Breaking Barriers on Reproductive Choice of Women: Role of Digital Healthcare Platforms in India*

Shubhangi Agrawal†

University of Edinburgh

Abstract

Despite availability of modern contraceptives, high unmet need for such methods persists in developing countries, suggesting that barriers beyond access constrain women's reproductive choices. Social stigma around contraceptive procurement may prevent women from acting on existing preferences. This paper exploits the staggered expansion of e-pharmacies across Indian districts to test whether digital healthcare platforms that provide anonymity and doorstep delivery causally affect women's reproductive outcomes. Using a difference-in-differences framework, I find that e-pharmacy access generates a significant and persistent decline in abortions while producing only short-run decline in fertility. These impacts are concentrated in rural districts and districts with lower female literacy- settings where social constraints are most binding. Survey evidence reveals that e-pharmacy access increases contraceptive use to delay pregnancy and enables women to make contraceptive use decisions independently. Critically, contraceptive usage rises without corresponding changes in awareness of modern methods, indicating that information was not the binding constraint. Distance to physical pharmacies exhibits no relationship with online sales or reproductive outcomes, ruling out physical access as the operative channel. These findings demonstrate that privacy and autonomy rather than information or access, constitute the binding constraints on contraceptive use. The results highlight the potential for digital technologies to expand women's reproductive choice in settings where social stigma limits access to reproductive healthcare.

Keywords: Digital Platforms, Contraceptive Use, Social Stigma

JEL Codes: I11; I12; I14; I15

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†Contact: sagrawal@ed.ac.uk

1. Introduction

The ability to plan fertility lies at the core of women's economic and social agency and has motivated decades of research and policy. Unintended pregnancies impose severe costs such as unsafe abortions, maternal mortality, and lasting disruptions to labour market participation and human capital accumulation with consequences that extend beyond the individual to the broader economy (Mooney-Somers et al., 2019; Mukherjee, Mahapatra, & Saggurti, 2021; Sully et al., 2020). Despite sustained supply-side interventions, including price subsidies, free provision, and awareness campaigns, unmet need for contraception remains persistently high in developing countries. In India, this gap stands at 27% among women of reproductive age and 71% among adolescents. This persistence suggests that the binding constraints extend beyond logistical constraints.

In societies governed by strong reproductive norms, a woman seeking contraception does not face merely a transaction; she faces a public cost with real social consequences. The cost of visibility has been starkly documented in India: a survey of pharmacies in Haryana found that 75% had never had a female customer purchase contraceptives over a ten-year period, and 72% of women who did visit reported feeling watched or fearing disclosure of their purchases (Jain & Rozario, 2013). Women therefore face a fundamental trade-off between the private benefit of fertility control and the social cost of being seen to seek it. A growing body of evidence suggests that concealable access to contraception is central to closing this gap.[1] Yet the conditions under which privacy-enhancing interventions can be delivered at scale in developing countries, where social norms most severely constrain reproductive choice, remain poorly understood.

This paper examines the role of an alternative-discreet venue i.e. digital healthcare platforms for procuring contraceptives on reproductive choices of women.[2] Beginning in 2015, e-pharmacies expanded rapidly across Indian districts in a market-driven staggered fashion. These digital platforms operate through mobile applications and websites, offering contraceptives alongside other healthcare products with minimal user information requirements and

[1] Research documents that concealable contraceptive access substantially increases uptake and improves reproductive and economic outcomes for women, operating through channels of privacy (Ashraf, Field, and Lee, 2014; Gallen et al., 2024).

[2] I use digital healthcare platforms or e-pharmacies interchangeably in this paper.

doorstep delivery within minutes or a maximum of 24 hours. Crucially, users maintain anonymity throughout the transaction, fundamentally altering the privacy structure of contraceptive access relative to traditional pharmacy purchases. I exploit this staggered geographic expansion of e-pharmacies using a difference-in-differences design at the district-year level, comparing reproductive outcomes in districts that gained e-pharmacy access to those that did not between 2014 and 2019. The analysis draws on administrative data covering 711 districts, combining information on births and abortions from IndiaStat Districts with newly constructed measures of e-pharmacy expansion obtained through partnerships with major digital healthcare platforms.

The main findings point to limited and short-lived effects on fertility, but a large and persistent decline in abortions following the entry of e-pharmacies. In the preferred specification, districts gaining access to e-pharmacies experience a reduction of around 2 births per 1,000 women, however, event-study estimates show that this effect dissipates within a year of platform entry. In contrast, abortion rates decline by approximately 16 percent (0.25 fewer abortions per 1,000 women), with the reduction emerging one year after entry and remaining statistically significant up to three years later. To further strengthen identification, I exploit postcode-level expansion data to construct a measure of treatment intensity, allowing for dose–response effects. Under this refined approach, abortion effects remain negative and statistically significant (same as baseline effect of β=-0.25), while effects on births become indistinguishable from zero. Finally, heterogeneity analysis indicate that declines in both outcomes are concentrated in settings where social constraints are likely most binding, with significantly stronger effects in predominantly rural districts and in districts with lower female literacy.

To examine the mechanisms underlying these effects, I use individual-level data from the National Family Health Survey (NFHS) for women aged 15–49. The analysis tests whether access to e-pharmacies enables women to act on existing preferences by delaying pregnancy, making contraceptive decisions autonomously and doing so privately. I find a 3% increase in reported contraceptive use to delay or avoid pregnancy and a 2.4% increase in women reporting sole decision-making over contraceptive use following e-pharmacy entry. Importantly, these increases in usage occur without corresponding changes in contraceptive knowledge, indicating that information was not the binding constraint. Instead, the results point to enhanced auton-

omy and privacy as the primary mechanism. These findings highlight that e-pharmacies allow women to obtain and use contraceptives while circumventing social stigma, partner opposition and visibility costs. Together, this evidence suggests that e-pharmacies operate by relaxing constraints on autonomy rather than by shifting preferences or awareness.

Another important implication of e-pharmacy expansion could be that it may mitigate barriers to physical access, hence the observed declining effects. If this mechanism is at play, then the presence and proximity of brick-and-mortar pharmacies should matter i.e. districts with more distant physical pharmacies would rely more on e-pharmacies for reproductive care products. Consequently, if e-pharmacies primarily operate by easing access constraints, their effect on fertility and abortions should be stronger in such areas. To test this hypothesis, I create a dataset on location of physical pharmacies across the districts of India. Using information on average nearest distance to physical pharmacies in each district, I find no relationship with online sales or reproductive outcomes, ruling out physical access as the operative channel. This evidence points towards the second key mechanism that the e-pharmacy effects operates through breaking barriers on social contraints by enhancing privacy rather than physical barriers.

These findings speak to several literatures. A growing body of work emphasizes that contraceptive uptake is shaped by community norms and intra-household dynamics rather than supply constraints alone (Munshi & Myaux, 2006). Most directly relevant, Ashraf, Field, and Lee (2014) demonstrate experimentally that providing Zambian women with private access to concealable contraceptives without spousal knowledge increased contraceptive adoption by 25% and reduced births by 27%. Their findings highlight that privacy and autonomy, not information or availability, constitute the binding constraint for many women. My results extend this insight to a real-world, non-experimental setting: by digitizing access, e-pharmacies replicate the autonomy and discretion that experimental interventions provide artificially, allowing women to circumvent social constraints without requiring changes in information, or physical infrastructure.

More broadly, this paper contributes to literature documenting the health and economic returns to improved contraceptive access. Prior work shows that such access reduces mater-

nal mortality, teenage pregnancies and fertility by nearly 4% (Ahmed, Li, Liu, & Tsui, 2012; Narita & Diaz, 2016), while also increasing women's labor market participation, wages and educational attainment (Ananat & Hungerman, 2012; Bailey, 2006, 2013; Bailey, Hershbein, & Miller, 2012; Goldin & Katz, 2002). Yet access alone does not guarantee uptake. Recent experimental evidence shows that free provision of contraceptives yields limited effects on fertility (Ashraf, Karlan, & Yin, 2010; Dupas, Jayachandran, Lleras-Muney, & Rossi, 2025), suggesting that non-price barriers remain binding. My findings help explain this puzzle: the dimension of access that matters is privacy, not price or physical availability.

