Waves of change? radio announcements and fertility decline

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Abstract

Can radio campaigns affect fertility preferences? I investigate this question by studying a national radio campaign in the late 1960s in Colombia. In 1969 Profamilia, one of the largest family planning organisations in the world, started a national radio campaign to spread the idea of family planning. To evaluate the effects of exposure to radio campaigns, this paper exploits exogenous variation in radio signal strength that results from topographic factors. I use individual-level data from the full count census of 1973 and collected data on the location and dates of establishment of Profamilia's clinics. I gathered information on the content, coverage, and timing of Profamilia radio programmes, and using the Irregular Terrain Model I predict radio signal strength in the country in the 1970s. I employ a difference-in-differences analysis to compare fertility rates in municipalities with strong and weak radio signal strength before and after the start of the radio campaign. The results suggest that the effects of the radio campaign were limited.

***keywords**: fertility transition, mass media, family planning, Colombia*

1 Introduction

Currently, there is no consensus regarding the role of contraception and family planning programs in the fertility decline of developing economies.[1] Several scholars argue that family planning can have substantial effects on fertility and suggest that knowledge and availability of contraceptive methods are one of the most fundamental

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[1]It is likely that contraception played an important role during the historical fertility transition in Western countries, although mainly by the implementation of withdrawal and abstinence given the high costs of condoms or the diaphragm (Guinnane, 2011). For the US case, scholars have argued that new contraceptive methods like the pill did not play a major role in the sharp drop in fertility after the 1960s (Bailey, 1973; Angrist & Evans, 1998).

barriers to fertility decline (Bongaarts, Mauldin & Phillips, 1990). On the contrary, others suggest that once changes in the demand for children are accounted for, the effect of contraceptives on fertility is small (Miller & Babiarz, 2016). Although the timing of the decline coincides with the introduction and popularisation of modern contraceptive methods and in particular with the release of birth control pills in the US, in the literature, the impact of family planning programs on fertility reductions vary from no effect in the case of Indonesia (Pitt, Rosenzweig & Gibbons, 1993) to around 22% to 30% in the case of China (Babiarz, Ma, Miller & Song, 2020).

This paper investigates if a national radio campaign promoting family planning clinics in the late 1960s in Colombia had an effect on the rapid fertility change that occurred across the country. This initiative by Profamilia, one of the largest family planning organisations in the world, started in 1969 and introduced publicly the concept of family planning. The radio campaign increased the availability of family planning information, especially in rural areas, where radio was the primary source of information. However, the campaign did little in promoting new social roles for women or in increasing the educational level of the population. It targeted mainly married couples and it was mostly used as an attempt to make them both aware of and interested in the programs and clinics, without providing specific information on the contraceptive methods.

Measuring the impact of the campaign is relevant as the use of new media and information technologies has the potential to affect the behaviour of people by spreading new information but at the same time it can shape attitudes. In this particular case, radio could promote family planning clinics and at the same time alter the behaviour of people by shaping new social roles, changing social norms and raising the educational level of the population.[2]

Furthermore, the radio became the most popular electronic communication device in the mid-20$^{\text{th}}$ century and this technological innovation coincided with other socio-demographic changes. In Colombia, the fertility transition started in the mid-1960s. The change was fast and widespread and fertility declined almost simultaneously in regions with traditionally high fertility levels as well as in regions with lower fertility rates. Not only in Colombia, but across the world fertility rates started decreasing faster than ever. Although this change coincides with the introduction and

[2]Recent literature has shown that the use of new media and information technologies has the potential to affect socioeconomic outcomes such as social capital (Olken, 2009), political outcomes (Wang, 2021), inter-group animosity (Adena, Enikolopov, Petrova, Santarosa & Zhuravskaya, 2015), and fertility decisions (La Ferrara, Chong & Duryea, 2012).

quickly popularisation of the pill across the world, especially in urban centres, the practices of fertility control were not common in rural areas. Also, the knowledge and use of contraception methods varied widely across the world. However, after 1965, fertility declined rapidly both in rural and urban areas in Colombia and the reasons behind such a rapid decline are still a matter of debate (Flórez-Nieto, 2000; Miller, 2010).

The radio campaign started in 1969 with 30-seconds ads that announced the availability of family planning services and locations of Profamilia clinics. The goal was to spread the idea of family planning and increase the number of visitors to the clinics. The ads did not describe any contraceptive method nor intended to persuade the listeners of the advantages of limiting fertility. Early evaluations of the radio campaign show that it reached the urban target population and accelerated information diffusion about fertility control and increased awareness of contraceptive methods (Bailey, 1973; Stycos & Avery, 1975; Bailey & Cabrera, 1981). Overall, the evaluations show an immediate increase in the number of visitors to the clinics during the period of the radio campaign, especially in large cities, but some suggest that this increase was at the expense of visitors that would have attended the clinics in the future (Stycos & Avery, 1975). Until now, the effect of this campaign on the rapid fertility decline of Colombia has not been measured.

To evaluate the effects of exposure to the radio campaign, this paper exploits exogenous variation in radio signal strength that results from topographic factors. I use individual-level data from the full count census of 1973 and collected data on the location and dates of the establishment of Profamilia's clinics. Given that I do not have exact data on the number of radio listeners or variation in access to radio at the individual level, I gathered information on the content, coverage, and timing of Profamilia radio programmes, and using the Irregular Terrain Model (Hufford, 2002) I predict the radio signal strength of several radio station in the country that were located in the cities were Profamilia launched its radio campaign, and use the predicted signal strength to estimate a lower bound of the intention to treat effect.

The main challenge to estimate the effects of the radio campaign on fertility is that it is possible that the location of the stations was not randomly allocated in the country, and therefore it could be correlated with other characteristics that could influence fertility. Although the configuration of the broadcasting stations was completed before the introduction of the campaign and previous research has shown that the spread of Profamilia was independent of fertility, I follow different empirical

strategies to minimise this concern. First, I adopt a strategy developed by Olken (2009) that has been used extensively in the literature (DellaVigna & La Ferrara, 2015; Wang, 2021). I regress fertility rates on the predicted radio signal strength while controlling for the hypothetical signal strength where there are no orographic obstacles such as mountains. Following this strategy, the identification of the effect should come from the residual variation of the signal strength as a result of idiosyncratic topographic factors along the signal transmission route. Second, I employ a difference-in-differences strategy to compare fertility rates before and after the start of the radio campaign. To avoid the potential correlation between the location of the clinics and radio transmitters and other characteristics that could influence fertility at the municipal level I exclude cities with transmitters in my analysis. The results show that there was no effect of the radio campaign on fertility rates across the country. Finally, I restrict the analysis to municipalities that were close to a Profamilia clinic to observe if the radio campaign affected fertility in these municipalities as they benefited from having access to the clinics. The results confirm that the Profamilia radio campaign had a limited effect on fertility rates even in municipalities located close to cities with a family planning clinic.

This research contributes to several debates in the literature. The first one is related to the effects of family planning programs on fertility decline. Although global funding for family planning tripled during the 1970s and early 1980s the effect of these programs on fertility is controversial (Miller & Babiarz, 2016). Some scholars argued that the large scale initiative to implement family planning programs across the world was successful in reducing fertility and population growth on a global scale.[3] However, the estimations at the country level range from no effect in the case of Indonesia in the 1970s and 1980s (Pitt et al., 1993) to 27% in the case of China with its "Longer, Later, Fewer" campaign (Babiarz et al., 2020). For the case of Colombia, Miller (2010) estimates that the foundation of a Profamilia clinic in a city accounted for around 6% to 7% of the decline by looking at the geographical spread of the organisation from 1965 to the beginning of the 1970s. My research confirms that access and knowledge of contraceptive methods had a limited effect on the fertility decline of the country.

This research is also related to the literature on the effects of media and information technologies on fertility. Mass media has the potential to alter the behaviour of people by providing new information but also by shaping the self-identity of

[3]For example, Bongaarts et al. (1990) estimate that without family planning programmes the population in Asia, Latin America, and Africa would have been 412 millions bigger by the early 1990s.

people, also known as ideational change (Williams & Singh, 1976; Barber & Axinn, 2004; Spolaore & Wacziarg, 2022).[4] For example, the literature finds that there is a significant association between mass media and fertility (Williams & Singh, 1976; Westoff & Rodriguez, 1995; Parr, 2002; Beach & Hanlon, 2019). At the cross country-level access to television, radio and newspapers are negatively related to fertility rates. Several reasons for these relationships have been suggested in the literature. Potentially, media can directly disseminate information about family planning, as in the case of my study or it can shape social roles, by presenting alternative lifestyles, examples of different aspirations or by raising the general level of education of the population. The paper by La Ferrara et al. (2012) on the case of Brazil is a clear example of this literature.[5] The study shows how the spread of soap operas affected the Brazilian fertility transition and how *telenovelas* spread a new idea of family and in particular raised women's economic aspirations.[6] Profamilia's radio campaign had a limited role in disseminating new social roles or in raising the economic aspirations of the population and it was used mostly as an attempt to make the population both aware and interested in the programs and clinics. Given that the campaign did little in terms of promoting new social roles, a process of imitation, as in the case of soap operas in Brazil, was difficult to accomplish.

