SEXUAL AND REPRODUCTIVE HEALTH IN LOCAL MINING CONTEXTS IN COLOMBIA

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ABSTRACT

Background. Research on the relationship between mining and sexual and reproductive health (SRH) is limited, almost exclusively concerned on the HIV spread in mining contexts. Colombia, like other Latin American and Caribbean countries, experienced an unprecedented mining boom since the mid-2000's with insufficient evidence on its effects on SRH. This dissertation study examined the relationship between the gold-mining boom and fertility—as a comprehensive measure for SRH, in Colombian municipalities, between 2001 and 2015.

Methods. I conducted a longitudinal ecological study using a multilevel model of change. I used data of gold-mining production and births of each of the 1112 municipalities of Colombia—excluding ten municipalities created after 2001. For the independent variable, I constructed the time-varying categorical variable Stages of gold-mining boom (SGMB). This variable represented the municipal status regarding a gold-mining boom at each year, by defining categories of pre-boom, boom—rapid increase (boom-up) and rapid decline (boom-down)—, and post-boom. For the dependent variable, I calculated general fertility rates (GFR), age-specific fertility rates (ASFR), and total fertility rates (TFR). I performed multilevel regression models of change to test the association between the stages of gold-mining boom and fertility change, controlling for socioeconomic confounders. I conducted a sensitivity analysis by including only the municipalities with acceptable live birth coverage by 2005 (N=191).

Results. The results indicated a positive longitudinal association between the gold-mining boom and fertility, in Colombian municipalities, between 2001 and 2015. Fertility (GFR and TFR) increased in the boom-down and post-boom periods. Among different age-groups, fertility (ASFR) increased in the periods of boom-up (age group 10-14), boom-down (age groups in the range 15-25, and 35-39), and post-boom (age group 15-19). The sensitivity analysis indicated the results were robust.

Conclusions. The rapid fertility change (including of adolescent fertility) observed in the short period of the boom stages suggests that SRH is deeply impacted in gold-mining boom contexts. This study provides a baseline for further global research on this critical but neglected topic of public health significance. New investigations must consider the gender dynamics triggered by a mining boom, which may configure contexts of unbalanced gendered power relations.

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ASFR	Age-specific fertility rate
DANE	National Administrative Department of Statistics (by its Spanish acronym)
ENDS	Demographic and Health Survey of Colombia (by its Spanish acronym)
GPPC	Gold production per capita
GFR	General fertility rate
ICVR	Internal conflict victimization rate
LAC	Latin America and the Caribbean
RUV	National Registry of Victims (by its Spanish acronym)
SGMB	Stages of gold-mining boom
SIMCO	National System of Mining Information (by its Spanish acronym)
SRH	Sexual and reproductive health
TFR	Total fertility rate
VAM	Municipal added value (by its Spanish acronym)

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1.0 INTRODUCTION

Consistent evidence characterizes mining as one of the world's most hazardous activities because of the high risk of occupational accidents and toxicological exposure among mineworkers and communities [1]. Conversely, the current knowledge about the relationship between mining and sexual and reproductive health (SRH) is limited. The existing literature has been almost exclusively concerned on the spread of HIV, mostly in Sub-Saharan Africa, where studies have observed that mining communities had a higher prevalence of HIV and other sexually transmitted diseases (STDs) than the general population [2, 3]. Some investigations found associations between having HIV/STDs and individual risk factors in mining contexts; these factors include single status, alcohol and drug use, history of previous STDs, partnership or sex with a mineworker, multiple sexual partners, paying for sex, transactional sex, and non-use of condoms [4-8]. While these studies focused mainly on groups considered at high-risk (typically mineworkers and sex workers), high prevalence of HIV/STDs and associations with similar risk factors have been described among other population groups in mining communities [4, 7, 9]. In general, this literature recognizes a relationship between the mining context and the dynamics of the HIV/STDs spread. Only a handful of studies have explored broader impacts of the mining dynamics on SRH such as early marriage, increased fertility, short birth intervals, and lack of reproductive decision-making among local women [10-12].

Colombia, like other Latin American and Caribbean (LAC) countries, has experienced an unprecedented mining boom since the mid-2000's with scarce and insufficient evidence on its effects on SRH. The gold-mining boom has received the most attention because of its environmental and social impacts at the local level. Gold is a high-valued mineral that can be extracted from operations of any scale (artisanal to industrial-scale mining) and different sources (alluvial and underground mines). Given the considerable increase in the international gold price during the 2000's [13], there was an expansion of operations and intensification of production in Colombia [14]. In 2011, informal gold mining reached almost 30% of all operations in the country [15]. Until 2014, alluvial gold exploitation had affected areas of 17 of the 32 departments of Colombia, with severe impacts especially on Afro-descendant and indigenous territories [14]. During the past decade, the gold economy attracted armed groups to the mining places (guerrilla and paramilitary groups, criminal organizations, and military forces) as criminal activities expanded from illegal drugs to mining [16-18]. Civil organizations reported human rights violations (e.g., homicides, kidnappings, extortion, and forced displacement) against miners and local communities [17, 18]. Women organizations reported that women, mainly from rural places, were affected by the displacement of traditional livelihoods by the gold-mining economy; lack of job opportunities within the mining sector; criminalization and stigmatization of women organizations; and gender violence in mining places (e.g., physical and sexual violence, and servitude and human trafficking for sex commerce) [19, 20]. The reported impacts of the boom phenomenon suggest broad effects on the sexual and reproductive health (SRH) of local populations, principally among vulnerable groups like rural women and adolescents.

In the following chapters, I present the components of this dissertation, from the identification of the main gaps in knowledge regarding the relationship between mining and SRH, in the LAC region, to the discussion of the main findings from this study and its contribution of in filling these gaps.

Chapter 2 provides background information about the current knowledge on the relationship between mining and SRH in LAC. In this chapter, I present a systematic scoping review of the available peer-reviewed literature regarding SRH in mining contexts in the region. Based on this review, I identified and discussed critical gaps in knowledge that must be addressed through empirical research.

In Chapter 3, I contextualize the mining boom phenomenon in Colombia, particularly regarding the gold-mining boom after 2000. I discuss the needs for empirical research given the dearth of information about the potential mining impacts in SRH in local contexts in this country. I provide also a conceptual framework for the study of the relationship between the gold-mining boom and fertility, in which I include a definition for *mining boom context* and a rationale for the use of fertility as a comprehensive measure for SRH.

In Chapters 4 and 5, I present the specific aims that I proposed to address the research question of whether there is a relationship between the recent gold-mining boom and SRH in local contexts in Colombia; as well as, the methodological approach that guided the study. I explain the methodological procedures for the construction of the time-varying categorical variable Stages of gold-mining boom (SGMB), which operationalizes the construct of *municipal gold-mining boom*—based on the definition of *mining boom context*. I also present the fertility measures (as the dependent variables) and the socioeconomic measures (as the confounders) that I included in the analysis. I explain the multilevel models of change method, which I used for the examination of within-municipal changes and inter-municipal differences to measure the longitudinal association between the stages of gold-mining boom and fertility, in Colombian municipalities.

In Chapter 6, I present the descriptive results, including the trajectories of the gold-mining, fertility, and socioeconomic variables at the municipal level, between 2001 and 2015; as well as, the findings from the multilevel models of change and the sensitivity analysis—to test the robustness of the results.

In Chapter 7, I discuss the trajectories and patterns of change of the independent and dependent variables, as well as of the confounders included in the regression models in light of the current knowledge in Colombia and LAC. Then, I discuss the findings from the multilevel models of change: first, the significant increase in fertility (GFR and TFR) during periods of boom decline and post-boom, which is consistent with previous studies in contexts of extractive booms and with the current knowledge about the effects of economic factors over individual fertility decisions and population fertility—economic models of fertility. Second, I discuss the inconsistency observed between the increased adolescent fertility during the stages of boom (rapid increase—boom-up, and rapid decline—boom-down) and the current knowledge from the economic models of fertility approach (for which the adolescent fertility is not correlated with economic growth but with poor socioeconomic status of girls, income inequality, and economic bust). Third, I discuss the rapid change in fertility as a key finding from this study. Based on the *intermediate factors of fertility* approach, and in light of the global literature on the factors associated with the HIV spread in mining contexts, I suggest that the rapid increase in fertility—including in adolescent fertility—may be related with intermediate factors including earlier sexual initiation, non-use of contraception, casual sex, transactional sex, sexual abuse, and sex commerce. I also suggest that the rapid increase in fertility may be related with changes in structural factors, including socioeconomic vulnerability and poverty, cultural beliefs related to health and sexual behaviors, and gender roles and power relations. Fourth, I discuss the relevance of the social disruption approach in the analysis of the impacts of a mining boom on fertility. I highlight that previous studies on the impacts of disruptive events on fertility—mainly referred to war and civil conflicts, humanitarian crises, and population displacement—do not offer an adequate reference point for the discussion of this dissertation findings, since the nature of the social disruption associated with a mining boom is different and may determine distinguishable patterns of fertility. I discuss the importance of interpreting these dissertation findings from a gender perspective, considering the gender dynamics triggered by a mining boom that define contexts of unbalanced gendered power relations. Finally, I comment on the main limitations derived from the methodological approach, which, however, takes the most advantage of the available data on mining and births at the municipal level in Colombia.

I conclude in Chapter 8 by revisiting the questions of what we know, given the findings of this dissertation, and what are the remaining gaps in knowledge that future studies need to address. I highlight the relevance of testing new hypotheses regarding the *unbalanced gendered power relations* construct to assess its significance in the determination of SRH in mining contexts.

2.0 WHAT IS KNOWN ABOUT SEXUAL AND REPRODUCTIVE HEALTH IN LATIN AMERICAN AND CARIBBEAN MINING CONTEXTS? A SYSTEMATIC SCOPING REVIEW

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2.1 ABSTRACT

Background. Latin America and the Caribbean (LAC) has experienced an unprecedented mining boom since the mid-2000's with unknown effects on sexual and reproductive health (SRH). This study takes the essential first steps of summarizing the available literature regarding SRH in mining contexts in LAC, identifying critical gaps in knowledge, and discussing main implications for future research.

Methods. We conducted a scoping review with a systematic search of health literature in four databases, reference lists of selected papers, and citations in Google Scholar.

Results. The systematic search yielded 592 primary references and 16 articles from LAC. The eleven papers finally selected were conducted in gold-mining contexts in Brazil, Venezuela, Guyana, Peru, and Colombia, between 1995 and 2016. Ten studies centered on measuring HIV/STDs prevalence among mineworkers and other populations; few examined associated risk factors. Eight studies reported high HIV/STDs prevalence in the study population. None of the studies explored broader SRH issues.

Conclusions. Available research is scarce and provides limited evidence on SRH in LAC mining contexts. Critical gaps include little knowledge on 1) broader SRH impacts besides HIV/STDs, 2) SRH in settings different from gold-mining contexts in Amazon countries, 3) mechanisms shaping SRH in LAC mining contexts, and 4) effective interventions in these scenarios. Future research must consider the distinctive demographic, environmental, socioeconomic, and gender dynamics triggered by the mining economy in the analysis of the relationship between mining and SRH, particularly in a period of extractive boom.

Keywords. Sexual health; reproductive health; HIV; mining industry; Latin America

2.2 BACKGROUND

Consistent evidence characterizes mining as one of the world's most hazardous activities because of the high risk of occupational accidents and toxicological exposure among mineworkers and communities [1]. Conversely, the current knowledge about the relationship between mining and sexual and reproductive health (SRH) is limited. The existing literature has been almost solely concerned with the spread of HIV, mostly in Sub-Saharan Africa, where studies have observed that mining communities had a higher prevalence of HIV and other sexually transmitted diseases (STDs) than the general population [2, 3]. Some investigations found associations between having HIV/STDs and individual risk factors in mining contexts; these factors include single status, alcohol and drug use, history of previous STDs, partnership or sex with a mineworker, multiple sexual partners, paying for sex, transactional sex, and non-use of condoms [4-8]. While these studies focused mainly on groups considered at high-risk (typically mineworkers and sex workers), high prevalence of HIV/STDs and associations with similar risk factors have been described among other population groups in mining communities [4, 7, 9]. In general, this literature recognizes a relationship between the mining context and the dynamics of the HIV/STDs spread. Labor migration—linked to single-sex lodging and isolation and separation of miners from families—has been strongly associated with HIV-transmission [2, 9, 21, 22]. Besides the spread of HIV/STDs, only a handful of studies have explored broader impacts of mining on SRH such as early marriage, increased fertility, short birth intervals, and lack of reproductive decision-making among local women [10-12].

2.2.1 Mining boom in Latin America and the Caribbean

The study of the relationship between mining and SRH in Latin America and the Caribbean (LAC) is pertinent, as the region has experienced an unprecedented mining boom since the mid-2000's. The increased global demand for and rising prices of minerals [23], along with national mining laws favoring foreign investment [24], fueled the recent mining boom in the region. Between 2005 and 2010 the prices of coal, nickel, and copper doubled, and the price of gold increased five times between 2002 and 2011 [25]. In the same period, LAC received 24% of the global mining exploration budget, the largest investment for a single region [26]. As a result, mining production increased significantly, leading to a reactivation and intensification of operations in towns with established mining activities and, more significantly, the arrival of new mining endeavors in non-mining areas. Despite 50% to 70% of the regional mining production coming from industrial mining, most of the mining operations corresponded to artisanal and small-scale mining (ASM), which employed the majority of the region's mining workforce [27]. In particular, illegal gold mining, predominantly of small-scale, was estimated to employ directly around 350,000 people in Amazon countries; and sustain about 500,000 people only in Bolivia and Peru [28].

Despite the high dividends from the mining sector commonly reported in the region (benefits for national economies remain debatable) [23, 29, 30], the mining boom has been associated with environmental, social, and health impacts at the local level, particularly affecting vulnerable populations. Studies and reports examining the impacts of mining in LAC have described environmental crises [28, 31, 32]; social conflicts and mobilization against extractive operations [33]; human rights violations to indigenous and Afro-descendant groups across the region [34]; child labor, sexual violence, sexual exploitation, and human trafficking linked to illegal gold mining in the Amazon [35, 36]; and environmental health effects, mental health impacts, and increased risks of infectious diseases, including STDs [37].

2.2.2 Sexual and reproductive health in Latin America and the Caribbean

The mining boom in LAC takes place in a scenario of pending challenges in SRH. Estimations of either intimate partner violence or non-partner sexual violence against women vary between 24% in the Southern LAC to 41% in the Andean LAC—higher than the global estimation of 35% [38]. The region has the second highest rate of adolescent childbearing worldwide, 73 births per 1000 women aged 15–19 [39]; and the highest estimated incidence of abortion and unsafe abortion, 44 and 31 abortions per 1000 women aged 15-44, respectively [40]. Most importantly, regional figures hide profound disparities in SRH between social groups. Lack of access to contraception, reproductive health services or maternal care, maternal mortality and morbidity, and sexual violence are higher among rural, low-income, low-educated, and ethnic minority women, principally indigenous and Afro-descendants, than the general population [39].

The recent mining boom in the region, in a scenario of profound SRH inequities, provides a strong rationale for examining to what extent the mining dynamics have impacted SRH at the local level. To this end, it is necessary to establish first what is currently known about the relationship between mining and SRH in the region. This scoping literature review takes the essential first steps of examining and summarizing the available literature regarding SRH in LAC mining contexts, identifying critical gaps in knowledge, and discussing primary implications for future research.

2.3 METHODS

A scoping review is a systematic process intended to explore the extent and nature of research on a particular topic, identify gaps in knowledge, and summarize and disseminate findings [41]. One of the key purposes of a scoping review is to provide an evidence background to guide future research, practice, and decision-making on the subject of interest [42]. A scoping review is particularly relevant when there is not a clear picture of the existing evidence regarding a field of research. That is, scoping reviews are useful to address emergent or unexplored topics.

We conducted a scoping review with a systematic search of health literature during May 2017, in PubMed and PaHO-VHL (Pan American Health Association-Virtual Health Library); and two LAC databases, LILACS (Latin American and Caribbean Health Sciences) and SciELO (Scientific Electronic Library Online). We scanned reference lists and citations of the selected papers in Google Scholar to identify additional studies.

For the search strategy, we used combinations of two groups of terms in English and Spanish (only English in PubMed). First, "mining" and "mining industry." Second, "sexual health," "reproductive health," "maternal health," "HIV," "sexually transmitted diseases," "sexually transmitted infections," "fertility," and "sexual behavior." To narrow the search in PubMed and PaHO-VHL, we used the term of exclusion "data mining."

We included only references placed in LAC countries, with no limitation by the date of publication. We excluded articles addressing exclusively environmental and occupational health (e.g., exposure to pollutants, even regarding reproductive health outcomes), health issues different from SRH (e.g., children's health), and non-health issues. We excluded non-primary research papers (e.g., reports, editorial comments, and letters to the editor). The selection process included the elimination of duplicates; selection of references based on titles and abstracts; identification of full-text papers; selection of additional studies from reference lists and citations in Google Scholar; and final selection of full-text primary research articles (Fig. 1).

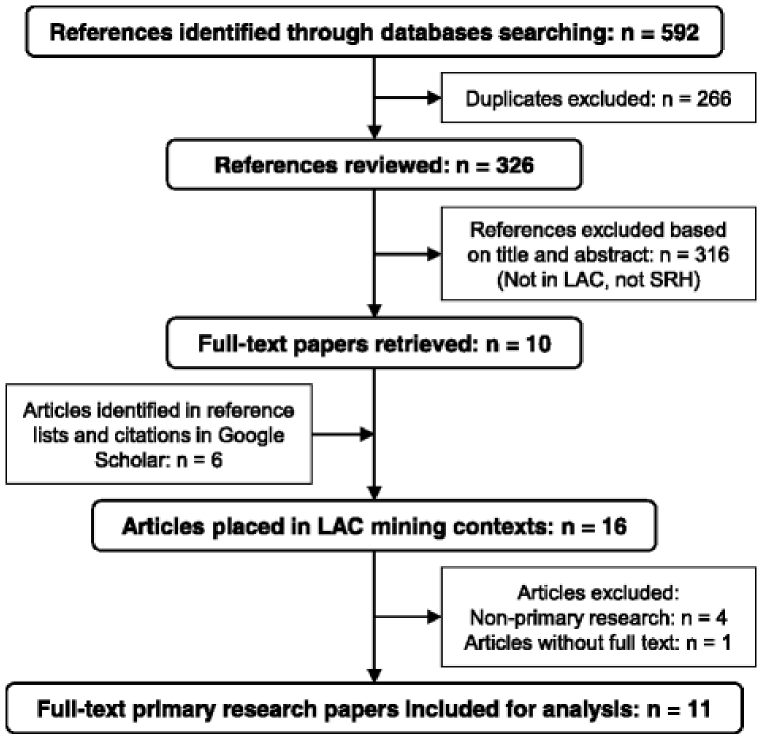


Figure 1. Scoping review selection process

Finally, we summarized and discussed the selected articles based on the country and sub-region of the study, key features of the mining operations (minerals, scale, and formality/legality), the purpose of the study, population and sample size, and main findings on SRH.

2.4 RESULTS

The scoping review yielded 592 primary references and retrieved 16 articles placed in LAC countries that focused on SRH (Fig.1). We eliminated one article without full text and four non-primary papers, which included two recent reviews on health impact assessment related to extractive industries and hydroelectric projects in the region [37, 43]. We finally selected eleven primary research articles for analysis. Table 1 shows the main findings of the scoping review.

2.4.1 General characteristics of the studies: places, times and populations

The eleven studies reviewed, conducted between 1995 and 2016 [44-54], were set in gold-mining contexts in South American countries, nine in Amazon areas. One study was set in a period previous to a mining exploitation phase [45]; and one in a period of mining decline [47]. The other nine were set in periods of full mining operations. Except for the study by Orellana et al. [48], the investigations used quantitative methods and cross-sectional designs, collecting data through surveys and biological samples for HIV and STDs tests. None of the studies used a longitudinal approach to incorporate temporality in the analyses. However, the study by Astete et al. [45] considered temporality and provided a baseline in a pre-exploitation period to evaluate the health impacts of mining during the subsequent phases. Three studies sampled mostly or exclusively male miners [49, 51, 52], one included only women [47], and one focused on indigenous population [48]. The rest of the studies sampled from the general population.

2.4.2 Purposes and main SRH findings of the studies

The eleven studies centered on HIV/STDs as the only SRH concern. The ten quantitative studies focused on measuring the prevalence of HIV and STDs. The study by Castro-Arroyave et al. [54] showed a low prevalence of HIV but a high prevalence of syphilis in a period of mining exploitation; the HIV prevalence contrasts with the high prevalence of HIV found by the rest of the quantitative studies in a similar stage of mining production. Astete et al. [45] described a low prevalence of HIV/STDs in a stage of pre-exploitation. Some studies identified a high prevalence of HIV/STDs among mineworkers [50], sex workers [46, 50], and health care workers [46] than the general population. Three investigations evidenced significant associations between HIV/STDs and individual risk factors such as having lived in a gold-miners camp [53], history of STDs [51, 52], and not having used a condom with last casual sex partner [51]. Most of the quantitative studies suggested labor migration and mobility as major factors involved in HIV/STDs transmission in mining places. Nevertheless, only Souto et al. [53] provided actual evidence on the association between STDs and mobility.

Two studies developed HIV-prevention interventions [46, 54]. They used behavioral change approaches aimed to increase knowledge, change attitudes and reduce stigma about HIV/STDs. Castro-Arroyave et al. [54] found change in perceptions and increases in knowledge among community leaders and other community members who participated in the program.

The study by Orellana et al. [48] provided unique insights into the links between mining and SRH. Qualitative in-depth data enabled the researchers to identify and discuss emerging themes such as population mobility and mixing, sociocultural factors (early sexual initiation, sexual identity, and gender roles), and interpersonal and behavioral factors (forced sex, unprotected sex, and transactional sex among poor women and young indigenous men). Authors concluded that "poverty, cultural beliefs related to health and sexual behaviors, gender inequality, lack of educational and employment opportunities, resource-extraction activities, and population mobility and mixing" interact and shape risk environments for the HIV/STDs spread among indigenous communities [48: p. 1246].