This paper makes three core contributions. First, it provides the first causal evidence linking digital healthcare platforms to women's reproductive outcomes in a developing country context, identifying effects on both fertility and abortion using quasi-experimental variation. This extends experimental findings on privacy and autonomy (Ashraf et al., 2014) to a scalable, market-driven intervention. Second, it isolates the mechanism through which digital platforms affect behavior, demonstrating that privacy and autonomy rather than information or physical access are the operative channels, consistent with theories emphasizing social norms and intra-household bargaining (Munshi & Myaux, 2006). Third, it contributes to broader literature on women's empowerment and the economic returns to reproductive control (Bailey, 2006, 2013; Bailey et al., 2012; Goldin & Katz, 2002), showing that technological innovations can expand women's agency even in the absence of cultural or institutional reform.

The remainder of the paper proceeds as follows. Section 2 describes the institutional background of e-pharmacy expansion in India. Section 3 presents the data and key variable construction. Section 4 outlines the empirical strategy including the difference-in-differences and intensity-based specifications. Section 5 presents the main results, heterogeneity analysis and mechanisms. Section 6 concludes with a discussion of policy implications and directions for future research.

2. Institutional Background

The rapid digital transformation of India in the early 2010s, driven by widespread smartphone adoption and affordable internet access, profoundly reshaped access to goods and services, including healthcare.[3] Within this broader digital revolution, online platforms that sell medicines and healthcare products referred as "e-pharmacies" (hereafter), emerged as a major innovation in healthcare delivery. A few early entrants quickly captured most of the market, creating a highly concentrated digital healthcare sector.[4] This paper focuses on two dominant platforms which capture roughly 50–60% of total online pharmaceutical sales.

E-pharmacies operate through websites and mobile applications that allow users to order both prescription and over-the-counter medicines.[5] Most major platforms adopt an inventory-based model, holding wholesale and retail licenses and dispensing medications through certified pharmacists.[6] Figure 1 provides a snapshot of Tata 1mg's web interface which is one of the key platforms that we study. Through such an interface, users can search for medications, upload prescriptions, make purchases online or via cash on delivery, and receive home delivery on the same day or within 48 hours. The user is not required to enter personal identifiable information apart from location of delivery, maintaining anonymity. Furthermore, each product page includes detailed information on benefits, side effects, and usage instructions, allowing users to make informed choices.

The convenience, low transaction costs and privacy of e-pharmacy services have made them an increasingly popular alternative to brick-and-mortar pharmacies. Figure 2 illustrates the rapid growth in sale of reproductive-care products on Tata 1mg over time. The composition of these sales (Figure 3) shows that contraceptive and pregnancy-related products increased from 27% to 38% of total reproductive-care sales since the platform's launch. Figure 4 further

[3] Figure A1 shows the decline in the digital use gap between men and women for both internet and mobile phone usage over the past decade, using the data from Digital Gender Gaps. The trend line reflects a steady narrowing of gender disparities in mobile(internet) use from 35%(53%) in 2015 to 18%(27%) in 2025.

[4] Four firms dominated the market in mid 2010s: Medlife (2014), Netmeds (2015), Pharmeasy (2015), and 1mg (2015). Pharmeasy acquired Medlife in 2021

[5] Although the current statutory framework lacks explicit provisions for the online sale of medicines, the Ministry of Health and Family Welfare released the Draft E-Pharmacy Rules in 2018 to formalize the sector. These remain under review.

[6] Some platforms use a marketplace model, acting as intermediaries between licensed pharmacies and consumers.

reveals a steady rise in products used by women, with the share converging toward that of products used by men.[7]

These descriptive patterns suggest that digital healthcare platforms have facilitated a quiet transformation in reproductive health behavior. The growing demand for female-oriented reproductive products points toward greater female engagement with digital healthcare. This provides suggestive evidence that online platforms may be easing constraints around privacy, stigma and autonomy. Motivated by these trends, we empirically investigate whether the expansion of e-pharmacies causally influenced women's fertility outcomes.

3. Data

This paper draws on administrative, survey and newly collected data from multiple sources to construct a novel dataset of pharmacy access and reproductive health outcomes in India. Each source is described in detail below.

Data on expansion of e-pharmacies: I constructed the dataset on expansion of e-pharamcies in India using both administrative and publicly available information from major companies. For one of the largest competitors, Tata 1mg, detailed postcode-level expansion data was obtained through a non-disclosure agreement. In addition to this, the company shared the information on sales of contraceptive products over the years. For another e-pharmacy, I collected expansion information by scraping of their public website.[8] In addition, I used Internet archives; a public platform that preserves historical snapshots of websites, to recover the year of entry of this e-pharmacy across postcodes. Combining the information from both sources yields a yearly timeline of expansion of e-pharmacies across postcodes in India. Furthermore, to identify intervention at a broader geographic scale, I combine this information with the Indian postcode data which links each postcode to a district. Districts are the primary administrative sub-division of an Indian state and they serve as a consistent and unique geographic identifier across all my datasets.[9] As a result, I constructed the intervention measure at both district-level

[7]The data on sales was obtained through a collaboration with Tata 1Mg. The organisation kindly shared the sales information for the period of 2017 till 2023 for the reproductive care products.

[8]This e-pharmacy is referred to as the *second company* throughout the paper for data protection reasons.

[9]As of 2024 there are 788 districts in India. This data is only able to cover 711, as per the 2011 census to be consistent and without delving into the issue of changing boundaries

and postcode-level. Figure 5 illustrates the roll-out of these two e-pharamacies across India between 2014 and 2024. The figure plots the cumulative number of districts (panel A) and postcodes (panel B) that gained access to atleast one e-pharmacy in each year. The first expansion occurred in 2015, when the second company in our data began operations in Mumbai. In 2016, this company expanded into 18 metropolitan cities and by 2017 both companies had scaled their operations nationwide, reaching 631 districts. By 2020, only 22 districts in the country remained without e-pharmacies and by 2024 all districts had access to an e-pharmacy. The staggered roll-out of these e-pharmacies across Indian districts (and postcodes) provides a clean source of exogenous variation for the empirical analysis.[10]

Data on abortions and fertility: To examine the effect of e-pharmacy's expansion on women's reproductive choice, I use two outcome measures; fertility and abortions. The data on number of births (live +still) and abortions from 2014 to 2020 for 711 districts in India is obtained from IndiaStat Districts, a private repository maintained by Datanet India. This platform aggregates information on socio-economic and demographic statistics published by various government ministries, state statistical offices, survey data and census reports into a structured district-year panel.[11] There were two main challenges with the raw outcomes. First, some districts have unusually high numbers of births or abortions (especially large metropolitan districts), which could drive biased estimates if left unchecked. I mitigate this by adjusting the extreme values to the 99 percentile of the distribution. Second, the year 2020 exhibits an abrupt drop in births and abortions, likely reflecting covid-related disruptions in reporting rather than true behavioral changes. To avoid contamination, I restrict the main analysis window to 2014-2019.[12] After these adjustments, I merge this data with the information on district's characteristics such as population, literacy rate, sex ratio, density etc obtained from 2011 census.[13] Finally, I construct

[10]These platforms primarily served as broad healthcare providers, selling a wide range of medical products beyond contraceptives. The early expansion of the second company was guided by logistical and financial considerations, focusing initially on pilot areas near warehouses where operations were cost-effective under limited funding. Hence, the roll-out of these e-pharmacies was largely exogenous to our key outcomes of interest i.e. fertility and abortion trends

[11]IndiaStat Districts compiles district-level tables on each socio economic indicators from official government sources (e.g., ministries, state statistical offices, census reports). Each table lists its original source for cross-verification. Although the data are provided "as is" and coverage varies across states, the platform is widely used in research because it aggregates dispersed government publications into a single consistent panel, especially valuable where no alternative public district-level vital statistics exist

[12]Graphs documenting both issues are available upon request.

[13]The data from 2021 census is still in the process of collection and unavailable for use yet.

two normalized outcome variables: births per 1000 women which represents the total number of births in a district (d) in year (t) divided by the total number of women in the district as per the baseline 2011 census, scaled by 1000 (see Equation 1).

$$\text{Births per 1000 women}_{dt} = \frac{\text{Number of births}_{dt}}{\text{Total number of women}_{d}} \times 1000 \tag{1}$$

Similarly, abortions per 1000 women represents the total number of abortions in a district (d) in year (t) divided by the total number of women in the district as per the baseline 2011 census, scaled by 1000 (see Equation 2).

$$\text{Abortion per 1000 women}_{dt} = \frac{\text{Number of abortions}_{dt}}{\text{Total number of women}_{d}} \times 1000 \tag{2}$$

The average outcome measures are plotted in Figure 6 for the period 2014-2019. The trend line shows a decline in abortion rate after 2016 (Panel A), while fertility rates remain largely stable over the same period (Panel B).

