fertility trend for cohorts born after 1975. The two latter approaches provide much more similar CFR point estimates and show a continutation of the fertility decline. From the forecasted cohort age-specific schedules it can be seen why the CFR forecasts for women born after 1975 differed between the two variants of the Bayesian model. According to the model with the shape prior, the fertility rates at older ages are likely to increase substantially among the youngest cohorts (Figure 4.5, left). The forecast from the model without the shape prior shows an emergence of an increase in fertility rates at older ages, but without a strong pattern of recuperation as on the left figure (Figure 4.5, right).

Figure 4.4. Cohort fertility rate observed and forecasted with 95% posterior probability intervals (Bayesian model) and 95% confidence bounds (Limited Extrapolation), cohorts 1951-85, total population, Brazil



Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

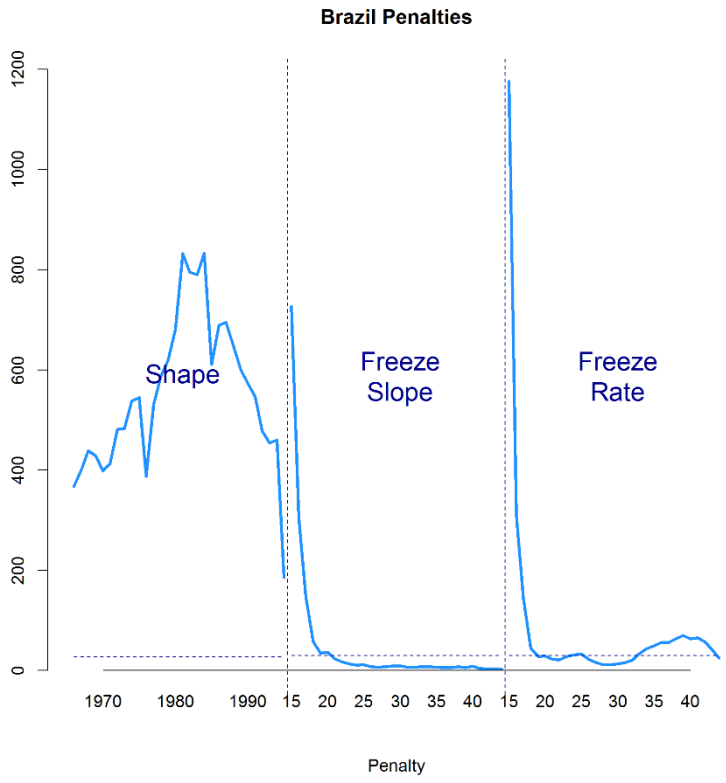
Figure 4.5. Cohort age-specific fertility schedules observed (solid lines) and forecasted posterior means (dotted lines), cohorts 1960-1985, total population, shape and time-series prior (left), time-series prior only (right), Brazil



Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

The reason for this difference can be further explored by looking at the penalty plots (Figure 4.6). The plots produced based on the Bayesian model with the shape prior show that the cohort shape penalty is very high and above the empirical average of 27 across all cohorts (dotted, horizontal line). This means that the Brazilian cohort fertility schedule is not well explained by the historical schedules and is not typical of the schedules which are the source of prior information in the model. As a results, the model imposes a heavy penalty on the Brazilian cohort age pattern. This means in practice that the model is drawing the information about the plausible future of cohort fertility schedule for Brazil from the settings in which fertility-change pattern differed substantially, as explained above. This is contributing to the unlikely future fertility trend produced by the model with the shape prior.

Figure 4.6. Penalties for rate surfaces over birth cohorts (1956-95) and ages (15-44), Bayesian model with the shape and time-series prior, Brazil



Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

For these reasons, in this study we use a Bayesian model without the shape prior and with the time-series prior only. This approach is preferred over the limited extrapolation method: consistently with the findings from existing research (Bohk-Ewald, Peng, and Myrskylä 2017), the limited extrapolation method might be underestimating uncertainty also in the case of Brazil. This can be concluded from Figure 4.4 which shows that the 95% confidence bounds of the forecast from this model are much narrower than the 95% probability intervals from the Bayesian model.

4.5.2. Forecasting of cohort fertility by education level

In order to forecast fertility for educational groups, in addition to including in the Bayesian model data for the total population for Brazil, the educational subgroups are included as separate populations. Treating educational groups as separate "national" populations can be justified by the pattern of fertility observed in Brazil. As described in Section 4.2, there exist large differences in the reproductive behaviour by socioeconomic status. In particular, the fertility pattern observed among women with the higher level of education has been distinct from that of low educated women and that observed at the population level. The pattern of highly educated women in Brazil has long been characterized by the below-replacement fertility level. This can be seen as similar to the pattern of fertility observed at the population level in some very low fertility countries which are part of the model, such as for example Singapore. The Bayesian model, through its strength of incorporating and drawing the knowledge about the changes over time in fertility rates from a large pool of countries, is explored in this study as a way of producing probabilistic forecasts for educational subgroups in Brazil.

4.5.3. Comparing TFR and CFR trends

We use the estimated time-series of ASFRs for years 1966-2010 to calculate the period total fertility rate - TFR (Eq.1), cohort total fertility rate - CFR (Eq.2) and cohort mean age of childbearing - MAC (Eq.3):

(1) $$TFR_t = \sum_{a=15}^{44\ or\ 49} f_{a,t}$$

(2) $$CFR_c = \sum_{a=15}^{44} f_{a,c}$$

(3) $$MAC_c = \frac{\sum_{a=15}^{44} a * f_{a,c}}{\sum_{a=15}^{44} f_{a,c}}$$

In the equations, $f_{a,t}$ is the age-specific fertility rate at age *a* in year *t;* $f_{a,c}$ is the age-specific fertility rate at age *a* for cohort *c*. The period measures are calculated for years 1966-2010. Combining the trends in the period age-specific rates from 4 censuses from 1966 to 2010 allows for the reconstruction of the entire age-specific fertility schedules and cohort fertility of women born between 1951 and 1966. The fertility experience of a cohort is considered in this study to be complete at the age of 44, since very few births usually occur beyond that age (Frejka and Sardon 2004). For women born between the 1966 and 1985 the full fertility schedules are not known. The forecasting approach suggested in the previous section is used to obtain the CFRs and the ASFRs for these cohorts. We calculate the mean age of childbearing for these cohorts using the forecasted posterior means of the cohort age-specific fertility rates, as in Equation 3. In order to compare the trends in the period and the cohort fertility we plot the two measures together, lagging the cohort fertility rate by the cohort mean age at childbearing[12].

The results for this paper are presented as follows. In the first section we show the trends in period fertility measures, both for the total population and by education level. Subsequently we show the detailed results of the cohort fertility analysis for total population and compare the TFR and CFR trends. In the last, third section, the corresponding anaysis by education level is presented.

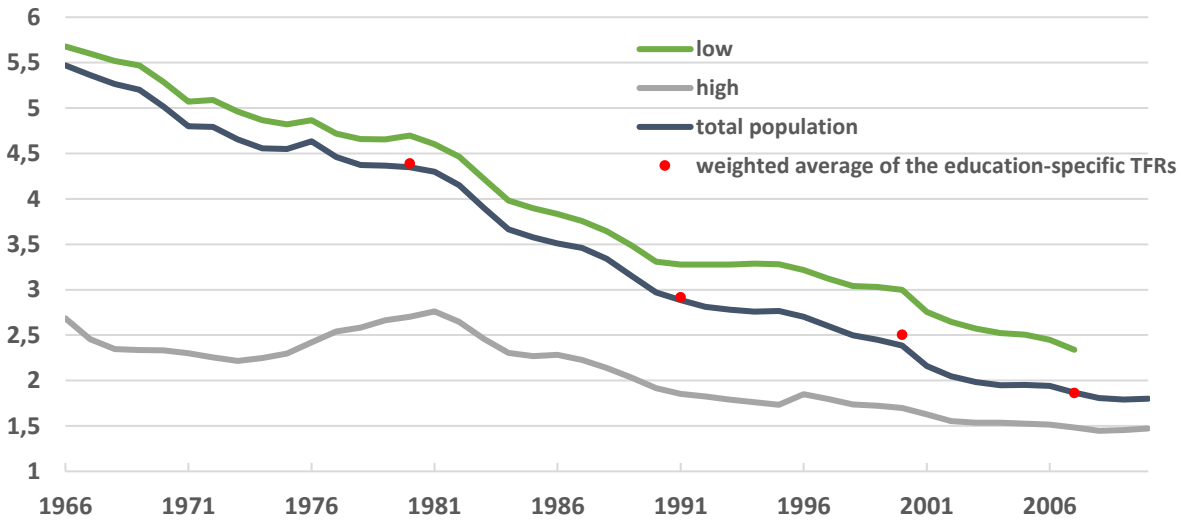
[12] Since in this study we consider the age of 44 to mark the end of the reproductive life in the cohort analysis, for consistency, in the comparison of the CFR and TFR we present the TFR estimate for the age group 15-44, and not 15-49.

4.6. Results

4.6.1. Period fertility trends

According to the reconstructed trends, the period fertility rates declined between 1966 and 2010 (Figure 4.7). The total population TFR fell to 1.79 in 2010 according to the OCM estimate. Fertility of those with the high level of schooling has been below 2 children per woman on average already since the 1990s. Among the low educated, the TFR remained above the replacement level in 2007 but the difference in fertility rates between the educational groups decreased substantially over time.

Figure 4.7. Reconstructed TFR trends, total population and educational groups (low and high level of education), 1966-2010 & weighted average of the education-specific TFRs, 1970, 1980, 1991, 2000, 2007, Brazil



Note: The TFR estimates for women with the low level of education are truncated starting year 2007 due to the reasons explained in the Data section.