This finding is also related to the seminal paper on Nazi radio and its effects on anti-Semitism by Adena et al. (2015) or the more recent papers on the effects of radio on political outcomes during the 1930s and 1960s in the US by Wang (2021) which underline the importance of persuasion in communication.[7] Unlike these studies, this paper focuses on a campaign of information that had limited power of persuasion. The campaign was focused on giving information on the location of the clinics and legitimising the idea of family planning and the announcements did not intend to persuade couples of the advantages of smaller families.

Finally, using both exogenous variations of signal strength and a difference in difference strategy, my research provides robust evidence of the limited influence of family planning promotion through radio on fertility behaviour. Since the 1850s fam-

[4]See also DellaVigna and La Ferrara (2015) for a recent survey on the impact of exposure to the media.

[5]See also Barber and Axinn (2004) on Nepal or Kearney and Levine (2015) for the US case.

[6]*telenovelas*, were developed in Mexico in the 1970s by Miguel Sabido, a producer in a Televisa, a Mexican multimedia mass media company. This type of tv drama spread quickly across the continent.

[7]See Dellavigna and Gentzkow (2010) for a recent survey in the effects and drivers of persuasive communication.

ily planning advocates have used mass media outlets to inform and motivate people on the methods and advantages of regulating fertility (Parry, 2013; Beach & Hanlon, 2019).[8] But with the rise of new media and information technologies in the 1950s the use of radio and TVs became popular to promote modern contraceptives given their wide coverage and potential effectiveness. The evidence of such effectiveness is mixed (Udry, Clark, Chase & Levy, 1972). Additionally, the interpretation of the evidence as causal could be limited as identification of exposure is not always clear.[9]

2 A brief history of the radio

As one of the biggest revolutions, the radio arrived in the country in 1929 and expanded through the territory during the 1930s. The first official (from the government) radio station, the HJN, was founded in Bogotá on the 5th of September 1929, while the first commercial radio station, *"La Voz de Barranquilla"*, was founded in Barranquilla on the 8th of December of the same year. The central goal of the radio was to consolidate a national project and to overcome the geographical barriers to unify the country. Public radio stations were mainly used for educational purposes and to connect the country while commercial radio was mainly used for advertisements (Blanco Sánchez, 2018).

By 1945 the radio had already established itself as the main means of mass communication in Colombia and with the introduction of the transistor radio in the mid-1950s, the radio became the most popular electronic communication device of the 1950s and incorporated the rural area to the national audience. In 1947 the foundation of *Radio Sutatenza*, the first Catholic radio station in Latin America, started an educational campaign through radio to alleviate the high levels of illiteracy in the rural and isolated areas (Roldán, 2014).

After 1957 almost all the radio stations had modernised their equipment and increased their power from 1 or 5 kilowatts to 10 or 20 kilowatts, which improved the coverage range of the radio. By the mid-1970s the radio was regarded as the method par excellence for reaching the lower-income population with around 20 million listeners across the country and 340 radio stations located in 109 municipalities (Ferreira

[8]For example, the dissemination of the Bradlaugh-Besant trial after 1877 in the United Kingdom or the pioneer pamphlet of 1914 called *Family limitations* that circulated in the US published by Margaret Sanger and was followed by the Comstock Laws.

[9]See for example the discussion on Jaeger, Joyce and Kaestner (2020) and the study for Ghana by Parr (2002).

& Straubhaar, 1988). The report of the 1973 census shows that 46% of indigenous families had a radio in the house.[10]

3 The *debut* of family planning

Catching up with Europe, like other Latin American countries, in the 1960s Colombia experienced a rapid fertility transition, and in only 25 years the number of children per woman fell from 6.8 to 3 (López Toro, 1968). Despite important regional disparities in development, the fertility decline in the country was not only rapid but also widespread. Both rural and urban women decreased their number of children and the reduction was evident in women of all ages. What explains such a rapid and widespread decline in fertility? There is still an open debate in the literature regarding the mechanisms that can account for the fertility decline but the increase in the knowledge, availability and use of contraceptive methods after the mid-1960s has drawn special attention as the fertility transition coincided with the approval of the pill by the FDA in the US in 1960 and its quick dissemination around the world.

In Colombia, the dissemination of modern contraceptive methods kicked off when the Colombian Association for Family Welfare (Profamilia) was founded in Bogota in 1965. As a result, by the early 1970s, the majority of women knew of at least one contraceptive method and approved family planning, and around 40% of urban women were practising contraception (Prada & Ojeda, 1987; Bailey, 1973). Although the use of modern contraceptive methods increased, the role that Profamilia played in the overall fertility decline was limited. Miller (2010) estimates that the introduction of Profamilia clinics in urban centres explains only between 6% and 7% of the fertility decline between 1964-1993. It is possible that family planning had a small effect on the fertility of urban women because by the early 1960s fertility in urban areas was already being controlled, possibly through more traditional methods and abortion. But the effects of Profamilia clinics on the fertility of women living in areas outside the city, which were on average more rural and less educated and where access to contraception was more limited, are still unknown.

As reported in Simmons and Cardona (1974), in 1969 63% of women living in Bogota had ever used a contraceptive method, while only 19% of rural women had. Similarly, abortion was commonly practised in big cities during the 1960s (Mendoza-Hoyos, 1968). According to Mendoza, more than 60% of abortions happened in women

[10]Unfortunately this question is absent from the private household form.

with seven or more births, suggesting then that abortion was a common practice to limit the number of children. Interestingly, abortion was present mainly in main cities where the induced abortion rate per pregnant woman was around 20%, while only 8% of women living in rural areas practised induced abortion (Requena, 1968).

As shown in Table 1, despite the difference in the practice of contraception and abortion, Simmons and Cardona (1974) show that in 1969 women living both in rural and urban areas had similarly favourable attitudes to family planning. This could indicate that the adoption of contraception in rural areas was limited by the availability of contraceptive methods and not so much by awareness or knowledge and that once access to contraception was ensured, the use of contraceptive methods should have increased for rural women. However, an increase in the utilisation of modern contraceptive methods after the establishment and promotion of family clinics does not necessarily imply an effect on fertility if couples were already effectively controlling their fertility.

Table 1: Favourability to family planning, 1969

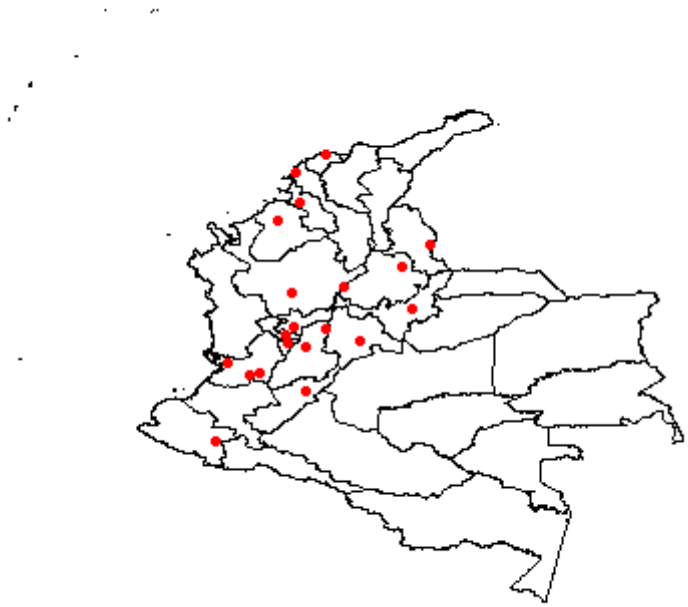
	Rural	Cartagena	Medellin	Bogota
Favourable to family planning	62	69	58	76
Have ever used a contraceptive method	19	48	52	63

Notes: Percent of respondents by place of residence in 1969. The table shows the difference in favourability and use between regions in Colombia, and small rural areas. Source: Simmons and Cardona (1974).

By 1969 Profamilia had established 17 clinics in urban centres covering most regions of the country, except for the National Territories (Fig. 1). In the same year, the organisation launched a radio campaign in 13 of the 17 cities in which they had a clinic. The main objective of the radio campaign was to spread the idea of family planning in Colombia and "to change the attitudes of Colombians toward the rational control of the size of their families" (Stycos and Avery, 151:1975). The campaign announced the availability of family planning services and locations of Profamilia clinics but it did not describe any contraceptive method. The announcements were broadcast several times a day between 8 am and 6 pm along with other commercial spots and were between 15 to 30 seconds long. Since the start of the campaign the ads were usually broadcast during the second six months of each year but due to financing constraints, there were occasional suspensions of broadcasting for weeks.