Survey data from the National Family Health Survey: To investigate the mechanisms underlying the main effects, I leverage the National family health survey (NFHS) data. The NFHS interviews women between the age of 15 to 49 on several socio-economic, demographic and health-related topics. For this study, I use the information from two waves conducted in 2014-15 (wave 4) and 2019-21 (wave 5).[14] Combining these waves provides cross-sectional data of women across 711 districts. Using the survey questions on reproductive care, I construct four outcomes. First, to understand current contraceptive use I create a dummy variable which equals 1 if the respondent is using contraception of some form at the time of survey. Second, I create a dummy variable which takes value 1 if the respondent has ever used a method to delay or postpone pregnancy. Third, I measure the decision-making power, recorded as a dummy variable which equals 1 if the respondent reports making contraception use decision independently and 0 if the decision is joint or made by the husband. Fourth, I capture awareness of modern contraception method, defined as a dummy equal to 1 if the respondent is aware of a modern contraception method and 0 otherwise. In addition, the NFHS also records important

[14]The survey was not conducted in 2017-18.

information on respondent's characteristics such as their marital status, literacy level, age of the respondent and residence type, which I include as controls in my analysis. Table 1 reports the summary statistics for these key variables. As highlighted, on an average approx. 43% of women in the sample report currently using some form of contraception, while around 54% report having ever used a method to delay or postpone pregnancy. Awareness of modern contraceptive methods is nearly universal (98%) while only about 9% of women report making contraceptive use decisions independently. In terms of sample characteristics, roughly 71% of respondents are married and about 27% reside in urban areas, with an average age of 30 years and just over three years of formal education on average.

Data on physical pharmacies: To complement the analysis of e-pharmacy expansion, I also construct measures of access to physical pharmacies across 640 districts in India as of 2025-26.[15] By accounting for offline accessibility to contraceptives, I can better distinguish whether observed effects arise from local accessibility constraints or from broader mechanisms such as stigma or social norms. Using the Google Maps Places API, I obtain geocoded locations of pharmacies registered on the platform across 640 districts of India.[16] To measure accessebility, I divide each district into uniform 20km x 20km grid cells and use the centroids of these grids to calculate distances. This approach ensures that even large districts are represented by multiple points, allowing me to capture local variation in access rather than relying on a single district centroid.[17] From this information, I create two district level measures: a) the average distance to the nearest pharmacy, defined as the mean of the minimum distances from each grid centroid to its nearest pharmacy and b) the number of unique pharmacies in a district and. Figure 7 illustrate the distribution of these two measures of physical pharmacy access across districts. Panel A shows that the average distance to the nearest pharmacy is relatively low for most districts, typically between 2 and 6 kilometers, although a small number of districts exhibit

[15] I conduct this analysis with a sample of 640 districts as the latest demarcated boundaries are available for only these districts per the 2011 census. The additional 71 districts were created out of these 640 districts in the latter years, which prevents me from getting the most updated shapefiles with geographical boundaries.

[16] Google maps data capture only those pharmacies registered on the platform, which may under-represent outlets in rural or less digitally connected areas. However, this remains the most comprehensive geocoded database of pharmacies currently available. To maximize coverage, I employ multiple search keywords (e.g. pharmacy, medicine shop etc.) and merge results after filtering for duplicates which reduces the likelihood of systematic undercounting.

[17] On an average the size of a district in India can be 4,948 sq km, with areas as vast as Kachchh (Gujarat) at over 45,000 sq km to tiny Mahé (Puducherry) at 8.69 sq km.

substantially larger distances. In my sample a nearest pharmacy is located at a distance of 4.9 km on an average. The second figure (Panel B) shows considerable variation in the number of pharmacies across districts, with most districts having several hundred outlets but a long right tail reflecting densely populated urban areas. In per capita terms, there are 1.19 unique pharmacies per 1000 population in a districts. Together, these distributions highlight substantial cross-district variation in physical pharmacy availability, which provides meaningful variation for examining whether the effects of e-pharmacies operate through physical access constraints. These variables are used in mechanism testing to address a key concern that observed effects of e-pharmacies on fertility and abortions may simply be driven by underlying physical barriers.

4. Identification Strategy

My identification strategy exploits the staggered roll-out of e-pharmacies across the districts of India. Using a difference-in-differences design with variation in treatment timing, I capture the average difference in outcomes for districts that gained access to e-pharmacies (treated districts) with those that did not (control districts). This is estimated using the following regression specification-

$$\mathbf{y_{dt}} = \beta_0 + \beta_1 \, \mathbf{E - pharmacy_{dt}} + \mu_d + \mu_t + \epsilon_{dt} \tag{3}$$

where y_{dt} is the outcome of interest i.e. births per 1000 women and abortions per 1000 women in a district (d) in year (t). $E - pharmacy_{dt}$ equals one if atleast one e-pharmacy operates in district (d) in year (t) and zero otherwise. District fixed effects (μ_d) account for time-invariant district-level characteristics such as baseline health infrastructure or demographic composition, while year fixed effects (μ_t) absorb nationwide shocks such as changes in policy, reporting systems, or macroeconomic conditions. The main coefficient of interest in this specification is β_1, which measures the causal effect of access to contraceptives through e-pharmacies on reproductive outcomes.[18] Standard errors are clustered at the district level.

[18]My estimates identify the intent-to-treat (ITT) or the changes in the outcome of being offered the treatment. Such a strategy is used in case of imperfect compliance where all those randomized out do not get the treatment; while those randomized in can choose not to take the treatment (Angrist, Imbens, & Rubin, 1996; Duflo,

In addition to the baseline two way fixed effect regression, I also implement a stacked difference-in-differences design that restricts comparisons to never treated districts.[19] This approach directly addresses recent concerns in the literature around bias in TWFE estimates when treatment timing is staggered due to implicit negative weighting of some cohort comparisons (De Chaisemartin & d'Haultfoeuille, 2020; Goodman-Bacon, 2021). To further avoid contamination from forbidden comparisons, I exclude districts that recieve treatment early on at the start of the sample (e.g. Bombay in 2015) as well as districts that receive treatment later in the sample (i.e. in and after 2020). This ensures that treatment effects are identified by comparisons between treated districts and a consistently untreated control group . Table 2 highlights the average socio-economic characteristics of the districts that were not-yet-treated by 2019 and the treated districts i.e. the districts with access to an e-pharmacy. The balance test shows that the two groups are broadly comparable across most dimensions such as growth rate, sex ratio, female literacy, land area and urban population with only notable difference in total population (as indicated by p-value).[20]

I next turn to the identification assumptions required for a causal interpretation of the estimates. The first assumption is no anticipation which requires that reproductive choices do no adjust across districts prior to arrival of e-pharmacies. This is unlikely in the present setting, as the timing of geographic expansion of e-pharmacies were not publicly announced in advance and followed a largely market-driven process, limiting the scope of altered behavior in anticipation of entry.

The second assumption of parallel trends require that in the absence of treatment, outcomes in the treated and the untreated districts would have evolved similarly. I test this assumption using the specification of the form:

$$\mathbf{y_{dt}} = \sum_{\mathbf{j=-1}} \beta_{\mathbf{j}} \mathbf{I}[\mathbf{j} = \mathbf{t} - \mathbf{t_{d,0}}] + \theta_d + \theta_t + \epsilon_{dt} \tag{4}$$

Glennerster, & Kremer, 2007).

[19]Given my analysis period is restricted from 2014 till 2019, the 22 districts that get treated post 2020 will be considered as never treated. As shown in Figure A3, districts that are not treated during the analysis window are geographically dispersed rather than concentrated in specific regions. This spatial pattern reduces concerns that treatment timing is driven by systematic regional differences correlated with reproductive health outcomes and assuages concerns around selection into treatment

[20]To account for this all regressions are weighted by district population

where $I[j = t - t_{d,0}]$ are the leads and lags relative to the year of e-pharmacy entry in a district. An insignificant β_j for the leads would satisfy this assumption denoting that outcomes for the treated and the comparison district evolved similarly prior to the advent of e-pharmacy. Together, these two assumptions ensure that the estimated coefficient captures the causal impact of e-pharmacy entry.