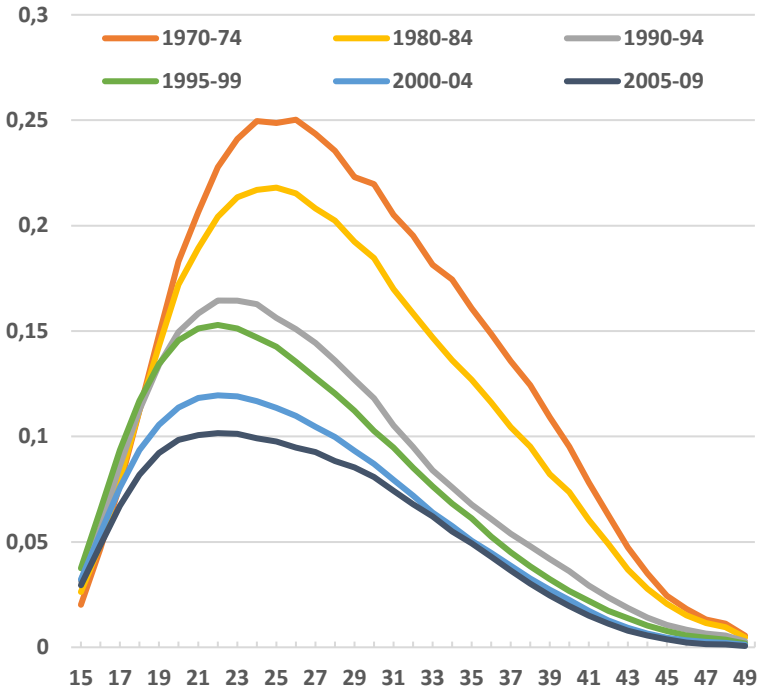
Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

Figure 4.7 also shows the average of the education-specific TFR estimates weighted by the percentage of women in each of the educational groups at a given point in time (shown in Table 4.2 in the Data section). This allows us to check the internal consistency of the reconstructed TFRs by education level. These estimates are very similar to the total population level estimates for years 1980, 1991 and 2007[13] but slightly higher for the year 2000. The age-specific fertility rates on the basis of which the TFR in the year 2000 is calculated are the average of the estimates for that year, calculated from the 2000 and the 2010 censuses. The consistency check of the reconstructed ASFRs in the Data section revealed that the agreement between the rates calculated from these two censuses is lowest of all censuses. This is likely reflected in the observed discrepancy between the total population TFR and the TFR calculated using the weighted average approach. This discrepancy should be noted, but in general the weighted average of the education-specific TFRs gives a good representation of the total population TFR and the difference is not substantial. This check gives confidence that the reconstructed education-specific fertility trends are internally consistent.

According to the age-specific schedules, the fertility rates at the population level declined vastly across all ages, with the initial exception of the youngest age groups (Figure 4.8). An increase in teenage fertility took place during the 1990s, but this process reversed in the 2000s. Moreover, the fertility rates ceased to decrease above the age of 30 between the last two periods, marking a change in the pattern of fertility thus far observed in Brazil.

[13] Due to truncation of the rates in year 2007 for women with the low level of education, it is not possible to calculate the weighted average for the year 2010. Instead, we calculate it for the year 2007, assuming the educational composition in that year is similar to that in 2010.

Figure 4.8. Period age-specific fertility rates, chosen years, total population, Brazil



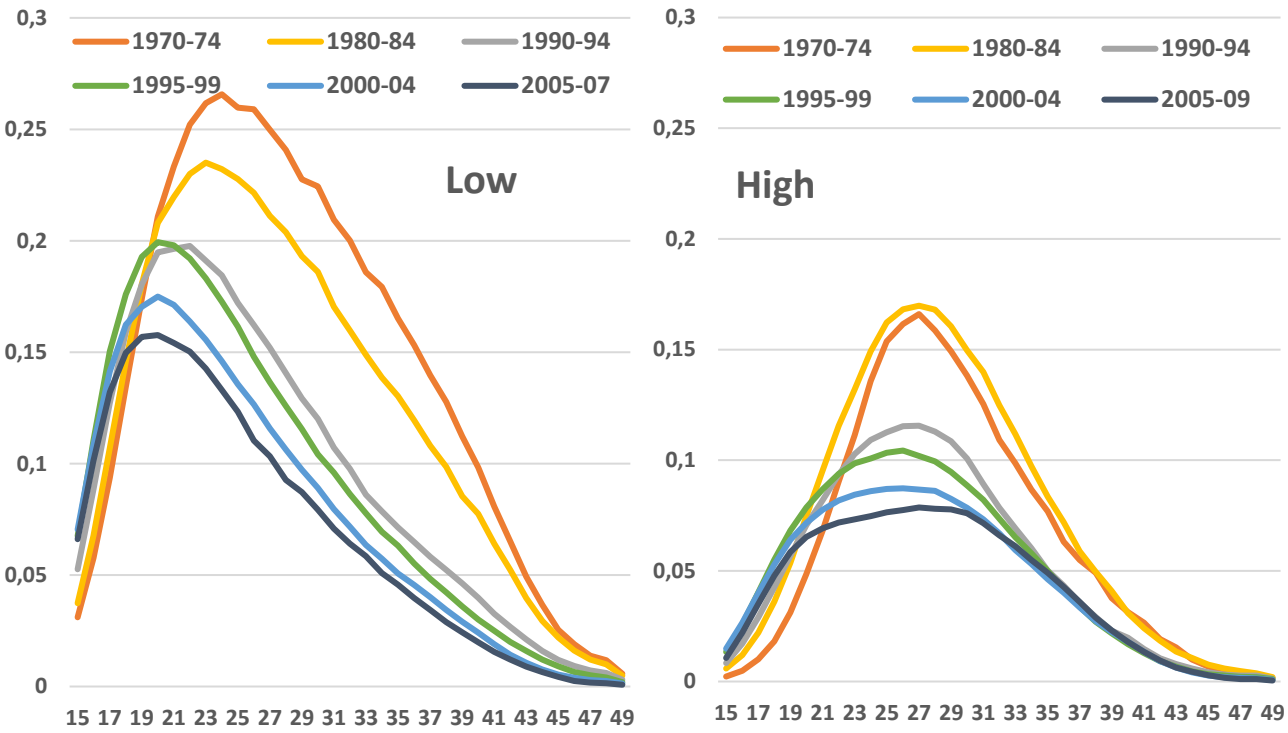
Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

Among women with the low level of education the fertility declines at older age continued concurrently with the substantial rejuvenation of the fertility schedule (Figure 4.9, left). The peak of the curve shifted to the left during the 1990s. Since the 2000s however, a decrease in the rates has been observed across all ages.

Among the highly educated, the fertility rates increased across all ages between 1970 and 1980 (Figure 4.9, right). A possible explanation for that process is the compositional change with respect to education. The percentage of women in secondary school doubled during that time period from 7% to 15% -- the biggest intercensal change observed since 1970 (own calculations). It is likely that this population group increasingly encompassed women from the lower socioeconomic strata who tend to have higher fertility rates. This could be responsible for the temporary increase in the ASFRs. Beyond the 1980s, the fertility rates declined substantially in the middle age groups, but increased for teenage years. This increase in not unexpected. As explained in the Data section, the highly educated group of women in this study encompasses those who entered secondary school. Although the teenage fertility increase was most pronounced among women with the lowest levels of schooling, it was observed among the secondary school entrants as well

(Martins 2016; Rodríguez 2013). Since the 2000s not only a reversal of this trend took place, but the rates of fertility ceased to decrease at older ages. The peak of the age-specific profile shifted to the age of 30.

Figure 4.9. Period age-specific fertility rates, chosen years, low and high level of education, Brazil



Note: The ASFR estimates for women with the low level of education are truncated from year 2007 due to the reasons explained in the Data section.

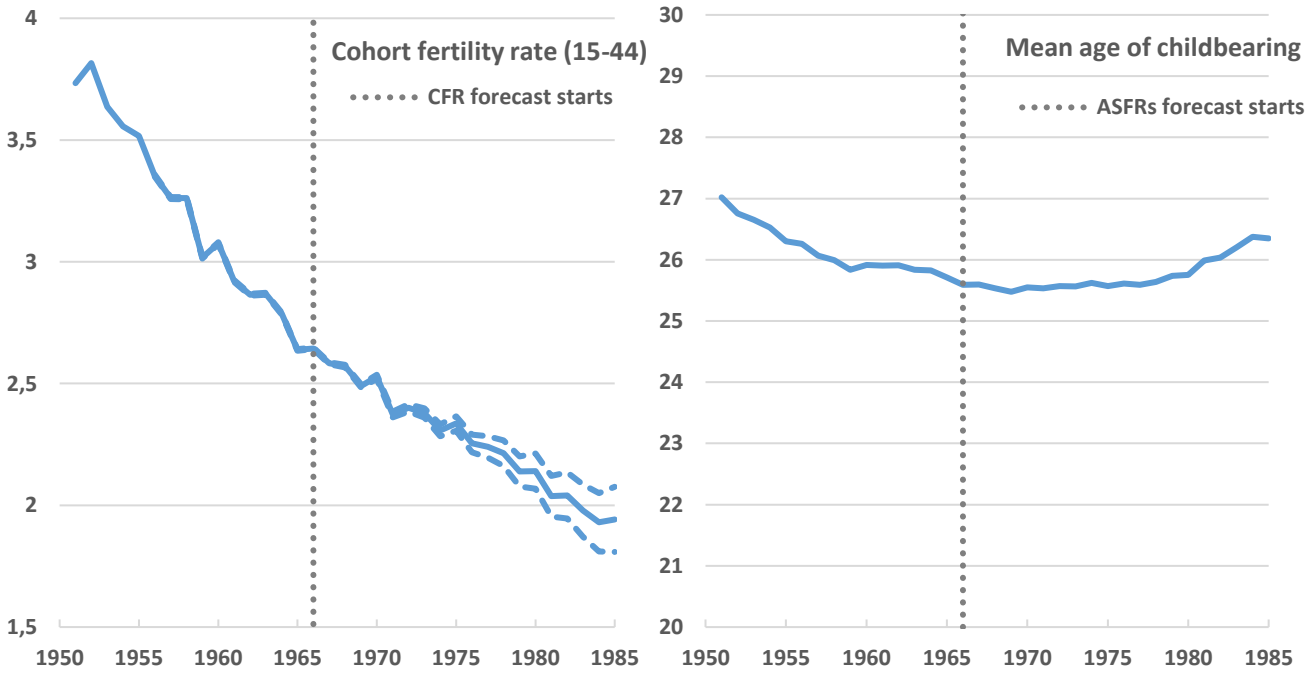
Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

The period fertility analysis shows that in the last decades substantial changes in the timing of childbearing took place in Brazil. In particular, as identified in the previous studies reviewed in the section 4.2, the initial trend towards earlier motherhood reversed in the recent years. The cohort fertility analysis in the next section explores how these changes have been related, and how they could be related in the future, to the changes in women's lifetime fertility.