The 1971 campaign was broadcast over 51 radio stations and every station aired one spot each half-hour, which means that about 900 announcements each day were aired (Stycos & Avery, 1975).

Figure 1: Profamilia clinics in 1969



Notes: The map shows the geographical location of Profamilia clinics by 1969. Sources: Based on Miller (2010)

There were different types of announcements but the following examples from Bailey (1973) show that the main message of the radio spots was to make the population aware of the ideas of family planning and fertility limitation while giving the exact location of the family planning clinics. These announcements introduced the concept of family planning and fertility control, raised awareness of the availability and by being so frequently on the radio, legitimated the concept of family planning.

> ***Announcer 1***: *Every child needs special attention. Therefore have only the number of children you can take care of.*
> ***Woman 1***: *Talk with your husband and go to Profamilia.*
> ***Woman 2***: *[Gives the address of a clinic]*

> ***Announcer 1***: *Do you know what family planning is?*

***A woman**: Family planning means to have the number of children one wants and to have them when they are wanted*
***Announcer 1:** [Gives the address of a clinic]*

The idea of this campaign was to promote the clinics so that couples that did not want any more children could have information about where to go to get access to family planning services. Given that in the 1970s radio was the best method for reaching lower-income and rural populations the campaign could have been successful in making the population both aware and interested in family planning programs, but as the campaign did little in promoting new social roles, increasing the educational level of women, persuading women or couples of the advantages of smaller families or raising the economic aspirations of the radio listeners, the impact of the campaign in the fertility decline of the country could have been limited. Additionally, it seems plausible that the information about family planning and fertility control was not new to radio listeners. As previously discussed, urban women were already limiting their fertility using other methods such as abortion and rural women were not only aware but also in favour of family planning.

In the eyes of Profamilia, the campaign was successful as the number of users increased soon after the radio campaign started and most importantly, it did not face any opposition from the public or the church, which demonstrated the broad acceptance of family planning in the country. Early evaluations of the radio campaign confirmed that it reached the urban target population and that it accelerated information diffusion about fertility control. Given that broadcasting was not cheap and Profamilia was a private initiative, financed particularly by USAID and Planned Parenthood Federation, most of these evaluations were concerned with the cost-effectiveness of the campaign. The evaluations estimated that the cost per new client was between $8 and $17 US dollars (Bailey, 1973; Stycos & Avery, 1975).[11]

In general, the evaluations find that the radio campaign added a substantial number of visitors to the clinics. Bailey (1973) showed that the number of visitors increased in the urban clinics immediately after the beginning of the campaign and that radio was the second most important source, after friends, neighbours and relatives, of information about the existence of the service. Bailey and Cabrera (1981) calculate that between 1971 and 1972 more than 8,000 new visitors went to a clinic

[11]The cost per client of the radio campaign was considerably low in comparison to the estimations of the 1971 campaign in the US by Udry et al. (1972) that estimated an average cost per additional new client between $75 and $5,000 US dollars.

because of the radio campaign, although it is possible that this increase was at the expense of visitors that would have attended the clinics in the future. Also, the major impact of the campaign was in two big cities, Bogota and Medellin, which accounted for almost 60% of the campaign's impact on the number of new visitors. Stycos and Avery (1975) argue that although the radio campaigns likely accelerated the process of information diffusion about fertility control, the campaign was less effective in smaller cities which suggest that informal channels of communication were sufficient to diffuse the information about the location of the clinics. On the whole, the evaluations seem to suggest that although the number of visitors increases in some cities, the overall effect of the campaign could be limited.

4 Data

To measure the effects of the national radio campaign on fertility I have assembled a unique data set using several sources. I collect data on the location and dates of the establishment of Profamilia's clinics and radio programmes. I gather data on transmitters' location, frequency, and power for the complete broadcasting network in Colombia and calculate radio signal strength in the country during the 1970s to measure exposure to the radio campaign. Using the full count census of 1973 and life tables I calculate several measures of fertility to address the potential heterogeneous effects of the campaign.

4.1 Exposure to the radio campaign

Using data from Miller (2010) I compile the location and dates of establishment of Profamilia clinics from 1965 to 1970. From Bailey (1973) and Stycos and Avery (1975) I collected the cities where the radio campaign started in 1969.

Although by the 1960s radio was very popular across the country the information on how many people had a radio at home, listened to the radio or the radio announcements is not available.[12] To overcome this, I exploit continuous variation in signal strength that results from topographic factors and proxy radio exposure in each municipality by a measure of its signal strength. Using the first National directory of broadcasting stations of 1976 published by the National Office of Statistics, I collect

[12]Table 7 presents statistics compile by Stycos and Avery (1975) on exposure of new visitors to radio. The table shows that on average 89% of women that went to a Profamilia clinic during July and August of 1971 listen to the radio, 40% of these women listen to the radio more than 36 hours per week, and 83% heard one of Porfamilia's spots.

information on the radio stations that had transmitters in all cities that broadcast the radio campaigns. Although this information comes from 1976, according to a report from DANE (1978), by 1957 most of the radio stations had increased their power from 1, 2 or 5 kilowatts to 10 or 20 kilowatts and those local radio stations that were unable to improve their coverage were mostly absorbed by bigger radio broadcasters. Therefore, by 1964 the configuration of the broadcasting stations was almost invariant except for some new independent radio stations that emerged after 1964 but these stations were not included in the data I collected.[13]

Given that I don't have information on the exact radio stations used by Profamilia to broadcast the radio announcements, I collected data by city on transmitters' location, frequency, and power from long-established radio stations in the country (Caracol, RCN and Todelar). It seems reasonable to focus on these stations to measure the effect of the radio announcements on fertility, given that as Stycos and Avery (1975) mention, Profamilia did achieve coverage of the most popular radio stations in the cities.

To exploit the exogenous variation in radio signal strength that results from topographic factors, I use the Irregular Terrain Model (ITM) developed by Hufford (2002).[14] Using a professional radio software, the model combines data on the location and characteristics of radio transmitters and the orographic characteristics of the country using a 1 km grid elevation data and information on surface refractivity, radio climate and conductivity of the ground to predict radio signal strength isolating the part of the radio reception that is lost due to the topographic obstacles. For each municipality-radio station pair, the ITM calculates the predicted signal power a receiver would get including the effects of topography and distance to the transmitter.[15] I use the maximum predicted signal strength in each municipality across all transmitters as the predicted signal strength in that municipality. Additionally, the model also calculates the hypothetical signal strength in free space, that is, the signal strength that a municipality would receive if there was no interference from geography or climate. The Fig. 2a shows the maximum predicted signal strength of Profamilia transmitters to all municipalities in the country and Fig. 2b shows the hypothetical signal strength in free space and Fig. 4 shows the distribution of the

[13]These radio stations are Radio Cadena Independiente, Coral, Super, Cadena Lider de Colombia and Radio Sistema Colibri.

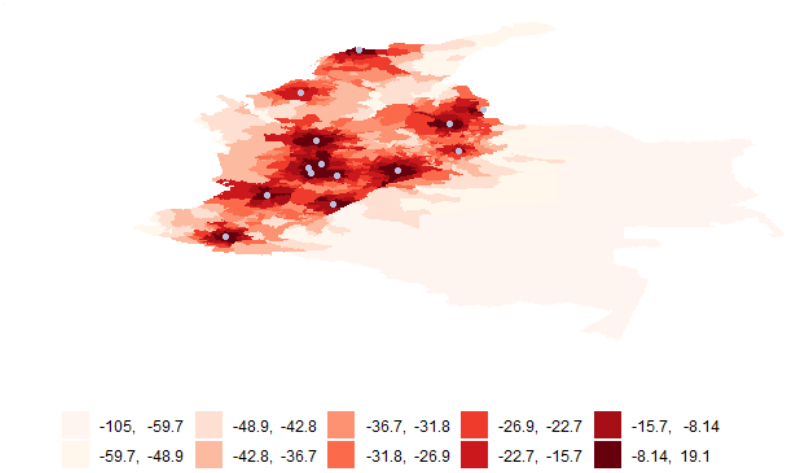
[14]I would like to thank the generosity of Benjamin Olken who kindly shared with me the ITM software.

[15]Following Olken (2009), Wang (2021) and others I use the centroid of each municipality as the receiver location.