To further refine the identification, I construct a continuous measure of treatment intensity that exploits the staggered roll-out of e-pharmacies at the pincode level (see Figure 5).[21] Since districts are larger and heterogeneous geographical units, assigning treatment at this finer level helps to alleviate concerns around within-district variation in access or localised patterns of urbanization. Specifically, I calculate the share of pincodes that have access to an e-pharmacy in a district (d) at time (t). The causal effect of an increase in exposure to e-pharmacies is estimated using the following equation

$$\mathbf{y_{dt}} = \beta_0 + \beta_1 \mathbf{Intensity\ of\ Exposure_{dt}} + \theta_d + \theta_t + \epsilon_{dt} \tag{5}$$

where y_{dt} is the outcome variable (births or abortions per 1000 women) measured at the district(d)-year (t) level. $Intensity\ of\ Exposure_{dt}$ is a continuous variable which represents the fraction of pincodes with access to e-pharmacy in a district (d) in year (t) out of the total number of pincodes in district (d).[22] θ_t and θ_d are year and district fixed effects. Standard errors are clustered at the district level.

[21] In India, a PIN (Postal Index Number) code represents a specific geographical area, structured hierarchically: the first digit is the zone, the second the sub-zone/state, the third the sorting/revenue district, and the last three digits pinpoint the specific delivery post office within that district, enabling efficient sorting of regions to smaller geographical units across such a vast country.

[22] Figure A2 the evolution of the treatment intensity (y axis) across the districts. The blue line shows a steady increase in share of treated pincodes between 2015 and 2017, after which the treatment intensity stabilizes, with relatively little additional variation beyond 2018. This stands in line with the district level roll-out of e-pharmacies.

5. Findings

5.1. Main Results

Table 3 represents the baseline estimates from Equation 8. Panel A reports estimates from TWFE specification, while panel B presents results from the stacked design which I view as the preferred specification since it restricts comparison to the never treated districts.[23]

Consistent with the hypothesis that access to e-pharmacies improves women's ability to better plan fertility, both specifications report a decline in births and abortions. In panel A, the roll-out of e-pharmacies reduces births by about 1 per 1000 women (a decline of 3% as compared to the mean). The stacked design yields larger effects, with births declining by 2 per 1000 women (approx 6%) in treated districts as compared to the never-treated districts. Further, while decline in abortions is smaller and insignificant in the TWFE model, when compared with the never-treated districts the decline in abortions becomes significant. As per the stacked specification, there are 0.24 less abortions per 1000 women or a decline of 16% as compared to the mean.

I further examine the event study estimates obtained from Equation 4.[24] Figure 8 presents the dynamic effects for births. The coefficients show an immediate decline in births in the first year following the launch of e-pharmacies, consistent with the baseline estimates. However, this decline is short-lived: by the second year, the effect becomes statistically indistinguishable from zero, and remains so in subsequent years. This suggests that the initial reduction in births may capture a short-run adjustment in fertility behavior rather than a persistent decline. At the same time, the presence of some pre-treatment deviations raises caution in interpreting these estimates, as they may reflect imperfect control group alignment.

In contrast, the abortion results in Figure 9 show a distinct pattern. The estimates indicate little immediate effect in the year of rollout but reveal a significant decline beginning one year after treatment. Importantly, this decline persists over the following three to four years, with

[23]The never treated comparison group includes 22 districts that did not have access to an e-pharmacy during the our period of study i.e. between 2014 to 2019. These districts eventually receive access, however, it happens post our study period.

[24]The analysis is restricted to the sample excluding forbidden groups (early and late adopters), ensuring valid comparisons.

coefficients remaining negative over time. The absence of systematic pre-trends in abortions strengthens confidence in the parallel trends assumption for this outcome. Together, these dynamics suggest that while the fertility effects of e-pharmacy access are concentrated in the short run, the effects on abortions are more gradual yet sustained, consistent with women using improved contraceptive access to better plan pregnancies and avoid unwanted ones over time.

Finally, I turn to the results obtained from Equation 5 documented in Table 4. This specification captures whether districts with greater penetration of e-pharmacies experience larger effects for fertility or abortion, providing a dose–response interpretation of the treatment effect. Similar to the baseline results panel A reports estimates from TWFE specification. The coefficients on the share treated are small and statistically insignificant across all specifications for both the outcomes. Panel B presents the stacked estimates, which remains my preferred specification. The results show a modestly different pattern. The birth coefficients become negative and insignificant while the abortion coefficients are negative and statistically significant at the 5 percent level (–0.22 to –0.23),in line with the baseline. This indicates that districts with greater intensity of e-pharmacy exposure experienced a more pronounced decline in abortion rates. Both estimates for birth and abortions are consistent with the effects observed in the event-study analysis.

Taken together, the main findings reinforce the baseline conclusion: while the expansion of e-pharmacies had limited average effects on fertility, it was associated with a sustained decline in abortions, particularly in districts with greater exposure intensity.

5.2. Heterogeneity in Treatment Effects

I next examine whether the observed baseline effects vary systematically across districts with different socioeconomic characteristics. Identifying where the effects are strongest helps to understand where digital access to reproductive care is most consequential. To formally assess heterogeneity in treatment effects, I estimate the baseline difference-in-differences specification separately across districts with different levels of development and literacy levels. Table 5 reports results for districts above and below the sample mean share of villages, as well as for districts with high versus low female literacy. All specifications include district and year fixed

effects and are weighted by population.

Two clear patterns emerge. First, both the decline in births and the decline in abortions are concentrated in districts with a higher share of villages. In these predominantly rural districts, e-pharmacy entry leads to statistically significant reductions in births and abortions, whereas effects in more urban districts are smaller and statistically insignificant. This pattern suggests that digital platforms are particularly impactful in settings where traditional access to reproductive care is more constrained and socially visible. Second, treatment effects are stronger in districts with lower female literacy. In these districts, e-pharmacy expansion is associated with larger declines in both births and abortions, while districts with higher female literacy exhibit muted responses. This pattern indicates that the effects of e-pharmacies may not operate uniformly across educational environments and are potentially shaped by differences in social constraints rather than awareness of it.

Taken together, the heterogeneity results indicate that the effects of e-pharmacy expansion are not uniform across space but are concentrated in settings where offline and social constraints are likely to be more binding. These patterns motivate a closer examination of the channels through which e-pharmacies affect reproductive outcomes. In the next section, I investigate these mechanisms directly using the survey data.

5.3. Mechanism

5.3.1. The role of autonomy

The absence of strong effects on birth rates, despite greater contraceptive access, suggests that the primary constraints to fertility control may lie in subtler margins such as women's ability to independently manage pregnancies by circumventing social stigma. These could be potential channels through which e-pharmacy availability matters. This section explores these mechanisms in detail.

As shown in the baseline results, I find a significant decline in abortions but no long-run change in fertility in districts where e-pharmacies became available. This pattern potentially implies that women are increasingly able to avoid unwanted or mistimed pregnancies i.e. those pregnancies that might otherwise have resulted in abortion without altering their desired num-

ber of children. To test this hypothesis, I use the survey data (NFHS) and estimate the following regression equation:

$$\mathbf{y_{itd}} = \beta_0 + \beta_1 \mathbf{Epharmacy_{idt}} + \theta_s + \theta_t + \gamma_{it} + \epsilon_{itd} \tag{6}$$

where y_{itd} is the outcome variable measured at the individual (i)- year (t)- district(d) level. $E - pharmacy_{idt}$ is a dummy which takes value 1 if individual (i) belongs to district (d) and period (t) is post intervention, zero otherwise. θ_t and θ_s represent year and state fixed effects.[25] γ_{it} represents a vector of controls such as age, education, marital status and residence. Standard errors have been clustered at the district level.

The results, presented in Table 6, show a significant increase of 3% in the reported use of contraceptives to delay or avoid pregnancy following e-pharmacy entry. This indicates that e-pharmacies help women plan and space births more effectively and independently. I also test whether access to e-pharmacies encourages independent decision making for women. Estimating Equation 6 shows a 2.4% increase in women reporting that the decision to use contraception was made by themselves, rather than jointly or by a partner. This rise in autonomous decision-making underscores that what e-pharmacies change is not merely access but agency. They enable women to act on existing preferences without external interference.