4.6.2. Cohort fertility trends: population level analysis

The cohort fertility rate of women born in 1951 was around 4 children per woman on average and has been decreasing among younger cohorts (Figure 4.10, left). According to the forecast, lifetime fertility will continue to decline for those born after 1966. The completed fertility of women born in 1975 with high certainty will be around 2.3. For those born in 1980 the CFR is likely to still remain close to 2 children per women. The 95% probability intervals suggest that its value could range from 2.07 to 2.21. Further decline is likely, but the uncertainty around the estimates increases. Consistent with previous research, cohort fertility generally can be precisely forecasted for women aged 30 and older, but less so for younger women (Myrskylä, Goldstein, and Cheng 2013; Schmertmann et al. 2014). For women born in 1985 (25 years old in 2010), the CFR could range from 1.81 to 2.08.

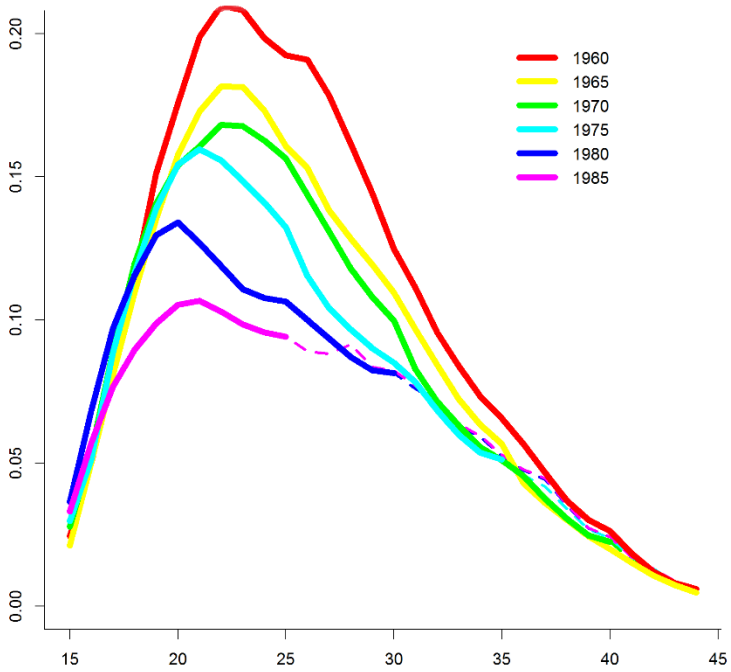
Figure 4.10. Cohort fertility rate, observed and forecasted with 95% posterior probability intervals (left); Mean age of childbearing (right), cohorts 1951-1985, Brazil



Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

Figure 4.10 (right) shows the evolution of the mean age of childbearing (MAC) across cohorts. After a steady decline, the MAC is likely to rebound among those born after 1970. Figure 4.11 depicts the age-specific fertility rates on the basis of which the MAC is calculated and casts light on this change. The age profile of fertility shifted initially to the left due to the general fertility decline -- this pushed the mean age downwards. For the youngest, 1985 cohort, the continuation of the fertility declines in the middle age groups was accompanied by a substantial decrease in teenage fertility. Consequently, the cohort age-specific schedule started to shift back to the right. Moreover, the forecast suggests an emergence of increases in fertility rates at older ages for cohorts born after 1970. This means a possible reversal of the downward trend in the rates above the age of 30 thus far observed in Brazil, and an emerging shift towards later motherhood among some members of the younger cohorts.

Figure 4.11. Cohort age-specific fertility schedules observed (solid lines) and forecasted posterior means (dotted lines), chosen cohorts, Brazil

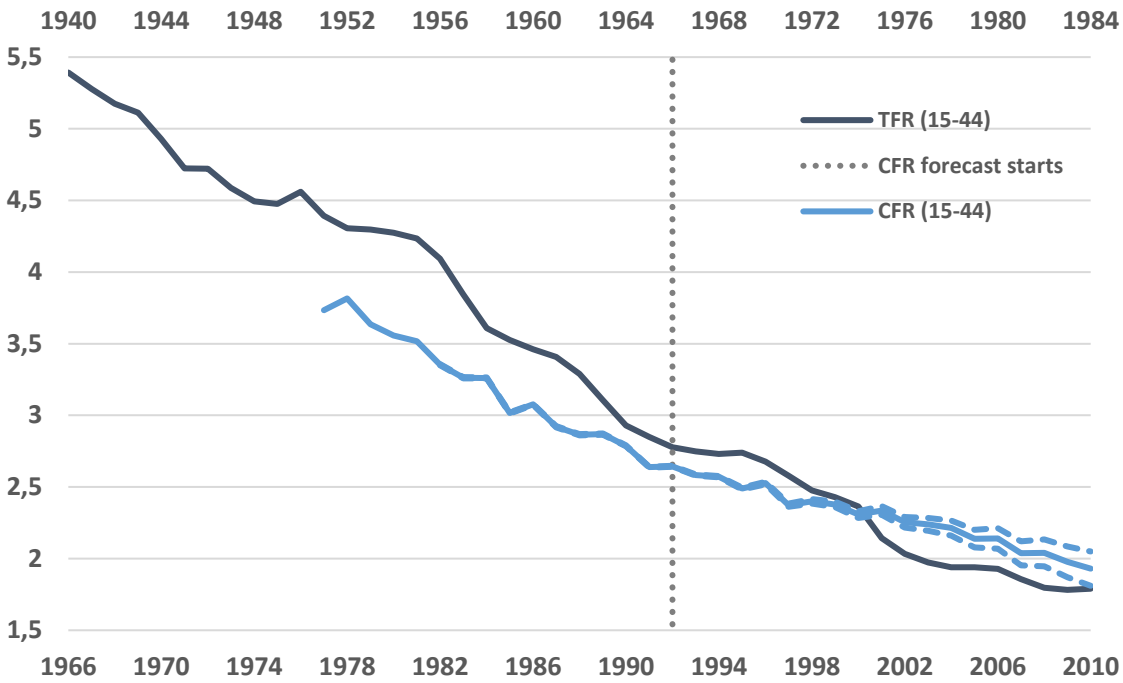


Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

To explore the relationship between the period and cohort fertility measures we compare the TFR and the CFR lagged by the cohort mean age of childbearing (Figure 4.12)[14]. During most of the study period, the total fertility rate was higher than the corresponding cohort fertility rate. The difference between the two measures declined over time. According to the forecast, the CFR of women born after 1975 will surpass the corresponding TFR. This shift in the relationship between the TFR and the CFR is related to the changing pattern of the timing of childbearing discussed above and can be explained as follows. The CFR relates to the average number of children women of a given cohort actually have during their lifetime. The TFR describes the average number of children who would be born to a hypothetical cohort of women assuming that they experience the age-specific fertility rates of a given time period throughout their reproductive life (Preston, Heuveline, and Guillot 2001). Due to this assumption, large reductions in fertility at older ages and the decreasing age at birth resulted in the initially higher levels of period fertility, as compared to cohort fertility. The subsequent decreases in fertility rates below the age of 30, which are anticipated to result in the emergence of higher levels of childbearing later in life among younger women, are responsible for the higher levels of cohort fertility, as compared to period fertility. The results from the forecast provide evidence that with a high probability, the cohort fertility of women born after 1975 will be higher than the recent, low levels of period fertility observed in Brazil.

[14] We lag the CFR by the MAC for the cohort born in 1966 (26 years). We choose the MAC value for the last cohort with a completed fertility schedule. Nevertheless, the results would be similar if lagged by any value of MAC from the range observed for cohorts born between 1951 and 1985.

Figure 4.12. Cohort fertility rate observed and forecasted, lagged by cohort mean age at childbearing, cohorts 1951-84 (top x-axis) & observed total fertility rate, time period 1966-2010 (bottom x-axis), Brazil



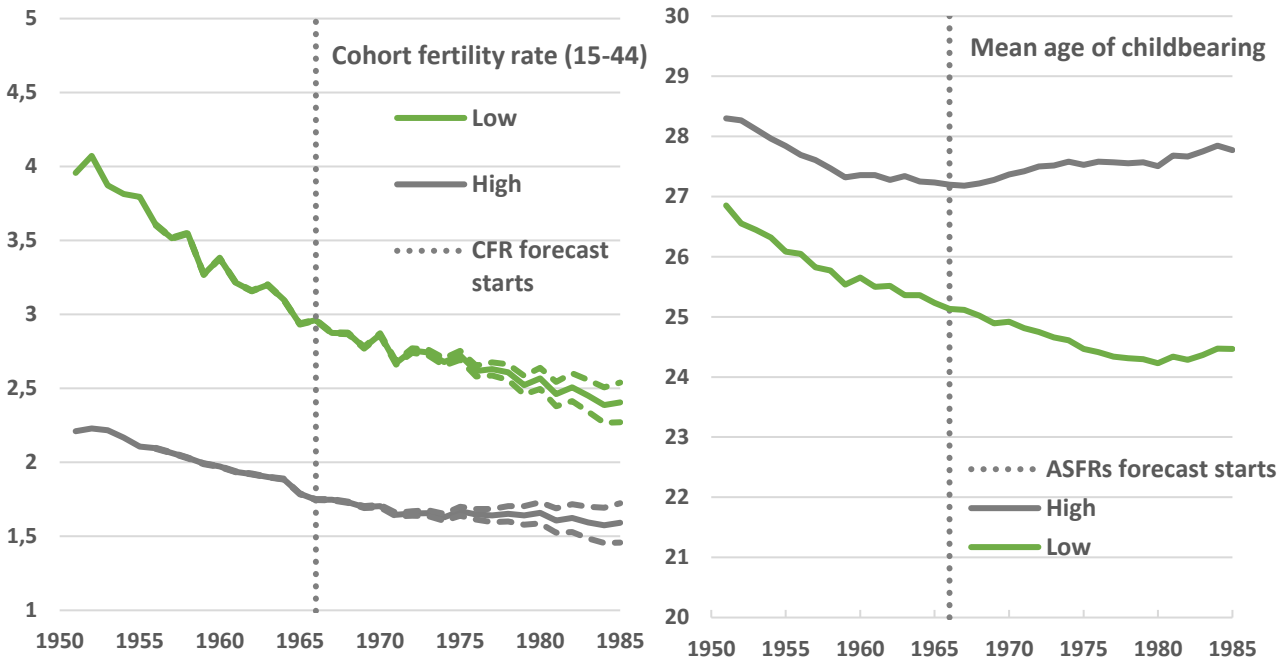
Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

4.6.3. Cohort fertility trends: analysis by education level

The cohort fertility has been declining among women who reached the end of their reproductive lives in both educational strata (Figure 4.13, left). The CFR was already below the replacement level among highly educated women born in 1960. For women born after 1970 the CFR will likely plateau at the level of around 1.6, but the uncertainty increases for women born after 1980. For low educated women, the fertility decrease is expected to continue but with a high probability the CFR value will remain above 2 children per woman. Moreover, it appears that the pace of the decrease in CFR among low educated women for whom the forecast is performed is likely to decelerate. Nevertheless, similarly as in the case of the TFR, the CFRs of the low and the highly educated women have been converging across cohorts. Figure 4.13 (right) shows that this convergence has been taking place concurrently with the diverging trends in the timing of motherhood. For both educational groups, the MAC was decreasing among older cohorts, but to a larger extent among the low educated. A reversal of this trend is anticipated for both groups: for

highly educated already among cohorts born at the end of 1960s, for low educated only for cohorts born after 1980.