Table 1. General characteristics and main findings of studies addressing SRH in LAC mining contexts

Authors (year)	Country, sub-region	Mining features	Aims	Population (n)	Main SRH findings
Santos et al. (1995) [42]	Brazil, Pará (AR)	Gold ASM/Informal	Describe general health conditions in a [mining] community	General population (n = 223)	Hep. B prevalence = 85 %. Syphilis prevalence = 41.6% (males, 33 %; females, 9 %); the highest among miners (48 %) and sex workers (38 %).
Souto et al. (1998) [45]	Brazil, Mato Grosso (AR)	Gold*	Determine the prevalence and risk factors of Hep. B virus among immigrants	General population (n = 783)	Hep. B prevalence = 54.7 %. Significant association between HBV markers and having lived in a gold-mining camp.
Faas et al. (1999) [38]	Venezuela, Bolívar (AR)	Gold Industrial & ASM/Informal	Determine the prevalence of HIV/STDs and implement prevention workshops	General population (survey, n = 2000; biological tests, n = 893)	HIV prevalence = 1 %. Syphilis prevalence = 16.6 %; highest among female sex workers (29.5 %) and health care workers (21.7 %). History of STDs = 19.6 %.
González & Rodríguez-Acosta (2000) [36]	Venezuela, Bolívar (AR)	Gold*	Determine the prevalence of STDs, among other health conditions	Attendants to a local health service (n = 166)	Prevalence of Syphilis = 6 %; gonorrhea = 4.8 %; and HIV = 0 %. History of STDs = 27.7 %.
Souto et al. (2001) [44]	Brazil, Mato Grosso (AR)	Gold*	Determine the prevalence and risk factors of Hep. B and C (and HBV subtypes)	Population of mine camps (n = 520)	Prevalence of Hep. B = 82.9 %; and Hep. C = 2.1 %. HBsAg positivity was significantly associated with previous STDs.
Palmer et al. (2002) [41]	Guyana (AR)	Gold ASM*	Determine the prevalence of HIV	Mineworkers—mostly males (n = 216)	HIV prevalence = 6.5 %.
Seguy et al. (2008) [43]	Guyana, three regions (AR)	Gold and diamonds*	Determine the prevalence of HIV and syphilis	Male mineworkers (n = 651)	Prevalence of HIV = 3.9 %; and syphilis = 6.4 %. Knowledge on HIV = 75%; having had casual sex in the last year = 54 %; having had sex with sex workers = 14.8 %. HIV was significantly associated with history of syphilis and not having used condom with last casual sex partner.
Miranda et al. (2009) [39]	Brazil, Pará (AR)	Gold ASM*	Describe the reproductive profile of and prevalence of STDs among women living in a former mining village	Women attending to a local health facility (n = 209)	Prevalence of HIV = 1.9 %; gonorrhea = 2.4 %; and HPV = 3.8 %. History of previous STDs = 11 %; having been involved in prostitution = 15.8 %; domestic violence reported = 17.7 %; having been raped = 10 %; having had an abortion = 29.2 %.
Astete et al. (2010) [37]	Peru, Apurimac	Gold, silver, copper, iron Industrial/Formal (Pre-exploitation)	Determine the prevalence of infectious diseases, mental health and environmental pollution in a community surrounding an upcoming mining project	General population (n = 453)	No cases of HIV, Hep. C or D. Prevalence of syphilis = 1.4% (similar to the national); and Hep. B = 7.1% (lower than the national).
Orellana et al. (2013) [40]	Peru, three departments (AR)	Gold ASM/Informal	Examine structural factors related to the increased HIV/STDs vulnerability among indigenous people	Indigenous population (40 in-depth interviews; nine focus groups, n = 98)	Complex interactions between structural factors characterize Amazon rivers in Peru as risk environments for the HIV/STDs spread among indigenous communities.
Castro-Arroyave et al. (2016) [46]	Colombia, Antioquia	Gold Informal*	Implement a CBPR intervention of HIV prevention and measure the prevalence of HIV	Community leaders (n = 10); general population (n = 277; survey and HIV tests, n = 183)	No cases of HIV. Prevalence of syphilis = 2.2 %. Lack of knowledge, false beliefs and stigma regarding HIV were identified. Participants increased their knowledge and changed perceptions about HIV issues.

* Scale and/or formality status not mentioned. AR: Amazon Region. ASM: Artisanal and small-scale mining. CBPR: Community-Based Participatory Research. Hep: Hepatitis.

2.5 DISCUSSION

The literature reviewed about SRH in LAC mining contexts is scarce and provides limited evidence in this area of research in the region. The increased prevalence of HIV/STDs among mineworkers, sex workers, or other population groups that most of the studies showed, along with the reported associations with individual risk factors, match findings from other regions [2, 3]. The low prevalence of HIV/STDs that Castro-Arroyave et al. [54] found in a gold-mining community in Colombia, however, contrasts with the global findings. Two studies provided evidence on the role of labor migration and mobility on the spread of HIV/STDs in LAC mining contexts [48, 53]. Although they are limited, similar findings have been reported globally [2, 9, 21, 22].

Based on the findings of this scoping review, we identify four critical gaps in the current knowledge on SRH in LAC mining contexts. First, there is no empirical research that examines SRH broadly beyond the spread of HIV/STDs. No studies have explored SRH issues related to sexual violence against women, adolescents and children, intimate partner violence, reproductive decision-making, use of contraception, early marriage, teenage pregnancy, abortion, maternal health, or access and use of SRH services. As discussed by Vargas-Riaño et al. in regard to maternal health research in the region [55], the dominant focus on HIV issues seems to respond primarily to research funding interests and not to the health needs of the LAC population. This gap in knowledge is also characteristic of the global research on this matter. Second, there is no empirical research regarding SRH issues in settings different from gold-mining contexts, and from Mexico and Central America, the Southern LAC, and the Caribbean. The lack of studies in these other contexts is salient since numerous communities throughout Latin America have experienced the extractive boom [23, 37] with unknown effects on their SRH. Third, there is no empirical research that explores the mechanisms or pathways through which SRH is shaped in LAC mining contexts, particularly in periods of extractive boom. Finally, there is a dearth of investigations about effective SRH interventions in LAC mining contexts. In light of these needs, we discuss two key areas to consider in future research: the mining context and the production of risk in these scenarios.

2.5.1 The mining context revisited

The study of the relationship between mining and SRH in LAC has overlooked the context where mining takes place. For most of the studies reviewed, the construct *mining* referred either to the setting that delimits the location of research (the *mining* community, the *mining* camp) or an individual sociodemographic variable (the *mineworker* occupation). Astete et al. [45] and Miranda et al. [47] also considered the stage of mining production in their research approach, suggesting differential effects of the time of mining on SRH. Nevertheless, only Orellana et al. [48] explored and reflected on mining and other resource-extraction activities as contextual factors that interact with others to determine a 'risk environment' for the spread of HIV/STDs.

The mining context in a period of extractive boom has been commonly characterized by disruptive demographic, environmental, socioeconomic, and gender dynamics triggered by the mining economy. Significant workforce migration to mining places (predominantly male) and high mining wages in mining communities relate to increases in the local demand and prices of land, housing, basic goods, and services, as described in countries like Peru [56]. The increased cost of living and high expectations of short-term returns from the mining economy pull people from rural settings to engage in mining activities and displace traditional livelihoods [57, 58]. Living conditions of migrant workers in camps and mining towns—including single-sex accommodation, isolation, and separation from families—along with large amounts of disposable cash among men have been associated with high demand for alcohol, drugs, and sex services [5, 59]. These factors have in turn been linked to an increase in the number of bars, nightclubs, and brothels [48, 60], as well as rising levels of crime and violence, particularly sexual violence, as observed in gold camps in Surinam [36] and Peru [61].

These dynamics determine a context of unbalanced gendered power relations, where women are disproportionally vulnerable to the environmental, socioeconomic, and health impacts of mining [60]. As reviewed by Jenkins [60], the mining sector often establishes a displacement from subsistence economies towards cash-economies controlled by men. Women shift away from their traditional roles to become mineworkers (mainly restricted to processing tasks) or providers of services—including sex. Female mineworkers are paid less than males, even when they are performing heavy tasks like those performed by men [35, 62]. Extreme poverty may lead young girls to get involved in prostitution, bonded labor, and sexual exploitation in places of ASM and informal mining, as described in Amazon countries [35, 36]. Some studies in mining settings worldwide observed that women might engage in transactional sex as a supplementary source of income, basic goods, or favors [4, 8]. Orellana et al. [48] reported transactional sex practices among poor women and indigenous teenage boys in the Peruvian Amazon. In general, women have little access to the economic benefits of mining and become highly dependent on men, resulting in a degradation of their social status and a reinforcement of male privileges [60].

2.5.2 The production of SRH risk in mining contexts

The simultaneous dynamics often described in mining contexts challenge the way we address the links between mining and SRH in research and intervention. Some studies in South African mining settings showed that prevention interventions typically based on biomedical and behavioral approaches had little impact in reducing or even controlling the spread of HIV [1, 4, 8, 63]. Based on these findings, Desmond et al. [8] argued that conventional approaches—restricted to the individual level of analysis, do not represent adequately the complexity of the social and sexual networks that take place in mining contexts. Instead, Desmond et al. [8] proposed the use of a *high-risk environment* approach which enables structural-level analyses and interventions. The study by Orellana et al. [48] coincides with this perspective as it focused on the structural and contextual production of risk. The authors examined *'ecosocial levels'* of influence and discussed the *'risk environment'* as an appropriate category of analysis about the spread of HIV/STDs among indigenous communities. Even though the authors did not explore broad aspects of the SRH—likely occurring in these same risk environments; this approach serves as a point of reference for further exploration about the way SRH is shaped in LAC mining contexts.

2.5.3 Implications for future research

To address the gaps in knowledge identified, new research efforts must consider key conceptual and methodological challenges. First, they require comprehensive approaches for SRH that include, in addition to the study of HIV and STDs, broader SRH aspects related to sexual violence against women, adolescents and children, intimate partner violence, reproductive decision-making, use of contraception, early marriage, adolescent pregnancy, abortion, maternal health, and access and use of SRH services. Second, future studies must consider the mining context as a critical component of analysis, by examining the demographic, environmental, socioeconomic, and gender dynamics triggered by the mining economy, involved in the production of SRH risk. This also requires taking into account the particularities of the mining operations, i.e., minerals of extraction, stages of mining, scales, and status of formality/legality. Third, empirical research should consider the use of categories like *risk environment* instead of *high-risk population*, as proposed by Desmond et al. [8] and Orellana et al. [48]; the use of qualitative methods and longitudinal designs for quantitative studies; and the use of multilevel approaches to examine structural, contextual, interpersonal, and individual factors and pathways of influence involved. Finally, future research requires integrating a gender perspective for the examination of the gender roles and gender relations in mining contexts. A gender approach would facilitate the exploration and understanding of phenomena such as the unbalanced gendered power relations as determinants of SRH.

2.5.4 Limitations

We conducted a scoping literature review looking for peer-reviewed publications. We did not examine grey literature, e.g., dissertations, technical reports, or conference papers. Despite potential drawbacks on availability and quality, grey literature might provide insights on how other researchers and stakeholders (international, government, industry, and civil organizations) have approached the relationship between mining and SRH in LAC. For instance, Organización Internacional del Trabajo, Gobierno de Chile and SEREMI Tarapacá [64] presented a survey on knowledge, perceptions of risk, attitudes, and practices regarding HIV among mobile mineworkers (n = 300), in the copper region of Tarapacá, Chile. Mineworkers showed high levels of knowledge in HIV issues, high demand for commercial sex (during life, 33.1 %; during the past year, 13.4 %), and little access to condoms (81.4% referred non-availability of condoms in the mining place). These findings, similar to those from Seguy et al. [51] also targeting male mineworkers, provide a background for further research on SRH in mining communities in Chile. At the same time, these results confirm the gaps in knowledge in the LAC region regarding the restricted interest on HIV and individual risk factors associated, as well as the lack of attention to the demographic, environmental, socioeconomic and gender dynamics linked to the mining economy as key factors determining SRH.

2.6 CONCLUSIONS

This scoping review clarifies the current knowledge about SRH in LAC mining contexts and joins the recent reviews by Drewry, Shandro, and Winkler [37] and Pereira et al. [43] towards the understanding and assessment of the health impacts of the extractive industries in the region. We found that available research is scarce and provides limited evidence on SRH in LAC mining contexts. This is significant considering the numerous communities along LAC that have experienced a mining boom during the past decade, with unknown effects on their SRH. The critical gaps identified include little knowledge on 1) broader SRH impacts besides HIV/STDs, 2) SRH in settings different from gold-mining contexts in Amazon countries, 3) mechanisms shaping SRH in LAC mining contexts, and 4) effective interventions in these scenarios. We expect these findings stimulate LAC research teams, stakeholders, and communities interested in sexual and reproductive health and rights, gender equity, environmental justice, occupational health, and community health, to advocate for and conduct new investigations on this critical but neglected topic of public health research.

3.0 SEXUAL AND REPRODUCTIVE HEALTH IN COLOMBIAN MINIG CONTEXTS

3.1 THE GOLD-MINING BOOM IN COLOMBIA

Colombia, the leading producer of coal and one of the top five gold producers in Latin America and the Caribbean (LAC) [65], has experienced a mining boom phenomenon since the early 2000's. The mining sector represented 2% of the gross domestic product (GDP) and less than 14% of the exports during the 1990's, increasing to near 3% of the GDP and more than 20% of the exports in the next decade [66]. Between 2004 and 2010, the number of mining permits and the area of land granted for mining increased by almost 300%, encompassing nearly 10% of the Colombian land [65]. In 2011, artisanal and small-scale mining (ASM) and medium-scale mining (MSM) represented 72% and 26% of all mining operations and employed 48% and 26% of all the workforce, respectively [15, 67]. In the same year, ASM and MSM were estimated to directly employ near 314,000 people in the country [68].

In this scenario, the gold-mining boom has received the most attention because of its environmental and social impacts at the local level. Gold is a high-valued mineral that can be extracted from operations of any scale (artisanal to industrial-scale mining) and different sources (alluvial and underground mines). Given the considerable increase in the international gold price during the 2000's [25], there was an expansion of operations and intensification of production in the country, principally across the Pacific region and the department of Antioquia [14]. In 2011, informal gold mining reached almost 30% of all operations in the country [15]. Until 2014, alluvial gold exploitation had affected areas of 17 of the 32 departments of Colombia, with severe impacts especially on Afro-descendant and indigenous territories [14]. Currently, the gold-mining region of Antioquia is considered the place with the highest mercury pollution per capita worldwide, as this substance is regularly used in the amalgamation process of gold ASM and MSM [32]. During the past decade, the gold economy attracted armed groups to the mining places (guerrilla and paramilitary groups, criminal organizations, and military forces) as criminal activities expanded from illegal drugs to mining [16-18]. Civil organizations reported human rights violations (e.g., homicides, kidnappings, extortion, and forced displacement) against miners and local communities [17, 18]. Women organizations reported that women, mainly from rural places, were affected by the displacement of traditional livelihoods by the gold-mining economy; lack of job opportunities within the mining sector; criminalization and stigmatization of women organizations; and gender violence in mining places (e.g., physical and sexual violence, and servitude and human trafficking for sex commerce) [19, 20]. The reported impacts of the boom phenomenon suggest broad effects on the sexual and reproductive health (SRH) of local populations, principally among vulnerable groups like rural women and adolescents.

3.2 RESEARCH NEEDS

In Colombia, only the study by Castro-Arroyave et al. (2016) has explored a SRH issue in a mining context. Set in a gold-mining community of the department of Antioquia, the study described an intervention of HIV prevention that included the measurement of the prevalence of HIV and syphilis [54]. The authors found no cases of HIV but a high prevalence of syphilis (2.2%) among the sample group (n=189) drawn from the general population. The authors also reported little knowledge, stigmatization, and false beliefs regarding HIV among the participants, at the first stages of the intervention. Despite the limitations in generalizability, these results raise questions about the HIV situation in mining places in Colombia, as they differ from the high HIV prevalence commonly described in mining settings in LAC (Chapter 2) and other mining contexts worldwide [2, 3]. The study by Castro-Arroyave et al. generates further interrogations on how the general SRH situation has been impacted by the recent mining phenomenon, for instance, regarding sexual violence, intimate partner violence, fertility patterns, use of contraception, teenage pregnancy, abortion, maternal health, and access to SRH services.

As suggested in Chapter 2, more investigation about SRH in mining contexts in Latin America and the Caribbean (LAC) is required. Future studies must address critical gaps in knowledge that include the restricted examination of SRH, so far only concerned with HIV/STDs issues. New investigations must consider, among the conceptual and methodological challenges, the use of a comprehensive approach for SRH; the inclusion of the mining context as an analytical construct; the characterization of the mining operations; and the use of multilevel approaches (Chapter 2).

3.3 CONCEPTUAL FRAMEWORK

Two theoretical approaches ground the examination of the relationship between the gold-mining boom and fertility in Colombia. There is the *social disruption* approach, which provides the basis for a *mining boom context* definition. In addition, there is the *intermediate factors of fertility* approach, which provides the rationale for the use of fertility as a comprehensive measure for SRH.

3.3.1 The social disruption approach and the mining boom context

Early literature from the United States described boomtowns as rural and remote communities with new mining or energy developments causing unprecedented demographic changes, intense demand on services and facilities, and social heterogeneity due to increased in-migration [69]. Emerged from the observation of the social life in boomtowns, *social disruption* was defined as a generalized crisis in most of the social aspects of the community, i.e. services and facilities, crime control, role structure, social values, and social ties [69: p. 231].

As discussed in Chapter 2, disruptive demographic, socioeconomic, and gender dynamics in mining contexts in periods of full-extraction have been commonly reported worldwide. Outnumbered male labor migration to mining boom places and high mining wages have been related to increases in the local cost of living [56]. Living conditions of mineworkers (i.e., single-sex lodging, isolation, and separation from families) have been linked to an increased demand for recreational services (alcohol, drugs, and sex services); increases in the number of bars, nightclubs and brothels; and rises in crime and violence—including sexual violence [5, 36, 48, 59-61, 70, 71]. The mining economy has been related to a displacement of local economies and an increased dependency on this sector, determining a greater vulnerability among the population not involved in mining, principally ethnic minority groups [57, 58, 72, 73]. Women, in particular, have much less access to the economic benefits of mining than men (linked to a shift in their traditional roles, engagement in subordinate mining jobs, and unequal payment as miners) [35, 62]; which leads them to a greater dependency on males [60]. Extreme poverty conditions may lead women and young girls to become involved in transactional sex, prostitution, bonded labor, and sexual exploitation [4, 8, 35, 36].

Following the social disruption approach and founded on the literature about the impacts of mining on communities, the *mining boom context* can be defined as the place with a rapid increase in mining production (either in non-mining or traditional mining places) where disruptive demographic, socioeconomic, and gender dynamics are triggered by the mining economy. The assessment of this notion requires the operationalization of a variable for *mining boom* as a function of temporality (stages of pre-boom, boom, and post-boom) and magnitude of production relative to the local context.

3.3.2 The intermediate factors of fertility

Fertility has served to examine the interactions between socioeconomic, cultural, and environmental factors and biological aspects of human reproduction. Developed by Davis and Blake (1956) [19], the intermediate factors approach established that there are intermediate variables through which contextual factors influence population fertility.

The intermediate factors can be grouped into three categories. First, variables associated with the frequency of sexual intercourse among women, which include the age of onset of sexual intercourse, age at first marriage, and time between unions. In a review of the effects of disruptive events on fertility, Hill (2005) also mentioned as factors in this category sexual intercourse outside unions, coercive sex, and commercial sex [20]. Second, intermediate factors associated with the conception which include the use of contraception and factors leading to temporary or permanent infertility (i.e., diseases, breastfeeding, or sterilization). Third, variables associated with gestation, mainly related to intrauterine mortality (e.g., spontaneous or induced abortion) [19, 20]. This approach is appropriate for the study of fertility as a comprehensive measure for SRH since it addresses fertility change as a function of different SRH factors.

As previously described, the disruptive dynamics in mining contexts may lead to increases in early marriage and early sexual intercourse initiation, demand for sex services and commercial sex, transactional sex, and sexual violence. The context of social disruption may also influence behavioral factors such as the non-use of contraception or affect the reproductive decision-making among women. Finally, it may have impacts on fertility by determining potential toxicological effects of environmental pollution including increased infertility or pregnancy loss.

In conclusion, according to the *social disruption* and *intermediate factors of fertility* approaches, the context of social disruption triggered by a mining boom would influence critical aspects of the SRH of the population (sexual behaviors, sexual risk factors, sexual violence, and reproductive health conditions among women), as intermediate factors, that may converge in the determination of particular fertility patterns.

4.0 SPECIFIC AIMS

In response to the research challenges regarding the relationship between mining and sexual and reproductive health (SRH) in the context of the recent mining boom phenomenon in Colombia, I attempt to address the following research question: Is there a relationship between the recent gold-mining boom and SRH in local contexts in Colombia? To this end, the purpose of this study was to examine the relationship between the gold-mining boom and fertility—as a comprehensive measure for SRH, in Colombian municipalities, between 2001 and 2015.

This dissertation study tests the hypothesis that there is an association between the gold-mining boom experienced in Colombia since the mid-2000's and the fertility patterns, at the municipal level; and therefore, that there is a relationship between mining and SRH—not restricted to HIV/STDs, that needs to be further examined in mining contexts in LAC.

The specific aims of the study are to:

1. Construct a measure of the municipal gold-mining boom, based on available data on gold-mining production by municipality, between 2001 and 2015.
2. Measure municipal fertility rates between 2001 and 2015. This aim involves measuring general fertility rates (GFR), age-specific fertility rates (ASFR), and total fertility rates (TFR), by using available data from the civil registration system.
3. Explore the trajectories of gold-mining, fertility, and socioeconomic variables at the municipal level, between 2001 and 2015.
4. Measure the longitudinal association between the gold-mining boom and fertility at the municipal level, between 2001 and 2015.

5.0 METHODOLOGICAL APPROACH

I conducted a longitudinal ecological study using a multilevel model of change design, with municipality as the unit of analysis. I created a longitudinal (municipality-year) dataset from national databases on gold-mining production, births, and socioeconomic characteristics of the municipalities. The data covered the period between 2001—from which yearly data on mining was available—and 2015.

5.1 MUNICIPALITIES AS UNITS OF ANALYSIS

The municipality is the primary territorial and administrative entity of the Colombian government. There are 1122 municipalities in the 32 departments of Colombia. In 2016, 89% of the municipalities (N=994) had a population of less than 50,000 people; 6% (N=65) had between 50,000 and 100,000; and 5% (N=63) had a population greater than 100,000. I excluded the ten municipalities created during the study period (in different years between 2001 and 2015). The study finally included 1112 municipalities.

In this analysis, *municipality* is the level of measurement and *municipality-year* is the period of measurement for a given place. The municipality-year allows for examining time-varying predictors [74], in this case, the relationship between the outcome—fertility—and time within each municipality. The study includes n=16,680 municipality-years that correspond to 1112 clusters of 15 municipality-years each.

5.2 MEASURES

5.2.1 Gold-mining measures

In Chapter 3, I conceptualized the *mining boom context* as the place with a rapid increase in mining production (either in non-mining or traditional mining places) where disruptive demographic, socioeconomic, and gender dynamics are triggered by the mining economy (p. 23). In accordance with this notion, I defined *municipal gold-mining boom* as the period characterized by a rapid and extreme growth in gold production that may have an impact over the municipal socioeconomic dynamics. To operationalize this definition, I calculated the measure *gold production per capita (GPPC)*, selected the municipalities with *substantial GPPC*, and constructed the categorical variable *stages of gold-mining boom (SGMB)*.

This section addresses the Specific Aim 1: to construct a measure of the municipal gold-mining boom, based on available data on gold-mining production by municipality, between 2001 and 2015.

5.2.1.1 Municipal gold production per capita

To calculate the *gold production per capita (GPPC)*, I used, for the numerator, data on gold-mining production by municipality, available since 2001 from the National System of Mining Information SIMCO (by its Spanish acronym) [75]. For the denominator, I used data on municipal population by year, from the National Administrative Department of Statistics DANE (by its Spanish acronym) [76].

5.2.1.2 Municipalities with substantial gold production per capita

Among the 334 municipalities with some gold production per capita by year (>0 gr.), between 2001 and 2015, several had a marginal production—even during years of maximum local production—which could not be considered enough to have an impact over the socioeconomic dynamics of the municipality. However, there is not a measure that determines how much gold production must be considered as marginal or substantial.

For the purposes of this study, I defined a *substantial gold production per capita (substantial GPPC)* as the production higher than the minimum GPPC among the municipalities where the gold-mining sector was the first or second contributing economy. This was based on the economic indicator *municipal added value* VAM (by its Spanish acronym)—available for 2013. The VAM is an indicator created by the Colombian Government that measures and ranks the contribution of each sector to the municipal economy [77]. This is the only measure in Colombia that assesses the gold-mining sector in relation to the local economy.

Based on the VAM of the gold-mining sector, I identified the gold-mining municipalities where this sector was ranked as the first or second contributing economy. Among those municipalities, I identified the minimum value of GPPC in 2013; based on this value, I established the value for the GPPC threshold. I defined municipalities with *substantial GPPC,* as those with at least one year of GPPC above that threshold.