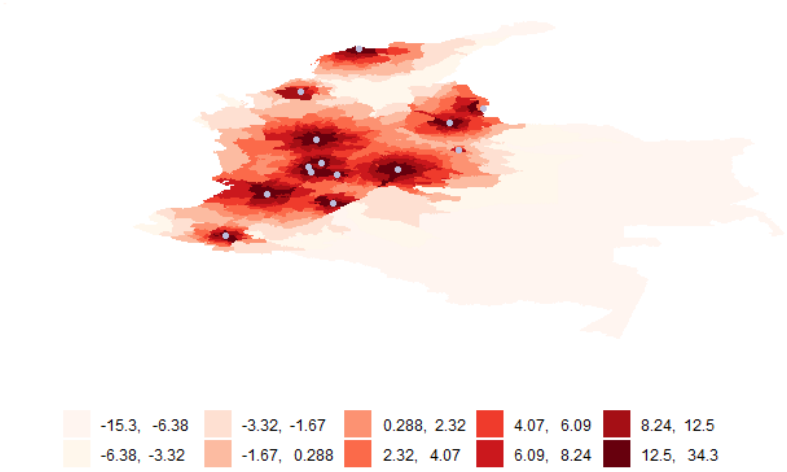
predicted signal strength.

Figure 2: Location and signal strength of Profamilia transmitters

(a) predicted signal strength



(b) free space signal strength



Notes: The maps show the maximum predicted signal strength and the free space signal strength for each municipality. The predicted and the hypothetical signal strength are computed using the Irregular Terrain Model (ITM) and measured in decibel-milliwatts (dBm). The grey dots are the transmitter location. Sources: Authors' calculations based on Miller (2010), Bailey (1973), Stycos and Avery (1975) and the National directory of broadcasting (1976).

4.2 Fertility measures

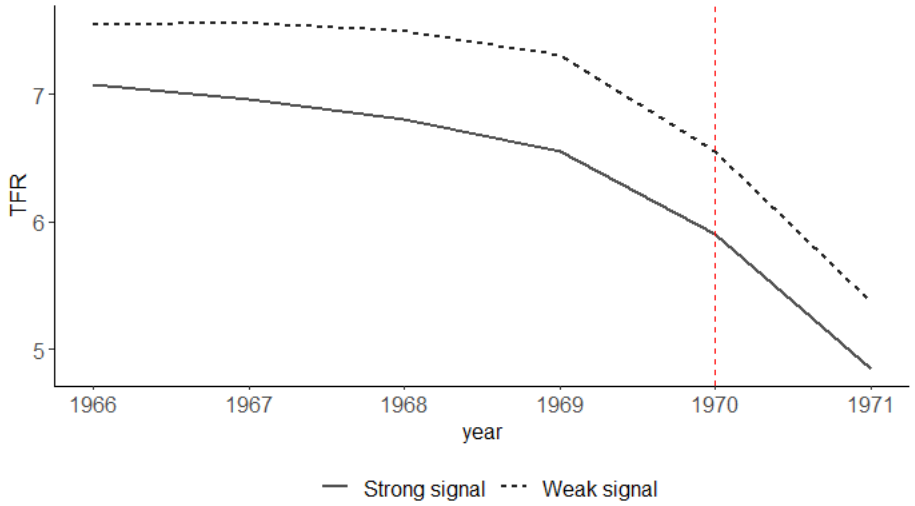
I use data from the full count census of 1973 and life tables to observe the short-term effects of the radio campaign on fertility. The first outcome of interest is a general

fertility rate calculated as the births per women aged 15 to 48. I divide the number of children between 0 to 3 years old by the number of women that are between 15 to 48 years old in each municipality.[16] I use this measure instead of the traditional Crude Birth Rate to account for differences in sex ratios and in age distribution which could be more problematic at the municipal level. The birth rate in the country was on average 611.6 live births per 1,000 women aged 15 to 48 and the distribution is shown in Appendix Fig. 6.

To observe the evolution of fertility over time, I compute the Total Fertility Rate, which is, the number of live births a woman could expect to have, given age-specific birth rates. I estimate the average TFR at the municipal level from 1966 to 1971 and I use the 1970 life-tables from CEPAL at the departmental level to include mortality adjustments. I focus on children that are between 0 to 7 to minimise the bias in estimates of the total fertility rate (Reid, Jaadla, Garrett & Schürer, 2020; Timæus, 2021). These children are more likely to live at home with their mothers and therefore are more likely to be matched to the mother minimising measurement error and providing a more robust estimation of the effect. Fig. 3 shows the Total Fertility Rate for 1966 to 1971 divided by places with a signal strength above the median signal strength of the sample and places with a signal strength below the median. The figure confirms that fertility declines fast and across different municipalities and it shows that municipalities with a signal strength above the mean had on average lower fertility in comparison to the municipalities with weaker signal strength. Noticeably, fertility declines faster after 1969 in both groups but the trends seem to suggest that fertility declines faster in places with weak signal strength.

[16]The general fertility rate can be calculated using children born to women aged 15 to 45. However, I include children aged 0 to 3 to account for the potential misreporting of ages at ages 0 and 1. Therefore, I also include women aged 45 to 48 to allow for births happening in the previous 3 years.

Figure 3: Total Fertility Rate, 1966-1971



Note: The figure shows the Total Fertility Rate (TFR) by the strength of the radio signal received. Calculations using the OCM and based on women between 15 and 64 years old and children between 0 and 7 years old. The estimations of the TFR are adjusted by mortality rates using life-tables from 1970. The dotted line shows the TFR for municipalities with a predicted signal strength below the median signal strength of the sample. The red line indicates the year in which the radio campaign was introduced. Sources: Authors' calculations based on 1973 full Census data.

Additionally, I compute Age-Specific Fertility Rates for the same period and at the municipal level to observe potential heterogeneous effects by age. In particular, I calculate ASFR for ages 15 to 19, 30 to 34 and 40 to 44. These age groups allow me to observe differences in fertility at different points in the fertility life of women. The first group shows the effect of the radio campaign on teen pregnancy and starting. The second group displays the effect on fertility for women that already started their fertility life, while the third group shows the effect of the radio campaign on stopping. If the radio announcements were indeed disseminating new information and new social norms, the potential heterogeneous effect could also come from differences in the adoption of contraception according to differences in age. For example, it is likely that younger women that grew up with constant information about family planning adopt contraception more easily in comparison with older women.

5 Empirical strategy

The baseline of my empirical strategy is to measure the effects of exposure to Profamilia's radio campaign on fertility during the onset of the fertility transition.

It would be ideal to measure the effect at the individual-level, however, I do not have exact data on the number of radio listeners or variation in access to radio at this level of information. Using the Irregular Terrain Model (Hufford, 2002), I predict the radio signal strength of the radio stations that were located in the cities where Profamilia launched its radio campaign. With the predicted signal strength as a proxy, I estimate a lower bound of the intention to treat the effect.

The main challenge of identification is that the location of the radio stations and the Profamilia clinics may not be randomly distributed in the country and that these locations could be correlated with other characteristics that influence fertility at the municipal level. As for the location of Profamilia clinics, Miller (2010) shows that the process of expansion of Profamilia was mostly arbitrary as it did not follow any clear geographical pattern (See Fig. 1). Furthermore, Miller (2010) demonstrates that programme placement was not correlated with pre-existing trends in socio-economic conditions of the municipalities.

Regarding the placement of the radio stations, the configuration of the broadcasting stations was completed in 1964, 5 years before the radio campaign started. However, to minimise further concerns of identification, I follow different empirical strategies.

First, I follow the empirical strategy pioneered by Olken (2009) to exploit the exogenous variation of the signal strength that results from topographic factors (DellaVigna & La Ferrara, 2015; Wang, 2021). To do so, the first model regresses fertility outcomes on the predicted signal strength calculated at the municipal level. To isolate the effects of topography on the transmission patterns, the model includes a control for the hypothetical signal strength in free space, that is, the signal strength without obstacles such as mountains. In this model, the identification of the effect comes from the residual variation of the signal strength as a result of idiosyncratic topographic factors along the signal transmission route. The specification is as shown in Eq. (1):

$$Y_m = \alpha + \beta * \text{signal}_m + \gamma * \text{Free}_m + \mathbf{X}_c\lambda + \delta_d + \epsilon_m \tag{1}$$

Where Y_m is births per women aged 15 to 48, $Signal_m$ is the actual signal strength measured in decibel milliwatts (dBm), $Free_m$ is the hypothetical signal strength without obstacles and δ_d are departmental fixed effects to control for any differences across regions. $\mathbf{X}_c$ is a vector of municipal geographical and historical

controls and urbanisation and population controls. Other unobserved factors are captured with the random error term ϵ_m. The standard errors are bootstrapped and clustered at the departmental level. As a robustness check, I estimate the same model but instead of using a continuous measure of the signal strength, I measure signal strength using dummy variables corresponding to different percentiles of the signal and the results are shown in Appendix Fig. 9.