Figure 4.13. Cohort fertility rate observed and forecasted with 95% posterior probability intervals (left); Mean age of childbearing (right), low and high level of education, cohorts 1951-85, Brazil



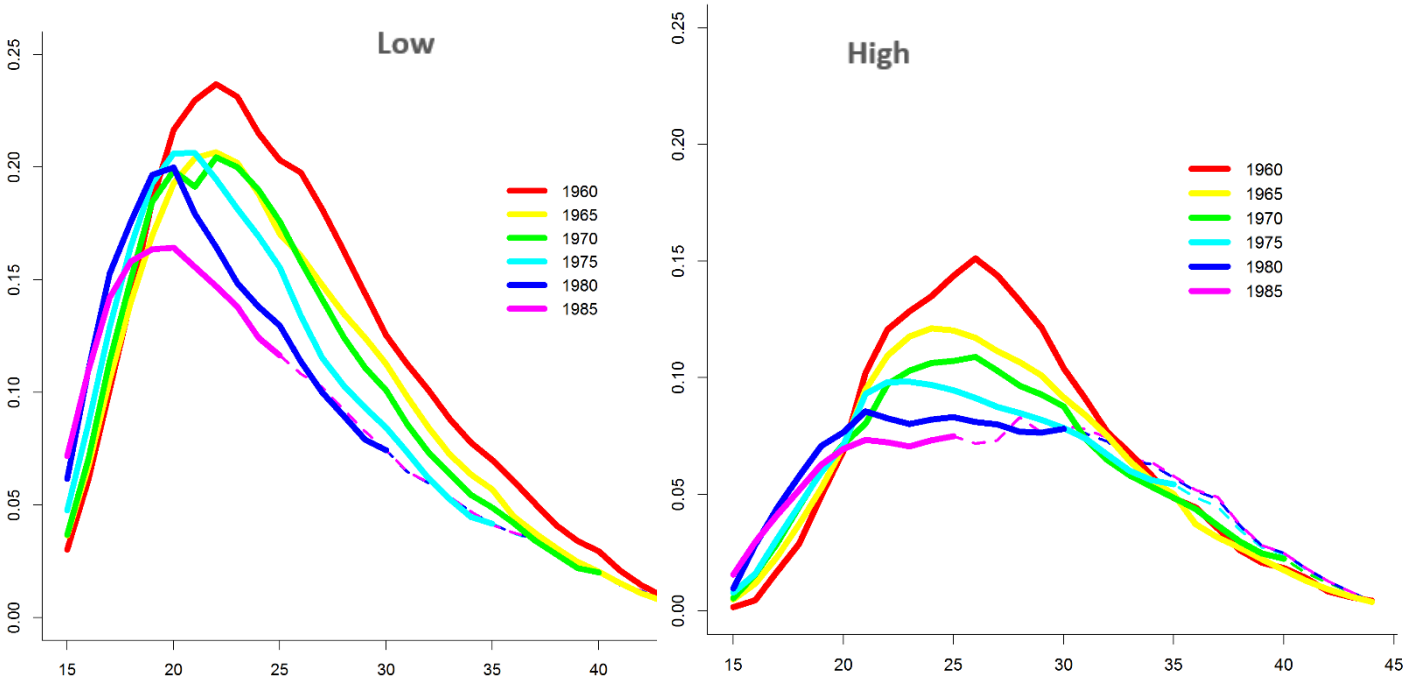
Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

The age-specific fertility schedules show what has been driving these changes (Figure 4.14). Among low educated women, a substantial decrease in fertility above the age of 20 and the initial teenage fertility increase were responsible for the MAC decrease. Only among the 1985 cohort, the adolescent fertility started to decline and fertility rates are forecasted to stop falling at older ages. This is reflected in the MAC reversal and marks the end of the process of rejuvenation of the cohort fertility schedule among low educated women.

Among highly educated women a pronounced decrease in fertility between the ages of 20 and 30 took place. For women born starting 1975, these declines are forecasted to be accompanied by increasing fertility rates at older ages. This is likely related to the realization of postponed motherhood among those who were reducing fertility in their 20s. The flattening of the fertility schedule as well as its widening due to the anticipated

increases in fertility rates later in life are responsible for the emerging MAC increase among women born around 1970. This process is likely to continue among women born in 1980 in spite of a marked elevation of teenage fertility among them. This adolescent fertility increase is consistent with the change observed in the period fertility schedules, as explained in the previous section. This trend reversed however among women born in 1985, in the same manner as among the low educated and at the population level.

Figure 4.14. Cohort age-specific fertility schedules observed (solid lines) and forecasted posterior means (dotted lines), chosen cohorts, low and high level of education, Brazil



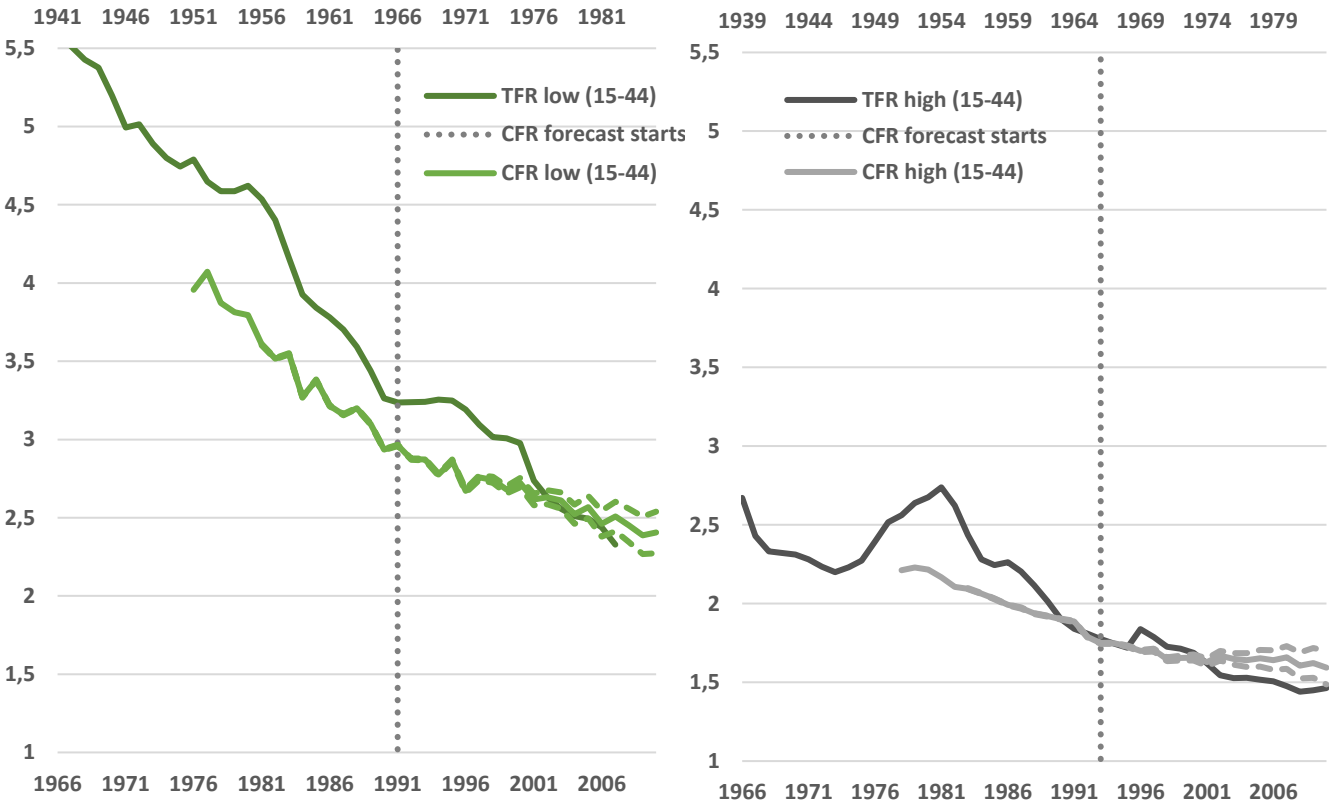
Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

These changes in the timing of childbearing are important for understanding the TFR and the CFR changes (Figure 4.15)[15]. Among women with low education, the CFR has been higher than the TFR but based on the CFR forecast the two measures are likely to converge. This pattern has been driven by a substantial decrease in the age at birth which is likely to cease for the youngest women. Among women with the higher levels of schooling the convergence of the CFR and TFR occurred already for those born during the 1960s. Starting with the 1974 cohort, the CFR surpassed the corresponding TFR and it is

[15] For the same reason as for the total population, we lag the CFR for each educational group by the MAC for the cohort born in 1966 (25 years for low educated and 27 years for high educated).

forecasted to remain at a higher level. This is a result of the continued reductions in fertility in the middle age groups which are likely to be compensated for to some extent later in women's life. It should be noted however that the CFR of highly educated women is likely to remain below the replacement level.