5.2.1.3 Construction of the time-varying categorical variable Stages of gold-mining boom

The categorical variable *stages of gold-mining boom (SGMB)* characterizes the gold-mining boom dynamics as the periods of pre-boom (no extreme change in production in the absence of a recent boom period); boom (rapid and extreme growth in production that may be followed by a period of rapid decline); and post-boom (no extreme change in production following a boom period).

To construct the SGMB variable, I followed two steps:

First, identification of municipality-years with extreme changes in gold production per capita. I defined *extreme change in gold production per capita (extreme ΔGPPC)* as an outlier value of the municipal distribution of change in GPPC per year, in the period 2001-2015. According to the definition of a statistical outlier, an *extreme ΔGPPC* corresponds to the absolute value of the change in GPPC in a year ($|\Delta GPPC|_{year\ i}$) that is greater than 1.5 times the interquartile range above the third quartile of the municipal distribution of change (absolute values of change per year, between 2001 and 2015):

$$|\Delta GPPC|_{year\ i} > (InterQuartileRange\ |\Delta GPPC|\begin{bmatrix}2015\\2001\end{bmatrix}*1.5) + Q3\ |\Delta GPPC|\begin{bmatrix}2015\\2001\end{bmatrix};$$

where, $\Delta GPPC_{year\ i} = GPPC_{year\ i} - GPPC_{year\ i-1}$.

This definition enables us to identify the municipality-years with an extreme ΔGPPC independently of the size of municipal production and considering the dispersion of change in each municipality.

Second, categorization of Stages of gold-mining boom. Based on the exploration of trajectories of municipal GPPC and the identification of years with extreme ΔGPPC, I defined four mutually exclusive categories for the municipal *stages of gold-mining boom (SGMB)*:

- *Pre-boom*—no extreme ΔGPPC or a rapid decline in production in the absence of a recent boom period:
  - a year with no extreme ΔGPPC that did not follow a boom-up or boom-down period or that followed three consecutive post-boom years;
  - a year with a rapid decline (negative extreme ΔGPPC) that did not follow a boom-up period;
  - all years of municipalities with no substantial GPPC.

- *Boom-up*—rapid and extreme growth and maximum production:
    - a year of rapid growth (positive extreme ΔGPPC);
    - two consecutive years of rapid growth (which sum of ΔGPPC was equal to one year of positive extreme ΔGPPC);
    - a year with no extreme ΔGPPC in the period that followed a rapid increase (maximum three consecutive years after a rapid increase period).
- *Boom-down*—rapid and extreme decline in production following a period of boom-up:
    - a year of rapid decline (negative extreme ΔGPPC) that followed a boom-up period;
    - two consecutive years of rapid decline (which sum of ΔGPPC is equal to one year of negative extreme ΔGPPC) that followed a boom-up period;
    - a year with no extreme ΔGPPC between periods of rapid decline (maximum three consecutive years between rapid decline periods).
- *Post-boom*—no extreme ΔGPPC following a boom period:
    - a year with no extreme ΔGPPC in the period that followed a boom-up or boom-down period (maximum three consecutive post-boom years).

The time-varying categorical variable SGMB represents the municipal status regarding a gold-mining boom at each year.

Example of the construction of the variable Stages of gold-mining boom in a municipality

Figures 2 to 5 illustrate the two steps for the construction of the SGMB categorical variable in one municipality with substantial GPPC, randomly selected for this purpose (MUN-ID 05790).

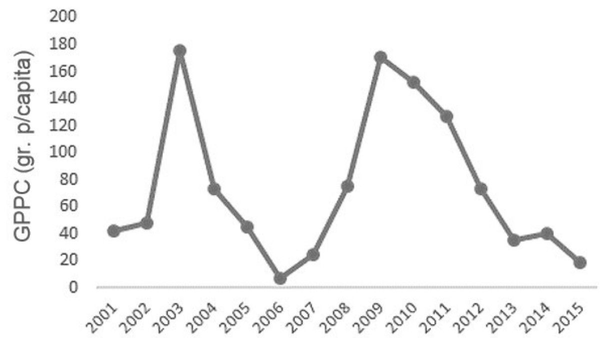


Figure 2. Gold production per capita in the municipality 05790, between 2001-2015

Figure 2 shows the gold production per capita (GPPC) trajectory for this municipality, with two peaks of production in 2003 and 2009.

Figures 3 and 4 illustrate the first step of the construction of the SGMB categorical variable: identification of municipality-years with extreme ΔGPPC.

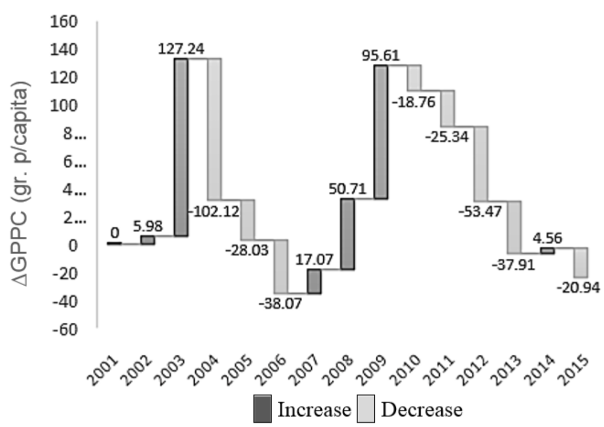


Figure 3. Change in gold production per capita in the municipality 05790, between 2001-2015

Figure 3 shows the change in gold production per capita (ΔGPPC) in correspondence with the cumulative GPPC.

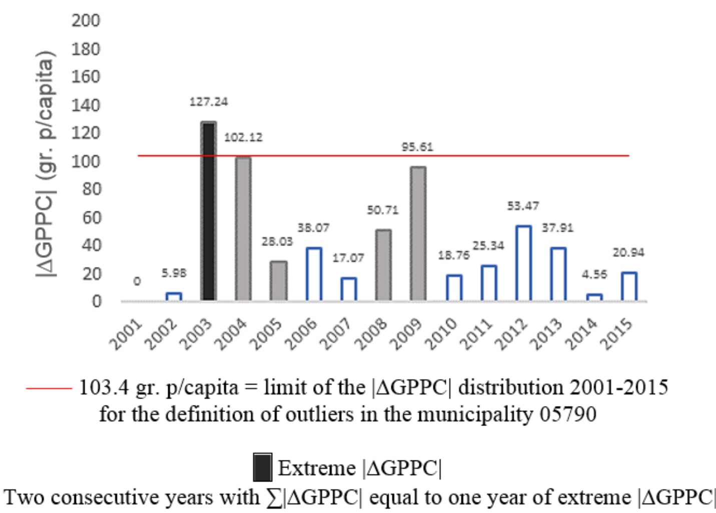


Figure 4. Absolute change in gold production per capita in the municipality 05790, between 2001-2015

Figure 4 shows the absolute values of change in gold production per capita (|ΔGPPC|), in relation with the limit of the municipal distribution of change ($|\Delta GPPC|_{[2001]}^{[2015]}$) for the definition of the outliers. The absolute change in 2003 was higher than the limit for this municipality, 103.4 gr. p/capita. The sum of the absolute changes for 2004-2005 and the sum for 2008-2009 were equivalent to one year of extreme ΔGPPC.

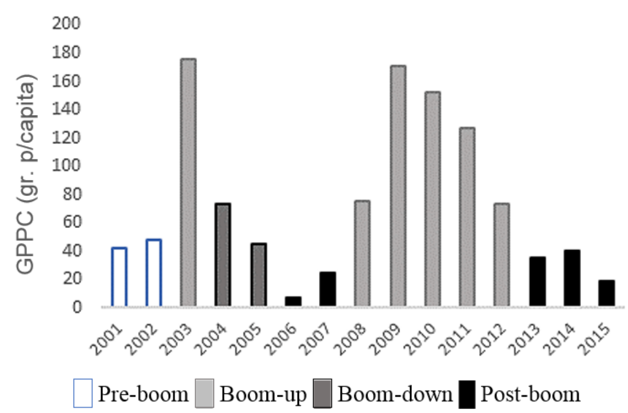


Figure 5. Stages of gold-mining boom in the municipality 05790, between 2001-2015

Figure 5 illustrates the second step, categorization of Stages of gold-mining boom (SGMB), by showing the municipality-years categorized as pre-boom (2001-2002), boom-up (2003 and 2008-2012), boom-down (2004-2005), and post-boom (2006-2007 and 2013-2015). The boom-up period between 2008 and 2012 included two years of rapid growth—as shown in Figure 4 (2008-2009), followed by three consecutive years with no extreme ΔGPPC (smooth declines instead of abrupt, between 2010 and 2012).

5.2.2 Fertility measures

This section addresses the Specific Aim 2 of the study: to measure municipal fertility rates between 2001 and 2015. For this purpose, I calculated three fertility measures by municipality of residence of the mother and year: general fertility rates (GFR), age-specific fertility rates (ASFR), and total fertility rates (TFR) (Table 2).

Table 2. Definitions and calculation of fertility measures

Fertility measure	Definition	Calculation
General fertility rate	The total live births per 1000 women aged 15-49, in a year	GFR = (B/P)*1000
Age-specific fertility rate	The live births per 1000 women classified in five-year age groups, in a year	$ASFR_a = (B_a/P_a)*1000$
Total fertility rate	The average number of children who would be born per women, according to the schedule of age-specific fertility rates in the same year	$TFR = (\sum ASFR_a) *5)/1000$

B: live births to women. P: population of women. a: age group of women (there are seven 5-year groups within the range 15-49 years of age).

The GFR—total live births per 1000 women aged 15-49, is a fertility measure that describes the population fertility in a period, partially controlling for the age composition of the population (as it accounts for the population of women of reproductive age). Despite useful to have a general picture of the fertility changes in a place, the GFR may be difficult to compare between municipalities with different age structures of the female population [78]. The ASFR—livebirths per 1,000 women in a specific five-year age group, resolves this limitation by measuring fertility over the specific population of women in each age group. The ASFR measures the age pattern of fertility, it is particularly sensitive to fertility changes and provides useful insights about the adolescent fertility patterns [78]. The ASFR serves to calculate the TFR—the estimated number of children that a woman would have by age 50 at the rates observed among the age groups in a given period. The TFR is a hypothetical measure that allows anticipating the completed fertility per woman if the age patterns of fertility would remain unchanged. Contrary to the GFR, variations in the age composition of the population do not affect TFR, which allows for comparisons between populations with different age structures. The TFR is associated with the contraceptive prevalence and serves as a proxy to assess the impact of family planning services on unintended fertility [78].

For the calculation of the three fertility rates, I used births data, from the civil registration system, for the numerators; and data on the municipal population of women by five-year age groups and by year, from the DANE [76], for the denominators.

The civil registration system provides the best available data on births at the local level, in Colombia. It provides annual data of all municipalities that allow for longitudinal analyses and examination of fertility trends by municipality, as well as comparisons within the country. These characteristics have advantages over the demographic and health surveys (DHS) as alternative sources of data, which provides only representative data at the state level (with a sample of municipalities by state). The coverage of the civil registration system in Colombia has been higher than 90% since the 2000s. The municipalities may have, however, differential performances of the local information systems, with variations in the coverage and quality of data. As I explain in section 5.3.2.1, to address this limitation, I conducted a sensitivity analysis with municipalities with adequate live birth coverage by 2005, to assess the robustness of the results from the analyses with all the municipalities.

5.2.3 Socioeconomic measures

As for the socioeconomic aspects, I included variables with available data (municipality-level data by year from 2001 to 2015) that could confound the relationship between the gold-mining boom and fertility: rurality (rural index), internal conflict violence (internal conflict victimization rate—ICVR), and coca production (percentage of coca crops area).

As mentioned in Chapter 3, the gold-mining boom in Colombia relates with the location of mining operations in rural and remote places [14], as well as, with criminality and violence against miners and local population associated with the presence of armed groups [16-18]. Additionally, a study by UNODC and the Colombian Government (2016) highlighted the association between the location of mining operations and the location of coca crops [14].

As for fertility, previous studies show associations with rurality (as consistently presented in the Demographic and Health Surveys in Colombia) [79-81] and violence (mainly regarding adolescent fertility) [82]. Castro Torres and Urdinola (2018) showed that, between 2000 and 2010, the internal armed conflict in Colombia had a positive association with fertility in rural areas [83].

The non-inclusion of additional socioeconomic variables likely correlated with both the gold-mining boom and fertility (e.g., poverty, labor migration, or school attendance) responded to the lack of longitudinal data for these variables at the municipality level.

Based on this knowledge and the availability of data, I included as confounders the following socioeconomic variables: *rural index*—the ratio of rural over total population (data from the *Centro de Estudios sobre Desarrollo Económico* CEDE) [84]. *Internal conflict victimization rate* (ICVR)—the number of victimization events of any type of violence associated with the internal conflict and registered in the National Registry of Victims RUV (by its Spanish acronym) per 1000 population [85]. The types of violence leading to a victimization event include forced displacement, terrorist attack, sexual violence, homicide, kidnapping, torture, anti-personnel mines, and others. *Percentage of coca crops area*—the percentage of municipal area (in hectares) with coca crops (data from the Drugs Observatory of Colombia) [86]. For the calculation of the ICVR and the percentage of the area of coca crops, I used as denominators data on municipal population and the municipal area from the DANE and CEDE [76, 84].

5.3 ANALYSIS

5.3.1 Descriptive analyses

This section addresses the Specific Aim 3 of the study: to explore the trajectories of gold-mining, fertility, and socioeconomic variables at the municipal level, between 2001 and 2015. For the exploration of the gold-mining trajectories, I examined the empirical growth plots of the gross gold production, gold production per capita (GPPC), change in gold production per capita (ΔGPPC), and stages of gold-mining boom (SGMB) of municipalities with substantial GPPC. As previously mentioned, the examination of the trajectories of GPPC and ΔGPPC informed the construction of the SGMB variable. As for the fertility trajectories, I observed the municipal fertility trends during the study period aggregated for all the municipalities and the municipalities with substantial GPPC and a gold-mining boom. Finally, I characterized the municipality-years aggregated by types of municipalities (according to the production of gold and the presence of a gold-mining boom) and SGMB categories—among the municipalities with substantial GPPC and a gold-mining boom, by rurality (rural index), internal conflict violence (internal conflict victimization rate—ICVR), and coca production (percentage of coca crops area). I used SPSS (version 24) for the descriptive statistics.

5.3.2 Multilevel models of change

This section addresses the Specific Aim 4 of the study: to measure the longitudinal association between the gold-mining boom and fertility at the municipal level, between 2001 and 2015.

To this purpose, I used a multilevel regression model of change to test the association between the stages of gold-mining boom (SGMB) and changes in fertility rates (trajectories), in municipalities of Colombia, between 2001 and 2015. The multilevel model of change collapses a level-1 sub-model, referred to each municipality growth model; and a level-2 sub-model referred to the systematic inter-municipal differences in change. In other words, the model distinguishes change *within* each subject (municipality) and differences in change *between* subjects (clusters of municipality-years) [74]. The goal of the level-1 analysis is to characterize each municipal shape or pattern of change; the goal of the level-2 analysis is to determine the relationship between predictors and the shape of each municipality growth trajectory.

According to Singer and Willet (2003) [74], the study of change requires, first, multiple waves of data; for this study, there are fifteen waves of data corresponding to available municipal data on mining production and births by year (between 2001 and 2015). Second, it requires a sensible metric of time; corresponding to YEAR, in this analysis. Third, it needs a continuous outcome that systematically changes over time; corresponding, in this case, to fertility rates (GFR, ASFR, TFR). For the fertility variables, I assessed normality by observing Histograms, Stem-and-Leaf plots, and Q-Q plots and performing the Kolmogorov-Smirnov test. Normality was met for

GFR and TFR, and for the ASFRs of the age groups in the range 15-39. Normality was not met for the ASFR of the age groups 10-14 (not included in the calculation of TFR), 40-44, and 45-49.

The multilevel model of change allows for addressing clustering since part of the variance could be explained by differences between municipalities; clustering implies that the observations within municipalities (municipalities-years) are correlated. Also, the model is appropriate because the trajectories of municipal fertility rates, as well as the effect of time, are appreciably different for each municipality (see Chapter 6, Section 6.1.2). As explained by Singer and Willet (2003) [74], with the multilevel model of change it is possible to have different subject trajectories for the outcomes with distinguishable shapes (nonlinear), as it is the case in this study.

I developed four composite models for the outcomes GFR and TFR: a) an initial growth model, with YEAR as predictor; b) a conditional growth model that included the main effect of SGMB; c) a conditional growth model with SGMB controlling for the confounders with significant association with fertility rates and SGMB (I tested the associations of each of the three confounders with the independent and dependent variables SGMB, GFR, and TFR); and d) a conditional growth model with SGMB controlling for all three confounders. For each ASFR five-year age group, I developed one conditional growth model with SGMB and YEAR as predictors. Since the ASFR of the age group 10-14 did not meet the normality assumption and the model for this variable showed an association with the SGMB (see Chapter 6, Section 6.2.3), I developed a specific model with a log-transformed $ASFR_{10\text{-}14}$ variable.

As an example of the multilevel models of change, below is the statement for model b) a conditional growth model for GFR with the main effect of SGMB.

$$Y_{ij} = \beta_0 + \beta_1 X_{1ij} + \beta_2 X_{2ij} + b_{0i} + b_{1i} X_{1ij} + \epsilon_{ij}$$

where,

ith = Municipality

jth = Observation

Y_{ij} = General Fertility Rate (GFR)

X_{1ij} = YEAR

X_{2ij} = Stages of Gold Mining Boom (SGBM)

$\beta_0, \beta_1, \beta_2$ = Fixed effects

$b_{0i}, b_{1i}, \epsilon_{ij}$= Random effects

I used SAS (version 9.4) for the statistical analyses.

5.3.2.1 Sensitivity analysis

The coverage and quality of data may differ between municipalities as local governments may have different performances on their information systems. As for the fertility measures, births among rural and minority populations (i.e., ethnic minority groups) may be underreported given the limited coverage of the civil registration system in some municipalities (less than 90%). Given this limitation, I conducted a sensitivity analysis to test the robustness of the results from the multilevel models of change, by including in the models for GFR and TFR only the municipalities with adequate livebirth coverage by 2005 (N=191) [87]. The consistency of the results would indicate that the models that include all the municipalities (N=1112) provide valid and robust findings.

6.0 RESULTS

6.1 DESCRIPTIVE RESULTS

The findings in this section respond to the Specific Aim 3 of the study: to explore the trajectories of gold-mining, fertility, and socioeconomic variables at the municipal level, between 2001 and 2015.

6.1.1 Municipal gold-mining trajectories

In this part, I present the trajectories of the national gross gold production and the municipal gold production per capita (GPPC). Among the municipalities with substantial GPPC, I describe the municipal stages of gold-mining boom (SGMB).

6.1.1.1 Colombian gross gold production and municipal gold production per capita

Figure 6 shows two waves of gross gold production in Colombia: the first wave had a peak in 2003 (46.5 metric tons) followed by a decline (15.3 metric tons in 2007); the second wave was much higher, reaching its maximum in 2012 (66.1 metric tons) and followed by a period of sustained production (around 57 metric tons).

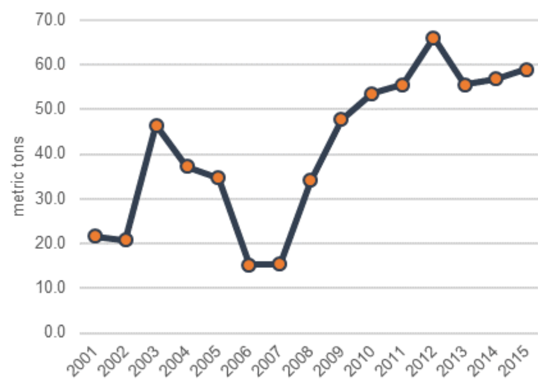


Figure 6. National gross gold production, Colombia, 2001-2015

At the municipal level, the GPPC—right skewed—had a different pattern for the median: flat between 2001 and 2011 (<0.4 gr p/capita) with a substantial increase in 2012 (>1 gr p/capita) (Figures 7).

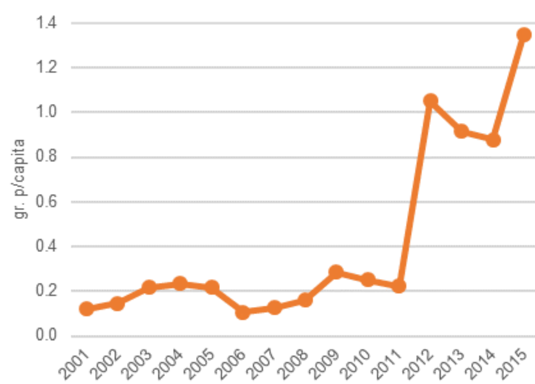


Figure 7. Median municipal gold production per capita, Colombia, 2001-2015

Figure 8 shows that the number of municipalities with a GPPC >1 gr p/capita increased after 2011 (>70 municipalities) despite the decrease in the total number of municipalities with gold production (from 196 in 2010 to the lowest number in 2014, 148).

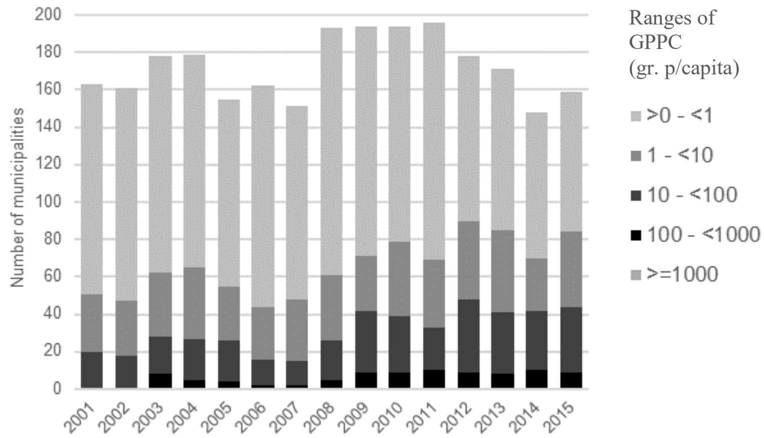


Figure 8. Municipalities by ranges of gold production per capita, Colombia, 2001-2015

These results indicate that the first wave of gross gold production in Colombia occurred with little change in the number of municipalities with intensified gold exploitation; in contrast, the second wave was related with the increase in the number and proportion of municipalities with intensified production after 2011.

Table A1 in Appendix A shows the complete information on the national and municipal gold-production, between 2001-2015.

6.1.1.2 Municipalities with substantial gold production per capita

The gold-mining sector contributed to the local economy (*municipal added value* VAM, by its Spanish acronym) in 50 municipalities, in 2013. In 26 municipalities, the gold mining constituted the first economic sector with a median contribution of 46% of the municipal economy; and the second sector in 6 municipalities, with a median contribution of 12% of the local economy. As shown in Figure 9, the minimum gold production per capita (GPPC) among these 32 municipalities was 11.7 gr. p/capita.