Next, I examine whether these effects operate through informational channels. Re-estimating Equation 6, I find a 1% effect in women's knowledge of modern contraceptive methods which disappears with a more demanding specification (see column (3) and (4) of Table 7), but a 3% increase in actual usage of modern methods after the intervention of e-pharmacies as highlighted in Table 7. This divergence between knowledge and use highlights that information was not the binding constraint. Instead, barriers to action stemming from stigma, negotiation with partners or lack of privacy appear to be the key. By gaining contraceptive access through private, judgment-free digital platforms, e-pharmacies lower the social visibility of contraceptive use and mitigate the perceived barriers associated with social disapproval or partner opposi-

[25] I do not use district FE due to the pooled cross-section nature of data

tion.[26]

Furthermore, estimating Equation 6 separately by marital status reveals systematic heterogeneity in the mechanisms through which e-pharmacy access operates Table 8. Among married women, e-pharmacy availability significantly increases the likelihood of reporting an attempt to delay pregnancy (by 3.8%). The use of contraceptives increases by 3.3% but remains insignificant, while effects on knowledge of methods are small and statistically insignificant. This suggests that for married women who are already highly informed about contraceptive options, digital access primarily relaxes barriers to autonomy over reproductive choices rather than information.[27] In contrast, among unmarried women, e-pharmacy entry generates a positive and significant increase in contraceptive use (0.9%) and a significant improvement in knowledge of modern methods (2.6%), despite no detectable change in reported attempts to delay pregnancy (as might be expected, given unmarried women are not involved in family planning yet). These effects suggest that e-pharmacies simultaneously relax informational constraints and reduce stigma-related barriers to private uptake, which are likely to be more binding outside marriage. Overall, the split-sample results reinforce the interpretation that digital platforms matter less by shifting overall fertility intentions and more by enabling women across marital statuses to implement those intentions under conditions of greater privacy and autonomy.

Together, these results reveal that e-pharmacies enable women to act on existing preferences i.e. to delay, to decide and to do so privately rather than altering demand. This interpretation closely mirrors findings from large scale experiments. In particular, Ashraf et al. (2014), using a field experiment in Zambia, found that women given private access to concealable injectables (without their husbands present) were 25% more likely to use contraceptives, and 27% less likely to give birth. The authors concluded that privacy and autonomy dramatically enhanced adoption. My results extend this insight to a real-world, non-experimental digital setting: by moving contraceptive access online, e-pharmacies replicate the autonomy and discretion provided experimentally in Ashraf et al. (2014). Digital autonomy allows women to circumvent

[26]To further validate the results, Table A1 in the appendix examines whether the effect of e-pharmacy availability on current contraceptive use differs by women's mobile phone ownership, comparing women who own a mobile phone to those who do not. E-pharmacy access increases contraceptive use significantly by 2% more among women who own mobile phones as compared to those that do not.

[27]The question on decision to use contraceptives is only asked from married women, hence it is not examined in heterogeneity check.

social constraints that otherwise limit contraceptive use.

5.3.2. Physical access vs social access

An important implication of e-pharmacy expansion could be that it may mitigate barriers to physical access. If this mechanism is at play, then the presence and proximity of brick-and-mortar pharmacies should matter: districts with more distant physical pharmacies would rely more on e-pharmacies for reproductive care products. Consequently, if e-pharmacies primarily operate by easing access constraints, their effect on fertility and abortions should be stronger in such areas. To test this, I use data on the spatial distribution of physical pharmacies and conduct two exercises. First, I examine whether a greater distance to physical pharmacies in a district is correlated with higher online sales of reproductive care products. Second, I causally test whether increasing distance to the nearest physical pharmacy amplifies the estimated effects of e-pharmacy availability on fertility and abortion outcomes.

To formally assess whether physical access drives the uptake of reproductive care products online, I estimate the following regression:

$$\mathbf{y_d} = \beta_0 + \beta_1 \mathbf{Distance\ to\ nearest\ pharmacy_d} + \gamma_d + \epsilon_d \tag{7}$$

where

y_d denotes average of total online sales of reproductive care products in district d from 2020 to 2025 per 1000 population.[28] Sales data are restricted to the post-2020 period to ensure that observed sales are not mechanically correlated with the e-pharmacy expansion phase, which is the treatment window in the main analysis. This helps isolate any transitional dynamics during rollout. The key explanatory variable, $Distance\ to\ nearest\ pharmacy_d$, is a continuous measure representing the average of the nearest distances (in km) from each 20 km central grid point within a district to the closest licensed physical pharmacy. γ_d includes controls for district-level population, total area, and pharmacy density (pharmacies per capita). Standard

[28] The outcome has been winsorized at 99 percentile to deal with extreme case of outliers.

errors are robust to heteroskedasticity. [29] Table 9 presents the results from Equation 7. Across all specifications and outcomes (total sales per 1000 population, total sale of male products per 1000 men and total sales of female reproductive care products per 1000 women) there is no statistically significant relationship between distance to the nearest pharmacy and online sales. The coefficients are small in magnitude. Thus, I can reject the hypothesis that a greater distance to physical pharmacies in a district is correlated with higher online sales of reproductive care products

Next, I test whether the effect of e-pharmacy on reproductive outcome varies with distance to physical pharmacy. Specifically, I extend the baseline specification (Equation 8) by including an interaction term for distance with the treatment indicator. The remainder of the model, including fixed effects for district and year remains identical to the main specification. The estimating equation is given by:

$$\mathbf{y_{dt}} = \beta_0 + \beta_1 \, \mathbf{E-pharmacy_{dt} x \, High \, Distance_d} + \mu_d + \mu_t + \epsilon_{dt} \tag{8}$$

where the dependent variables are the number of births and abortions per 1,000 women. $E-pharmacy_{dt}$ is a dummy that equals 1 if an e-pharmacy operates in district d at time t, while $High\ Distance_d$ equals 1 if the district's average distance to the nearest physical pharmacy is above the sample mean. The coefficient captures whether the treatment effect differs across districts with relatively higher vs lower access to physical pharmacy. Results obtained from the above equation are reported in Table 10. The estimated interaction coefficients are close to zero and statistically insignificant across all specifications. Importantly, the absence of a significant coefficient indicates that the effect of e-pharmacy expansion on reproductive outcomes does not depend on proximity to physical pharmacies. Hence, barrier to access can be ruled out as a channel through which e-pharmacies influence reproductive outcomes.

Corroborating evidence from both tests reveal that the baseline effects observed for e-pharmacy is not driven by physical inaccessibility. Instead, these null effects reinforce the interpretation that e-pharmacies operate through channels of stigma; improving privacy and

[29] Additionally, this regression is only restricted to 618 treated districts and does not include the 22 never treated districts.

enhancing women's autonomy to act on their reproductive preferences. The e-pharmacy setting therefore provides a unique institutional environment where the visibility of contraceptive use is reduced, allowing women to exercise greater control over fertility decisions within the same structural and informational environment.

5.4. Robustness Checks

In this section, I conduct a series of robustness checks to assess the sensitivity of the main findings to alternative estimation strategies, outcome definitions, and inference procedures. Across all exercises, the core results remain unchanged: access to e-pharmacies is associated with a decline in abortions and limited average effects on fertility.

Alternative specification-Poisson models: The main specifications estimate treatment effects in levels of births and abortions per 1,000 women. To assess robustness to alternative distributional assumptions appropriate for count outcomes, I re-estimate the baseline specifications using Poisson quasi–maximum likelihood estimation. These models allow treatment effects to be interpreted as semi-elasticities and relax the assumption of linearity in levels. As shown in Appendix Table A2, the Poisson estimates yield effects of similar sign and magnitude to the baseline results, with a statistically significant decline in abortions and minor decline in births. This indicates that the findings are not driven by functional form assumptions.

Alternative outcome definitions: I next test whether the results are sensitive to the construction of the outcome variables. First, I re-estimate the stacked difference-in-differences models using unadjusted outcomes, without winsorizing extreme values. Second, I construct alternative outcomes winsorized at the 99th percentile rather than using the baseline adjustment. Appendix Table A3 shows that the estimated coefficients remain stable across these alternative definitions. In particular, the decline in abortions persists across all specifications, while effects on births remain small and less precisely estimated. This suggests that the results are not driven by outliers or specific trimming choices.

Alternative inference- clustering at the state level: In the main analysis, standard errors are clustered at the district level to account for serial correlation within districts. To address concerns about spatial correlation and shocks within states, I re-estimate the main specifications

clustering standard errors at the state level instead. Appendix Table A4 shows that statistical significance is largely preserved, particularly for abortion outcomes, indicating that inference is robust to more conservative clustering.

Alternative definition of treatment intensity: I assess robustness to an alternative measure of exposure intensity. Rather than exploiting year-to-year variation in the share of treated pincodes, I define intensity using the median share of treated pincodes within each district over the period 2018–2024. This approach captures long-run exposure while mitigating concerns about limited within-district variation over time. Appendix Table A5 reports results estimating Equation 5 using this median-based intensity measure as the independent variable. Consistent with the baseline intensity results, districts with greater exposure experience larger declines in abortions, while effects on births remain modest and statistically insignificant.