Figure 4.15. Cohort fertility rate observed and forecasted, lagged by cohort mean age at childbearing, cohorts: 1951-85 (low educated), 1951-82 (high educated) (top x-axis) & observed total fertility rate, time period 1966-2010 (bottom x-axis), Brazil



Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

The results show that the total population analysis conceals important differences in fertility behaviour between the population groups. Among highly educated women the TFR is providing a picture of fertility level which is lower than the likely completed fertility of women born after 1974. Similarly as at the population level, emerging motherhood postponement among some members of this group is responsible for this process. The cohort fertility of the low educated women born after 1974 on the other hand is expected to be at a similar level as the TFR. This is related to the fact that the changes

in the timing of childbearing, if any, were occurring entirely towards earlier, not later motherhood. This process ceased only among the youngest women, contributing to the likely TFR and CFR convergence.

4.7. Discussion and conclusions

There has been a growth in research about the changing pattern of motherhood timing and fertility falling to a low level in Brazil and Latin American countries more broadly. So far how these changes could be related in the future to women's completed fertility have not been examined. This is the first study for Brazil and Latina America to provide a comprehensive picture of the changes in cohort fertility, a measure which is free from the impact of tempo-distortions. Unlike the tempo-adjustments of the TFR, this approach allows for the examination of how many children on average women might actually have over their life. Moreover, it allows for the quantification of uncertainty, and therefore the assessment how likely that could be the case.

This study shows that, with high certainty, the total population CFR of women born after 1975 in Brazil will be higher than the recent low levels of TFR. Among women born until 1980 for whom the forecast has relatively low uncertainty, the cohort fertility is likely to remain at the level of around 2 children per woman on average. Further declines are likely among women born in 1985, but the uncertainty around the estimates increases. Their future fertility rate could range from 1.8 to 2.1. Hence, researchers and policy makers need to be careful when interpreting the low TFR levels currently observed in Brazil as necessarily corresponding to equally low completed fertility of women who are still in childbearing ages. The application in this study of a method which allows for the evaluation of the forecast uncertainty is important to cast light on what the likely future of fertility in Brazil could be.

The results from this study mean that due to the fact that the long standing early motherhood pattern in Brazil has weakened, the TFR is starting to provide a limited picture of changes in fertility levels. It can be anticipated that this is the case, or will be the case in the future, also for other Latin American countries. Brazil is only one of the countries in the region where women have started to postpone motherhood, as described in Chapter 1. Consequently, it is important that more attention is paid to studying cohort fertility in

Latin America. It is likely that the period fertility measures are increasingly affected by the changing pattern of motherhood timing.

Beyond the substantive findings about the possible trends in fertility in Brazil, this study has three additional contributions. First, the results highlight that it is important to explore and assess how the existing methods of fertility forecasting designed to study fertility mainly in Europe, Asia and the US can be utilized in the context of countries in which the course of the fertility transition differed markedly. An important contribution of this study is to show that careful considerations about the features of fertility change are needed to understand what methodological approaches might be suitable to forecast fertility in a given context. This research shows that by implementing small modifications to the existing methods, it is possible to substantially enhance the understanding of the future of fertility in Latin America. As a direction for future research it should be explored whether and how these methods could be applied to other low- and middle-income settings.

Secondly, this paper shows how the method designed to forecast total population cohort fertility can be exploited to forecast education-specific fertility trends. The suggested approach casts light on how the trend in cohort fertility could differ between women depending on their level of education. This is important as, in particular in the Latin American context, the total population analysis conceals important differences in fertility between population strata.

The results reveal that in spite of the diverging trends in the timing of childbearing, the cohort fertility has been converging between the educational groups -- this convergence is likely to continue in the future. This finding is consistent with the literature about the diffusion and homogenization of fertility declines across social strata in Latin American countries (Bravo 1996). Even among women with the low level of education who experienced substantial shifts to very early motherhood, the cohort fertility continued to decline uninterruptedly. This is related to a strong pattern of family limitation observed among all population groups in Brazil. Nevertheless, differences in cohort fertility between the educational strata still exist and are likely to remain for women for whom the forecast was performed. Among those with the low level of education, the cohort fertility is still likely to remain above 2 children per woman on average.

For the highly educated, the period fertility has become affected by the substantial reductions in motherhood rates in the middle age groups. These decreases reflect

motherhood postponement among some members of that population group and are forecasted to be compensated for to some extent later in life. The levels of cohort fertility are expected to be higher, as compared to the very low period fertility levels observed in recent years. In spite of that, with high probability, the cohort fertility of highly educated women will remain at a low level below the replacement, at around 1.6 for those born after 1975. It is evident that more educated Brazilian women are increasingly stopping motherhood after the first child and future studies could explore the factors behind this pattern. The finding of this study might mean that women who transition to motherhood later in life might either not have enough time to "catch up" or do not want to continue childbearing. To cast light on these processes, future research should focus on exploring the determinants of cohort fertility in Brazil and Latin America more broadly. While an increasing body of studies investigates the socioeconomic disparities in the timing of childbearing in the region, there are currently no studies which look into the determinants of socioeconomic differences in completed fertility.

The last important contribution of this study is that it provides a thorough description of the process of the estimation of the time-series of age-specific fertility rates and the cohort fertility analysis which can be replicated for other countries in Latin America. The IPUMS censuses are harmonized and publicly available for a number of countries in the region. As mentioned in Chapter 3, and further elaborated on in the Conclusion, access to the full Population and Housing Censuses in the region is often more restricted. Another advantage of IPUMS data for the estimation of the time-series of fertility rates using OCM is the availability of the constructed family interrelationship variables which allow for an easy identification of mothers and their children. This substantially facilitates analyses. One of the greatest barriers to studying and forecasting cohort fertility in the context of LMICs is the lack of necessary input data. This study showed that using IPUMS censuses it is possible to indirectly estimate detailed and consistent across-census trends in fertility rates by single year and age at the total population level, at least for Brazil. Such internal consistency of the ASFRs does not guarantee their accuracy but it assures that the trends are not systematically distorted by problems which might accompany the fertility estimates in LMICs. Obtaining such estimates by measures of socioeconomic status is more challenging and has more limitations, as thoroughly described in this paper. Nevertheless, in light of a scarcity of published time-series data on fertility rates in settings like Brazil,

either at the population level or by education level, the fertility reconstruction techniques, as done in this study, provide a promising alternative.

Although increasingly we know more about the past and possible future of cohort fertility in high-income countries, its evolution still remains unexplored outside of that context. Further research on the topic in low- and middle-income settings is needed in order to complete our knowledge about the fertility transition worldwide.

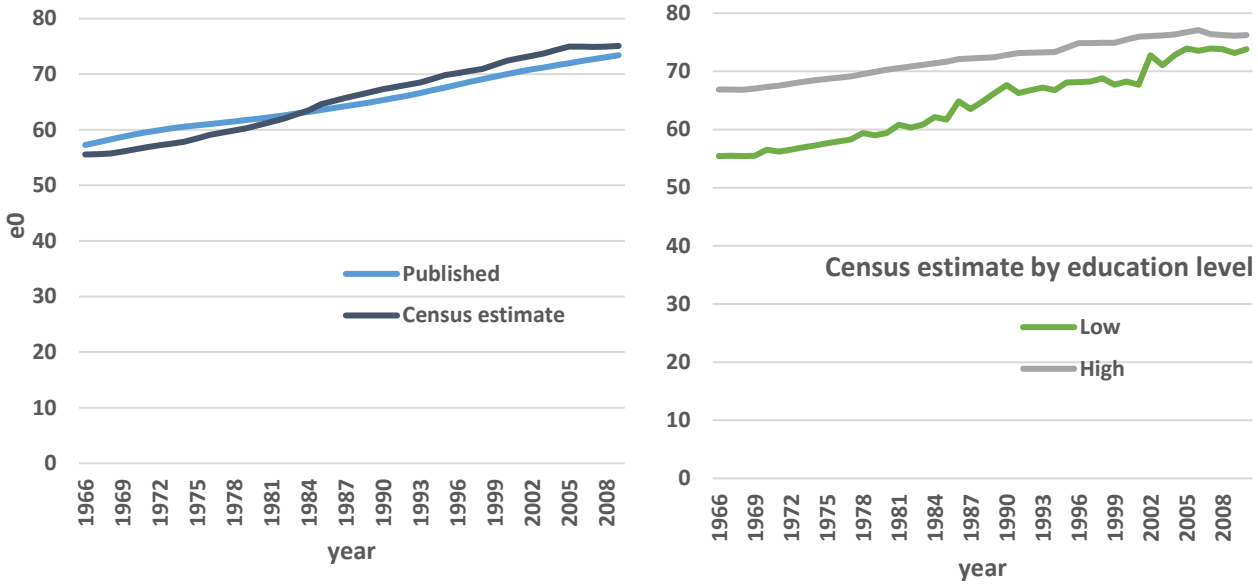
4.8. Appendix: Sensitivity analysis of the cohort fertility trends to mortality assumptions

The Own Children Method (OCM) relies on the estimates of mortality for the reverse-survival procedure. Since detailed life tables or estimates of life expectancy at birth are not available for Brazil for subpopulations, in this study we assumed that the mortality pattern is the same among all individuals. As a sensitivity analysis we examined how the results would differ if differentiated patterns of mortality between educational groups were assumed.

In order to obtain the estimates of the possible differences in mortality by level of education we used the Brass method of estimating child mortality from census data (Brass 1975). From data about the number of children even born and surviving by the age of women from each census we estimated child mortality levels for 15 years preceding each census. Subsequently, we matched the child mortality estimates with the Coale-Demeny model life tables using the MORTPAK programme (United Nations 2013). This procedure permits obtaining the complete life tables for all ages for the time period 1966-2010. This method has been previously suggested as a way of approximating the mortality patterns using census data when the estimates from external sources are not available (Cho, Retherford, and Choe 1986).

Figure A4.16 (left) shows the trend in life expectancy at birth (e0) from the Brass method and compares it with the published estimate of e0 used in this study. The difference between the two is not substantial and does not exceed 2.5 years. This means that the Brass method approximates the trend in e0 for Brazil for the total population. Figure A4.16 (right) shows the trends in e0 for educational groups from the census using the Brass method. As expected, the life expectancy at birth for more educated women is higher than that of women with the low level of education. The difference between the educational groups ranges between 11 to 2 years depending on the time period.