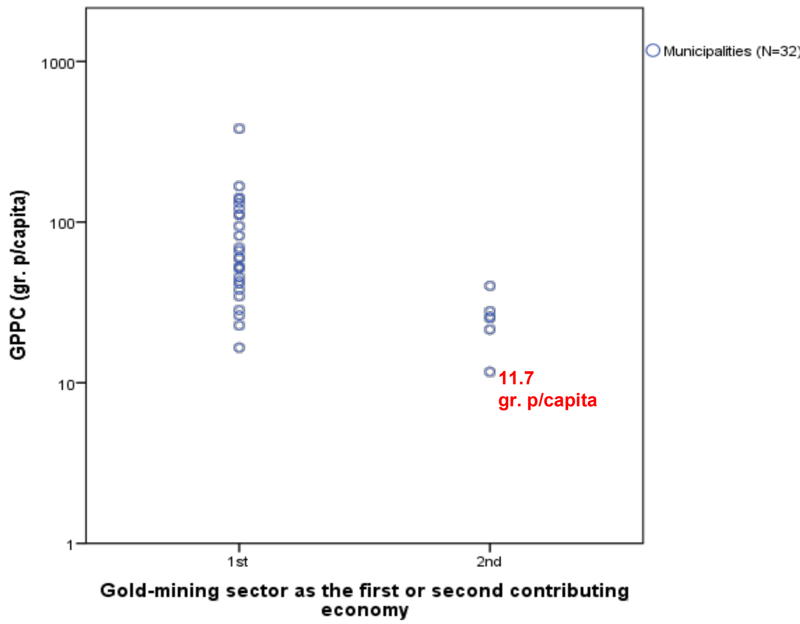


Figure 9. Gold production per capita (GPPC) of municipalities where the gold-mining sector was the first or second contributing economy, Colombia, 2013

Based on these findings, I established a GPPC threshold of 10 gr. p/capita to define the municipalities with substantial GPPC. Out of the 334 municipalities that had some gold production during the study period, 88 municipalities had at least one year with a GPPC ≥ 10 gr. p/capita.

6.1.1.3 Stages of gold-mining boom

The construction of the SGMB measure responded to the Specific Aim 1. Out of the 88 municipalities with substantial GPPC between 2001 and 2015 (≥ 10 gr. p/capita in at least one year), ten did not show extreme increases in gold production per capita that determine a category of rapid growth (boom-up). In those ten municipalities, the gold production can be considered as substantial but regular.

Table 3 shows the distribution of years by the stages of gold-mining boom (SGMB) categories among the 78 municipalities with substantial gold production per capita and a gold-mining boom.

Table 3. Distribution of years by stages of gold-mining boom among municipalities with substantial gold production per capita and a gold-mining boom (N=78), Colombia, 2001-2015

	Years by municipality					Total
	Mean	Median	S.D.	Max	Min	Municipality-Years (%)
pre-boom	9.9	10.0	2.0	14	2	771 (66%)
boom_up	2.2	2.0	1.4	7	1	170 (14.5%)
boom_down	1.0	1.0	0.8	4	0	78 (6.7%)
post-boom	1.9	3	1.4	5	0	151 (13%)
						1170 (100%)

The average time of the boom-up period by municipality was 2.2 years; of boom-down, one year; and of post-boom, 1.9 years. Out of the 1170 municipality-years—corresponded to 78 clusters of 15 municipality-years, 21.2% (n=248 municipality-years) were categorized as boom years (boom-up and boom-down).

Figure 10 shows the distribution of SGMB categories by year among the 78 municipalities in which the category boom-up was determined.

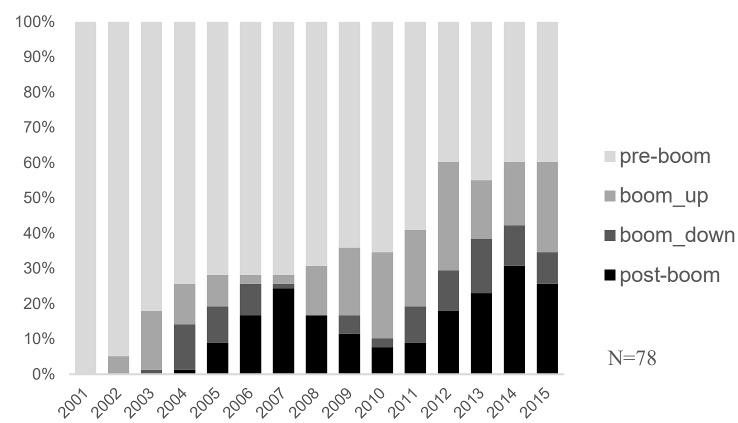


Figure 10. Stages of a gold-mining boom among municipalities with substantial gold production per capita and a gold-mining boom, Colombia, 2001-2015

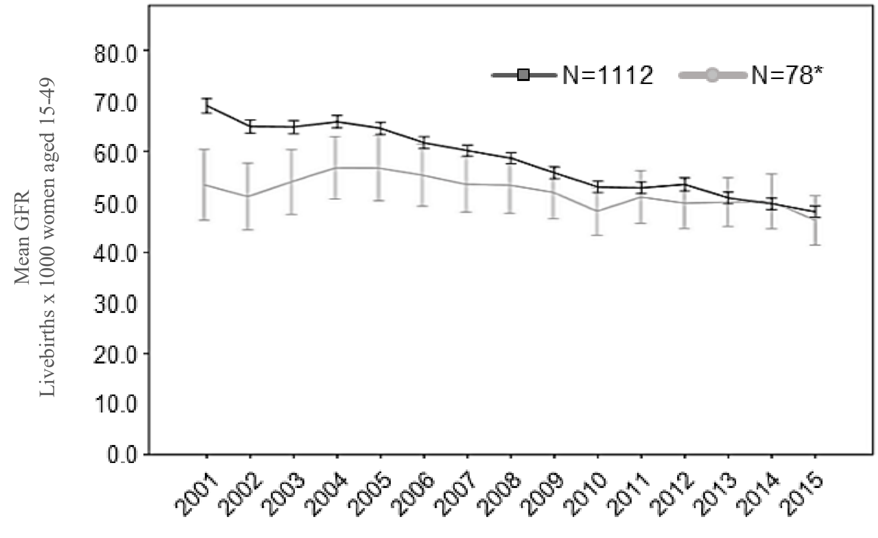
The periods with the highest number of municipalities in a stage of rapid growth in gold production (boom-up) were 2003-2005 (17% in 2003) and 2008-2015 (31% in 2012). The periods with the highest number of municipalities in a stage of boom decline were 2004-2006 (13% in 2004) and 2011-2015 (15% in 2013). The periods with the highest number of municipalities in a post-boom stage were 2005-2009 (24% in 2007) and 2011-2015 (31% in 2014). Table A2 in Appendix A shows the complete information on the municipal SGMB, between 2001-2015.

This distribution shows two common periods of boom: 2003-2006 and 2008-2015. The years with most municipalities in each of the stages of boom correspond to 2003 (boom-up), 2004 (boom-down), 2007 (post-boom), for the first wave; and 2012 (boom-up), 2013 (boom-down), and 2014 (post-boom), for the second wave.

6.1.2 Municipal fertility rates

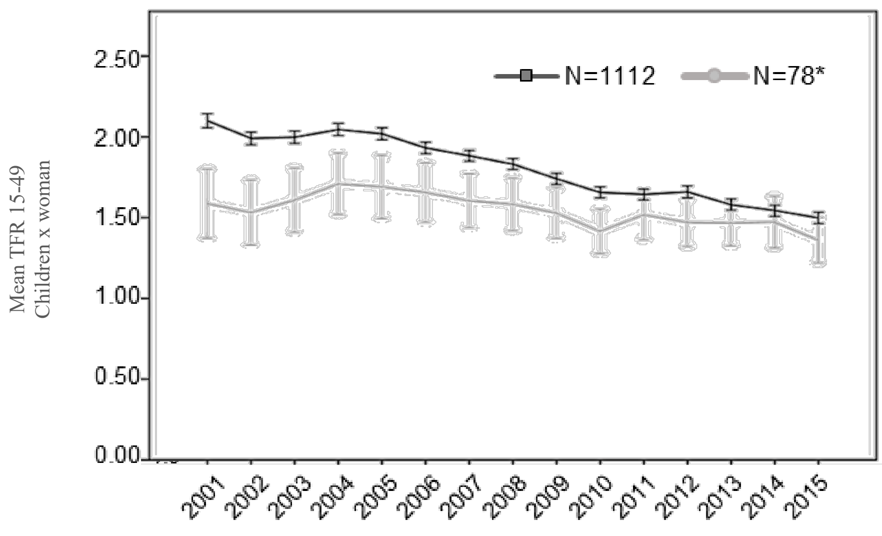
In this part, I present the municipal trajectories of the general fertility rates (GFR), age-specific fertility rates (ASFR), and total fertility rates (TFR), between 2001 and 2015, which correspond to the Specific Aim 2 of the study.

Trajectories of municipal fertility rates (GFR and TFR) of municipalities with gold production, substantial GPPC, and substantial GPPC and a gold-mining boom; I observed trajectories appreciably different for each municipality (e.g. decreasing trends along the study period or municipalities with flat or increasing trends during different parts of the study period). Figures 11 and 12 show the GFR and TFR among all municipalities (N=1112) and the municipalities with substantial GPPC and a gold-mining boom (N=78). The averages of municipal GFR and TFR among all municipalities followed a decreasing trend. Among the municipalities with substantial GPPC and a gold-mining boom, the fertility trajectories showed lower averages in the first years of the study period (between 2001 to 2004, for the GFR; and 2001 to 2008, for the TFR).



CI 95%
* Municipalities with substantial GPPC and a gold-mining boom

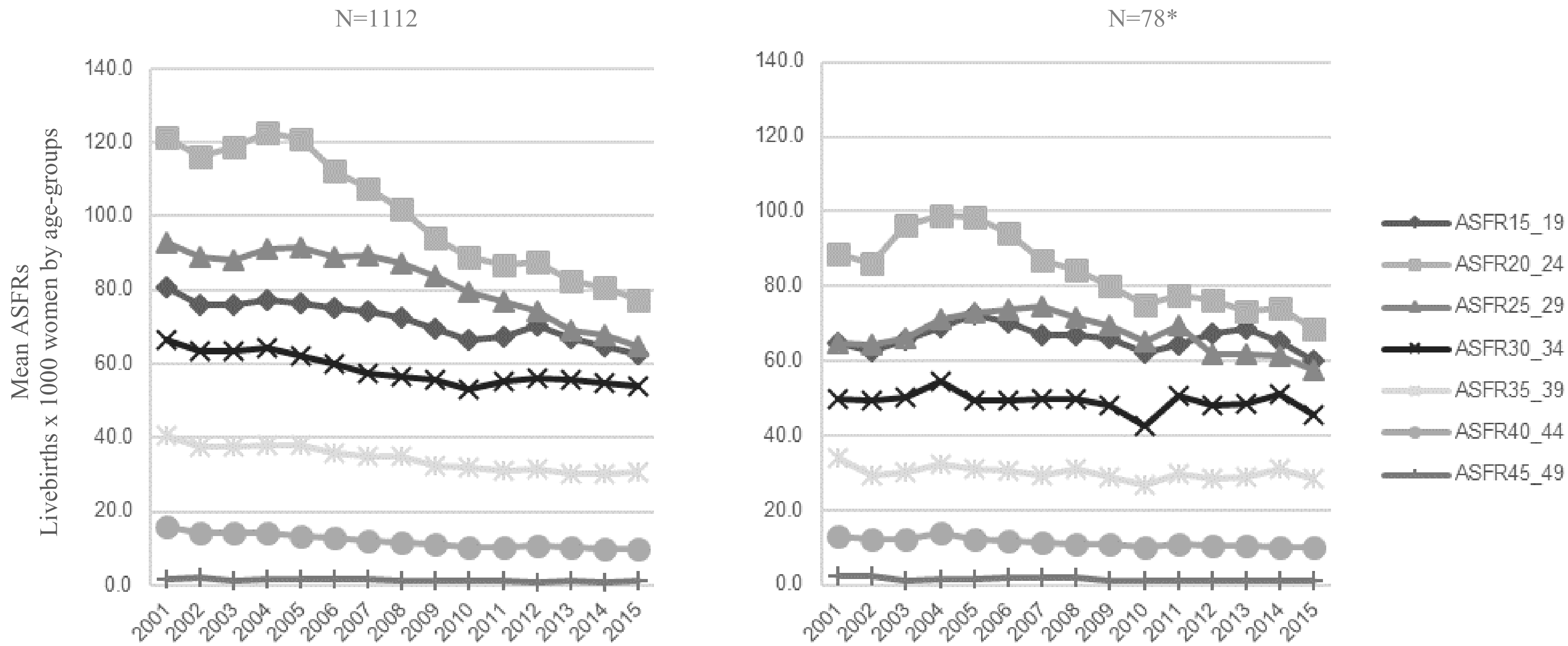
Figure 11. Municipal general fertility rates (GFR), Colombia, 2001-2015



CI 95%
* Municipalities with substantial GPPC and a gold-mining boom

Figure 12. Municipal total fertility rates (TFR), Colombia, 2001-2015

Figure 13 shows the age-specific fertility rates (ASFRs) among all municipalities (N=1112) and the municipalities with substantial GPPC and a gold-mining boom (N=78).



* Municipalities with substantial GPPC and a gold-mining boom

Figure 13. Municipal age-specific fertility rates (ASFR), Colombia, 2001-2015

The averages of ASFRs for all municipalities and municipalities with substantial GPPC and a gold-mining boom showed different trajectory patterns for the age groups in the range 15-34: lower averages during the first half of the study period (Figure 13).

Appendix B shows the complete information on the municipal fertility rates (GFR, TFR, ASFR), between 2001-2015.

6.1.3 Municipal socioeconomic variables

Figures 14 to 16 show the trajectories of the municipal rural index, internal conflict victimization rate (ICVR), and percentage of coca crops area, among all municipalities (N=1112) and the municipalities with substantial GPPC and a gold-mining boom (N=78).

The trajectories o the rural indexes progressively decreased for both groups of municipalities (N=1112 and N=78) (Figure 14). The median rural index among municipalities with substantial GPPC and a gold-mining boom were similar to the median of all the municipalities.

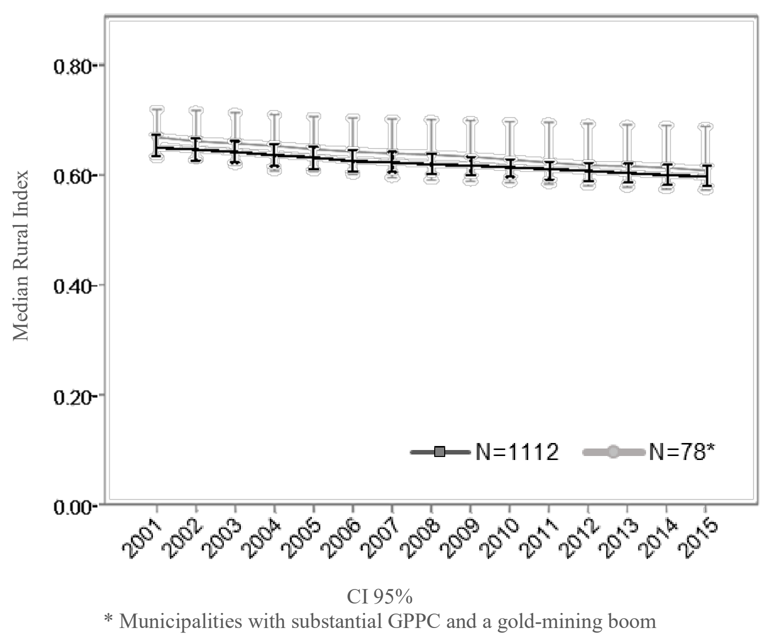
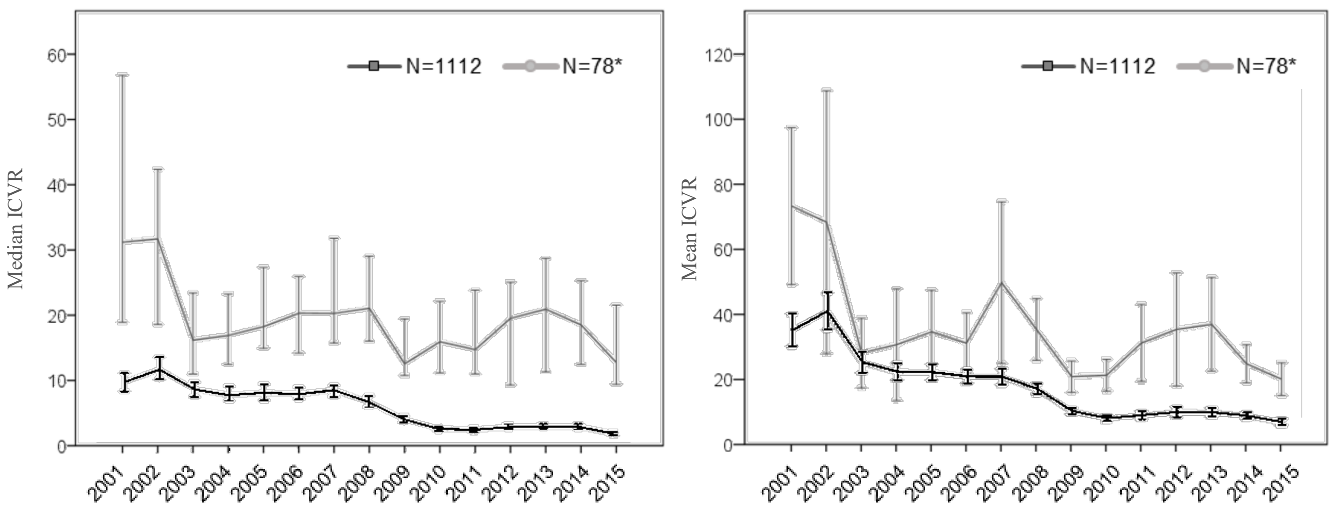


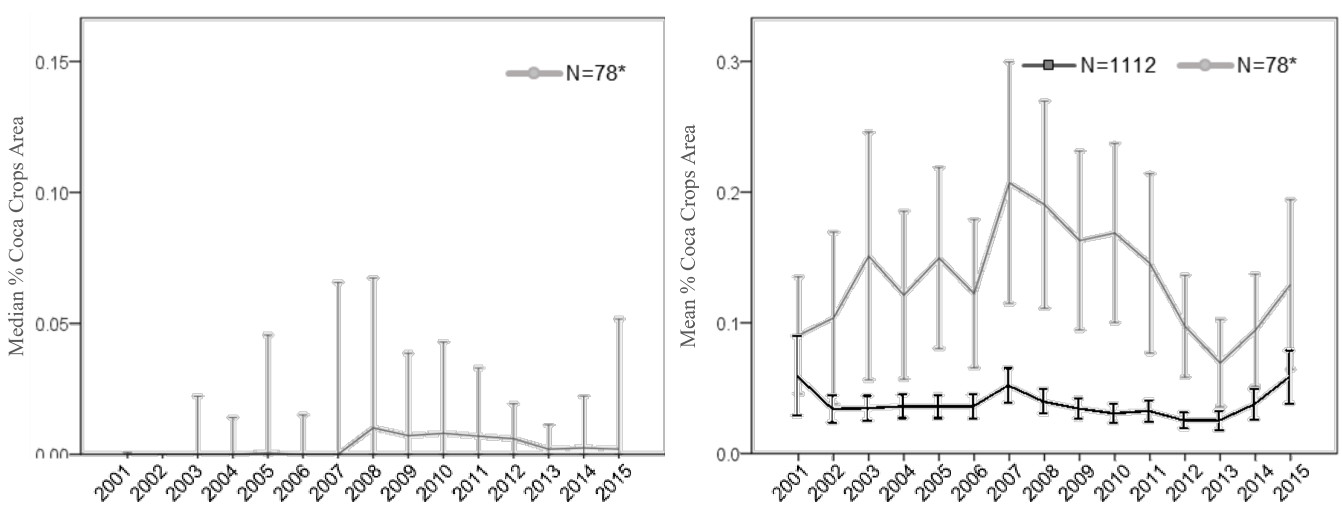
Figure 14. Municipal rural index, Colombia, 2001-2015

As presented in Figure 15, the municipal ICVR among all municipalities decreased since 2002. Among the municipalities with substantial GPPC and a gold-mining boom (N=78), the median and mean municipal ICVR were higher (along the study period and after 2006, respectively), following a sinuous trajectory (highest ICVR in 2001-2002, 2007-2008, and 2013).



CI 95%
* Municipalities with substantial GPPC and a gold-mining boom

Figure 15. Municipal internal conflict victimization rate (ICVR), Colombia, 2001-2015



CI 95%
* Municipalities with substantial GPPC and a gold-mining boom

Figure 16. Municipal percentage of coca crops area, Colombia, 2001-2015

As Figure 16 shows, the median percentage of coca crops area of all municipalities between 2001 and 2015 was zero, indicating that most of the municipalities had no coca production during the study period. Among the municipalities with substantial GPPC and a gold-mining boom (N=78), the median followed a similar trajectory, with a slight (but not significant) increase after 2007. On the contrary, the mean percentage of coca crops area followed different patterns. Among all municipalities, the trajectory was flatter with a little peak in 2007. Among the municipalities with substantial GPPC and a gold-mining boom, the mean was higher between 2003 and 2012, with a maximum level in 2007, and a final growth after 2013. These patterns indicate that the coca crops area is concentrated in few municipalities.

Table 4 shows the distribution of municipality-years by socioeconomic variables, types of municipalities (according to the production of gold and the presence of a gold-mining boom), and SGMB.

Table 4. Municipality-years by socioeconomic variables, types of gold-mining municipalities, and Stages of gold-mining boom, 2001-2015

	Rural index			ICVR (per 1000)			Area of coca (%)			Municipality-years
	Median	Mean	S.D.	Median	Mean	S.D.	Median	Mean	S.D.	
Municipalities with NO gold production (N=778)										
pre-boom*	0.65	0.61	0.23	3.7	15.1	41.4	0.00	0.02	0.18	11670
Municipalities with NO substantial GPPC (N=246)										
pre-boom*	0.51	0.48	0.26	6.8	19.8	44.1	0.00	0.05	0.28	3690
Municipalities with substantial GPPC but no gold-mining boom (N=10)										
pre-boom	0.52	0.56	0.23	17.2	28.4	34.0	0.04	0.10	0.16	150
Municipalities with substantial GPPC and a gold-mining boom (N=78)										
pre-boom	0.64	0.64	0.19	19.8	41.0	86.3	0.00	0.14	0.32	771
boom_up	0.64	0.62	0.18	20.7	35.5	62.9	0.00	0.13	0.23	170
boom_down	0.64	0.62	0.22	11.8	20.9	23.7	0.00	0.14	0.24	78
post-boom	0.62	0.61	0.19	14.9	27.0	37.8	0.00	0.11	0.21	151

* The municipality-years of municipalities with no gold production or no substantial GPPC were all categorized as pre-boom.
ICVR: Internal conflict victimization rate.

The municipalities with no substantial GPPC (N=246) and substantial GPPC without a gold-mining boom (N=10) showed the lowest rural index (mean ≤ 0.56; median ≤ 0.52). The municipalities with a gold-mining boom (N=78) showed the highest ICVR, during the stages of pre-boom and boom-up (Mean >35 victimization events per 1000 people; Median >19); with a decrease in the ICVR during the stages of boom-down and post-boom. The municipalities with no gold production (N=778) and no substantial GPPC (N=246) showed the lowest ICVR (Mean <20 victimization events per 1000 people; Median <7). The municipalities with substantial GPPC and a gold-mining boom showed the highest mean percentages of coca crops area (Mean >0,11%); however, with medians close to zero. Appendix C shows the complete information on the municipal socioeconomic data, between 2001-2015.

6.2 MULTILEVEL MODELS OF CHANGE

This section responds to the Specific Aim 4 of the study: to measure the longitudinal association between the gold-mining boom and fertility at the municipal level, during the study period. The results indicate a consistent and positive longitudinal association between the stages of gold-mining boom (SGMB) and fertility rates in municipalities of Colombia, between 2001 and 2015.

In this section, I present the findings from the four composite models of change for the fertility rates—general fertility rates (GFR), total fertility rates (TFR), and age-specific fertility rates (ASFR): a) a growth model, with YEAR as predictor; b) a conditional growth model with the main effect of SGMB; c) a conditional growth model with SGMB controlling for the confounders with significant association with fertility rates and SGMB; and d) a conditional growth model with SGMB controlling for all three confounders. For the third and fourth models, I tested the association of the confounders rural index, internal conflict victimization rate (ICVR), and percentage of coca crops area, with SGMB, GFR, and TFR. I found associations between rural index and percentage of coca crops area both with SGMB and the fertility rates.