Mediation analysis with sales and outcome: As an additional robustness exercise, I explore whether the district-level heterogeneity in estimated treatment effects is related to the online purchases of female reproductive health products. Specifically, I estimate district-specific treatment effects using the following specification:

$$\mathbf{y_{dt}} = \beta_0 + \beta_1 \mathbf{Epharmacy_{dt}} * \theta_d + \theta_t + \epsilon_{dt} \tag{9}$$

where, y_{dt} is the outcome variable measured at the district(d)-year (t) level, β_1 gives the treatment effect for each district, θ_t represent year fixed effect and use robust standard errors. Using the information on sales from Tata 1mg, I obtain the average per-capita sales of female reproductive products at the district level.[30] Figure A4 plot the estimated district-level treatment effects on births and abortions against average sales per 1,000 women[31] The patterns reveal a negative association between sales and treatment effects on abortions and a positive slope for births. While these correlations are not interpreted causally, they are consistent with the hypothesized mechanism for abortions whereby increased access to contraceptive products through online channels may as lower abortion responses.

[30] This does not include pregnancy test kits or menopausal pills

[31] The β_1 are weighted by standard errors obtained from Equation 9

Overall, these robustness checks support the main conclusions of the paper. The estimated effects of e-pharmacy expansion are not sensitive to functional form, outcome construction, clustering choices, or alternative definitions of exposure intensity, reinforcing the interpretation that digital access primarily affects reproductive outcomes through channels related to privacy, autonomy, and the ability to act on existing preferences rather than through physical access or information alone.

6. Conclusion

This paper provides the first causal evidence on the impact of digital healthcare platforms on women's reproductive outcomes in a developing country context. Exploiting the staggered geographic expansion of e-pharmacies across Indian districts between 2014 and 2019, I find that access to digital contraceptive procurement channels generated persistent reductions in abortion rates while producing only short-run effects on fertility. In the preferred stacked difference-in-differences specification, districts with e-pharmacy access experienced a 16% decline in abortions per 1,000 women, an effect that persisted three to four years after platform entry. In contrast, the initial 6% reduction in births dissipated within two years. These effects are concentrated in rural districts and districts with lower female literacy precisely the settings where social constraints on contraceptive access are likely most binding.

Mechanism analysis reveals that e-pharmacies operate through enhanced privacy and autonomy rather than information provision or improved physical access. Survey evidence shows that women increasingly use contraceptives to delay pregnancy and make contraceptive decisions independently, without corresponding changes in knowledge of modern methods. Together, these findings demonstrate that when digital platforms reduce the social visibility of contraceptive procurement, women gain the ability to act on existing fertility preferences without requiring changes in norms, information, or physical infrastructure.

The results have important implications for reproductive health policy in developing countries. First, they suggest that interventions aimed purely at expanding physical access or providing information may miss the fundamental barrier: social stigma and lack of privacy. Poli-

cies that reduce the visibility of contraceptive use, whether through digital platforms or other discrete distribution channels may be more effective than traditional clinic-based or pharmacy-based provision in settings where normative constraints are binding. Second, the concentration of effects in rural and low-literacy districts indicates that digital health technologies can serve as equalizers, expanding reproductive autonomy precisely where it has been most constrained. This points to a potential role for targeted digital health interventions in reducing geographic and socioeconomic disparities in reproductive outcomes. Third, the persistent decline in abortions without a corresponding long-run decline in fertility suggests that e-pharmacies enable women to avoid unwanted or mistimed pregnancies rather than reducing desired family size. This distinction matters for policy design: platforms that enhance contraceptive privacy may improve welfare through better pregnancy timing and spacing without necessarily altering completed fertility.

More broadly, these findings contribute to ongoing debates about the economic returns to reproductive control. The literature has established that contraceptive access can reduce maternal mortality, increase labor force participation, and improve educational attainment (Ahmed et al., 2012; Bailey, 2006; Goldin & Katz, 2002). Yet recent experimental evidence shows that free provision alone yields limited fertility effects (Ashraf et al., 2010; Dupas et al., 2025), raising questions about which dimensions of access matter most. My results help resolve this puzzle: the critical margin is not price or physical availability but privacy and autonomy. By extending the experimental findings of Ashraf et al. (2010) to a real-world, market-driven setting, this paper demonstrates that technological innovations can replicate the autonomy-enhancing effects documented in controlled trials, offering a scalable pathway to expanding women's reproductive agency in settings where social norms remain restrictive.

The findings also speak to the role of digital platforms in alleviating market frictions driven by discrimination and social norms. In labor markets, competition has been shown to reduce gender wage gaps and improve female occupational outcomes by raising the cost of discriminatory hiring (Black & Brainerd, 2004). In the reproductive health domain, e-pharmacies appear to operate analogously: by offering an alternative procurement channel that bypasses social gatekeepers, they reduce the implicit cost that stigma imposes on contraceptive access.

This suggests that market structure and platform design can shape not only the efficiency of resource allocation but also the distribution of agency and empowerment across demographic groups. Future research could leverage platform-level policy changes, randomized promotional campaigns or regulatory shocks to generate more cleanly exogenous variation in access.

Several limitations of this study point toward directions for future research. First, the analysis focuses on administrative outcomes births and abortions and cannot directly measure women's subjective wellbeing, relationship quality, or long-run economic trajectories such as labor market participation and educational investments. Second, the survey data do not permit identification of which specific contraceptive methods women adopt or how method choice varies with platform access, limiting understanding of the precise pathways through which abortion declines occur. Third, the analysis is restricted to the 2014–2019 period due to data availability and COVID-19 disruptions, precluding assessment of longer-run effects on completed fertility or intergenerational outcomes.

Despite these limitations, the evidence presented here establishes that digital healthcare platforms can meaningfully expand women's reproductive autonomy in developing countries where social stigma constrains contraceptive access. As digital infrastructure continues to expand across the developing world, understanding how to design platforms that maximize privacy, minimize barriers, and empower marginalized groups will become increasingly important. The findings suggest that when technology reduces the social cost of exercising reproductive choice, women respond by acting on preferences they already held, preferences that traditional delivery channels prevented them from realizing. In this sense, e-pharmacies do not create new demand but unlock latent demand that social constraints had suppressed. The policy challenge is to ensure that such platforms remain accessible, affordable, and designed with women's autonomy at the center, so that technological progress translates into genuine empowerment rather than merely shifting constraints from one domain to another.

References

Ahmed, S., Li, Q., Liu, L., & Tsui, A. O. (2012). Maternal deaths averted by contraceptive use: An analysis of 172 countries. *The Lancet*, *380*(9837), 111–125.

Ananat, E. O., & Hungerman, D. M. (2012). The power of the pill for the next generation: Oral contraception's effects on fertility, abortion, and maternal and child characteristics. *Review of Economics and Statistics*, *94*(1), 37–51.

Angrist, J. D., Imbens, G. W., & Rubin, D. B. (1996). Identification of causal effects using instrumental variables. *Journal of the American Statistical Association*, *91*(434), 444–455.

Ashraf, N., Field, E., & Lee, J. (2014). Household bargaining and excess fertility: an experimental study in zambia. *American Economic Review*, *104*(7), 2210–2237.

Ashraf, N., Karlan, D., & Yin, W. (2010). Female empowerment: Impact of a commitment savings product in the philippines. *World development*, *38*(3), 333–344.

Bailey, M. J. (2006). More power to the pill: The impact of contraceptive freedom on women's life cycle labor supply. *The Quarterly Journal of Economics*, *121*(1), 289–320.

Bailey, M. J. (2013). *Fifty years of family planning: New evidence on the long-run effects of increasing access to contraception* (Tech. Rep.). National Bureau of Economic Research.

Bailey, M. J., Hershbein, B., & Miller, A. R. (2012). The opt-in revolution? Contraception and the gender gap in wages. *American Economic Journal: Applied Economics*, *4*(3), 225–54.

Black, S. E., & Brainerd, E. (2004). Importing equality? the impact of globalization on gender discrimination. *ILR Review*, *57*(4), 540–559.

De Chaisemartin, C., & d'Haultfoeuille, X. (2020). Two-way fixed effects estimators with heterogeneous treatment effects. *American Economic Review*, *110*(9), 2964–96.

Duflo, E., Glennerster, R., & Kremer, M. (2007). Using randomization in development economics research: A toolkit. *Handbook of Development Economics*, *4*, 3895–3962.