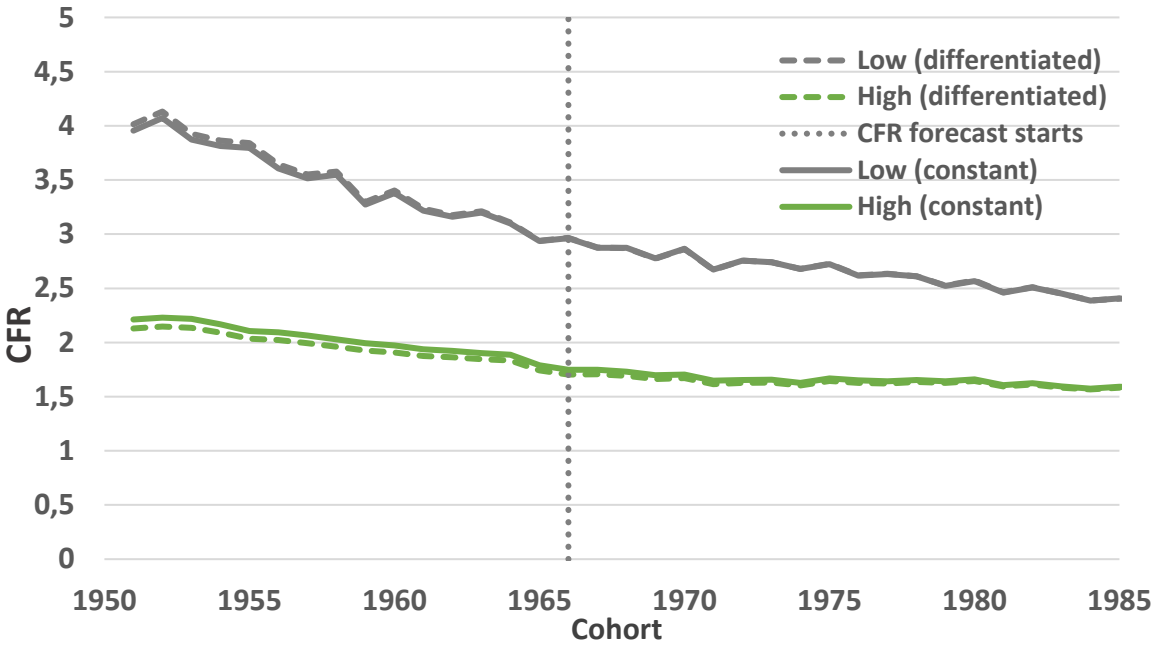
Figure A4.16. Life expectancy at birth (e0) for total population, published and estimated from censuses using Brass method (left); life expectancy (e0) by education level estimated from censuses using Brass method (right), 1966-2010, Brazil



Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010 and World Bank (2018) for the published estimates of e0

We examined how not accounting for the differences in mortality by education level in the OCM estimation could bias the main results of this study. Figure A4.17 shows the trends in the cohort fertility rate, observed and forecasted, obtained when using the constant and the differentiated by education level mortality patterns. The results labelled "constant mortality" relate to those obtained when using the published estimates of mortality for the total population for all women when reconstructing the ASFR. The "differentiated mortality" estimates were obtained using the education-specific mortality patterns shown above. The differences in the results are small and in the expected direction. As found in previous studies (Retherford, Chamratrithirong, and Wanglee 1980), the use of the constant mortality pattern underestimates the level of fertility among women with the low level of education and overestimates fertility among women with the high level of education. Nevertheless the differences between the two scenarios are small. As mentioned earlier, this is consistent with the studies which show that OCM is unlikely to be sensitive to mortality assumptions (Cho, Retherford, and Choe 1986; Retherford, Chamratrithirong, and Wanglee 1980; Scalone and Dribe 2017).

Figure A4.17. Cohort fertility rate observed and forecasted (posterior mean), cohorts 1951-85, comparison between the constant and differentiated mortality pattern for low and high level of education, Brazil



Source: Authors' calculations from IPUMS censuses 1980, 1991, 2000 and 2010

5. Conclusions

This thesis was motivated by the fact that the pattern of reproductive behaviour in Latin American has long differed and continues to differ from other world regions. The studies conducted as part of this thesis explored questions relating to contraceptive behaviour and unintended motherhood, educational differences in motherhood timing and future of fertility in Colombia, Peru, Ecuador and Brazil. These four countries experienced fast fertility transitions in the second half of the 20th century. Currently they are entering a phase in which TFRs are heading towards a low level. This fertility decline has been occurring in the context of increasing contraceptive prevalence rates but also increasing teenage and unintended motherhood. The aim of the thesis was to fill in the gaps in the knowledge about these processes, to identify the patterns of reproductive behaviour through cross-country comparisons and to explore an untapped potential of the available, yet rarely used data sources and methodological approaches to study fertility and contraceptive use in the region. In this chapter, I summarize the main findings of this thesis and I discuss their implication. Finally, I outline the main limitations and present recommendations for the future research.

5.1. Findings of this thesis

The starting point for this thesis was a review of the literature about contraceptive behaviour and unintended childbearing, educational differences in the age at first birth and fertility levels in Latin America, focusing on the latest developments in these processes. In the introduction I also situated Colombia, Ecuador, Peru and Brazil within the broad context of changes in fertility and contraceptive use in the region.

In Chapter 2 I used monthly contraceptive histories extracted from DHS reproductive calendars to examine the dynamics of contraceptive use in relation to an unintended birth experience in Colombia and Peru. This study was motivated by the paucity of research which examined the relationship between unintended motherhood and contraceptive use in a more holistic way, beyond looking at this association at one point in women's reproductive lives. To the best of my knowledge it was the first study to investigate in a comprehensive way the association between unintended birth experience and contraceptive behaviour change. I found that, in both countries, among users of less effective

contraceptives, the method switching after an unintended pregnancy was occurring towards a more effective practice postpartum. This means that after an unintended birth women seek and are able to obtain more effective means to prevent future pregnancies in both countries. Moreover, the users of the most effective methods before unintended pregnancy were less likely to re-initiate these methods after birth. This signifies that some women who might be highly motivated to avoid pregnancy are experiencing problems with the use of these methods, which not only leads to an unintended pregnancy but the abandonment of these effective methods altogether. The study showed that women's contraceptive practices after unintended pregnancies were more effective in Colombia than in Peru. This suggests that in settings with a wider accessibility and acceptability of different contraceptives, as in Colombia compared to Peru, it might be easier for women to choose an adequate method after pregnancy.

More broadly, the study showed that unintended childbearing is an important determinant of a change in contraceptive practices and that there exists a strong relationship between the contraceptive behaviour before and after pregnancy. This highlights that when studying contraceptive use postpartum, it is important to take into account women's pre-pregnancy method choice. This aspect has been so far ignored in the research on postpartum contraceptive use in general and especially in research about the relationship between pregnancy intentions and method choice after birth.

In Chapter 3 I examined the evolution of the educational disparities in the age at first birth in Ecuador, Peru and Colombia. This study was motivated by the growing evidence about the increasing heterogeneity in the pattern of motherhood timing between the population strata in Latin American countries, but a scarcity of research about the long-term trends in age at first birth by education level and their variation across countries in the region. It was the first study to estimate the first-birth age-specific rates disaggregated by measures of education level and to examine how they have changed throughout the fertility transition for the Andean region. The results revealed a pronounced divergence in the pattern of the age at first birth between the educational groups. The probability of first birth in adolescence increased to the largest extent among women who dropped-out of secondary school; the disparity in motherhood timing increased vastly between them and women who completed secondary education. Such strengthening association between school abandonment and early pregnancy suggests that the factors behind the teenage fertility increase in the region could be closely connected with the factors behind the high

levels of secondary school drop-out. Moreover, the study showed that the growing disparities between the highest and the lowest educated women have not been driven by the fact that the latter group has been becoming an adversely select one due to the changing educational composition of the cohorts. Lastly, I identified that the first-birth age-specific schedules of women who completed higher education started shifting to older ages across cohorts in all three countries. These results highlight that the emerging turn to later motherhood among highly educated women in Latin America is not confined to countries with the lowest fertility levels where this process has been so far studied.

The analyses conducted in Chapter 4 aimed to forecast cohort fertility in Brazil. The study was motivated by the increasing number of Latin American countries with below-replacement TFRs, and the consequent growing need to investigate the possible future of fertility in the region. The paper explored and discussed how the existing methods can be used and modified in order to forecast cohort fertility in the context of a Latin American country and how they can be exploited to forecast fertility by education level. The substantive findings revealed that due to the emerging motherhood postponement, the CFR of women born after 1975 in Brazil is likely to be higher than the recently observed low levels of TFR. The cohort fertility of those born until 1980 is likely to remain around 2 children per woman; further declines are likely but the uncertainty around the estimates increases for the younger cohorts. The education-specific forecasts showed that the CFR of more educated women will also be higher than the recent TFR, but it is likely to remain at the low level of around 1.6. Overall, the findings show that the TFR in Brazil is providing a limited picture of fertility levels. The future research there and in Latin America in general should focus on exploring cohort measures which provide an account of the actual changes in fertility levels across generations.

This study contributed to knowledge about low fertility in Brazil and Latin America more broadly by showing how such analyses can be conducted in that context, including for women who are still in their childbearing years. The study also showed that IPUMS data can be used to obtain consistent time-series of age-specific fertility rates. This is an important finding as currently the availability of detailed fertility estimates for Latin American countries is very limited.

By examining the patterns in closely related aspects of reproductive behaviour in the context of four countries, this thesis provides a deeper understanding of the fertility and

contraceptive use changes in the region. The processes examined in the three studies can be seen as part of the same continuum of transitions women make throughout their reproductive lives, although the connections between some of them have not been examined here or the processes have been explored in the context of different countries.