As an alternative strategy, I employ a Difference-in-Differences design to compare fertility rates before and after the start of the radio campaign. To address potential concerns of endogeneity in the treatment, I exclude cities with transmitters in my analysis. In this model, the identification of the effect comes from comparing changes in fertility rates in municipalities that received a strong radio signal (treated) with the changes in fertility rates of the municipalities that received a weak radio signal. The difference-in-differences (DD) setup is indicated in equation Eq. (2).

$$Y_{m,t} = \alpha_m + \theta_t + \beta \text{strong signal}_m \times post + \epsilon_{m,t} \tag{2}$$

Where $Y_{m,t}$ is some measure of fertility in municipality m in year t. For example, $Y_{m,t}$ is the Total Fertility Rate from 1966 to 1971 or the Age-Specific Fertility Rate for different age groups. The main coefficient of interest is the interaction term between the post-treatment indicator ($post_t$) and treatment status strong signal_m, where treated-status means that the signal strength of the municipality is above the median signal strength in the case of a binary treatment. Although the campaign started in 1969, it is only after around 9 months that we expect to see an effect, given that fertility takes time to respond to this type of policy, therefore the post-treatment indicator will take the value of 1 after 1970. The estimation includes municipality fixed effects to control for both observed and unobserved municipality characteristics with time-invariant effects on fertility and year-fixed effects, which control for time-varying factors affecting fertility rates in the country in the same manner (for example, it accounts for the downward trend of fertility across all municipalities as shown in Fig. 8). In some specifications I also include municipality-specific time trends allowing for differential time-trends as suggested by Jaeger et al. (2020). Other unobserved factors are captured with the random error term $\epsilon_{m,t}$. The standard errors are robust and clustered at the municipality level to account for the possibility of serial correlation in the error term.

A potential concern from the previous specification is the definition of treat-

ment status as using the median of the distribution is a somewhat arbitrary threshold. This is even more crucial when the treatment is not clear on and off treatment, as in the case of the radio. A recent paper by Callaway, Goodman-Bacon and Sant'Anna (2021) suggests that using a binary treatment when the treatment is continuous can bias the results due to treatment effect heterogeneity and that the bias could be ambiguous. To deal with this issue and following Lindo, Myers, Schlosser and Cunningham (2020), I allow the treatment to vary in dosages to see if there were nonlinearities in treatment effects. More importantly, this model allows me to compare the effect of radio signal strength on fertility at different points in the radio signal distribution providing a more robust estimation. In this case, the estimation of the effect of signal strength on fertility rate corresponds to the Eq. (3):

$$Y_{m,t} = \alpha_m + \theta_t + \beta \text{signal}_m \times post + \epsilon_{m,t} \tag{3}$$

Where $Y_{m,t}$ is some measure of fertility in municipality m in year t and $signal_m$ is a set of signal strength ranges. The estimation includes time and municipality fixed effects and the standard errors are robust and clustered at the municipality level.

5.1 Testing knowledge and access to family planning

It is possible that the radio campaigns had an effect only on those municipalities that had a radio strong signal (knowledge) and that at the same time had *access* to a Profamilia clinic. To evaluate this, I limit the sample of municipalities to those that were not further away than 70 kilometres from the city with a Profamilia clinic. I exclude the cities that had the clinic because it is likely that urban centres differ considerably from their rural neighbours. With this sample of municipalities, I can compare places that had access to a Profamilia clinic, but that had different strengths in radio due to the orographic characteristics of the terrain.[17] I repeat the estimations of Eq. (2) and Eq. (3) for this sample of municipalities.

[17]Fig. 5 shows the predicted signal strength of Profamilia transmitters to the neighbouring municipalities and Table 10 presents the summary statistics for these municipalities.

6 Results

Table 2 shows the estimated effects of exposure to the Profamilia radio campaign on the births per women aged 15 to 48 following Eq. (1). Column 1 includes only the predicted radio signal strength and department fixed effects and the coefficient suggests that higher signal strength, that is an increase in exposure to the radio programme, is associated with a decrease in fertility rates. The effect is almost insignificant in economic terms: an increase of 1 standard deviation in the signal strength is associated with a reduction of 37.5 births per 1,000 women. When the hypothetical free-signal space is included, the size of the coefficient decreases as well as its significance and the effect found is insignificant and also close to zero. The results in Column 3 corroborate this finding. Once geographical, historical and population controls are added into the model, the coefficient remains small and non-significant. The results imply that there were no effects of the radio announcements promoting the family clinics on the number of births per women aged 15 to 48. The results in Appendix Fig. 9 confirm that the effects were non-significant and small even in municipalities with the strongest radio signal.

Table 2: Estimated effects of signal strength on births per 1,000 women

	births per women		
	(1)	(2)	(3)
radio signal strength	-2.58***	-0.46	-0.53
	(0.15)	(0.70)	(0.29)
Departament fe	Y	Y	Y
Free space signal		Y	Y
Geographical controls			Y
Historical controls			Y
Urbanisation			Y
Population controls			Y
Adj R^2	0.26	0.27	0.60
Num. obs.	939	939	937
N Clusters	20	20	20
Mean	612	612	612
sd	111.3	111.3	111.3

Notes: Estimates are based on a OLS model. The outcome variables are birth rates, calculated as the proportion of children between age 0 and 3 to women between ages 15-48 years old in 1973. The explanatory variable is radio signal strength. Free-space signal is the hypothetical signal strength in the free-space (i.e. assuming no topography). Geographic controls include altitude and size of the municipality. Historical controls include year of foundation of the municipality. Urbanization and population controls such as sex-ratio are measured at municipal level in 1973. Bootstrap standard errors in parentheses are clustered at the departmental level, and $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$ indicate statistical significance.

A similar picture is shown by the results of the DID analysis in Table 3. Column 1 reports the unconditional correlation between the Total Fertility Rate and receiving a signal strength above the median signal strength. The correlation is negative, corroborating, as shown in Fig. 3, that on average the TFR in places with a stronger signal is lower over the period. In Columns 2 to Column 5, I present the results from the average post-treatment difference, that is, the average effect in the municipalities after the campaign started. The results in Column 2 show that the average post-treatment effect on the Total Fertility Rate is non-significant and very close to zero, which indicates a null effect of the campaign on the TFR. When we observe the Age-Specific Fertility Rates for women between 15 to 19, 30 to 34 and 40 to 44, the results in Columns 3 to 5 establish that this null effect is also present in the different age groups despite the potential differences in fertility behaviour at different points in the fertility life of women. This again corroborates that the radio

campaign did not affect fertility rates.

Table 3: Estimated effects of radio signal strength on fertility - binary treatment

	TFR	TFR	ASFR 15-19	ASFR 30-34	ASFR 40-44
	(1)	(2)	(3)	(4)	(5)
Strong signal	-0.57***				
	(0.04)				
Strong signalxPost		0.037	0.005***	-0.004*	0.001
		(0.04)	(0.002)	(0.003)	(0.003)
((Intercept)	6.99***				
	(0.03)				
Mean	6.7	6.7	0.12	0.28	0.13
sd	1.5	1.5	0.05	0.08	0.08
Municipality fe	N	Y	Y	Y	Y
Year fe	N	Y	Y	Y	Y
R^2	0.04	0.87	0.71	0.66	0.65
Num. obs.	5,514	5,514	5,488	5,501	5,470
N Clusters	513	513	513	513	513

Notes: Estimates are based on a OLS model evaluating expected fertility rates in Colombian municipalities excluding cities were the transmitters were located. Strong signal$_m$ equals 1 if the signal strength of the municipality is above the median signal strength. Standard errors in parentheses are clustered at the municipality level, and $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$ indicate statistical significance.

However, a potential concern from the previous results is the definition of the treatment status as a dichotomous variable given that signal strength is a continuous variable. To overcome this, I allow the treatment to vary in dosages grouping the signal strength into 5 groups. In this specification, the average post-treatment effect is the differential fertility after 1970 between the group of municipalities with the weakest signal strength (-105 dBm to -48.9 dBm) and municipalities under different ranges of signal strength. In general, the results from Table 4 show non-significant and economically small effects very close to zero which confirms what has been previously discussed. Interestingly, the results in Column 1 suggest that in comparison to the municipalities with the weakest signal strength the municipalities with the strongest signal reception (-15.7 dBm to 19.1 dBm) experienced a slower fertility decline. The difference, however, is minimal. The results imply that although fertility was changing rapidly after 1970 across the territory, these changes were not associated with radio announcements.