6.2.1 Change in general fertility rates

Table 5 shows the results for the models 1 to 4 for the GFR.

Table 5. Multilevel models of change for the longitudinal association between municipal general fertility rates and stages of gold-mining boom, Colombia (N=1112), 2001-2015

	Model 1 Initial growth model		Model 2 Conditional growth model with SGMB		Model 3 Conditional growth model with two confounders[b]		Model 4 Conditional growth model with three confounders[c]	
Composite model	**B**	**95% CI**	**B**	**95% CI**	**B**	**95% CI**	**B**	**95% CI**
Intercept (initial status)	69.86***	68.51, 71.21	69.86***	68.5, 71.21	81.93***	79.2, 84.65	81.96***	79.24, 84.68
Year (rate of change)	-1.47***	-1.57, -1.36	-1.47***	-1.58, -1.36	-1.53***	-1.64, -1.42	-1.53***	-1.64, -1.42
SGMB[a]								
boom-up			0.88	-0.90, 2.66	0.93	-0.85, 2.71	0.93	-0.85, 2.71
boom-down			3.51**	1.16, 5.86	3.52**	1.18, 5.87	3.51**	1.16, 5.86
post-boom			2.24*	0.35, 4.12	2.21*	0.33, 4.10	2.21*	0.33, 4.10
Goodness of fit								
Deviance	126960.2		126943.7		126820.9		126831.0	
AIC	126968.2		126951.7		126828.9		126839.0	
BIC	126988.3		126971.7		126849.0		126859.1	

[a] Reference group: SGMB pre-boom. [b] Confounders with significant association with fertility rates and SGMB: rural index and municipal proportion of coca crops. [c] Confounders based on theory: rural index, municipal proportion of coca crops, and internal conflict victimization rate. ~ $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Model 1 is an unconditional growth model. Model 2 includes the main effect of SGMB as a fixed effect. Models 3 and 4 add the confounders to the model.

Model 1 shows a decreasing trend of GFR during the study period (-1.47 live births per 1000 women aged 15-49 for each additional year). Model 2 (that includes the SGMB variable) indicates that the GFR significantly increased during the stage of boom-down and post-boom (3.51, $p < 0.01$; and 2.24, $p < 0.05$, respectively). Models 3 (controlling for the two confounders with association) and 4 (controlling for the three confounders) show little change in the positive association between GFR and the stages of rapid decrease (boom-down) and post-boom. According to the goodness of fit tests, the Model 3 explains better the variability of the data.

6.2.2 Change in total fertility rates

Table 6 shows the results for the models 5 to 8 for the TFR, which are similar to those observed for GFR.

Table 6. Multilevel models of change for the longitudinal association between municipal total fertility rates and stages of gold-mining boom, Colombia (N=1112), 2001-2015

Composite model	Model 5 Initial growth model		Model 6 Conditional growth model with SGMB		Model 7 Conditional growth model with two confounders[b]		Model 8 Conditional growth model with four confounders[c]	
	B	**95% CI**	**B**	**95% CI**	**B**	**95% CI**	**B**	**95% CI**
Intercept	2.15***	2.11, 2.19	2.15***	2.11, 2.19	2.54***	2.46, 2.62	2.54***	2.46, 2.62
Year	-0.04***	-0.05, -0.04	-0.04***	-0.05, -0.04	-0.04***	-0.05, -0.04	-0.04***	-0.05, -0.04
SGMB[a]								
boom-up			0.03	-0.03, 0.08	0.03	-0.03, 0.08	0.03	-0.03, 0.08
boom-down			0.11**	0.03, 0.18	0.11**	0.03, 0.18	0.11**	0.03, 0.18
post-boom			0.07*	0.01, 0.13	0.07*	0.01, 0.13	0.07*	0.01, 0.13
Goodness of fit								
Deviance	11339.1		11343.1		11227.4		11244.6	
AIC	11347.1		11351.1		11235.4		11252.6	
BIC	11367.1		11371.2		11255.5		11272.6	

[a] Reference group: SGMB pre-boom. [b] Confounders with significant association with fertility rates and SGMB: rural index and municipal proportion of coca crops. [c] Confounders based on theory: rural index, municipal proportion of coca crops, and internal conflict victimization rate. ~ $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Model 5 is an unconditional growth model. Model 6 includes the main effect of SGMB as a fixed effect. Models 7 and 8 add the confounders to the model.

Model 5 shows a significant trend of decline in TFR during the study period (-0.04 points—children per woman, for each additional year). Model 6 indicates that TFR significantly increased during the stage of boom-down (rapid decrease) and post-boom (0.11, $p < 0.01$; and 0.07, $p < 0.05$, respectively). The Models 7 and 8 show that TFR still increased significantly during the rapid decrease stage after controlling for the confounders. Also, the Model 7 represents better the variability of the data, as shown by the goodness of fit tests.

6.2.3 Change in age-specific fertility rates

Table 7 shows the results for the models 9 to 16 for the age-specific fertility rates (ASFR).

Table 7. Multilevel models of change for the longitudinal association between municipal age-specific fertility rates and stages of gold-mining boom, Colombia (N=1112), 2001-2015

	Model 9 ASFR 10_14		**Model 10 ASFR 15_19**		**Model 11 ASFR 20_24**		**Model 12 ASFR 25_29**	
	B	**95% CI**	**B**	**95% CI**	**B**	**95% CI**	**B**	**95% CI**
Intercept	3.47***	3.18, 3.76	98.37***	94.73, 102.0	157.67***	152.9, 162.4	118.8***	114.8, 122.7
Year	0.02***	0.01, 0.04	-1.21***	-1.35, -1.07	-3.70***	-3.90, -3.49	-2.07***	-2.23, -1.91
SGMB[a]								
boom-up	0.62**	0.16, 1.07	2.20	-0.91, 5.30	0.18	-4.10, 4.46	3.59~	-0.42, 7.61
boom-down	0.35	-0.27, 0.97	4.42*	0.29, 8.54	7.52**	1.83, 13.21	4.52~	-0.84, 9.88
post-boom	0.46~	-0.02, 0.94	4.36**	1.08, 7.65	2.58	-1.95, 7.11	3.62~	-0.62, 7.87

	Model 13 ASFR 30_34		**Model 14 ASFR 35_39**		**Model 15 ASFR 40_44**		**Model 16 ASFR 45_49**	
	B	**95% CI**	**B**	**95% CI**	**B**	**95% CI**	**B**	**95% CI**
Intercept	75.77***	72.87, 78.67	42.33***	40.42, 44.23	13.09***	12.20, 13.98	1.33***	1.11, 1.54
Year	-0.92***	-1.05, -0.79	-0.75***	-0.83, -0.66	-0.40***	-0.44, -0.35	-0.06***	-0.08, -0.05
SGMB[a]								
boom-up	-1.32	-4.66, 2.02	-0.60	-3.10, 1.91	1.12	-0.39, 2.64	-0.05	-0.69, 0.58
boom-down	0.31	-4.15, 4.77	4.92**	1.54, 8.30	1.00	-1.09, 3.08	-0.11	-1.01, 0.79
post-boom	-0.09	-3.62, 3.44	1.17	-1.48, 3.82	0.94	-0.66, 2.55	-0.03	-0.71, 0.64

[a] Reference group: SGMB pre-boom. ~ $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. All models are conditional growth models that add the main effects of $ASFR_a$ as a fixed effect and include the confounders with significant association with fertility rates and SGMB (rural index and municipal proportion of coca crops).

Only the Model 9 shows an increasing trend of the fertility rate ($ASFR_{10\text{-}14}$), during the study period. The rest of the models show a decreasing trajectory of ASFR, between 2001 and 2015. Models 9 to 11 and Model 14 (age groups in the range 10-25, and 35-39) show significant increasing trends in ASFR associated with either the stage of boom-up or boom-down. Model 10 also shows a significant increase in ASFR (for the age group 15-19) in the stage of post-boom.

Since the ASFR of the age group 10-14 did not meet the normality assumption and the model for this variable showed an association with the SGMB, I developed a specific model with a log-transformed $ASFR_{10\text{-}14}$ variable (I summed the mean value of the distribution to the $ASFR_{10\text{-}}$

14 to include the zero values of municipal fertility). The model also showed a significant increasing trend in ASFR associated with the stage of boom-up ($p < 0.05$).

6.2.4 Sensitivity analysis

Table 8 shows the sensitivity analyses for the GFR and TFR, by including only the municipalities with adequate live birth coverage by 2005 (N=192 municipalities; n=2880 municipality-years) and controlling for socioeconomic variables.

Table 8. Multilevel models of change for the longitudinal association between general and total fertility rates and stages of gold-mining boom, in municipalities with acceptable birth coverage by 2005 (N=192), Colombia, 2001-2015

	Model 17 Initial growth model GFR		**Model 18 Conditional growth model with SGMB GFR**		**Model 19 Conditional growth model with SGMB GFR[b]**		**Model 20 Conditional growth model with SGMB GFR[c]**	
Composite model	**B**	**95% CI**	**B**	**95% CI**	**B**	**95% CI**	**B**	**95% CI**
Intercept	71.30***	68.56, 74.03	71.24***	68.49, 73.98	73.76***	69.15, 78.36	73.82***	69.21, 73.43
Year	-1.31***	-1.53, -1.09	-1.31***	-1.54, -1.09	-1.34***	-1.56, -1.11	-1.34***	-1.56, -1.12
SGMB[a]								
boom-up			3.91*	0.44, 7.39	3.92*	0.45, 7.39	3.91*	0.44, 7.39
boom-down			6.52*	1.21, 11.84	6.42*	1.11, 11.72	6.37*	1.07, 11.68
post-boom			4.03*	0.41, 7.66	3.73*	0.10, 7.66	3.74*	0.11, 7.37

	Model 21 Initial growth model TFR		**Model 22 Conditional growth model with SGMB TFR**		**Model 23 Conditional growth model with SGMB TFR[b]**		**Model 24 Conditional growth model with SGMB TFR[c]**	
Composite model	**B**	**95% CI**	**B**	**95% CI**	**B**	**95% CI**	**B**	**95% CI**
Intercept	2.20***	2.12, 2.29	2.20***	2.12, 2.28	2.31***	2.18, 2.45	2.31***	2.18, 2.45
Year	-0.04***	-0.04, -0.03	-0.04***	-0.04, -0.03	-0.04***	-0.05, -0.03	-0.04***	-0.05, -0.03
SGMB[a]								
boom-up			0.11~	-0.00, 0.21	0.11~	-0.00, 0.21	0.11~	-0.00, 0.21
boom-down			0.19*	0.02, 0.35	0.19*	0.02, 0.35	0.19*	0.02, 0.35
post-boom			0.12*	0.00, 0.23	0.11~	-0.00, 0.22	0.11~	-0.00, 0.22

[a] Reference group: SGMB pre-boom. [b] Confounders with significant association with fertility rates and SGMB: rural index and municipal proportion of coca crops. [c] Confounders based on theory: rural index, municipal proportion of coca crops, and internal conflict victimization rate.~ $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Model 17 and 21 are unconditional growth models. Models 18 and 22 include the main effect of SGMB as a fixed effect. Models 19-20, and 23-24 add the confounders to the model.

All models show a declining trajectory in the fertility rates, between 2001 and 2015. Models 17 to 20 show significant increasing GFR trends during the stages of boom (boom-up and boom-down) and post-boom ($p < 0.05$), with little change after controlling for the confounders. Model 22 shows a significant increasing TFR trend during the stage of boom-down and post-boom. Models 23 and 24 show a significant increasing TFR trend only during the stage of boom decline, after controlling for the confounders.

7.0 DISCUSSION

I present this section in three parts: first, I discuss the descriptive results—the trajectories and patterns of change of the independent and dependent variables, and of the confounders included in the regression models. Second, I discuss the results from the multilevel regression models of change, which is the core content of the study. In this part, I delve into the relevance of a gender perspective to discuss the findings in light of the disruptive gender dynamics that may take place in mining boom contexts. Finally, I discuss the main limitations of the methodological approach.

7.1 GOLD MINING, FERTILITY AND SOCIOECONOMIC VARIABLES IN COLOMBIAN MUNICIPALITIES, 2001-2015

7.1.1 Municipal gold mining trajectories

The total gold production in Colombia between 2001 and 2015 showed a pattern—small peak in 2003 and a larger in 2012—that differs from the trajectory of the median of municipal gold production per capita (GPPC)—with a clear increase after 2011 due to the increasing number of municipalities with gold production >1gr. p/capita. Among the 78 municipalities with substantial GPPC (at least one year of gold production $\geq$ 10 gr. p/capita) and a gold-mining boom (in which the category of rapid growth in production was determined), two predominant periods of municipal boom were identified in the study period: 2003-2006 and 2008-2015. These results suggest two dynamics in Colombia: 1) before 2007, in which the intensification in national gold production occurred with little change in the number of municipalities with intensified production; 2) after 2009, in which the intensification in national production occurred along with the increase in the number of municipalities with intensified gold exploitation.

Regardless of the dynamics at the country level, each municipality had a unique and discernible pattern of change over time regarding the gold production. The magnitude of the municipal gold production relative to the population (GPPC) was highly heterogeneous (between 0 and >1000gr. p/capita per year). Despite that the boom-up and boom-down categories were delimited by theoretical definitions (although, based on the observation of production trajectories), the moment and extent of these periods were determined by the presence of an extreme change in the gold production, given the sequence pre-boom/boom/post-boom. These stages described diverse nonlinear and discontinuous trajectories. Due to the complexity of the municipal gold-mining patterns of change—heterogeneous, nonlinear and discontinuous—, the use of the categorical variable SGMB was appropriate to inform the particularities of the trajectories and to simplify the depiction of the dynamics of a local boom phenomenon.

The use of a novel measure that accounts for the relationship between gold production, the local population, changes in production over time, and the sequence of pre-boom/boom/post-boom is innovative and contributes to the understanding of the mining impacts in health and other social dimensions. Previous studies from different disciplines interested in examining the impacts of the mining boom in Colombia used mining variables based on the gross mining production per mineral, the mining permits, and the presence of mining operations [88-94]. These variables do not account for any input of the local contexts (e.g., municipal population, population involved in mining activities, or contribution of the mining sector to the municipal economy), failing in representing the local dynamics linked to the mining activities. For instance, the same gross mining production might have distinctive socioeconomic significance between municipalities given the local population or the occurrence of extreme changes in a period. Also, the existence of a mining permit does not inform the actual use of land for mining purposes but only the intention of exploring and exploiting the land for mining and the location and extension of the area. Similar approaches—of using mining variables relative to the operations with no input of the mining context—are often observed in studies worldwide [95-97].

This dissertation addressed the limitations of the previous literature regarding the characterization of the mining phenomenon at the local level. As the results demonstrated, ten municipalities with substantial GPPC did not have a gold mining boom since they had a regular and sustained production instead of experiencing extreme changes in short periods. Such particularity differentiates the mining dynamics and impacts in municipalities with similar levels of mining production, area of land for mining, or mining revenues.

7.1.2 Municipal fertility rates trajectories

The decreasing trajectories of the municipal general fertility rates (GFR), total fertility rates (TFR), and age-specific fertility rates (ASFR) were consistent with the trends evidenced by the demographic and health surveys of Colombia (ENDS by its Spanish acronym) [79-81]. The ENDS show that the TFR decreased from 2.4 for the period 2002-2005, to 2.0 for the period 2012-2015. The ENDS also show similar decreasing trends by age groups for the whole period. The ASFR for the 15-19 age group decreased from 90 (live births per 1,000 women in that group) for the period 2002-2005, to 75 for the period 2012-2015. According to Batyra (2016), the fertility pattern of decline in Colombia is similar to the Brazilian pattern, characterized by a slight reduction or increase in the adolescent fertility along with the postponement of the second birth—which explains the overall reduction in fertility [98, 99].

Among the municipalities with substantial GPPC and a gold-mining boom (N=78), the trajectories of the mean and median municipal GFR, TFR, and ASFR followed a flatter instead of decreasing pattern. Since these trajectories and those for all municipalities (N=1112) converged and touched in the final years of the study period, it is likely that these differences corresponded to coverage issues (low coverage of the municipal civil registration systems during the first years of the study period) which progressively improved along the study period.

7.1.3 Municipal socioeconomic variables trajectories

The results show a decreasing trend of the municipal rural index, which is a general tendency in Latin America and Colombia. The percentage of rural population in the region has decreased from 24% in 2001 (rural index: 0.32) to 20% in 2015 (rural index: 0.25); and in Colombia, from 27% in 2001 (rural index: 0.37) to 24% in 2015 (rural index: 0.32) [100].

The trajectory of the internal conflict victimization rate (ICVR) describes the historical changes related to the internal conflict after 2000. As summarized by Castro Torres and Urdinola (2018), the internal armed conflict in Colombia has deep roots in historical conflicts related to the use and distribution of land in rural areas since the first half of the 20th century [83]. After the 1970's, the conflict was fueled by the illegal drugs economies (coca cultivation, drug production, and drug trafficking). The 1990's was a period of intensification of violence by the different actors involved (corrupt government institutions, guerrillas, and paramilitaries); this was considered the bloodiest decade of the internal conflict. During the 2000's, the government deployed a frontal military response against the armed groups, entering in 2012 in a period of peace negotiations with the FARC guerilla (the largest and oldest in Latin America) and a peace treaty in 2016 [83]. The general decline in the ICVR between 2001 and 2015, observed in this study, describes the period of reduction in the conflict intensity for most of the municipalities. The higher and sinuous pattern of ICVR among the municipalities with substantial GPPC and a gold-mining boom (N=78)—with peaks in 2002, 2008, and 2013—may respond to the concentration of the conflict in areas of booming extractive economies, as explained by Castro Torres and Urdinola [83]. The highest ICVR among these municipalities during the stages of pre-boom and boom-up may be associated with periods of intensified conflict as the boom established. These results are consistent with the previous literature about the relationship between the mining economy, the involvement of armed groups, and the internal conflict in Colombia [16-18].

Although the results showed that most of the municipalities had no coca crops (median percentage near to zero), the trajectories for the mean municipal coca crops area indicate that the coca production concentrated in few municipalities. This is consistent with the reports from the United Nations Observatory of Drugs and Crime (UNODC) and the Colombian Government, which sustained that the last trend of growth corresponded to an increase in production focused in fewer territories [101]. Finally, various reports sustain that the periods of conflict, peace process and the peace treaty with the FARC guerilla established complex territorial dynamics in which the coca and the mining economies interacted [14, 101-103].

7.2 INCREASE IN FERTILITY ASSOCIATED WITH A MUNICIPAL GOLD-MINING BOOM

This study provides evidence on the longitudinal positive association between the gold-mining boom and population fertility in Colombian municipalities, between 2001 and 2015. The multilevel models of change for GFR and TFR showed that the population fertility significantly increased during periods of boom decline and post-boom after controlling for the rural index, internal conflict victimization rate, and percentage of coca crops area. The increasing trend of fertility during these stages contrasted with the general decline in fertility in Colombian municipalities during the study period. The sensitivity analysis confirmed the increasing trend in fertility (GFR and TFR) during the boom decline (boom-down). For the GFR, the sensitivity analysis also confirmed the significant increasing trends during the periods of rapid growth and maximum production (boom-up) and post-boom.

Additionally, among different age groups of women, fertility rates increased during the periods of boom-up (age group 10-14), boom-down (age groups in the range 15-25, and 35-39), and post-boom (age group 15-19). These results suggest that the contribution to the increasing GFR and TFR during the stages of boom is distributed among different age-groups of women—mainly the youngest, with differentials in the magnitude of the contribution.

The increasing trends of GFR and TFR during the stage of boom-down (consistent with the sensitivity analysis models) suggest that the gold-mining boom had an early effect on the sexual and reproductive practices and behaviors along the boom-up stage (duration: mean=2.2 years, median=2 years; N=78), subsequently revealed as a local fertility change in the stage of boom decline (duration: mean and median=1 year; N=78). The sensitivity analysis for the GFR that indicates also a significant increase during the boom-up period suggests that the limitations in the coverage of the civil registration system at the municipality level did not allow to detect an early change in fertility in this period (negative confounding).

7.2.1 Increase in general fertility

A couple of studies in contexts of extractive booms (coal and fracking) in the United States [96, 97] showed similar results regarding the increase in the general fertility during boom periods. The authors identified a positive correlation between fertility and the improvement in the economic status of men—as job opportunities and earnings increased for men but maintained or decreased for women [96, 97].

In this regard, the economic models of fertility (concerned on the effects of economic factors over individual fertility decisions and population fertility) suggest that the gender-specific labor market conditions are principal in the explanation of the mining boom and fertility relationship. Numerous studies show that the negative correlation between economic development and fertility—evidenced globally during the second half of the 20th century [104-106]—is associated with the increased participation of women in the job market and the rise in female wages, despite the limited improvements in narrowing the gender wage gap [107-111]. In the examination of economic shocks (referred to short-term periods), numerous investigations—including those mentioned regarding extractive booms—have described a positive correlation between male income and fertility [96, 97, 112-114]. In contrast, a study examining the impacts of an agricultural boom in a developing country found that the improvements in employment and wages of women—mostly benefited by this type of economy—were associated with a significant decrease in fertility [115]. As sustained by Schaller [114], fertility is positively associated with improvements in male labor-market conditions and negatively with improvements in these conditions for women; as well as, that the impacts of economic fluctuations on fertility are mostly explained by variations in earnings of men [114]. These economic models of fertility would suggest that improvements in the male labor-market conditions in Colombian municipalities experiencing a gold-mining boom would explain a pattern of increased fertility.

7.2.2 Increase in adolescent fertility

The increase in adolescent fertility during the stages of gold-mining boom is inconsistent with the negative association commonly observed between economic growth (i.e., increase in household wealth, minimum wage, or GDP) and adolescent fertility [113, 116, 117]. Instead, several studies have shown that adolescent fertility is positively correlated with poor socioeconomic status of girls and income inequality [118-120]; and one study described that a decline in the male labor-market opportunities (in contexts of economic busts) leads to a decrease in general fertility but an increase in adolescent fertility [121]. In other words, an increase in adolescent fertility could be linked to worsening male-labor market conditions instead of improvements. Such inconsistency suggests that the analysis of the male labor-market conditions, generally portrayed as improved in contexts of gold-mining boom, is insufficient to explain the fertility change found in this study.

The increased adolescent fertility found in the stages of gold-mining boom must be discussed in light of the general situation of the adolescent fertility and the vulnerability of this population regarding SRH in Colombia. The adolescent fertility rate (75 per 1000 adolescents aged 15-19 for the period 2012-2015) [81] is one of the highest worldwide (64.6 in LAC and 43.9 in the world) [122]. The adolescent fertility is significantly higher in rural (20% of adolescents aged 15-19 have a child) than in urban populations (11.6%); in groups with primary education (36% have a child) than with secondary education (13.8%); and in the lowest wealth quintile (22.7% have a child) than in the highest (3.5%) [81]. Among rural women, around 27% report first intercourse before age 15 (17% in the total population) and 58%, before age 20 (40% in the total population) [81]. Finally, more than 6000 births among girls aged 10-14 occur every year in Colombia [123], which is an indirect indicator of child abuse. The increased ASFR of this age group in the stage of boom-up, observed in this study, supports the urgency of examining sexual violence against girls and adolescents in the contexts of gold-mining boom.