First, in spite of the fact that teenage fertility remains a pressing issue, as shown in Chapter 3 in particular among women who discontinue education, among other population groups motherhood postponement is under way. Even in countries with relatively higher levels of TFRs such as Peru and Ecuador, highly educated women born around 1950-60 started to progress to motherhood at a reduced rate during their 20s. Analyses conducted in Chapter 4 for Brazil allow for a discussion of what influence these changes could have on the period and cohort fertility measures for this population strata in these countries. In spite of the fact that the behaviour of university educated women could not specifically be examined in Chapter 4, the forecasts revealed that the reductions in fertility rates in the middle age groups among relatively more educated women in Brazil are likely to be recuperated to some extent later in life. Although remaining at a low level, the cohort fertility among them is likely to be higher than period fertility. The surveys conducted in Colombia and Peru during the 2010s indicated that the TFRs of women who entered university were already as low as 1.4 in Colombia and 1.7 in Peru (Measure DHS 2018). Given the similarities in the changes in fertility and motherhood timing by education level in the countries considered in this thesis, it is likely that the interactions between childbearing timing, period and cohort fertility in Ecuador, Peru and Colombia are, or in the near future will be similar as in Brazil. This is likely as in all of the examined Andean countries there are already signs of the increases in first-birth rates at older ages among the highest educated women, as shown in Chapter 3. Therefore, it can be anticipated that, similarly as in Brazil, the cohort fertility measures among university educated women in Colombia and Peru will be higher than the emerging very low period fertility levels.

Moreover, when thinking about reproductive behaviour from a life-course perspective and considering a broader literature on the Latin American fertility change, the findings from Chapter 2 about contraceptive behaviour connect further the conclusions from Chapters 3 and 4. This thesis showed that an unintended birth is associated with a change in contraceptive behaviour, largely towards a more effective practice postpartum. In the context of substantial levels of reporting of unintended teenage births in Latin America, this finding can be important to cast light on the changes in birth intervals and, inevitably,

completed fertility. Postpartum contraceptive use is a vital factor for birth spacing (WHO 2013). If women change their contraceptive behaviour after an unintended first birth, this might have consequences on the timing of their subsequent pregnancies. Studies show that in spite of the process of advancement of first births over time in countries such as Colombia and Brazil, women have been postponing transition to second births (Batyra 2016; Miranda-Ribeiro, Rios-Neto, and Ortega 2008). Although many factors could be responsible for the increasing first-to-second birth interval in Latin America[16], the changes in the contraceptive practices could be one of the proximate determinants. The considerations about the potential determinants of birth intervals in Latin America are increasingly important. As discussed for the case of Brazil in Chapter 4, transition to second birth is becoming a decisive factor in determining women's completed fertility.

Overall, the three studies conducted as part of this thesis considered together present conclusions which complement each other and form a basis for the directions for further research suggested in the next sections.

5.2. Implications

5.2.1. For policy

This research has a series of implications for policy initiatives. First, the results from Chapter 2 highlight the need to strengthen family planning programmes, including postpartum, in Colombia and Peru. The study identified that the users of the most effective methods before unintended pregnancy were less likely to re-initiate these methods postpartum. In particular, the turn away from the use of IUDs and implants after an unintended pregnancy was visible in both countries. The abandonment of these highly effective methods in the context of an unintended pregnancy indicates that a certain group of women who want to use LARCs is experiencing method-related problems. Potentially among some of these women such problems could be addressed through provision of information and counselling. Generally, the use of LARCs is still low in both countries. One of the reasons for that is that there exist obstacles to the provision of IUDs and implants due to their limited choice in the method offer in Peru and a limited number of health facilities in which these methods can be obtained in both countries (Chávez and

[16] Also shown in Casterline and Odden (2016)

Távara 2010; Ward, Santiso-Gálvez, and Bertrand 2015). The strengthened capacity to make these methods more available could have a positive effect on the level of their use in general. Importantly, the increased number of points at which these methods could be obtained, including after delivery and before discharge, could also increase the opportunities for the provision of counselling about their side effects or health concerns among women who have previous experience with using them. My informal conversations with experts working on reproductive health issues in the Ministry of Health and health practitioners in Colombia confirmed that making LARCs more accessible is one of biggest challenges to the family planning provision, in particular postpartum. This study provides evidence that addressing this issue should be one of the priorities in both countries.

In the context of low use and acceptability of sterilization in Peru, it is particularly important to strengthen the provision of LARCs. As the use of health services such as antenatal visits, health facility deliveries and postnatal care services is high in Peru, comprehensive postpartum family planning services could be an effective way of promoting the use of IUDs and implants. The evidence from the randomized control trials suggested that immediate postpartum method provision can have a positive influence on the use of LARCs in Peru (Foreit et al. 1993). The results of this study highlight that such interventions should be particularly tailored to reach women who had an unintended pregnancy. The protocols for antenatal and postpartum family planning counselling are in place both in Colombia and Peru. These guidelines also involve the collection of information about pregnancy intendedness during antenatal visits which could facilitate identifying women who experience unintended pregnancies (MPS 2007, 2008; Toledo Manrique et al. 2004). However, whether the guidelines related to family planning counselling are followed in practice in both countries is not known. It would be important to conduct investigations and evaluations of whether women actually receive contraceptive counselling, for example during antenatal visits, and whether this translates into enhanced opportunities for them to obtain preferred methods after delivery.

Second, Chapter 3 revealed a pronounced increase in teenage fertility among women who drop-out of secondary school in Ecuador, Peru and Colombia. From the policy perspective, I stressed the importance of creating conditions not only for school entrance but also the continuity of school attendance in the context of increasing school coverage in these countries. The fact that the relationship between leaving school and teenage pregnancy is strengthening in the region means that the interventions to reduce school

drop-out could potentially be one of the channels to address to some extent the high level of adolescent birth rates. Tackling the barriers to secondary school completion such as disparities between the socioeconomic strata in terms of opportunities to receive quality education and school segregation should be a priority in the three countries.

Moreover, identifying the reasons behind the school drop-out as a strategy to understand better teenage fertility change in Latin America could be considered as one of the future policy avenues. For instance, the Ministry of Education in Peru has recently conducted an evolution of a programme which examined whether providing information to poorer students about the benefits of completing education affects their drop-out rates (Neilson, Gallego, and Molina 2015). From other settings like Dominican Republic it is known that students' low perceptions about the returns to education can contribute to school drop-out (Jensen 2010b). Research on adolescent motherhood has shown that the perception of limited opportunities is one of the factors that can be associated with teenage pregnancy among women from poorer backgrounds (Kearney and Levine 2014). School drop-out and teenage motherhood are likely to have similar root causes. Therefore, potentially, the findings from programmes which aim to understand what drives secondary school drop-out in Latin America could be used as inputs for the design of interventions aiming at understanding the factors behind the high levels of teenage pregnancies among less advantaged population groups.

Lastly, for teenagers who experience unintended pregnancies and subsequently interrupt their education it is important to create conditions which will facilitate their return to school. This is important as obtaining a secondary school degree has become a necessary threshold in order to stave off poverty and gain work outside of the informal sector in the region (ECLAC 2010; Hopenhayn 2012). There is very little evidence about the accessibility or effectiveness of programmes aimed at ensuring the continuity of school attendance of teenagers who become pregnant in Latin America (Azevedo et al. 2012). However, qualitative research suggests that the lack of special arrangements allowing for the combination of motherhood and education is a contributing factor to secondary school abandonment altogether among teenage mothers in the region (Näslund-Hadley and Binstock 2011). Ensuring that programmes providing health, educational and social services which can facilitate school attendance among young mothers are in place in the three countries should be one of the policy priorities.

5.2.2. For data collection

This thesis has a number of implications for the collection of data in Latin America. First, the collection of DHS calendar in the region should be sustained. Apart from the already mentioned case of Brazil, in recent years also in Peru the calendar module was dropped after the implementation of the survey became the responsibility of the Peruvian Statistical Office. The halting of calendar collection in these settings is happening at the time when the DHS Program intensifies attempts to make its analyses easier. Only last year for the first time the DHS Contraceptive Calendar Tutorial was released with the aim of making the analysis of the module more accessible (USAID 2017). This indicates that there is a need to make a greater use of that data source. The understanding of reproductive behaviour including unintended motherhood, teenage fertility and contraceptive practices will continue to be important in Latin America, even if the population level indicators related to these processes see improvements. The region is the most unequal in the world and even with the progress visible at the national level, monitoring of the situation among the population groups that might lag behind in the improvements in reproductive health should remain a priority. Insights from the analyses of the calendar data, as done in Chapter 2, facilitated by the recently released materials by DHS Program on how to use the module, could be an important part of that process.

Second, in Chapter 3 I highlighted the usefulness of the information about the age and year of first birth from Population and Housing Censuses for the examination of the changes in motherhood timing. This has several implications. First, this piece of information should be systematically collected in censuses, even in countries which have DHS surveys. The collection of censuses in Latin America is likely to continue. Inclusion of that variable in the subsequent census rounds would make sure that the data on the age at first birth also continues to be available, even if the collection of surveys stalls. The advantage of such data is that by having only one census with a variable about the age at first birth it is possible to examine recent as well as past, long-term trends in motherhood timing. Therefore, even in countries which do not have other sources of past data or long series of surveys, trends in the age at first birth could be studied. Moreover, Latin American countries have entered the "postponement" phase and without a doubt there will be a growing interest and need to study this aspect of change in the timing of childbearing in the region. As shown in Chapter 3, census data are important for the estimation of the

first-birth age-specific schedules in general, and in particular among those subpopulations that are likely to be postponing motherhood.

There are two main barriers to the use of these data in the region which should be addressed. First, for some countries such as Colombia, the access to the census data is restricted. I conducted most of the analysis of the 2005 Colombian census for the purpose of this study in the Statistical Office in Bogota, since the main way in which it can be accessed is on the premises of DANE. An obvious recommendation would be to make the census data available online, as it is in the case of for example Ecuador, or available on request as in the case of Peru. An alternative suggestion would be to enlarge the scope of the fertility variables available in IPUMS. The inclusion of the information about the age and year of first birth could not only facilitate its use but possibly also increase the awareness of the existence of this variables in censuses. Second, there should be greater efforts made to ensure the quality of the fertility information in censuses. As in the case of Peru, there is a large percentage of missing values for the variable describing the age at first birth in the 2007 census. As shown in this thesis this is due to the lack of initial recording of information about the number of children ever born.