Table 4: Estimated effects of radio signal strength on fertility - continuous treatment

	TFR	ASFR 15-19 3	ASFR 30-34	ASFR 40-44
	(1)	(2)	(3)	(4)
$[-105, -48.9)dBm$xPost (ref. group)				
$[-48.9, -36.7)dBm$xPost	0.06	0.01^{**}	0.01	-0.01
	(0.07)	(0.00)	(0.00)	(0.01)
$[-36.7, -26.9)dBm$xPost	0.10	0.01^{*}	0.00	-0.00
	(0.07)	(0.00)	(0.00)	(0.01)
$[-26.9, -15.7)dBm$xPost	0.10	0.01^{*}	0.00	-0.00
	(0.07)	(0.00)	(0.00)	(0.01)
$[-15.7, 19.1)dBm$xPost	0.11	0.01^{***}	0.00	-0.00
	(0.07)	(0.00)	(0.00)	(0.00)
Mean	6.7	0.12	0.28	0.13
sd	1.5	0.05	0.08	0.08
Municipality fe	Y	Y	Y	Y
Year fe	Y	Y	Y	Y
R^2	0.82	0.70	0.64	0.64
Num. obs.	5,628	5,602	5,615	5,584
N Clusters	936	936	936	936

Notes: Estimates are based on a OLS model evaluating expected fertility rates in Colombian municipalities excluding cities were the transmitters were located. The excluded category is signal strength between -105 dBm to -48.9 dBm. Standard errors in parentheses are clustered at the municipality level, and $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$ indicate statistical significance.

6.1 Municipalities with access to a clinic

The previous results raise the potential concern that when looking at women in the whole country, the limited effects of the radio campaign could be explained by limited access to a Profamilia clinic, as the clinics were located far away from several municipalities. This is also a mechanism through which family planning could have affected fertility: not only through knowledge of availability but also through access. In Table 5 and Table 6 I report the result for the estimated effects of radio signal strength on fertility for women living in municipalities located less than 70 km away from cities that had a Profamilia clinic by 1970 following Eq. (2) and Eq. (3).[18] All of these municipalities had access to a clinic while experiencing differences in signal strength due to topographic factors.

The results from Table 5 show that even when limiting the sample to muni-

[18]I considered 70 km because this distance allows people to move from the centre of a municipality to another in approximately 1 hour and a half in public transportation. Table 11 and Table 12 show the results changing the distance from the centre of the city for 30 km and 140 km. In both cases, there is no effect of the radio programme on fertility.

cipalities near a clinic, places that received a stronger radio signal did not experience a faster fertility decline one year after the radio campaign started. The results in Columns 2 to Column 4 that report the average post-treatment difference indicate that the effect on the different fertility rates was non-significant and economically marginal. This implies that radio exposure did not have a heterogeneous effect on fertility behaviour in women of different ages. Women between 15 to 19 years old that were exposed to the campaign and lived in a municipality close to a Profamilia clinic, did not reduce their fertility in comparison to women of the same age group that received a weaker radio signal.

In Table 6 I address again the issue regarding the threshold of the treatment status accounting for differences in the intensity or dosage of the radio signal. Once again, the results confirm that there is no effect of the intensity of the radio signal after the start of the campaign on fertility rates, either by looking at the TFR or by looking at different age-groups fertility. Overall, municipalities that received a stronger radio signal (-7.15 dBm to 16.3 dBm) did not experience lower fertility one year after the start of the radio campaign compared to those municipalities that received the weakest signal strength (-41.5 dBm to -24.5 dBm), even though these group of municipalities had access to a Profamilia clinic.

Table 5: Estimated effects of radio signal strength on fertility - binary treatment

	TFR	ASFR 15-19	ASFR 30-34	ASFR 40-44
	(1)	(2)	(3)	(4)
Strong signalxPost	-0.0098	0.0028	-0.0029	-0.0004
	(0.0456)	(0.0023)	(0.0032)	(0.0032)
Mean	6.5	0.11	0.27	0.13
sd	1.3	0.05	0.07	0.07
Municipality fe	Y	Y	Y	Y
Year fe	Y	Y	Y	Y
R^2	0.86	0.70	0.70	0.64
Num. obs.	3,078	3,072	3,078	3,070
N Clusters	513	513	513	513

Notes: Estimates are based on an OLS model evaluating expected fertility rates in municipalities less than 70 km away from cities that had a Profamilia clinic by 1970. Strong signal$_m$ equals 1 if the signal strength of the municipality is above the median signal strength. Standard errors in parentheses are clustered at the municipality level, and $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$ indicate statistical significance.

Table 6: Estimated effects of radio signal strength on fertility - continuous treatment

	TFR	ASFR 15-19 3	ASFR 30-34	ASFR 40-44
	(1)	(2)	(3)	(4)
$[-41.5, -24.5)dBm$xPost (ref. group)				
$[-24.5, -18.2)dBm$xPost	−0.16	−0.01	−0.01	0.00
	(0.08)	(0.02)	(0.01)	(0.01)
$[-18.2, -12.4)dBm$xPost	−0.13	−0.02	−0.02	0.02
	(0.08)	(0.01)	(0.01)	(0.01)
$[-12.4, -7.15)dBm$xPost	−0.15	−0.02	−0.02	0.01
	(0.08)	(0.01)	(0.01)	(0.01)
$[-7.15, 16.3)dBm$xPost	−0.08	−0.01	−0.02	0.01
	(0.07)	(0.01)	(0.01)	(0.01)
Mean	6.5	0.11	0.27	0.13
sd	1.3	0.05	0.07	0.07
Municipality fe	Y	Y	Y	Y
Year fe	Y	Y	Y	Y
Adj. R^2 0.76	0.61	0.59	0.56	
Num. obs.	3,078	3,078	3,078	3,078
N Clusters	513	513	513	513

Notes: Estimates are based on an OLS model evaluating expected fertility rates in municipalities located less than 70 km away from cities that had a Profamilia clinic by 1970. The excluded category is signal strength between −41.5 dBm and −24.5 dBm. Standard errors in parentheses are clustered at the municipality level, and $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$ indicate statistical significance.

6.2 Caveats

All the specifications pointed to a limited effect of Profamilia's radio campaign. It is possible that the information that the radio announcements were disseminating had little impact on fertility rates because the ads did not distribute particular new information or social norms, and did little to shape new behaviours or to persuade couples to limit their fertility. Another reason could be that the radio announcements are broadcast when the fertility decline is already on its way across the whole country and therefore the information about contraception and fertility control is not new.

However, three caveats should be taken into consideration to interpret these results. First, the timing of the campaign and the limited effects that I found in the previous section could indicate that the campaign did not spread any new information that could result in changes in behaviour or increase the adoption of contraceptive methods. Unfortunately, the effects on general contraceptive usage are still largely unknown since there is no systematic information on utilisation in the census

data. However, the statistics collected by Simmons and Cardona (1974) and shown in Table 1 confirm that by 1969 more than 60% of the women in the country, including women living in rural areas were favourable to family planning. Furthermore, the positive reaction that the public had to the radio campaign as suggested by the director of Profamilia indicates that fertility control was already known and accepted in the country, even before the start of the radio campaign.

Second, I am evaluating the short-term effects on the fertility of the radio campaign. Because the census was carried out 4 years after the release of the campaign I can only provide fertility estimations for the period 1966 to 1971 and post-treatment effects for 1971. The reason why I do not include the TFR of 1972 is that this estimation is likely to be biased downward due to under-registration or misreporting of ages, as discussed in the previous paper.

Additionally, estimating the effects of the radio campaign in the long term could be challenging because of the other potential interventions that could affect fertility. For instance, in 1973 Profamilia started another radio campaign in alliance with one of the most important radio stations in the country: Radio Sutatenza. The station, which was the first Catholic radio station in Latin America, was originally founded in the town of Sutatenza in the department of Boyaca in 1947 with the idea of combating adult illiteracy. In 1973, with the most powerful transmitters and with national coverage the radio station launched the campaign "Responsible Procreation" with several radio spots that lasted between twenty to sixty seconds several times a day between 5:00 am and midnight (Roldán, 2014). As the previous Profamilia campaign, the campaign did not explicitly recommend a particular form of birth control but instead promoted mutual respect and shared decision-making between spouses as core values of the Christian marriage. The spots were supported with newspapers, radio dramatisations of 15 minutes long and theatre scripts. The campaign defended the idea of having a child as a deliberate choice in which both spouses had equal say but it also extend health education (Roldán, 2014).

7 Conclusions

This paper investigates if a national radio campaign by Profamilia promoting family planning clinics in the late 1960s in Colombia accelerated the fertility decline across the country. Some argue that contraception was, without question, the main force underlying the fertility decline of developing economies (Weinberger, 1987). But

for Colombia, Miller (2010) shows that, in urban areas, the effects of Profamilia on lifetime fertility were modest. I focus on the effects of the Profamilia radio campaign on fertility, as mass media increases the availability of information, especially in rural areas. Additionally, mass media has the potential to shape new social roles, change social norms and raise the level of education of the population.