Dupas, P., Jayachandran, S., Lleras-Muney, A., & Rossi, P. (2025). The negligible effect of free contraception on fertility: Experimental evidence from burkina faso. *American*

Economic Review, *115*(8), 2659–2688.

Goldin, C., & Katz, L. F. (2002). The power of the pill: Oral contraceptives and women's career and marriage decisions. *Journal of Political Economy*, *110*(4), 730–770.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, *225*(2), 254–277.

Jain, D., & Rozario, N. M. (2013). *Voices from the field: Women's access to contraceptive services and information in Haryana.* Centre for Health Law, Ethics and Technology, Jindal Global Law.

Mooney-Somers, J., Lau, A., Bateson, D., Richters, J., Stewart, M., Black, K., & Nothnagle, M. (2019). Enhancing use of emergency contraceptive pills: A systematic review of women's attitudes, beliefs, knowledge, and experiences in Australia. *Health Care for Women International*, *40*(2), 174–195.

Mukherjee, S., Mahapatra, B., & Saggurti, N. (2021). Why women do not use contraceptives: Exploring the role of male out-migration. *PloS one*, *16*(3), e0249177.

Munshi, K., & Myaux, J. (2006). Social norms and the fertility transition. *Journal of development Economics*, *80*(1), 1–38.

Narita, R., & Diaz, M. D. M. (2016). Teenage motherhood, education, and labor market outcomes of the mother: Evidence from brazilian data. *Economia*, *17*(2), 238–252.

Sully, E., Biddlecom, A., Darroch, J., Riley, T., Ashford, L., Lince-Deroche, N., ... Murro, R. (2020, 07). Adding it up: Investing in sexual and reproductive health 2019.

Figure 1: Web interface of Tata1Mg: The figure shows the product search interface of the digital healthcare platform for contraceptive products. It includes product listings, prices, delivery timelines, ratings and filtering options. The interface suggests a low-friction purchasing environment, where reproductive health products are easily discoverable, comparable and accessible to users with minimal search or transaction costs.

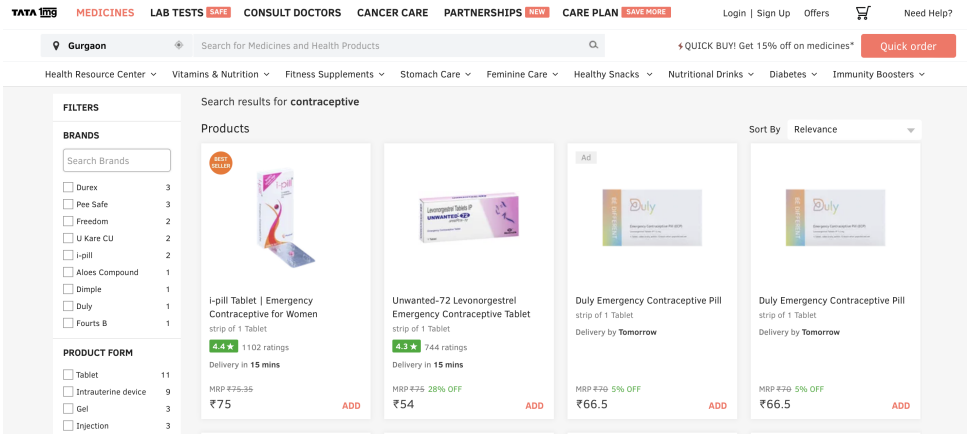


Figure 2: Total sales of reproductive healthcare products by Tata 1mg: The figure plots annual total units sold between 2017 and 2023. The red line shows a steady and sharp increase in sales volume over time. This upward trend indicates a rapid expansion in demand for reproductive health products on the platform, consistent with growing adoption of digital health marketplaces for such purchases.

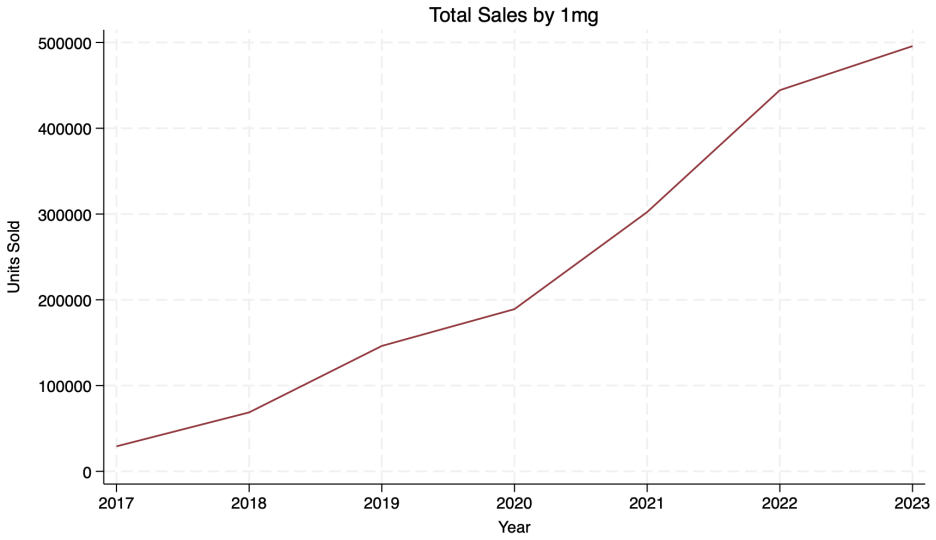


Figure 3: Composition of contraceptive sales on Tata 1Mg: The figure presents the percentage composition of total contraceptive sales by product category between 2017 and 2023. The changing distribution suggests an increasing relative importance of contraceptive pills and pregnancy-related products, alongside a gradual decline in the dominance of condoms within total sales.

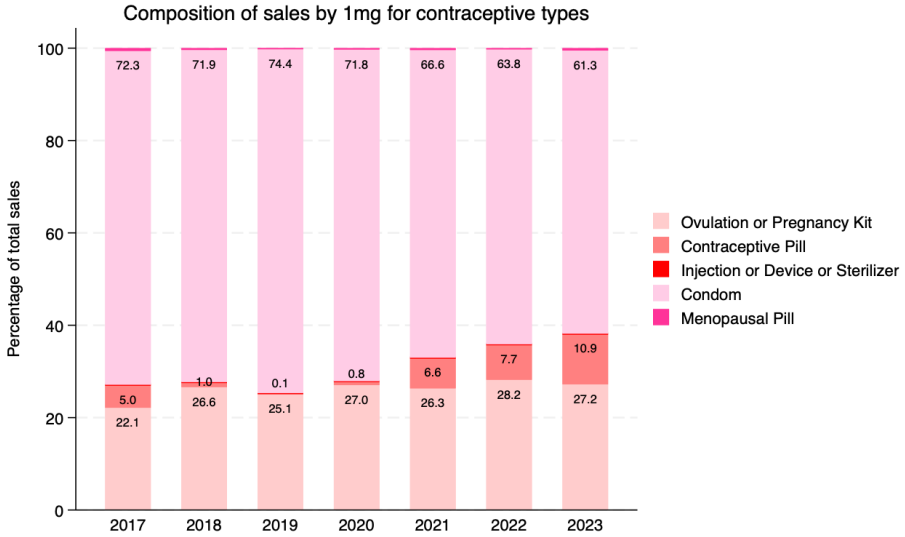


Figure 4: Share of sales by male vs female oriented products: The figure shows the sale of annual share of total reproductive care products attributed to male and female use between 2017 and 2023. The convergence in these shares over time suggests a relative increase in demand for female-oriented reproductive health products compared to male-oriented products on the platform.