7.2.3 Rapid change in fertility associated with a gold-mining boom

Another key finding of this study regards to the short period in which the fertility change is evidenced. According to the *intermediate factors* analytical framework [124, 125], the gold-mining boom would influence fertility through intermediate factors impacted in the short term (considering the short duration of the boom and post-boom stages). As previous studies described (mostly focused on the HIV spread in mining contexts), these factors may include: increases in early sexual initiation [10-12, 48], and increases in sexual risk factors including the non-use of contraception, casual sex, transactional sex, sexual abuse, and sex commerce [2, 3, 6-9, 21, 22, 48, 51-53].

The intermediate factors associated with infertility and pregnancy loss related to the toxicological effects of environmental pollution due to the gold mining [126] may not be observed in the short term given the natural course of these conditions. At this point, it is necessary to clarify that, under the intermediate factors approach, fertility (as an aggregated measure of live births) and pregnancy are not equivalent concepts. Increased fertility may involve, simultaneously, an increased number of pregnancies that get to term (live births) and an increased number of pregnancy losses—for instance, abortions. It is likely that the number of pregnancies exceeds the number of live births; however, this study does not provide evidence on the variation of the total number of pregnancies and pregnancy losses during the stages of a local gold-mining boom.

The intermediate factors potentially related to a rapid increase in fertility may involve structural aspects, as explained by Orellana et al. in the examination of the HIV spread in Amazon indigenous communities [48]. Structural factors include socioeconomic vulnerability and poverty, cultural beliefs related to health and sexual behaviors, and gender roles and power relations. Given the rapid change in fertility found in this study, it is necessary to question to what extent the gold-mining boom determines rapid changes in structural sociocultural aspects of local populations.

Finally, the rapid change in fertility and the variety of intermediate factors potentially involved suggest that the impacts of a gold-mining boom may transcend specific groups with certain risks and vulnerabilities, impacting also vulnerable groups not considered as at high-risk (mineworkers and sex workers have been typically defined as high-risk groups in mining contexts).

7.2.4 Fertility change in contexts of social disruption

The literature on the fertility impacts of the economic growth, including the previous studies examining extractive booms [96, 97], do not provide a sufficient basis for the discussion of the findings, particularly, of the increased adolescent fertility—commonly associated with worsening socioeconomic conditions of girls in contexts of income inequality and economic recession. The investigations sustaining that the improvement in the male-labor market demand is the main socioeconomic factor explaining fertility change overlook the disruptive dynamics commonly described in mining boom contexts worldwide. As explained in Chapters 2 and 5, extensive literature from different disciplines has characterized the mining boom contexts as places where disruptive demographic, socioeconomic, and gender dynamics take place.

Despite the relevance of the social disruption approach in the analysis of the impacts of a mining boom on fertility, there are no previous attempts in this direction. The current literature on the relationship between disruptive events and fertility has been mainly referred to war and civil conflicts, humanitarian crises, and population displacement. The evidence from this research field is limited and shows varied effects on fertility according to the population and nature of the event [125, 127, 128]. The review by Hill [125] indicates that there is no sufficient evidence supporting immediate effects of war and population displacement on fertility; famine and separation of families are likely to cause a reduction in fertility in the medium-term; and the effects in the long-term seem to be marginal. Guha-Sapir and D´Aoust [127] sustain that fertility patterns are not stable in periods of civil conflict given the complexity of the reproductive decisions and behaviors. Fertility reduction could result from "violence, psychological stress, wealth uncertainty and poor health"; fertility rise could occur as a coping strategy against the economic shock associated with the disruptive event [127: p. 8-10]. Cetorelli [128] found that the stable trend of the total fertility rate observed during a period of war (in Irak during the 2000's) was due to two countervailing trends among less-educated women: a decreased fertility among married women, likely motivated by the harsh living conditions, though, with fair availability of family planning services; and an increased adolescent fertility associated with early marriage, likely occurred as a coping mechanism against insecurity and lack of opportunities.

The literature on the fertility impacts of a disruptive event offers elements that must be considered in the examination of the fertility and SRH impacts of a gold-mining boom (e.g., availability of family planning services, early marriage, and wealth uncertainty among women). However, the nature of the social disruption associated with a mining boom is different from that of war or civil conflict; for instance, the immigration dynamics (high influx of male labor force) instead of population displacement, or the context of economic boom instead of recession. Therefore, the mining boom may determine distinct patterns of fertility from those determined by other types of disruptive events.

7.2.5 Fertility change in contexts of unbalanced gendered power relations

The economic models of fertility and the social disruption approach find common ground from a gender perspective. The economic models of fertility highlight the importance of the gender-specific market conditions in the determination of fertility patterns (improved job opportunities and earnings for men but not for women in mining contexts). The social disruption approach allows identifying the gender dynamics triggered by the mining economy that may shape the pathways that drive the population patterns of fertility.

The gender dynamics traverse different levels of influence within the social context, from the macro level of the public policies—e.g., related to the legal restrictions of the mining sector to the participation of women in specific tasks [60]—to the individual level of the differential exposures, risks, and health effects. To have a better understanding of the mechanisms linking the social and economic dynamics in mining settings with the way gender relations are constructed, it is necessary to delve into the sexual division of labor and economic power and the roles and status of women in these contexts.

Women involved in mining have the lowest status both in industrial mining and artisanal and small-scale mining (ASM). In the industrial mining, the participation of women is marginal (around 10% of the workforce globally) [129]. The roles of women are usually limited to the administrative, corporate social responsibility, and public relations departments [60]. Work practices like fly-in/fly-out or commuting are disadvantageous for women, especially for those with caring responsibilities [36, 130]. Even when women perform the same tasks than men, payment is lower. Additionally, women in industrial mining face disadvantages such as inappropriate safety equipment, lack of maternity leave, inappropriate infrastructure, and, principally, stereotypes related to mining as male work [129, 131].

Women's involvement in ASM is higher than in industrial mining (30% of the global workforce) but more informal. In the late 1990s, the participation of women as mineworkers was estimated 40-50% in Africa, 10-20% in Latin America, and 10% in Asia [132]. The level of participation of women in ASM is related to the quantity of mineral production and the value of the commodity [59]. Women have more participation in ASM of small production; for instance when mining is a family endeavor, when it is a subsistence livelihood, or when it supplements other subsistence livelihoods like agriculture. Women have greater engagement in extraction (even digging or trading) of low-valued products like clay, stones quarries, limestone, and salt; and a higher restriction in the mining labor of high-value products like gold [59].

Women may engage in mining tasks when ASM is part of the traditional livelihoods of families and communities. However, the involvement of women as mineworkers is usually due to the transformation of agricultural land for extractive purposes and the displacement of local subsistence livelihoods and economies (in which women play essential roles, i.e., environmental protection, food safety, family care, and community cohesion) towards a mining cash-economy controlled by men [59, 133].

Roles of women as mineworkers in ASM are mostly limited to processing activities. These include hazardous tasks like crushing, sieving, and washing of ore, and, in the case of gold mining, amalgamation through the use of toxic materials like mercury [59, 131]. These activities have the lowest economic profits but use considerably much manual labor. On the contrary, it is very uncommon to find women performing more relevant functions as mine or equipment owners or as product dealers [60]. The subordinated work performed by women is related to the informality of the ASM, the lack of expertise and training of women, and the concurrence of household obligations usually carried by women [134]. Women wages are considerably lower than the wages of men, even when they perform heavy tasks like those performed by men [35, 62]; besides, women may have less control over their earnings, in some cases given to their male partners or counted as the husband's revenue [59, 135-138].

In mining contexts, the role of women usually involves the provision of services (e.g., as cooks, barmaids, or storekeepers), including sex services [59, 60, 135]. Sex work is related to the increased demand for sex by men, which is also related to the high influx of male workers to the mining places, the isolation and separation of men from their families, and the high amounts of disposable cash of men. The literature describes two different situations regarding sex work in mining contexts [60]: one, in which sex work is an income alternative for young and adult women in situations of extreme poverty and few economic opportunities [4, 139]; and other, in which sex work is due to sexual exploitation or bonded labor of women, children and young adolescents [35, 140-143]. Reports of sexual exploitation and human trafficking in mining places are, nevertheless, very uncommon because victims fear to worsen the abuse or to lose their source of income [144].

Transactional sex has also been commonly reported in different mining settings as a supplementary source of income and basic goods and a way to obtain favors [4, 46, 48, 145-147]. Transactional sex is referred to the "sexual interactions in which something is exchanged or transferred, though on a more informal basis than, and conceptually distinct from, commercial sex work" [145, p.438]. In Guinea, women being paid less than men for the same mining labor may trade sex in exchange for more money or gold [146]. In South Africa, mineworker women may provide sex services in exchange for assistance in underground mining tasks [147]. In mining communities in Tanzania, transactional sex has been described among women working in food and recreational facilities and among local women [4, 8]. In Peru, in Amazonian river ports and ferryboats in gold-mining and oil zones, poor women and indigenous teenage boys may involve in transactional sex with boat crews and passengers in exchange of transportation and favors during trips [48].

A gender analysis requires to consider also the issue of masculinities and the male perspective. According to Campbell (1997) [148] and Campbell & Williams (1999) [63], rural poverty and lack of employment opportunities force males to migrate and endure extreme working conditions (i.e., exhausting shifts of dangerous work, often in confined spaces, and under extreme circumstances of heat and humidity). The daily hazardous conditions of mining labor may produce a constant sense of fear of accidents and death and high levels of stress. Male miners deal with this sense of powerlessness through the reinforcement of their masculine identities, which comprise ideas of bravery and persistence, but at the same time, a notion of "*macho*" sexuality. In this way, the coping mechanisms developed by male mineworkers include high-risk behaviors (i.e., high consumption of alcohol, multiple sex partners, high demand for sex services, and non-use of condoms).

In summary, the mining economy may determine a displacement from traditional economies and livelihoods towards cash-economies controlled by men. These disruptive changes determine, at the same time, particular gender dynamics. Women shift away from their traditional roles towards roles as mineworkers (mainly restricted to subordinated tasks) or providers of services, including sex. Women experience a degradation of their social status, lack of access to the benefits of mining, and high economic dependency on men. Among males, the harsh working conditions of mining, as well as conditions of poverty, migration, isolation, and separation from families, may determine a reinforcement of masculine identities expressed through *"macho"* behaviors of high demand of alcohol, drugs and sex services. These simultaneous and complex dynamics define contexts of unbalanced gendered power relations where women are disproportionally vulnerable.

Certainly, the findings from this dissertation do not provide evidence to claim that the increased fertility during the gold-mining stages of boom decline and post-boom in Colombian municipalities, including the increased adolescent fertility during the stages of boom, is explained by or is linked to an unbalanced gendered power relations phenomenon. The questions of why fertility changes in such short term and why even the adolescent population is affected need to be addressed in future investigations. The discussion of the findings in light of the disruptive gender dynamics that may take place in mining boom contexts, however, does provide insightful elements for new studies regarding SRH in local mining contexts in Colombia, Latin America and the Caribbean, and other regions worldwide.

7.3 LIMITATIONS

This study takes advantage of the available data on mining and births at the municipal level in Colombia to examine how changes in the mining dynamics were associated with changes in fertility patterns, between 2001 and 2015. The quantitative nature of this dissertation, however, limits the scope of the findings; they document the existence of a relationship between the gold-mining boom and fertility change in Colombian municipalities. A qualitative approach would provide evidence on the mechanisms and factors involved in shaping the SRH outcomes among different groups of population, in local gold-mining boom contexts.

In regard to the methodological approach used in this study, there are some limitations that must be discussed.

The limited available longitudinal data narrowed the scope (examination of the relationship between the gold-mining boom and fertility, but not of the mechanisms involved), time (2001—as the first year with available data on mining production—to 2015), and level of analysis (municipality-level) of the investigation. The methodological approach performed in this study, however, made the best use of the available data on gold mining (municipal gold production) and fertility—as a comprehensive measure of SRH, demonstrating a relationship between these constructs in Colombian municipalities.

To examine the mechanisms involved in the determination of the fertility changes and SRH impacts, researchers need to consider other dimensions of the gold-mining boom (and in general, of the gold mining economy) and other socioeconomic factors of the populations. Such investigation would require longitudinal data (not currently available in Colombia) on labor and general migration; population involved in mining; mining operations (i.e. type of extraction, scales, and status of formality/legality); socioeconomic aspects of the population (i.e. education level, school attendance among adolescents, and socioeconomic status); economic conditions of the municipalities (i.e. poverty and income inequality); and access to health care and SRH services. Moreover, researchers would need to assess the effects of the gold-mining boom in smaller levels of analysis than municipality (e.g., neighborhood or urban/rural areas) to observe whether the impacts target specific contexts and groups of population or spread across the municipal population.

Another limitation refers to the quality of the available data, which may differ between municipalities as local governments may have different performances on their information systems. As explained in Chapter 5, to account for this limitation, I performed a sensitivity analysis including only the municipalities with adequate live birth coverage by 2005, which indicated that the results were robust. A similar approach was developed by Chiavegatto and Kawachi (2015) in their longitudinal analysis of the relationship between income inequality and adolescent fertility in municipalities of Brazil [119].

As for this limitation, it is necessary to consider that the relationship between mining and SRH may be determined, in fact, by the development and performance of local institutions and governments. As studied in mining contexts in developing countries [33, 149], a mining boom may have more severe impacts in places with poor institutional and governmental performance; which may also correspond to places with weaker information systems (usually, the most rural and deprived areas) [150]. Despite the sensitivity analysis indicating that the results were robust, it is likely that the inadequate live births coverage among municipalities with poor civil registration systems and weak local institutions and governments—likely associated with worse boom impacts—may wash a stronger association between the gold-mining boom and fertility change.

Another limitation involves the use of the categorical variable *stages of gold-mining boom* (SGMB), which I established as the independent variable. The construction of the time-varying SGMB variable implied the definition of *extreme change*, in order to determine the years with an extreme increase or decrease in the gold production per capita (GPPC). I defined *extreme change* as an outlier value of the municipal distribution of change in GPPC per year, in the period 2001-2015 (Chapter 5). This definition determined the categorization of the stages of gold-mining boom, as the definitions of each of the categories depended on the presence of an extreme change given the sequence pre-boom/boom/post-boom. This definition also restricted the interpretation of the findings to the period 2001-2015, as the municipal distribution of change accounts specifically for this time lapse.

I also established a definition for *substantial GPPC* given the need to determine how much gold production per capita in a municipality should be considered as marginal or substantial to have an impact on the local socioeconomic dynamics. This was required since there were municipalities with extreme changes in GPPC but with a low production per capita (that could correspond to a marginal production), which could misrepresent the depiction of a gold-mining boom. To fulfill this fundamental requirement, I used the *municipal added value* VAM for the definition of *substantial GPPC*, which is the only measure in Colombia that assesses the contribution of the gold-mining sector to the local economy. I defined *Substantial GPPC* as the production greater than the minimum GPPC among the municipalities where the gold-mining sector was the first or second contributing economy by 2013 (year of the VAM measure); the minimum GPPC observed was 11.7 gr. p/capita. Based on this value, I established 10 gr. p/capita as the GPPC threshold to identify the municipalities with *substantial GPPC*—those with at least one year of GPPC above that threshold during the study period. Certainly, the variation of the threshold value would produce changes in the number of municipalities identified as with substantial GPPC and in the correlation between the SGMB and fertility. For instance, a threshold lower than 10 gr. p/capita would add more municipalities with substantial GPPC and a gold-mining boom to the regression analysis, with a potential reduction of the effect of the SGMB on fertility change. Future studies may include sensitivity analyses that examine changes in the correlation between the SGMB and fertility at different threshold values for the *substantial GPPC*, and that identify at what level the correlation is no more observed.

Additionally, availability of data restricted the categorization of the first year of the study (2001) as pre-boom, for all the municipalities in the study. Since there was no available data on mining production for the years previous to 2001, there was not possible to know whether the GPPC in the first year followed a trend of change (including an extreme change) or stability.

Despite these limitations, these strategies responded to the need of a standardized measure to represent the complexity of the municipal gold-mining patterns of change at the local level (given the lack of previous attempts in this direction). The use of the categorical variable SGMB was appropriate to inform the particularities of the municipal trajectories and to simplify the depiction of the dynamics of a local boom phenomenon. New studies are required to validate this measure, for instance, by observing the correlation of the SGMB categories with factors commonly reported as impacted in mining boom contexts, which may include crime, male employment, or local inflation, in a sample of municipalities with available good quality data. Future research may consider the use of this measure to examine other health impacts of the gold-mining boom, as well as impacts in other dimensions.

8.0 CONCLUSIONS - WHAT IS KNOWN NOW AND WHICH GAPS IN KNOWLEDGE REMAIN?

In the first part of the dissertation, I discussed critical gaps in the investigation of sexual and reproductive health (SRH) in Latin American and Caribbean (LAC) mining contexts: "[the] little knowledge on 1) broader SRH impacts besides HIV/STDs, 2) SRH in settings different from gold-mining contexts in Amazon countries, 3) mechanisms shaping SRH in LAC mining contexts, and 4) effective interventions in these scenarios" (Chapter 2) [151].

This study addressed the first critical gap by providing evidence about the impacts of a mining boom on fertility—as a comprehensive measure for SRH. The longitudinal positive association between the gold-mining boom and population fertility in Colombian municipalities, during the study period, as well as the rapid change in fertility observed in the short period of the boom stages, suggest that SRH is deeply impacted, both at the individual level of the sexual and reproductive behaviors and practices and in the contextual level of the population fertility patterns. This study urges for continuing the examination of different SRH aspects in mining contexts, not only concerned with HIV/STDs, and not exclusively among mineworkers and sex workers. Of particular interest is the assessment of access to care and SRH services (i.e. access to contraception, safe abortion and post-abortion care, antenatal and postnatal care, and medical attention and support in cases of sexual violence), which may be affected and, simultaneously, influence SRH (and availability of SRH data) in the mining contexts.

As for the second gap—regarding the mining settings involved, this study indeed focused on the gold mining context, as most of the previous studies in the LAC region; however, the methodological approach offered new insights on the dynamics of a gold-mining boom. In the first place, the study included all the Colombian municipalities during fifteen years, which provided a longitudinal view of the national gold-mining boom phenomenon reflected at the local level. Additionally, the use of the time-varying categorical variable *stages of gold-mining boom* (SGMB), based on the gold production per capita (GPPC), facilitated the analyses of the heterogeneous, nonlinear, and discontinuous trajectories of gold production and simplified the depiction of the dynamics of the municipal mining boom phenomena. Since there are no previous attempts to examine the longitudinal characteristics of the stages of a gold-mining boom (pre-boom/boom/post-boom) in Latin America and the Caribbean and other regions worldwide (to my knowledge), the use of the SGMB variable becomes a functional method to be validated for the examination of other impacts of a mining boom (other health aspects or additional environmental, socioeconomic, or cultural issues).

As for the third gap—referred to the mechanisms involved, the evidence from this dissertation is circumscribed to the existence of a relationship between the gold-mining boom and fertility change in Colombian municipalities. The fertility patterns in municipalities experiencing a gold-mining boom differed from those in gold-mining municipalities with no boom and municipalities with no gold production. In other words, the findings showed that the gold-mining boom involved differential dynamics that determined changes in fertility. Certainly, this study does not respond by which mechanisms or pathways fertility changed, but it does offer critical insights that ground new hypotheses on the mechanisms and pathways involved.

Such new hypotheses must consider, principally, the gender dynamics triggered by a mining boom. As discussed, the analysis of the improvement in the economic status of men as a determinant of the fertility change (due to the increased male labor-market demand that characterizes the mining economy) is insufficient to interpret the study findings. The increased adolescent fertility (commonly associated with worsening socioeconomic conditions of girls, in contexts of economic recession and income inequality) justifies, first, the analysis of the disruptive economic dynamics described in mining contexts (e.g. displacement of local economies, high dependency on the mining sector, high vulnerability among the population not involved in mining). Second, it justifies the analysis of the gender dynamics triggered by the mining economy, i.e. limited access of women to the economic benefits of mining, high dependency on men, and high vulnerability of women and adolescents under extreme poverty conditions. As reviewed by Jenkins (2014), the mining places configure contexts of unbalanced gendered power relations where the privileges of men are reinforced, and the social status of women is degraded [60].

New studies are needed to examine the *unbalanced gendered power relations* construct and assess its significance in the determination of SRH in these contexts. The development of qualitative investigations in gold-mining boom places is essential to explore the gender imbalances and power differentials that may have effects on the sexual and reproductive behaviors and practices. An important target group for such exploration would be women working in mining or women married or united to miners, given their direct involvement in the mining dynamics; however, other groups of women and adolescents, not directly involved in the mining activities, may provide insightful elements regarding the way a mining boom impacts groups not typically considered at high SRH risk. Qualitative research would inform quantitative studies to operationalize and measure the *unbalanced gendered power relations* construct at the local level and along the different stages of a mining boom (pre/boom/post).

Other investigations (both qualitative and quantitative) may explore the coping mechanisms associated with the reinforcement of masculine identities and “macho” behaviors in mining contexts, as suggested by Campbell (1997) [148] and Campbell & Williams (1999) [63];

practices like transactional sex, commonly described in these contexts as a particular factor of risk and vulnerability among poor youngsters and women; and violence not related to the internal conflict, since more intimate expressions of power like the intimate partner violence may influence gender relations and SRH.

As for the fourth gap, a better understanding on the relationship between mining and SRH and the mechanisms and pathways involved will support adequate and effective SRH interventions in mining contexts addressing sexual risk behaviors, sexual violence against women and adolescents, unintended pregnancies and adolescent pregnancies (e.g., among girls aged 10-14, which is related with child abuse), unsafe abortion, and HIV and STDs. More research is required to adequately fulfill this gap in knowledge.

This dissertation study is the first empirical attempt in Colombia and LAC (and worldwide, to my knowledge) in examining the relationship between mining and fertility, as a comprehensive measure for SRH. The findings feed into the growing discussion about the health impacts of the extractive industries by providing new evidence on this relationship and suggesting new questions and novel investigation lines that need to be addressed. Given the profound inequities and pending challenges in SRH in the LAC countries, the study constitutes a baseline for further research on this critical but neglected topic of public health significance. In this sense, this investigation is relevant for multidisciplinary research teams, local and national governments, and civil organizations interested in public health, SRH and gender issues (principally, women organizations), and more importantly, for communities experiencing a mining boom. The final stage of dissemination of the findings (without which this research process will not be completed) must be directed to these groups.