To measure the effectiveness of the radio campaign on fertility this paper exploited exogenous variation in radio signal strength that results from topographic factors. Using professional radio software I predicted the radio signal strength of a traditional radio station that was located in the cities where Profamilia launched its radio campaign. With the predicted signal strength, I estimate a lower bound of the intention to treat the effect. As a first strategy, I regressed fertility rates on the predicted radio signal strength while controlling for the hypothetical signal strength where there are no orographic obstacles such as a mountain. Additionally, I employed a difference-in-differences strategy to compare fertility rates before and after the start of the radio campaign. Finally, I test two mechanisms through which the campaign could have affected fertility: through knowledge of availability or through access to clinics and contraceptive methods. To do so, I restricted the sample of municipalities to those not further away than 70 kilometres from a city with a family clinic.

The results from this paper show that the Profamilia radio campaign had a limited effect on fertility rates. Although several evaluations of the period suggested that the announcements were successful in increasing the number of visitors to the clinics, the findings in this paper demonstrate that the overall short-term effect of the campaign was limited, as it was not translated into a decrease in fertility rates. Overall, places with a stronger signal strength did not experience lower fertility rates one year after the campaign was introduced. The test for the mechanisms reveals that not even places that were close to a Profamilia clinic experienced faster fertility. Miller (2010) had previously shown that access to family planning had a minor effect on the rapid fertility decline of the country. My results confirm this finding and show that knowledge of family planning also had a moderate effect.

As the radio campaign did little in disseminating new social roles or raising the economic aspirations of the population, the results suggest that the potential effects of media on fertility rely more on the promotion of new social norms than on the diffusion of information about family planning. Similar to what the literature has found, these findings suggest that most of the effects of radio on socioeconomic outcomes are explained by the capacity of persuasion and not only by the diffusion

of information (Dellavigna & Gentzkow, 2010; La Ferrara et al., 2012).

The modest role of Profamilia in the Colombian fertility decline suggests that other forces explain the fertility decline. In particular, changes in the demand for children could be the driver of the fertility decline. Jayne and Guilkey (1998) and Miller (2010) suggest that the single most important factor in the fertility decline in Colombia was not the availability of contraceptives but access to education.

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8 Appendices

8.A Family planning and radio

This appendix provides additional information regarding exposure to the radio.

By the end of the 1960s radio was very popular across the country with close to 20 million listeners in urban as well as rural areas. However, the information on how many people had a radio at home or listened to the radio is not available. Table 7 presents statistics compile by Stycos and Avery (1975) for 1971 on the exposure to the radio of new visitors of different Profamilia clinics. The table shows that on average 89% of women that went to a Profamilia clinic during July and August of 1971 listen to the radio, 40% of these women listen to the radio more than 36 hours per week, and 83% heard one of Porfamilia's spots.

Table 7: Exposure of new clients to radio and Profamilia announcements, 1971

City	**Listen to Radio (%)**	**Listen 36 Hrs. + per week (%)**	**Heard Profamilia announcement (%)**
Bogotá	97	30	96
Medellín	97	55	89
Cali	64	22	44
Barranquilla	87	71	86
Bucaramanga	84	32	74
Manizales	98	44	95
Pereira	90	47	86
Cúcuta	79	27	74
Ibagué	94	78	94
Palmira	94	45	91
Pasto	90	20	82
Armenia	89	26	80
Neiva	90	44	91
Total	**89**	**40**	**83**

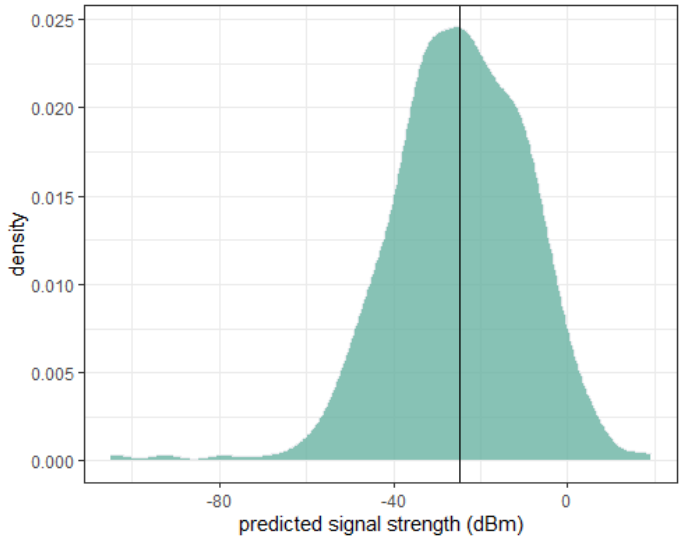
Notes: The data comes from Stycos and Avery (1975) and shows the results of interviews of women who attended the clinics during July and August 1971.

8.B Data

This appendix presents additional information on the data collected and estimated. First, it shows the distribution of the predicted signal strength for the whole country. Then I show the predicted signal strength calculated for each neighbouring municipality that is less than 70 km away from the transmitter of the radio stations. I also present the distribution of the Crude Birth Rate for the whole country, and the Total Fertility Rate by quintiles for the whole country and for each neighbouring municipality.

8.B.1 Signal strength

Figure 4: Distribution of the predicted signal strength



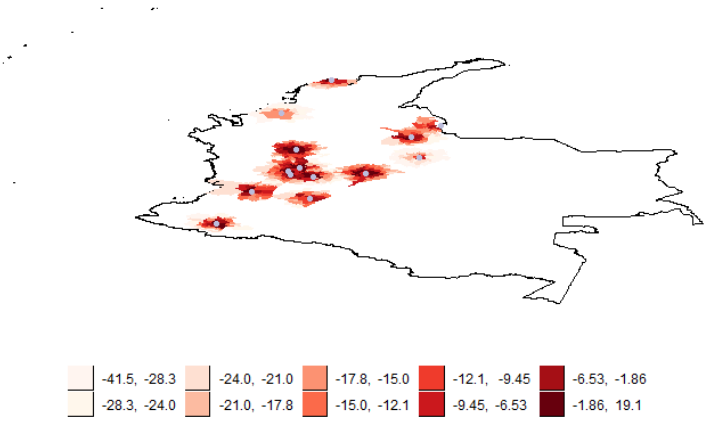
Notes: The graph shows the distribution of the predicted signal strength of the radio stations, computed using the Irregular Terrain Model (ITM) and measured in decibel-milliwatts (dBm). The black line is the median of the distribution. Sources: Authors' calculations based on Miller (2010); Bailey (1973); Stycos and Avery (1975) and the National directory of broadcasting (1976).

Table 8: Descriptive statistics predicted radio signal

	Min	Median	Mean	Max	sd
Effective signal strength	104.84	-24.25	-24.91	19.10	15.94

Notes: Descriptive statistics of the predicted signal strength of radio stations, computed using the Irregular Terrain Model (ITM) and measured in decibel-milliwatts (dBm) using the complete sample. Sources: Authors' calculations based on Miller; Bailey; Stycos and Avery and the National directory of broadcasting (1976).

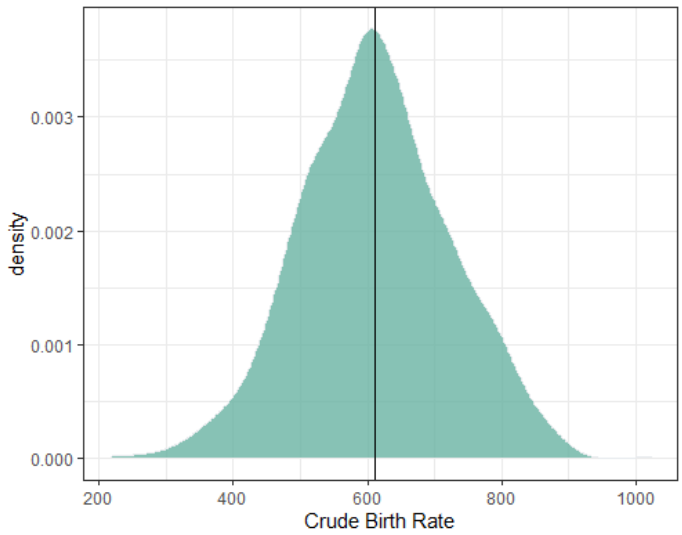
Figure 5: Location and signal strength of Profamilia transmitters - municipalities close to a Profamilia clinic



Notes: The map shows the maximum predicted signal strength in each neighbouring municipality that is less than 70 km away from the transmitter radio stations and it is computed using the Irregular Terrain Model (ITM) and measured in decibel-milliwatts (dBm). The grey dots are the transmitter location. Sources: Authors' calculations based on Miller; Bailey; Stycos and Avery and the National directory of broadcasting (1976).