5.2.3. For research

The results of this thesis have implications for research on fertility and socioeconomic disparities in reproductive behaviour in Latin America and more broadly. First, in terms of approaches to studying fertility in the region, Chapter 4 highlighted the importance of cohort fertility analysis. The relevance of considering the impact of the changes in the timing of childbearing on the levels of period fertility in the region has been acknowledged (Rios-Neto and Miranda-Ribeiro 2015). As described in Chapter 4, this aspect has so far been studied by performing TFR tempo-adjustments. The discussions and the results from this thesis show that instead of estimating synthetic fertility measures, one can estimate and forecast more intuitive, cohort fertility indicators for Latin American countries. This approach is preferred not only because cohort fertility reflects the actual levels of women's lifetime fertility, it is also important for the dissemination of the information about demographic indicators beyond the circle of researchers. The interpretation of the TFR tempo-adjustment measures (for example as suggested by Kohler and Ortega (2002)) involves complex discussions of the tempo, quantum and parity composition effects. Such

concepts are not easy to convey to non-academic audiences, for example policy makers. Cohort fertility indicators on the other hand are easily interpretable and understandable. Such discussions and dialogues between researchers, policy makers and the general public are likely to be increasingly important with the collection of the 2020 Latin America censuses. The upcoming census round will reveal whether the period fertility declines continued in the last decade in the region. The discussions about methodological approaches to studying fertility in Latin America and the substantive findings presented in this thesis form an important basis for the development of the future research agendas on fertility change in the region, in light of the incipient low-fertility context.

Second, Chapter 3 provided evidence that in order to understand the current differences in the timing of childbearing by education level in Latin America, research should focus on looking at their long-term trends. This thesis showed that the first-birth age-specific schedules of women who completed university in Colombia, Ecuador and Peru have started to shift to older ages already among cohorts born around 1960s. This change has so far been small. Nevertheless, given the very early motherhood pattern in Latin America observed for many years and only recently emerging evidence about motherhood postponement, this is an important finding. The trend towards later first birth both at the population level and among highly educated women has been attributed to the beginning of the 20th century (Rosero-Bixby, Castro-Martín, and Martín-García 2009). Research conducted thereafter for Brazil showed however that highly educated women have been postponing motherhood since the 1980s (Miranda-Ribeiro and Garcia 2013). In Uruguay this process has been visible since the 1960 cohort (Nathan 2015). The results from these studies and this thesis taken together provide evidence that the emergence of a trend towards later motherhood among highly educated women in Latin America is not a recent phenomenon, but has been slowly evolving for decades. The findings from this thesis underline that it is important that the research in the region employs a long-term perspective to studying changes in the timing of childbearing.

The first-birth postponement in Latin America still needs to be examined in greater depth in future research. Nevertheless, the observed trend towards later motherhood among highly educated women can be seen as in line with the existing theories which highlight the role of the most educated women in initiating first-birth postponement, due to factors such as: (i) longer educational enrolment (Blossfeld and Huinink 1991; Ní Bhrolcháin and Beaujouan 2012), (ii) higher opportunity cost of childbearing among more educated

women who are in employment (Becker 1991; Rindfuss, Morgan, and Offutt 1996) or (iii) ideational changes and reduced orientation towards family values which first appear among the most educated strata of the population (van de Kaa 1987). The pattern of childbearing timing documented in Chapter 3 that is more difficult to explain considering the existing theories of fertility change is that while signs of motherhood postponement have been emerging among the highest educated women, the lowest educated women have been advancing first births. These two processes led to the increasing differences in the timing of motherhood between the educational strata.

The widening of the first-birth educational disparities was found in other settings like Britain, the United States or Southern European countries (Berrington, Stone, and Beaujouan 2015; Rendall et al. 2010; Sigle-Rushton 2008). There, increasing differences were driven by motherhood postponement among highly educated women and lack thereof among low educated women. The theoretical perspectives on why in some countries the timing of first births is more heterogeneous than in other settings are still few. The existing theories developed based on the experience of the countries highlighted above focused on exploring, for example, the role of the type of family policy regime in determining whether low educated women follow the "postponement" behaviour of higher educated ones or not (Rendall et al. 2009, 2010). Compared to these settings, the distinctiveness of Latin American countries lies in the fact that the increasing educational differences resulted not only from the lack of postponement among low educated women, but were exacerbated by the decreasing age at first birth among them. Such pattern has not been observed in any other context. Therefore, the existing theories about the processes of convergence and divergence in motherhood timing between the socioeconomic strata are unlikely to be sufficient to fully explain the childbearing pattern in the region. It was beyond the scope of this thesis to propose the theoretical explanations for the increasing disparities in the age at first birth in Latin America. A very important first step which this thesis took was to shed light on the course of change in this process in the last decades in selected countries. The implication for research that emerges from these analyses is that there is a need for more theories explaining the patterns of change in the educational differences in motherhood timing which incorporate evidence from outside of the context of high-income settings. This is important as, as in Latin American countries, these differences are more pronounced than in settings where these processes have been so far studied.

5.3. Limitations and directions for future research

Notwithstanding the contributions to knowledge, this thesis has a number of limitations that should be discussed. Highlighting such limitations is important also in order to identify the potential areas for future research. In this section I do not repeat the shortcomings already mentioned in each of the papers but discuss those that apply more broadly.

The main limitation of the study conducted in Chapter 2 is the use of the simplest definition of unintended childbearing. As described in the introduction and in the paper, pregnancy intentions are a complex concept and can be associated with contraceptive use behaviour through also complex mechanisms. Demographic and Health Surveys do not include additional attitudinal questions that could help us understand better the meaning of unintended pregnancies examined in this thesis. For example questions about happiness in response to finding about pregnancy or whether women were actively trying to become pregnant or not have been found to be useful in identifying additional pregnancy-intention dimensions (Santelli et al. 2009). Moreover, pregnancy planning, wanting and intending might be very different concepts (Trussell, Vaughan, and Stanford 1999) and these dimensions cannot be captured by measures available in DHS. Applying to future studies more detailed and nuanced classifications of "unintendedness" could be helpful to identify and understand better the mechanisms behind the contraceptive behaviours found in this thesis. Further, the paper focused on unintended births only and could not take into account pregnancies which resulted in termination. A direction for further research would be to examine the contraceptive use behaviour change among women who turn to abortion. Suggested analyses cannot be conducted for Latin American countries due to lack of data, but surveys which include such additional information for other settings could be used to explore these aspects in future research. Lastly, the study found that among many women unintended pregnancy was associated with a change towards a more effective method after birth. Whether the improved contraceptive practice among them was sustained was not assessed in the paper. It could be a direction for future studies to examine the patterns of method continuation and switching within the postpartum period and explore whether they differ by birth intention status.

The study presented in Chapter 3 has several limitations. With respect to some aspects it opened up questions which will be important to explore in the future research in order to understand the pattern of socioeconomic differentials in motherhood timing the region.

First, with the data used I could not identify whether women who dropped-out of secondary school did so before or after first birth. Such information, and in particular whether the pattern of sequencing of these two events changed over time, would be crucial to cast further light on the factors behind the high and increasing levels of teenage pregnancy in that group. To the best of my knowledge there are currently no quantitative investigations using nationally representative data for Latin America which examine whether teenage pregnancies are more likely to follow or precede school abandonment. Available longitudinal studies could potentially be explored to study this aspect, for example the Colombian Longitudinal Survey (ELCA) or Mexican Family Life Survey (MxFLS). Moreover, the study could not examine the changes in the age at first birth by other measures of socioeconomic status apart from the level of education, for example household wealth. This is due to the fact that all of the collected characteristics relate to the time of the census only and the analyses involved reconstruction of the long-term cohort trends in the age at first birth. Lastly, I could not explore other transitions closely related to the first birth experience such as changes in the pattern of union formation. Census data allow for the study of certain aspects in greater depth such as long-term trends in motherhood timing and allow for the disaggregation of these trends by more detailed measures of education level. Census data are limited however in other ways such as lack of provision of information about union histories, for example the age at first marriage or cohabitation. With respect to that, survey data offer more possibilities, as done in Esteve and Florez-Paredes (2018).

The main limitation of cohort fertility forecasting analysis in Chapter 4 is the inability to disaggregate the trends by more detailed levels of education for women with higher levels of schooling. In Brazil and Latin America more broadly these are the women who enter university education among whom TFRs are lowest (Measure DHS 2018; Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018). Therefore it would be important to distinguish between these women and women who completed secondary school only. This is one of the limitations of this study that cannot be addressed in any setting. It stems from the fact that it is not possible to estimate the necessary input data for fertility forecasting according to such detailed educational groups, as described in Chapter 4. Moreover, based on the evidence provided in Chapters 3 and 4 I could only speculate in my conclusions that the interactions between the timing of childbearing, period and cohort fertility in the Andean region might be similar to that of Brazil. Nevertheless, an important contribution

of Chapter 4 is that it suggested a methodological approach which can be used to study fertility change in other countries in the region. The analyses conducted for Brazil could be replicated for example for both Ecuador and Colombia. Among other countries, long series of census data are available for these settings in IPUMS. As a direction for further research, the cohort fertility forecasts, as done in this study could be performed for these two countries, as well as other Latin American countries which are part of IPUMS. Such analysis would be particularly important for Colombia where, similarly as in Brazil, the total fertility rate has also fallen to the below replacement level in recent years. Lastly, future research could explore the course of change and the determinants of socioeconomic disparities in completed fertility in Latin America. As mentioned in Chapter 4 for Brazil, at the level at which the total population cohort fertility is likely to reach the replacement level, the educational differences are likely to still be substantial. This is not merely due to the relatively high CFR of low educated women but also forecasted very low CFR among higher educated. The educational disparities in completed fertility at low fertility levels will be an important aspect for consideration in the future studies on reproductive behaviour in the region.

More broadly, although providing an account of reproductive behaviour in four Latin American countries which constitute almost half of its population, the scope was limited to Brazil and the Andean region. The direction for future research could be, given data availability, to examine the processes under study in the other parts of Latin America, such as Central America, the Caribbean or countries of the Southern Cone.

Lastly, an important direction for further research that became apparent in the process of the writing of this thesis is the need for more studies which examine reproductive behaviour in Latin America from a life-course perspective. As mentioned in the previous sections, this thesis examined closely connected processes but did not explore the links between some of them directly. The research in the region rarely focuses on examining the interdependencies between different aspects of reproductive behaviour or on looking into how experiencing one of the transitions is related to future fertility outcomes. For example, for the understanding of changes in women's completed fertility it would be important to explore how the experience of a teenage first birth or first birth late in life shapes women's perceptions on childbearing and influences their progression to subsequent motherhood. How these relationships vary between women with different levels of education or between women whose first birth was intended or not could further enhance the understanding of

the reproductive behaviour disparities in the region. Both qualitative research and quantitative studies possibly using available longitudinal data will be needed to provide a holistic picture of fertility changes in Latin America in the future.

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