APPENDIX A - MUNICIPAL GOLD-MINING PRODUCTION IN COLOMBIA, 2001-2015

Table A-1. Municipal gold-mining production in Colombia, 2001-2015

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Municipality-years 2001-2015
Total gold production in Colombia, N=1112 (metric tons)																**N=16680**
	21.7	20.8	46.5	37.3	34.8	15.3	15.5	34.2	47.8	53.6	55.6	66.1	55.6	56.9	59.0	620.7
Municipalities with gold production between 2001-2015 by GPPC (gr p/capita)																**N=2582**
N	163	161	178	179	155	162	151	193	194	194	196	178	171	148	159	2582
Median	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.2	0.3	0.3	0.2	1.1	0.9	0.9	1.3	0.3
Mean	7.2	6.2	12.6	11.8	13.3	5.1	6.0	12.3	13.4	17.8	24.2	23.1	15.6	18.3	16.9	13.8
S.D.	29.1	16.9	44.3	38.7	45.2	18.1	25.7	78.1	36.8	57.5	120.5	82.3	41.1	38.3	33.0	56.1
Range	328.9	121.9	373.9	351.1	415.4	163.3	264.5	1041.1	255.7	379.9	1330.4	863.6	381.5	250.3	146.0	1330.4
>0gr - <1gr (%)	112 69%	114 71%	116 65%	114 64%	100 65%	118 73%	103 68%	132 68%	123 63%	115 59%	127 65%	88 49%	86 50%	78 53%	75 47%	1601 62%
1gr - <10gr (%)	31 19%	29 18%	34 19%	38 21%	29 19%	28 17%	33 22%	35 18%	29 15%	40 21%	36 18%	42 24%	44 26%	28 19%	40 25%	516 20%
10gr - <100gr (%)	19 12%	17 11%	20 11%	22 12%	22 14%	14 9%	13 9%	21 11%	33 17%	30 15%	23 12%	39 22%	33 19%	32 22%	35 22%	373 14%
100gr - <1000gr (%)	1 1%	1 1%	8 4%	5 3%	4 3%	2 1%	2 1%	4 2%	9 5%	9 5%	9 5%	9 5%	8 5%	10 7%	9 6%	90 3%
>=1000gr (%)	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	1 1%	0 0%	0 0%	1 1%	0 0%	0 0%	0 0%	0 0%	2 0%

Table A-2. Municipalities with substantial GPPC and a gold-mining boom* by SGMB, 2001-2015 (N=78)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Municipality-years 2001-2015
																N=1170
pre-boom (N, %)	78 100%	74 95%	64 82%	58 74%	56 72%	56 72%	56 72%	54 69%	50 64%	51 65%	46 59%	31 40%	35 45%	31 40%	31 40%	771 65.9%
boom_up (N, %)	0 0%	4 5%	13 17%	9 12%	7 9%	2 3%	2 3%	11 14%	15 19%	19 24%	17 22%	24 31%	13 17%	14 18%	20 26%	170 14.5%
boom_down (N, %)	0 0%	0 0%	1 1%	10 13%	8 10%	7 9%	1 1%	0 0%	4 5%	2 3%	8 10%	9 12%	12 15%	9 12%	7 9%	78 6.7%
post-boom (N, %)	0 0%	0 0%	0 0%	1 1%	7 9%	13 17%	19 24%	13 17%	9 12%	6 8%	7 9%	14 18%	18 23%	24 31%	20 26%	151 12.9%

* Corresponds to municipalities with substantial GPPC in which the category boom-up (rapid growth in production) was determined.

APPENDIX B - MUNICIPAL FERTILITY RATES IN COLOMBIA, 2001-2015

Table 8-1. Municipal fertility rates in Colombia, 2001-2015

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
N	1107	1109	1110	1108	1110	1109	1109	1112	1112	1112	1112	1112	1112	1112	1112
	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median	Mean SD Median
GFR															
	69.0 24.1	64.9 22.0	64.8 21.9	65.9 21.0	64.6 20.1	61.7 19.7	60.1 18.6	58.6 19.0	55.8 19.1	52.9 19.2	52.8 19.6	53.5 21.2	50.8 19.4	49.6 19.4	48.1 19.4
	70.0	65.8	64.6	65.4	64.0	60.9	59.6	57.4	55.0	51.4	50.4	51.0	48.9	47.7	45.7
ASFR 10_14															
	2.7 2.8	2.7 2.8	2.7 2.8	2.9 3.2	3.0 2.9	3.0 2.9	3.0 2.8	3.1 3.1	3.2 3.0	3.0 3.1	3.0 3.0	3.3 3.6	3.2 3.2	3.2 3.4	2.9 3.3
	2.3	2.3	2.1	2.4	2.4	2.5	2.6	2.5	2.8	2.6	2.4	2.7	2.7	2.4	2.3
ASFR 15_19															
	80.8 34.0	75.8 31.3	76.2 30.9	77.3 29.4	76.4 29.8	75.2 29.4	74.1 28.0	72.4 27.6	69.6 27.7	66.6 26.1	67.2 27.2	70.3 29.3	67.1 27.6	64.7 27.6	62.4 28.3
	80.6	75.0	74.3	76.1	75.0	74.1	73.8	71.8	69.1	65.9	65.6	68.2	65.3	63.3	59.0
ASFR 20_24															
	121.3 46.7	116.4 43.6	118.8 43.6	122.7 43.8	120.9 42.5	112.2 39.3	107.6 37.4	102.0 36.4	94.2 36.2	88.8 34.9	86.9 34.8	87.9 35.7	82.6 34.4	80.8 34.1	77.1 34.1
	123.8	118.5	120.6	123.6	121.0	112.4	109.4	102.0	92.9	87.6	84.3	84.0	80.9	78.1	75.4
ASFR 25_29															
	93.0 37.3	89.0 34.4	88.0 33.8	91.0 33.3	91.4 32.6	88.8 33.4	89.3 32.7	87.4 33.5	84.0 34.7	79.4 35.7	76.9 32.6	74.1 33.1	69.0 31.1	67.6 31.2	64.9 29.0
	95.1	90.2	88.8	91.6	90.9	89.2	89.3	86.4	81.0	76.3	74.0	70.8	66.3	64.3	62.4
ASFR 30_34															
	66.6 27.9	63.3 25.8	63.4 26.1	64.5 26.3	62.3 24.7	59.8 25.2	57.2 22.9	56.5 24.1	55.7 23.9	52.9 23.2	55.2 26.2	56.3 28.5	55.7 26.4	54.7 26.3	53.7 25.8
	67.1	63.3	62.7	64.1	61.5	58.1	56.6	55.2	54.1	50.6	52.3	53.2	51.7	51.9	50.6
ASFR 35_39															
	40.7 20.8	37.6 18.9	37.5 19.3	38.0 17.5	37.9 18.0	35.9 16.7	34.9 16.0	35.0 17.0	32.5 16.0	31.9 21.2	31.2 15.8	31.7 18.7	30.3 16.6	30.2 16.8	30.5 16.4
	38.3	35.9	35.7	36.2	36.6	34.5	33.6	33.9	31.3	29.2	29.4	29.6	27.8	27.9	28.0
ASFR 40_44															
	15.7 12.9	14.0 10.5	14.2 11.2	14.1 10.4	13.4 9.4	12.8 8.9	12.1 8.1	11.4 8.3	11.0 11.0	10.4 9.3	10.3 8.2	10.6 8.9	10.2 8.8	9.8 9.7	10.0 12.2
	13.2	12.0	12.1	12.0	11.7	11.2	10.8	10.2	9.8	9.0	9.2	9.4	8.8	8.5	8.2
ASFR 45_49															
	1.8 3.4	2.0 4.2	1.4 2.9	1.5 2.9	1.6 3.8	1.8 4.2	1.5 3.0	1.4 2.8	1.2 2.7	1.1 2.3	1.1 2.5	1.0 2.0	1.0 3.0	0.9 2.4	1.0 10.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TFR 10_49															
	2.1 0.7	2.0 0.7	2.0 0.7	2.1 0.6	2.0 0.6	1.9 0.6	1.9 0.6	1.8 0.6	1.8 0.6	1.7 0.6	1.7 0.6	1.7 0.6	1.6 0.6	1.6 0.6	1.5 0.6
	2.2	2.1	2.0	2.1	2.0	2.0	1.9	1.8	1.7	1.6	1.6	1.6	1.6	1.5	1.4
TFR 15_49															
	2.1 0.7	2.0 0.7	2.0 0.7	2.0 0.6	2.0 0.6	1.9 0.6	1.9 0.6	1.8 0.6	1.7 0.6	1.7 0.6	1.6 0.6	1.7 0.6	1.6 0.6	1.5 0.6	1.5 0.6
	2.2	2.0	2.0	2.1	2.0	1.9	1.9	1.8	1.7	1.6	1.6	1.6	1.5	1.5	1.4

Table 8-2. Municipal fertility rates among municipalities with substantial GPPC and a gold-mining boom (N=78), 2001-2015

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD
	Median	Median	Median	Median	Median	Median	Median	Median	Median	Median	Median	Median	Median	Median	Median
GFR															
	53.5 31.1	51.1 29.2	54.0 28.5	56.8 27.3	56.8 28.6	55.3 27.1	53.5 24.2	53.4 24.5	52.0 23.2	48.2 20.9	51.0 23.1	49.8 22.6	50.0 21.5	50.1 24.0	46.4 21.6
	53.5	47.2	53.5	57.1	60.3	56.6	56.9	56.2	52.7	49.9	49.8	49.5	49.4	49.3	45.3
ASFR10_14															
	2.5 2.4	2.9 2.7	2.9 3.1	3.3 3.2	3.8 3.1	3.4 2.9	3.7 2.7	3.7 3.1	3.8 3.1	4.1 3.5	4.1 3.4	4.2 3.2	4.0 3.6	4.6 3.9	3.9 3.7
	2.0	2.6	2.0	2.7	2.8	3.0	2.9	3.5	3.3	3.7	3.7	4.1	3.5	3.8	3.4
ASFR15_19															
	64.7 42.2	62.5 38.0	65.5 36.5	68.9 35.7	72.7 39.7	70.3 39.5	66.8 35.5	66.7 34.8	66.2 31.4	62.4 31.5	64.5 33.1	67.5 35.3	68.8 31.5	65.3 32.2	60.2 30.1
	60.8	58.1	66.2	73.5	76.3	69.9	66.2	64.7	66.5	61.8	63.0	68.9	67.7	61.2	58.7
ASFR20_24															
	88.6 55.1	86.1 51.6	96.2 56.1	98.8 51.4	98.4 54.1	94.1 46.1	86.9 41.1	84.3 43.5	80.2 38.8	74.9 36.0	77.5 36.5	76.4 36.9	73.3 31.9	74.3 36.4	68.6 33.3
	82.6	80.8	93.9	99.6	101.2	93.5	87.9	87.1	80.4	75.1	77.3	76.3	72.4	72.4	65.7
ASFR25_29															
	64.6 41.1	64.3 39.3	65.9 36.9	71.3 37.1	72.7 40.0	73.6 40.1	74.5 40.9	71.6 35.5	69.6 37.0	65.3 32.3	69.4 36.4	61.9 30.1	62.0 31.1	61.4 31.7	57.7 28.5
	68.9	64.2	63.7	71.3	72.0	76.5	77.0	73.8	70.1	64.0	65.5	60.8	60.1	60.9	58.3
ASFR30_34															
	50.1 32.5	49.4 30.6	50.4 32.6	54.4 31.8	49.3 27.8	49.3 27.9	49.9 24.9	49.9 23.8	48.3 25.4	42.4 20.9	50.7 25.8	48.1 25.8	48.7 25.1	51.1 32.0	45.6 24.4
	46.0	43.5	50.4	51.7	51.0	47.3	47.6	49.0	47.5	42.1	48.4	44.7	45.7	45.5	44.2
ASFR35_39															
	34.0 23.1	29.6 21.2	30.1 21.1	32.5 20.8	31.1 18.6	30.5 18.3	29.2 16.1	31.2 18.8	29.1 16.8	26.7 14.1	29.6 16.5	28.4 17.0	28.9 16.7	31.1 18.9	28.5 18.2
	33.0	25.4	26.7	30.1	30.9	29.1	29.0	30.1	29.5	24.8	29.3	25.8	25.7	28.7	24.7
ASFR40_44															
	13.2 11.1	12.3 10.4	12.3 10.9	14.2 12.1	12.2 9.4	11.7 8.5	11.3 7.5	11.1 7.2	11.0 7.8	10.2 7.1	10.8 7.5	10.7 7.9	10.6 7.2	10.3 8.4	10.3 9.3
	11.2	10.7	9.0	12.2	12.0	10.2	10.4	11.6	9.6	11.0	10.3	8.2	10.1	8.7	8.1
ASFR45_49															
	2.4 4.0	2.3 4.1	1.3 2.2	1.7 2.8	1.8 2.6	1.9 2.5	2.1 3.3	1.9 3.2	1.4 2.3	1.2 2.1	1.1 1.9	1.1 2.3	1.3 1.9	1.1 2.1	1.1 2.4
	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TFR10_49															
	1.6 1.0	1.5 0.9	1.6 0.9	1.7 0.9	1.7 0.9	1.7 0.8	1.6 0.7	1.6 0.7	1.5 0.7	1.4 0.6	1.5 0.7	1.5 0.7	1.5 0.6	1.5 0.7	1.4 0.6
	1.6	1.4	1.6	1.7	1.8	1.7	1.7	1.7	1.6	1.4	1.5	1.5	1.4	1.5	1.4
TFR15_49															
	1.6 1.0	1.5 0.9	1.6 0.9	1.7 0.8	1.7 0.9	1.7 0.8	1.6 0.7	1.6 0.7	1.5 0.7	1.4 0.6	1.5 0.7	1.5 0.7	1.5 0.6	1.5 0.7	1.4 0.6
	1.6	1.4	1.6	1.7	1.8	1.7	1.7	1.6	1.5	1.4	1.5	1.5	1.4	1.5	1.3

APPENDIX C - MUNICIPAL SOCIOECONOMIC VARIABLES IN COLOMBIA, 2001-2015

Table C-1. Municipal rural index, internal conflict victimization rate (ICVR), and percentage of coca crops area, Colombia (N=1112), 2001-2015

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Rural index															
Mean, SD	0.60 0.24	0.60 0.24	0.60 0.24	0.59 0.24	0.59 0.24	0.59 0.24	0.58 0.24	0.58 0.24	0.58 0.24	0.57 0.24	0.57 0.24	0.57 0.25	0.57 0.25	0.56 0.25	0.56 0.25
Median	0.65	0.65	0.64	0.64	0.63	0.62	0.62	0.62	0.62	0.61	0.61	0.61	0.60	0.60	0.60
Internal conflict victimization rate, ICVR (per 1000)															
Mean, SD	35.1 84.8	40.9 96.1	25.2 54.8	22.3 44.4	22.2 40.9	20.9 36.5	20.8 42.1	17.0 27.3	10.2 15.6	8.0 14.0	8.9 20.5	9.9 26.8	9.8 23.4	8.8 16.7	6.9 17.1
Median	9.76	11.70	8.65	7.76	8.12	7.91	8.53	6.69	4.06	2.60	2.43	2.85	2.93	2.92	1.85
Proportion of municipal area with coca crops (%)															
Mean, SD	0.06 0.52	0.03 0.18	0.03 0.16	0.04 0.15	0.03 0.15	0.03 0.16	0.05 0.22	0.04 0.16	0.03 0.13	0.03 0.12	0.03 0.14	0.02 0.11	0.02 0.13	0.04 0.20	0.06 0.35
Median	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table C-2. Municipal rural index, internal conflict victimization rate (ICVR), and percentage of coca crop area among municipalities with substantial GPPC and a gold-mining boom (N=78), 2001-2015

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Rural index															
Mean, SD	0.66 0.18	0.65 0.18	0.65 0.18	0.64 0.18	0.64 0.19	0.64 0.19	0.63 0.19	0.63 0.19	0.62 0.19	0.62 0.19	0.62 0.20	0.62 0.20	0.61 0.20	0.61 0.20	0.61 0.20
Median	0.67	0.66	0.66	0.65	0.65	0.64	0.64	0.64	0.63	0.63	0.62	0.62	0.62	0.61	0.61
Internal conflict victimization rate, ICVR (per 1000)															
Mean, SD	73.8 105.9	68.9 177.6	29.1 47.0	31.6 75.5	35.5 56.2	32.1 40.9	50.5 108.9	36.3 41.5	21.9 21.1	22.3 21.3	32.2 51.8	36.3 76.4	37.8 63.3	25.8 25.7	21.1 22.1
Median	31.2	31.7	16.2	16.9	18.2	20.3	20.3	21.1	12.5	15.9	14.7	19.5	20.9	18.5	12.8
Proportion of municipal area with coca crops (%)															
Mean, SD	0.09 0.20	0.10 0.29	0.15 0.42	0.12 0.28	0.15 0.31	0.12 0.25	0.21 0.41	0.19 0.35	0.16 0.30	0.17 0.30	0.15 0.30	0.10 0.17	0.07 0.15	0.09 0.19	0.13 0.29
Median	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00

BIBLIOGRAPHY

1. Stephens C, Ahern M: **Worker and community health impacts related to mining operations internationally. A rapid review of the literature**. In: *Mining and Minerals for Sustainable Development Project.* vol. 25: International Institute for Environment and Development London, UK; 2001.
2. Carney JG, Gushulak BD: **A Review of Research on Health Outcomes for Workers, Home and Host Communities of Population Mobility Associated with Extractive Industries**. *J Immigr Minor Health* 2016, **18**(3):673-686.
3. Dawson AJ, Homer CS: **How does the mining industry contribute to sexual and reproductive health in developing countries? A narrative synthesis of current evidence to inform practice**. *J Clin Nurs* 2013, **22**:3597-3609.
4. Clift S, Anemona A, Watson-Jones D, Kanga Z, Ndeki L, Changalucha J, Gavyole A, Ross DA: **Variations of HIV and STI prevalences within communities neighbouring new goldmines in Tanzania: importance for intervention design**. *Sex Transm Infect* 2003, **79**:307-312.
5. Lightfoot E, Maree M, Ananias J: **Exploring the relationship between HIV and alcohol use in a remote Namibian mining community**. *Afr J AIDS Res* 2009, **8**:321-327.
6. Xu JJ, Wang N, Lu L, Pu Y, Zhang GL, Wong M, Wu ZL, Zheng XW: **HIV and STIs in clients and female sex workers in mining regions of Gejiu City, China**. *Sex Transm Dis* 2008, **35**(6):558-565.
7. Auvert B, Ballard R, Campbell C, Carael M, Carton M, Fehler G, Gouws E, MacPhail C, Taljaard D, Van Dam J *et al*: **HIV infection among youth in a South African mining town is associated with herpes simplex virus-2 seropositivity and sexual behaviour**. *Aids* 2001, **15**:885-898.
8. Desmond N, Allen CF, Clift S, Justine B, Mzugu J, Plummer ML, Watson-Jones D, Ross DA: **A typology of groups at risk of HIV/STI in a gold mining town in north-western Tanzania**. *Soc Sci Med* 2005, **60**(8):1739-1749.
9. Corno L, De Walque D: **Mines, migration and HIV/AIDS in Southern Africa**. *J Afr Econ* 2012, **21**:465-498.
10. D'Souza M, Karkada S, Somayaji G, Venkatesaperumal R: **Women's well-being and reproductive health in Indian mining community: need for empowerment**. *Reprod Health* 2013, **10**:1-12.
11. D'Souza M, Karkada S, Somayaji G: **Factors associated with health-related quality of life among Indian women in mining and agriculture**. *Health Qual Life Outcomes* 2013, **11**:1-9.
12. D'Souza M, Somayaji G, Subrahmanya N: **Determinants of reproductive health and related quality of life among Indian women in mining communities**. *J Adv Nurs* 2011, **67**:1963-1975.
13. **IMF Primary Commodity Prices** [http://www.imf.org/external/np/res/commod/index.aspx]

14. UNODC, Gobierno de Colombia: **Explotación de oro de aluvión. Evidencias a partir de percepción remota**. In.: Oficina de las Naciones Unidas contra la Droga y el Delito (UNODC) y Gobierno de Colombia; 2016.
15. Ministerio de Minas y Energía de Colombia: **Censo Minero Departamental Colombiano 2010–2011**. In. Bogotá: MINISTERIO DE MINAS Y ENERGÍA DE COLOMBIA (MINMINAS); 2012.
16. Eslava A, Giraldo Ramírez J, González AC, Hillón Y, Ríos A, Silva S, Zapata O, Correa L, Preciado A, Trujillo JP: **ORO COMO FORTUNA. Instituciones, capital social y gobernanza de la minería aurífera colombiana**. In. Edited by Eslava A. Medellín: Universidad EAFIT - Departamento Administrativo de Ciencia Tecnología e Innovación, Colciencias; 2014.
17. Giraldo Ramírez J, Muñoz Mora J: **Informalidad e ilegalidad en la explotación del oro y la madera en Antioquia**. Medellín: Universidad EAFIT, Fundación Proantioquia,; 2012.
18. Escobedo R, Guío N: **Oro, crimen organizado y guerrillas en Quibdó**. Bogotá: Fundación Ideas para la Paz; 2015.
19. Bermúdez RC, Rodríguez T, Roa T: **Mujer y Minería. Ámbitos de análisis e impactos de la minería en la vida de las mujeres-Enfoque de derechos y perspectivas de género. Encuentro Latinoamericano Mujer y Minería.** In. Bogotá; 2011.
20. Bermúdez Rico RE: **Impacto de los grandes proyectos mineros en Colombia sobre la vida de las mujeres** In: *Minería, territorio y conflicto en Colombia.* edn. Edited by Toro C, Fierro J, Coronado S, Roa T. Bogotá: Universidad Nacional de Colombia. Facultad de Derecho, Ciencias Políticas y Sociales. Instituto Unidad de Investigaciones Jurídico-Sociales Gerardo Molina (UNIJUS); 2012: 355-370.
21. Rees D, Murray J, Nelson G, Sonnenberg P: **Oscillating migration and the epidemics of silicosis, tuberculosis, and HIV infection in South African gold miners**. *Am J Ind Med* 2010, **53**(4):398-404.
22. Weine SM, Kashuba AB: **Labor migration and HIV risk: a systematic review of the literature**. *AIDS Behav* 2012, **16**:1605-1621.
23. Monaldi FJ: **The mining boom in Latin America**. *ReVista (Cambridge)* 2014, **13**(2):6.
24. Chaparro Ávila E: **La pequeña minería y los nuevos desafíos de la gestión pública [Small-scale mining and the new challenges of governance]**, vol. 70. Santiago de Chile: Comisión Económica para América Latina y el Caribe (CEPAL) - UN; 2004.
25. International Monetary Fund: **International Monetary Fund - Primary Commodity Prices**. In. www.imf.org: International Monetary Fund (IMF); 2015.
26. Economic Commission for Latin America and the Caribbean: **Natural resources: status and trends towards a regional development agenda in Latin America and the Caribbean.** . Santiago, Chile: Economic Commission for Latin America and the Caribbean (ECLAC) - UN; 2013.
27. Walter M: **Extractives in Latin America and the Caribbean: The Basics**: Inter-American Development Bank; 2016.
28. Sociedad Peruana de Derecho Ambiental: **La realidad de la minería ilegal en países amazónicos [The reality of illegal mining in Amazon countries]** Lima: Sociedad Peruana de Derecho Ambiental (SPDA); 2014.
29. Delgado Ramos GC: **La gran minería en América Latina, impactos e implicaciones [The large-scale mining in Latin America, impacts and implications]**. *Acta Sociol [Mexico]* 2010(54):17-47.

30. Gómez ET, González ML: **Auge minero y desindustrialización en América Latina [Mining boom and deindustrialization in Latin America]**. *Revista de Economía Institucional* 2017, **19**(37).
31. Porto M: **A tragédia da mineração e do desenvolvimento no Brasil: desafios para a saúde coletiva [The tragedy of mining and development in Brazil: public health challenges]**. *Cad Saude Publica* 2016, **32**(2).
32. Cordy P, Veiga MM, Salih I, Al-Saadi S, Console S, Garcia O, Mesa LA, Velásquez-López PC, Roeser M: **Mercury contamination from artisanal gold mining in Antioquia, Colombia: The world's highest per capita mercury pollution**. *Sci Total Environ* 2011, **410**:154-160.
33. Bebbington A (ed.): **Social Conflict, Economic Development and the Extractive Industry: Evidence from South America**: Routledge; 2012.
34. Comisión Interamericana de Derechos Humanos: **Pueblos indígenas, comunidades afrodescendientes y recursos naturales: protección de derechos humanos en el contexto de actividades de extracción, explotación y desarrollo [Indigenous peoples, Afro-Colombian communities and natural resources: human rights protection in the context of mining activities, exploration and development]**: Comisión Interamericana de Derechos Humanos (CIDH); 2015.
35. International Labour Organization: **Girls in Mining: Research Findings from Ghana, Niger, Peru and United Repubic of Tanzania**. Switzerland: International Labour Organization (ILO); 2007.
36. Heemskerk M: **Self-employment and poverty alleviation: Women's work in artisanal gold mines**. *Hum Organ* 2003, **62**:62-73.
37. Drewry J, Shandro J, Winkler MS: **The extractive industry in Latin America and the Caribbean: health impact assessment as an opportunity for the health authority**. *Int J Public Health* 2016:1-10.
38. World Health Organization: **Global and regional estimates of violence against women: prevalence and health effects of intimate partner violence and non-partner sexual violence**. Geneva; 2013.
39. United Nations Department of Economic and Social Affairs: **The Millennium Development Goals Report 2015**. New York: United Nations, Department of Economic and Social Affairs, Population Division 2015.
40. Sedgh G, Bearak J, Singh S, Bankole A, Popinchalk A, Ganatra B, Rossier C, Gerdts C, Tunçalp Ö, Johnson BR: **Abortion incidence between 1990 and 2014: global, regional, and subregional levels and trends**. *Lancet* 2016, **388**:258-267.
41. Arksey H, O'Malley L: **Scoping studies: towards a methodological framework**. *International journal of social research methodology* 2005, **8**(1):19-32.
42. Daudt HM, van Mossel C, Scott SJ: **Enhancing the scoping study methodology: a large, inter-professional team's experience with Arksey and O'Malley's framework**. *BMC medical research methodology* 2013, **13**(1):48.
43. Pereira CA, Périssé AR, Knoblauch AM, Utzinger J, de Souza Hacon S, Winkler MS: **Health impact assessment in Latin American countries: Current practice and prospects**. *Environmental Impact Assessment Review* 2016.
44. González N, Rodríguez-Acosta A: **Epidemiología de las enfermedades de transmisión sexual en la zona minera Las Claritas, estado Bolívar, Venezuela**. *Invest Clin* 2000, **41**(2):81-91.