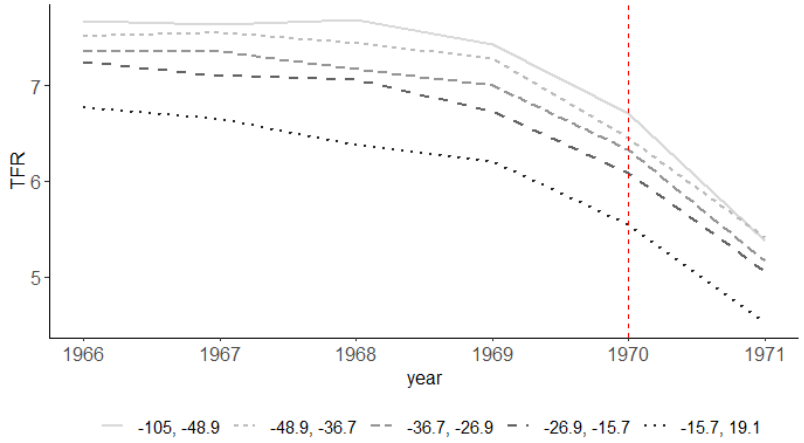
8.B.2 Fertility

Figure 6: Distribution of the General Fertility Rate



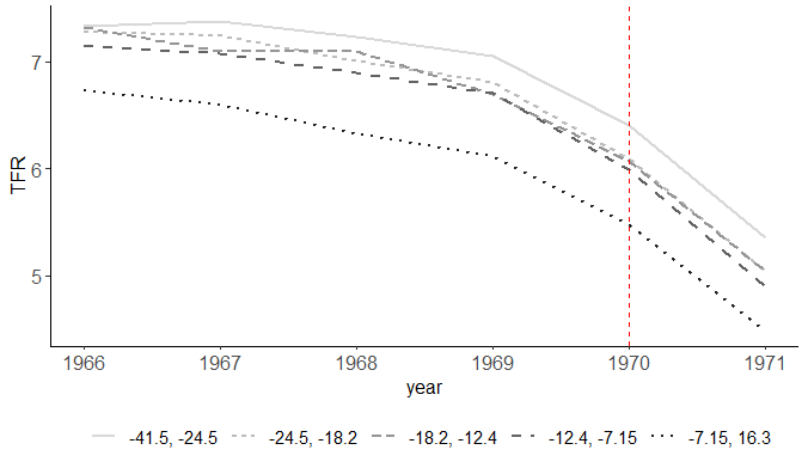
Notes: The graph shows the distribution of the General Fertility Rate, computed using children between 0 to 3 years old and women between 15 to 48 years old. The black line is the median of the distribution. Sources: Authors' calculations based on Miller; Bailey; Stycos and Avery and the National directory of broadcasting (1976).

Figure 7: TFR 1966-1971, National



Note: The figure shows the Total Fertility Rate (TFR) for municipalities in Colombia grouping them based on the strength of the signal radio they receive. Calculations using the OCM. Women between 15 and 64 years old and children between 0 and 7 years old. Sources: Authors' calculations based on 1973 full Census data.

Figure 8: TFR 1966-1971, Municipalities close to a Profamilia clinic



Note: The figure shows the Total Fertility Rate (TFR) for municipalities that are less than 70 km. away from the transmitter. Calculations using the OCM. Women between 15 and 64 years old and children between 0 and 7 years old. Sources: Authors' calculations based on 1973 full Census data.

Table 9 presents summary statistics dividing the municipalities in the country into those that received signal strength above the median with those that received a signal strength below the median. On average municipalities with a strong signal had lower fertility, were more populated and were closer to a Profamilia clinic.

Table 9: Summary statistics by signal strength - All country

	Strong signal	**Weak signal**
Total Fertility Rate in 1968	6.80	7.50
	(1.20)	(1.46)
General Birth Rate in 1970-1973	581	645
Population in 1973	27,890	14,285
Urbanization rate	37%	31%
Distance to Profamilia city (kms.)	42.17	113.70
Sex ratio	0.89	0.97
Number of municipalities	468	470

Notes: Summary statistics for municipalities of Colombia. Strong signal strength means that the municipality received a signal strength that is above the median. The Total Fertility Rate is computed using the Own Child Method. The General Birth Rate is the proportion of children age 0 to 3 years old in the census to women ages 15 to 48. Sex ratio is the proportion of men ages 15 to 50 to women ages 15 to 48. Source: Authors' calculations based on 1973 full Census data.

Table 10 presents summary statistics dividing the neighbouring municipalities of cities with a Profamilia clinic by 1970 into those that received signal strength above the median with those that received signal strength below the median. On average municipalities with a strong signal had lower fertility, were more populated and were closer to a Profamilia clinic.

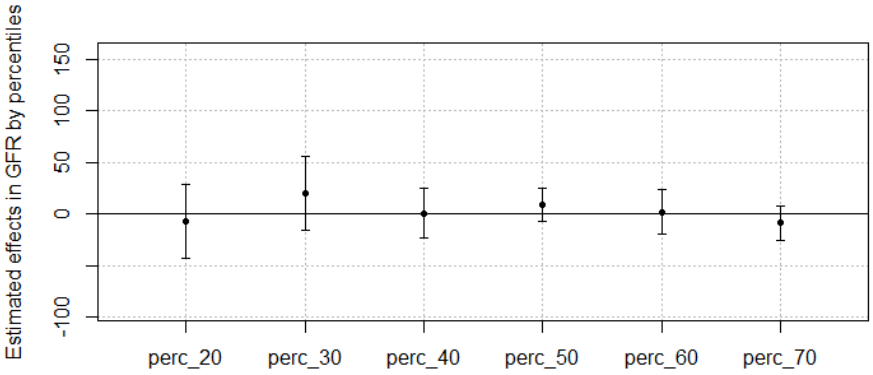
Table 10: Summary statistics by signal strength - municipalities with access to clinic

	Strong signal	**Weak signal**
Total Fertility Rate in 1968	6.72	7.11
	(1.14)	(1.20)
General Birth Rate in 1970-19	572	615
Population in 1973	14,770	12,197
Urbanization rate	38%	31%
Distance to Profamilia city (kms.)	31.61	54.34
Sex ratio	0.96	0.97
Number of municipalities	248	265

Notes: Summary statistics for neighbouring municipalities of cities with a Profamilia clinic by 1970. Strong signal strength means that the municipality received a signal strength that is above the median. The Total Fertility Rate is computed using the Own Child Method. The Crude Birth Rate is the proportion of children age 0 to 3 years old in the census to women ages 15 to 48. Sex ratio is the proportion of men ages 15 to 50 to women ages 15 to 48. Source: Authors' calculations based on 1973 full Census data.

8.C Robustness

Figure 9: Effects on births per women aged 15 to 48 by percentiles of signal strength



Note: The figure shows the coefficients and standard errors from Eq. (1) where $signal_m$ is measured using dummy variables corresponding to different percentiles of the signal. Estimates are based on an OLS model. The outcome variables are birth rates, calculated as the proportion of children between age 0 and 3 to women between ages 15-48 years old in 1973. Geographic controls include altitude and size of the municipality. Historical controls include year of the foundation of the municipality. Urbanization and population controls such as sex-ratio are measured at the municipal level in 1973. Standard errors in parentheses are clustered at the departmental level.

Table 11: Effects of radio signal strength on fertility (30 km away from clinic)

	TFR	TFR	ASFR 15-19	ASFR 30-34	ASFR 40 - 44
Strong signal	-0.4560***				
	(0.0908)				
Strong signalxPost-1970		-0.0855	0.0048	-0.0067	0.0006
		(0.0762)	(0.0037)	(0.0047)	(0.0044)
(Intercept)	6.318***				
	(0.0642)				
Municipality fe	N	Y	Y	Y	Y
Year fe	N	Y	Y	Y	Y
Adj. R^2	0.031	0.88	0.74	0.73	0.69
Num. obs.	780	780	780	780	779
N Clusters	130	130	130	130	

Notes: Estimates are based on an OLS model evaluating expected fertility rates in municipalities living less than 30 km away from cities that had a Profamilia clinic by 1970. Strong $signal_m$ equals 1 if the signal strength of the municipality is above the median signal strength. Standard errors in parentheses are clustered at the municipality level, and $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$ indicate statistical significance.

Table 12: Effects of radio signal strength on fertility (140 km away from clinic)

	TFR	TFR	ASFR 15-19	ASFR 30-34	ASFR 40-44
Strong signal	-0.5346***				
	(0.0376)				
Strong signalxPost		0.0109	0.0023	-0.0053**	0.0016
		(0.0386)	(0.0018)	(0.0025)	(0.0026)
(Intercept)	6.913***				
	(0.0266)				
Municipality fe	N	Y	Y	Y	
Year fe	N	Y	Y	Y	
R^2	0.039	0.85	0.709	0.67	0.61
Observations	4,974	4,974	4,965	4,974	4,957
N Clusters	829	829	829	829	829

Notes: Estimates are based on an OLS model evaluating expected fertility rates in municipalities living less than 140 km away from cities that had a Profamilia clinic by 1970. Strong signal$_m$ equals 1 if the signal strength of the municipality is above the median signal strength. Standard errors in parentheses are clustered at the municipality level, and $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$ indicate statistical significance.