45. Astete J, Gastañaga MC, Fiestas V, Oblitas T, Sabastizagal I, Lucero M, Abadíe JM, Muñoz ME, Valverde A, Suarez M: **Enfermedades transmisibles, salud mental y exposición a contaminantes ambientales en población aledaña al proyecto minero Las Bambas antes de la fase de explotación, Perú 2006 [Comunicable diseases, mental health and exposure to environmental pollutants in population living near Las Bambas mining project before exploitation phase, peru 2006]**. *Rev Peru Med Exp Salud Publica* 2010, **27**:512-519.
46. Faas L, Rodríguez-Acosta A, Echeverría de Pérez G: **HIV/STD transmission in gold-mining areas of Bolívar State, Venezuela: Interventions for diagnosis, treatment, and prevention**. *Rev Panam Salud Publica* 1999, **5**:58-65.
47. Miranda AE, Merçon-de-Vargas PR, Corbett CE, Corbett JF, Dietze R: **Perspectives on sexual and reproductive health among women in an ancient mining area in Brazil**. *Rev Panam Salud Publica* 2009, **25**(2):157-161.
48. Orellana ER, Alva IE, Cárcamo CP, García PJ: **Structural Factors That Increase HIV/STI Vulnerability Among Indigenous People in the Peruvian Amazon**. *Qual Health Res* 2013, **23**(9):1240-1250.
49. Palmer CJ, Validum L, Loeffke B, Laubach HE, Mitchell C, Cummings R, Cuadrado RR: **HIV prevalence in a gold mining camp in the Amazon region, Guyana**. *Emerg Infect Dis* 2002, **8**(3):330-331.
50. Santos E, Loureiro E, de Jesus I, Brabo E, da Silva R, Soares M, Câmara V, de Souza M, Branches F: **Diagnóstico das condições de saúde de uma comunidade garimpeira na região do Rio Tapajós, Itaituba, Pará, Brasil, 1992 [Diagnosis of the health conditions of a gold mining community in the Tapajós River region, Itaituba, Para, Brazil, 1992]**. *Cad Saude Publica* 1995, **11**:212-225.
51. Seguy N, Denniston M, Hladik W, Edwards M, Lafleur C, Singh-Anthony S, Diaz T: **HIV and syphilis infection among gold and diamond miners--Guyana, 2004**. *The West Indian medical journal* 2008, **57**:444-449.
52. Souto FJ, Fontes CJ, Gaspar AM: **Prevalence of hepatitis B and C virus markers among malaria-exposed gold miners in Brazilian Amazon**. *Rev Panam Salud Publica* 2001, **10**:388-394.
53. Souto FJ, Fontes CJ, Gaspar AM, Lyra LG: **Hepatitis B virus infection in immigrants to the southern Brazilian Amazon**. *Trans R Soc Trop Med Hyg* 1998, **92**:282-284.
54. Castro-Arroyave D, Patino S, Gómez N, Gómez L, Ospina D, Osorio JD, Galvis R, Rojas C: **Formación de líderes para la prevención del VIH: percepciones y conocimientos sobre el virus en un contexto minero de Colombia**. *Desacatos* 2016(52):128-143.
55. Vargas-Riaño E, Becerra-Posada F, Tristán M, Becerril-Montekio V: **Maternal health research outputs and gaps in Latin America: reflections from the mapping study**. *Globalization and health* 2017, **13**(1):74.
56. Ward B, Strongman J, Eftimie A, Heller K: **Gender-sensitive approaches for the extractive industry in Peru : improving the impact on women in poverty and their families - guide for improving practice.** . Washington, DC: World Bank; 2011.
57. Siegel S, Veiga MM: **The myth of alternative livelihoods: artisanal mining, gold and poverty**. *Int J Environ Pollut* 2010, **41**:272-288.
58. Maconachie R: **Re-agrarianizing livelihoods in post-conflict Sierra Leone? Mineral wealth and rural change in artisanal and small-scale mining communities**. *J Int Dev* 2011, **23**(8):1054-1067.

59. Hinton J, Veiga M, Beinhoff C: **Women and artisanal mining: Gender roles and the road ahead**. In: *The Socio-Economic Impacts of Artisanal and Small-Scale Mining in Developing Countries.* edn. Edited by Hilson G. Netherlands: AA Balkema, Sweets Publishers; 2003.
60. Jenkins K: **Women, mining and development: An emerging research agenda**. *The Extractive Industries and Society* 2014, **1**:329-339.
61. Kuramoto JR: **Artisanal and Informal Mining in Peru**: International Institute for Environment and Development London, UK; 2001.
62. Chaparro Avila E, Lardé J: **El papel de la mujer en la industria minera de Centroamérica y el Caribe [The role of women in the mining industry of Central America and the Caribbean]**, vol. 144. Santiago de Chile: Comisión Económica para América Latina y el Caribe (CEPAL) - UN; 2009.
63. Campbell C, Williams B: **Beyond the biomedical and behavioural: towards an integrated approach to HIV prevention in the southern African mining industry**. *Soc Sci Med* 1999, **48**(11):1625-1639.
64. Organización Internacional del Trabajo, Gobierno de Chile, SEREMI Tarapacá: **Informe y análisis de la encuesta Vida de mineros: Condiciones de trabajo y salud sexual de mineros chilenos en la región de Tarapacá [Report and analysis of the survey Life of miners: Working conditions and sexual health of Chilean miners in the region of Tarapacá]**. In. Santiago de Chile: Organización Internacional del Trabajo (OIT); 2015.
65. Gaitán L, Martínez M, Pérez P, Velásquez F: **El sector extractivo en Colombia**. In.: Foro Nacional por Colombia; Revenue Watch Institute; 2011.
66. Cárdenas M, Reina M: **La minería en Colombia: Impacto socioeconómico y fiscal**. In.: Fedesarrollo; 2008.
67. Echavarria C: **'What is legal?' Formalising artisanal and small-scale mining in Colombia**. London & Colombia: The International Institute for Environment and Development (IIED); 2014.
68. Ministerio de Minas y Energía de Colombia: **Política nacional para la formalización de la minería en Colombia - Versión final**. In. Bogotá: MINISTERIO DE MINAS Y ENERGÍA DE COLOMBIA (MINMINAS); 2014.
69. England JL, Albrecht SL: **Boomtowns and Social Disruption**. *Rural Sociology* 1984, **49**(2):230-246.
70. Carrington K, Hogg R, McIntosh A: **The resource boom's underbelly: Criminological impacts of mining development**. *Australian & New Zealand Journal of Criminology* 2011, **44**(3):335-354.
71. Petkova-Timmer V, Lockie S, Rolfe J, Ivanova G: **Mining developments and social impacts on communities: Bowen Basin case studies**. *Rural Society* 2009, **19**(3):211-228.
72. Gamu J, Le Billon P, Spiegel S: **Extractive industries and poverty: A review of recent findings and linkage mechanisms**. *The Extractive Industries and Society* 2015, **2**:162-176.
73. Downing TE: **Avoiding new poverty: mining-induced displacement and resettlement**, vol. 58: International Institute for Environment and Development London, UK; 2002.
74. Singer JD, Willett JB: **Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence**: Oxford University Press; 2003.
75. Sistema de Información Minero Colombiano SIMCO: **Producción Minera de Oro por Municipio 2001-2016**. In: *Producción Minera por Municipio.* www1.upme.gov.co

Retrieved 03/28/2017 from http://www.upme.gov.co/generadorconsultas/Consulta_Series.aspx?idModulo=4&tipoSerie=116&grupo=496& Unidad de Planeación Minero Energética (UPME); 2017.
76. DANE: **Estimación y proyección de población nacional, departamental y municipal por sexo, grupos quinquenales de edad y edades simples de 0 a 26 años 1985-2020**. In: *Demografía y población.* www.dane.gov.co Retrieved 3/31/2017 from http://www.dane.gov.co/index.php/estadisticas-por-tema/demografia-y-poblacion/proyecciones-de-poblacion: Departamento Administrativo Nacional de Estadísticas (DANE); 2017.
77. DANE - DSCN: **Metodología para calcular el Indicador de Importancia Económica Municipal Cuentas Departamentales – CD**. In.: Departamento Administrativo Nacional de Estadísticas (DANE) - Dirección de Síntesis y Cuentas Nacionales (DSCN) 2015.
78. World Health Organization: **Reproductive health indicators: guidelines for their generation, interpretation and analysis for global monitoring**. 2006.
79. Profamilia: **Encuesta Nacional de Demografía y Salud 2005**. In. Bogotá, Colombia; 2006.
80. Profamilia: **Encuesta Nacional de Demografía y Salud 2010**. In. Bogotá, Colombia; 2011.
81. Profamilia: **Encuesta Nacional de Demografía y Salud 2015**. In. Bogotá, Colombia; 2016.
82. Pickett KE, Mookherjee J, Wilkinson RG: **Adolescent birth rates, total homicides, and income inequality in rich countries**. *American Journal of Public Health* 2005, **95**(7):1181-1183.
83. Castro Torres AF, Urdinola BP: **Armed Conflict and Fertility in Colombia, 2000–2010**. *Population Research and Policy Review* 2018:1-41.
84. Centro de Estudios sobre Desarrollo Económico (CEDE): **Panel Municipal del CEDE**. In: *Anual.* https://datoscede.uniandes.edu.co/: Centro de Estudios sobre Desarrollo Económico (CEDE) - Facultad de Economía - Universidad de los Andes,,; 2017.
85. Unidad para las Víctimas-Gobierno de Colombia: **Registro Único de Víctimas (RUV)**. In. www.unidadvictimas.gov.co: Unidad para las Víctimas - Red Nacional de Información - Gobierno de Colombia; 2017.
86. Observatorio de Drogas de Colombia: **Cultivos Ilícitos**. In. www.odc.gov.co: Observatorio de Drogas de Colombia - Ministerio de Justicia; 2017.
87. DANE: **Municipios con calidad aceptable de registros vitales en 2005**. In. Provided by DANE after request 09/25/2017: Departamento Administrativo Nacional de Estadísticas (DANE); 2005.
88. Ibáñez A, Laverde M: **Los Municipios Mineros en Colombia: características e impactos sobre el desarrollo**. In., edn. Edited by Benavides J: Insumos para el desarrollo del Plan Nacional de Ordenamiento Minero. Universidad de los Andes, Centro Interdisciplinario de Estudios sobre Desarrollo (CIDER), Unidad de Planeacion Minero Energética (UPME). 2014.
89. Roldán Ortega J: **Demografía y minería en Colombia**. In: *Insumos para el desarrollo del Plan Nacional de Ordenamiento Minero* edn. Edited by Benavides J: Universidad de los Andes, Centro Interdisciplinario de Estudios sobre Desarrollo (CIDER), Unidad de Planeacion Minero Energética (UPME); 2014.

90. CREER: **Evaluación integral sectorial de impactos en derechos humanos. La minería que no se ve**. Bogotá: Centro Regional de Empresas y Emprendimientos Responsables (CREER); 2016.
91. Idrobo N, Mejía D, Tribin AM: **Illegal gold mining and violence in Colombia**. *Peace Economics, Peace Science and Public Policy* 2014, **20**(1):83-111.
92. Castellanos A, Chaparro-Narváez P, Morales-Plaza CD, Alzate A, Padilla J, Arévalo M, Herrera S: **Malaria in gold-mining areas in Colombia**. *Memórias do Instituto Oswaldo Cruz* 2016, **111**(1):59-66.
93. Dube O, Vargas JF: **Commodity price shocks and civil conflict: Evidence from Colombia**. *The Review of Economic Studies* 2013, **80**(4):1384-1421.
94. Saavedra S, Romero M: **Local incentives and national tax evasion: The response of illegal mining to a tax reform in Colombia**. In.; 2016.
95. Hajkowicz SA, Heyenga S, Moffat K: **The relationship between mining and socio-economic well being in Australia's regions**. *Resources Policy* 2011, **36**(1):30-38.
96. Black DA, Kolesnikova N, Sanders SG, Taylor LJ: **Are children "normal"?** *The review of economics and statistics* 2013, **95**(1):21-33.
97. Kearney MS, Wilson R: **Male Earnings, Marriageable Men, and Nonmarital Fertility: Evidence from the Fracking Boom**. In.: National Bureau of Economic Research; 2017.
98. Batyra E: **Fertility and the changing pattern of the timing of childbearing in Colombia**. *Demographic Research* 2016, **35**:1343-1372.
99. de Miranda-Ribeiro A, Rios-Neto E, Ortega JA: **Declínio da fecundidade no Brasil e México e o nível de reposição: efeitos tempo, parturição e quantum**. *Población y salud sexual y reproductiva en América Latina Rio de Janeiro: ALAP* 2008.
100. World Bank: **World Bank Open Data**. In.: World Bank,; 2018.
101. UNODC, Gobierno de Colombia: **Colombia - Monitoreo de territorios afectados por cultivos ilícitos 2015** In.: Oficina de las Naciones Unidas contra la Droga y el Delito (UNODC) y Gobierno de Colombia; 2016.
102. Angrist JD, Kugler AD: **Rural windfall or a new resource curse? Coca, income, and civil conflict in Colombia**. *The Review of Economics and Statistics* 2008, **90**(2):191-215.
103. LeGrand CC, van Isschot L, Riaño-Alcalá P: **Land, justice, and memory: challenges for peace in Colombia**. In.: Taylor & Francis; 2017.
104. Herzer D, Strulik H, Vollmer S: **The long-run determinants of fertility: one century of demographic change 1900–1999**. *Journal of Economic Growth* 2012, **17**(4):357-385.
105. Jones LE, Schoonbroodt A, Tertilt M: **Fertility theories: can they explain the negative fertility-income relationship?** In.: National Bureau of Economic Research; 2008.
106. Chatterjee S, Vogl T: **Escaping Malthus: Economic Growth and Fertility Change in the Developing World**. *American Economic Review* 2017.
107. Siegel C: **Female relative wages, household specialization and fertility**. *Review of Economic Dynamics* 2017, **24**:152-174.
108. Galor O, Weil DN: **The gender gap, fertility, and growth**. *The American Economic Review* 1996, **86**(3):374.
109. Day C: **Economic growth, gender wage gap and fertility rebound**. *Economic Record* 2012, **88**(s1):88-99.
110. Fang H, Eggleston KN, Rizzo JA, Zeckhauser RJ: **Jobs and kids: female employment and fertility in China**. *IZA Journal of Labor & Development* 2013, **2**(1):12.

111. Beguy D: **The impact of female employment on fertility in Dakar (Senegal) and Lome (Togo)**. *Demographic Research* 2009, **20**:97.
112. Dettling LJ, Kearney MS: **House prices and birth rates: The impact of the real estate market on the decision to have a baby**. *Journal of Public Economics* 2014, **110**:82-100.
113. Lovenheim MF, Mumford KJ: **Do family wealth shocks affect fertility choices? Evidence from the housing market**. *Review of Economics and Statistics* 2013, **95**(2):464-475.
114. Schaller J: **Booms, Busts, and Fertility Testing the Becker Model Using Gender-Specific Labor Demand**. *Journal of Human Resources* 2016, **51**(1):1-29.
115. Van den Broeck G, Maertens M: **Female employment reduces fertility in rural Senegal**. *PloS one* 2015, **10**(3):e0122086.
116. Bullinger LR: **The effect of minimum wages on adolescent fertility: A nationwide analysis**. *American journal of public health* 2017, **107**(3):447-452.
117. Santelli JS, Song X, Garbers S, Sharma V, Viner RM: **Global trends in adolescent fertility, 1990–2012, in relation to national wealth, income inequalities, and educational expenditures**. *Journal of Adolescent Health* 2017, **60**(2):161-168.
118. Castro R, Fajnzylber E: **Income inequality and adolescent fertility in low-income countries**. *Cadernos de saude publica* 2017, **33**:e00203615.
119. Chiavegatto Filho AD, Kawachi I: **Income inequality is associated with adolescent fertility in Brazil: a longitudinal multilevel analysis of 5,565 municipalities**. *BMC public health* 2015, **15**(1):103.
120. Kearney MS, Levine PB: **Income inequality and early nonmarital childbearing**. *Journal of Human Resources* 2014, **49**(1):1-31.
121. Autor D, Dorn D, Hanson G: **When Work Disappears: Manufacturing Decline and the Falling Marriage-Market Value of Men**. In.: National Bureau of Economic Research, Inc; 2017.
122. World Health Organization: **Millennium Development Goals (MDGs): MDG 5: Maternal and reproductive health**. In.: World Health Organization,; 2018.
123. DANE: **Resultados nacimientos y defunciones**. In.: Departamento Administrativo Nacional de Estadísticas (DANE); 2015.
124. Davis K, Blake J: **Social structure and fertility: An analytic framework**. *Economic development and cultural change* 1956:211-235.
125. Hill K: **War, humanitarian crises, population displacement, and fertility: A review of evidence**: National Academies Press; 2005.
126. Sharara FI, Seifer DB, Flaws JA: **Environmental toxicants and female reproduction**. *Fertility and sterility* 1998, **70**(4):613-622.
127. Guha-Sapir D, D'Aoust O: **Demographic and health consequences of civil conflict**. 2011.
128. Cetorelli V: **The Effect on Fertility of the 2003–2011 War in Iraq**. *Population and development review* 2014, **40**(4):581-604.
129. Eftimi A, Heller K, Strongman J: **Gender dimensions of the extractive industries: mining for equity**. In.: The World Bank; 2009.
130. Macintyre M: **Women working in the mining industry in Papua New Guinea: a case study from Lihir**. In: *Women miners in developing countries: Pit women and Others.* edn. Edited by K L-D, M M; 2006: 131-134.

131. Lahiri-Dutt K: **Mainstreaming gender in the mines: results from an Indonesian colliery**. *Development in Practice* 2006, **16**(02):215-221.
132. International Labour Organization: **Social and Labour Issues in Small-scale Mines: Report for Discussion at the Tripartite Meeting on Social and Labour Issues in Small-scale Mines, Geneva, 1999**: International Labour Organization (ILO); 1999.
133. Lahiri-Dutt K, Macintyre M: **Women miners in developing countries: Pit women and others**: Ashgate Publishing, Ltd.; 2006.
134. Dreschler B: **Small-scale mining and sustainable development within the SADC region**. In: *Mining, Minerals and Sustainable Development.* vol. 84; 2001.
135. Hentschel T, Hruschka F, Priester M: **Global report on artisanal and small-scale mining**. *Report commissioned by the Mining, Minerals and Sustainable Development of the International Institute for Environment and Development Download from* http://www *iied org/mmsd/mmsd_pdfs/asm_global_report_draft_jan02 pdf on* 2002, **20**(08):2008.
136. Tallichet SE, Redlin MM, Harris RP: **What's a woman to do? Globalized gender inequality in small-scale mining**. In: *The Socio-economic Impacts of Artisanal and Small-Scale Mining in Developing Countries* edn. Edited by Hilson G. Lisse, Netherlands: Swets and Zetlinger BV; 2003: 205-219.
137. Van Hoecke E: **The invisible work of women in the small mines of Bolivia**. In: *Women miners in developing countries: Pit women and others.* edn. Edited by Lahiri-Dutt K, Macintyre M: Ashgate Publishing; 2006: 265-287.
138. Hargreaves S: **Women Miners: Navigating Difficult Terrain Underground.** In: *WoMin and International Alliance on Natural Resources in Africa.* Johannesburg; 2014. Cited by Jenkins K. Women, mining and development: An emerging research agenda. The Extractive Industries and Society. 2014;1(2):329-39.
139. Mahy P: **Sex Work and Livelihoods: Beyond the 'Negative Impacts on Women'in Indonesian Mining**. In: *Gendering the Field: Towards Sustainable Livelihoods for Mining Communities.* edn. Edited by Lahiri-Dutt K: Australian National University E Press; 2011: 49–66.
140. Dhaatri Resource Centre for Women and Children and Samata: **Contesting Women's Rights Within the Political Economy of Mining in India**. In. Andhra Pradesh, India; 2010.
141. Perks R: **Towards a Post-Conflict Transition: Women and Artisanal Mining in the Democratic Republic of Congo**. In: *Gendering the Field: Towards Sustainable Livelihoods for Mining Communities.* edn. Edited by Lahiri-Dutt K: Australian National University E Press; 2011: 177-196.
142. Veiga MM: **Introducing new technologies for abatement of global mercury pollution in Latin America**: CETEM/CNPq; 1997.
143. Campbell C: **Selling sex in the time of AIDS: the psycho-social context of condom use by sex workers on a Southern African mine**. *Social science & medicine* 2000, **50**(4):479-494.
144. Mines and Communities: **Impacts of Mining on Women's Health, Mines, Minerals and People** In.; 2003. Cited by CCSG Associates. Overburdened: Understanding the Impacts of Mineral Extraction on Women's Health in Mining Communities. MiningWatch Canada, 2004 0713-3235.
145. Deane K, Wamoyi J: **Revisiting the economics of transactional sex: evidence from Tanzania**. *Review of African Political Economy* 2015, **42**(145):437-454.

146. Development UAfI: **Mining for Gold in Siguiri: A Close Look at a High-Risk Population, Report on Guinea**. In.: US Agency for International Development (USAID); 2000. Cited by Hinton J, Veiga MM, Beinhoff C. Women and artisanal mining: Gender roles and the road ahead. In: Hilson G, editor. The Socio-Economic Impacts of Artisanal and Small-Scale Mining in Developing Countries. Netherlands: AA Balkema, Sweets Publishers; 2003.
147. Benya A: **Women face the rock face: what challenges**. *South African Labour Bulletin* 2010. Cited by Jenkins K. Women, mining and development: An emerging research agenda. The Extractive Industries and Society. 2014;1(2):329-39., **33**(5):5-7.
148. Campbell C: **Migrancy, masculine identities and AIDS: the psychosocial context of HIV transmission on the South African gold mines**. *Social science & medicine* 1997, **45**(2):273-281.
149. Banks G: **Drilling and Digging: Extractives, Institutions and Development**. *Development and Change* 2014, **45**(1):191-204.
150. Peters BG: **Civil Registration and Vital Statistics as a Tool to Improve Public Management**. In.: Inter-American Development Bank; 2016.
151. Wilches-Gutierrez J, Documet P: **What is known about sexual and reproductive health in Latin American and Caribbean mining contexts? A systematic scoping review**. *Public Health Reviews* 2018, **39**(1):1.