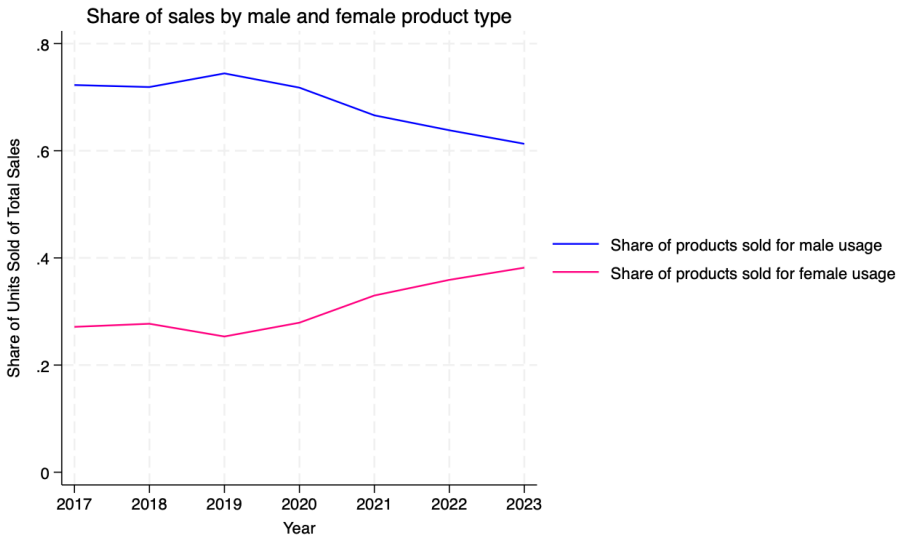


Figure 5: Expansion of e-pharmacies across India. Panel A plots the cumulative number of Indian districts and Panel B plots the cumulative number of pincodes that gained access to at least one e-pharmacy between 2014 and 2024. The staggered expansion began in 2015 and progressed to universal coverage by 2024.

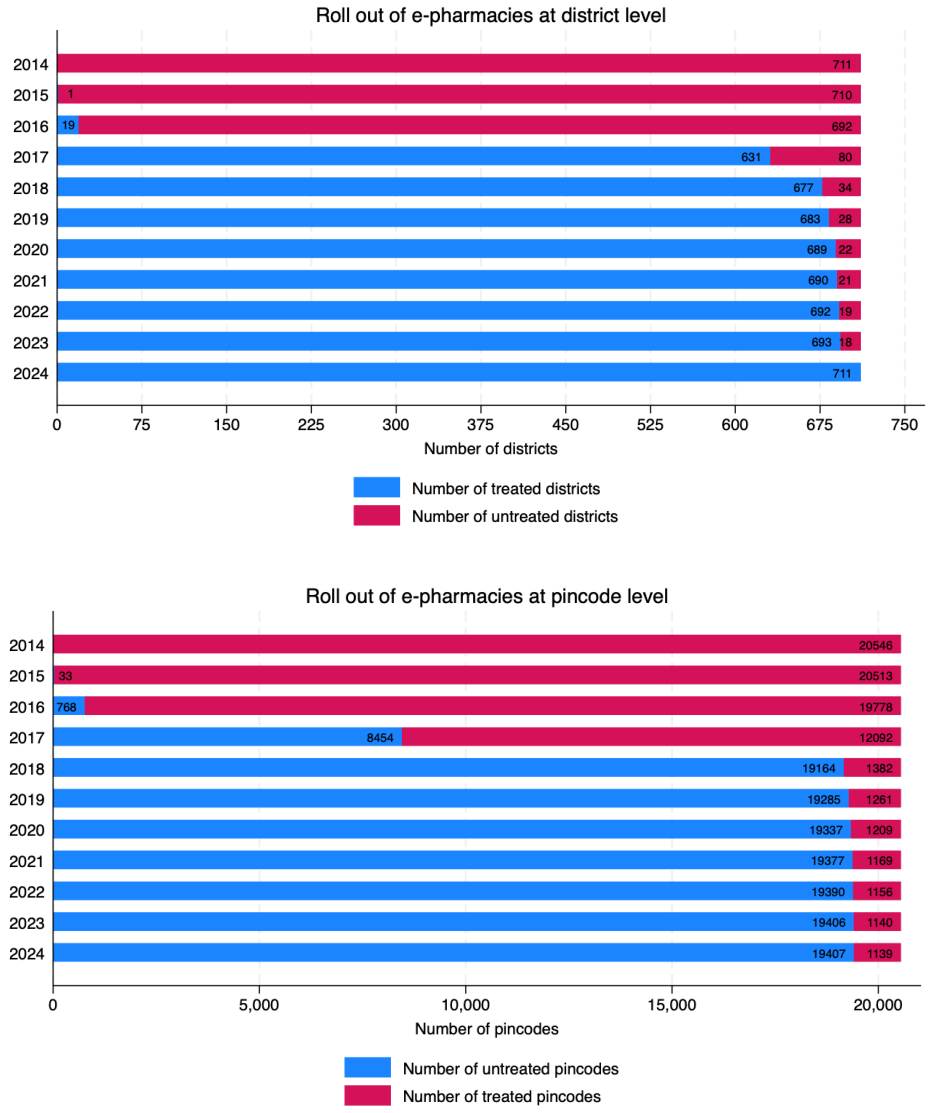


Figure 6: Trends in abortions and births over the study period: Panel A plots the average number of abortions per 1,000 women and Panel B plots the average number of births per 1,000 women between 2014 and 2019.The trend line shows a decline in abortion rate after 2016, while fertility rates remain largely stable over the same period

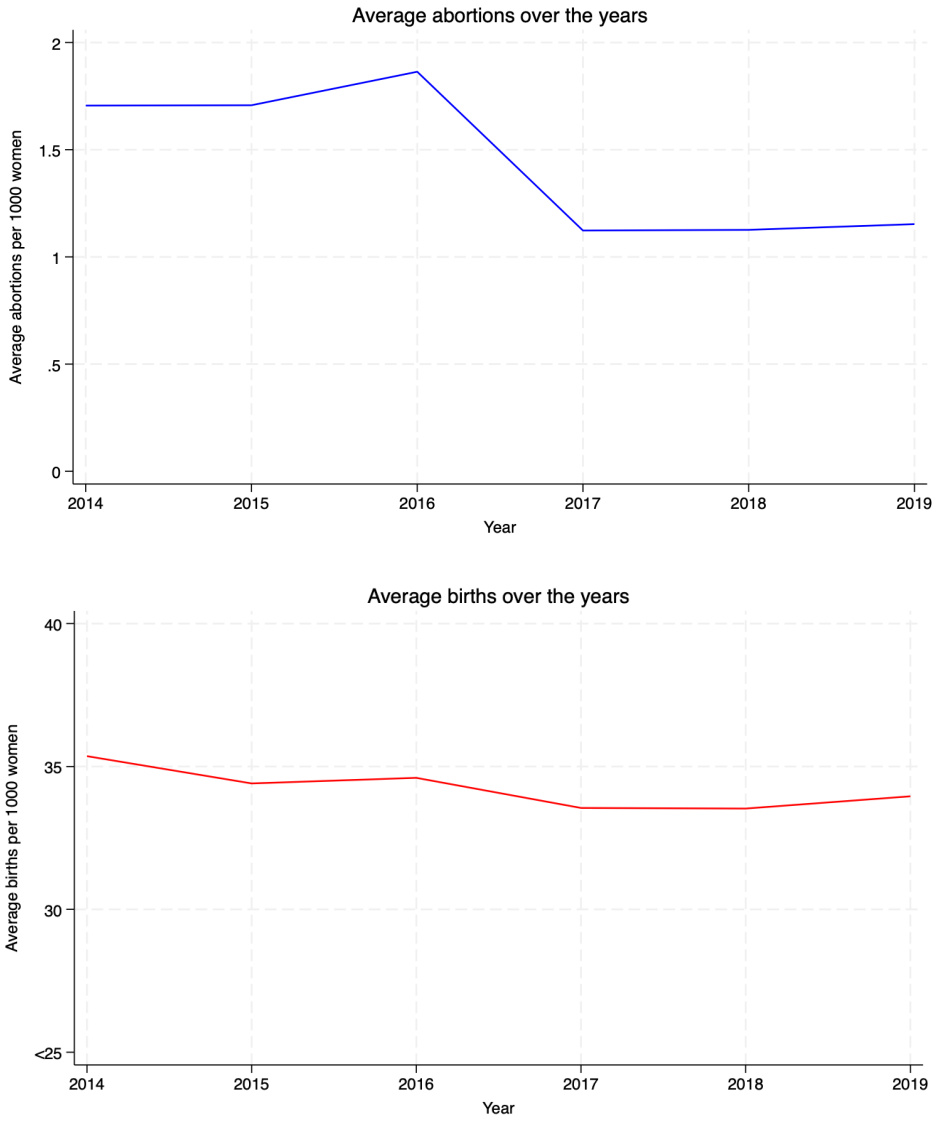


Figure 7: Distribution of physical pharmacies across districts Panel A plots the distribution of number of unique pharmacies identified in each district and Panel B shows the distribution of the district-level measure of physical access to pharmacies in year 2025-26 obtained from google maps API. The two histograms represent considerable variation in access to physical pharmacies across districts.

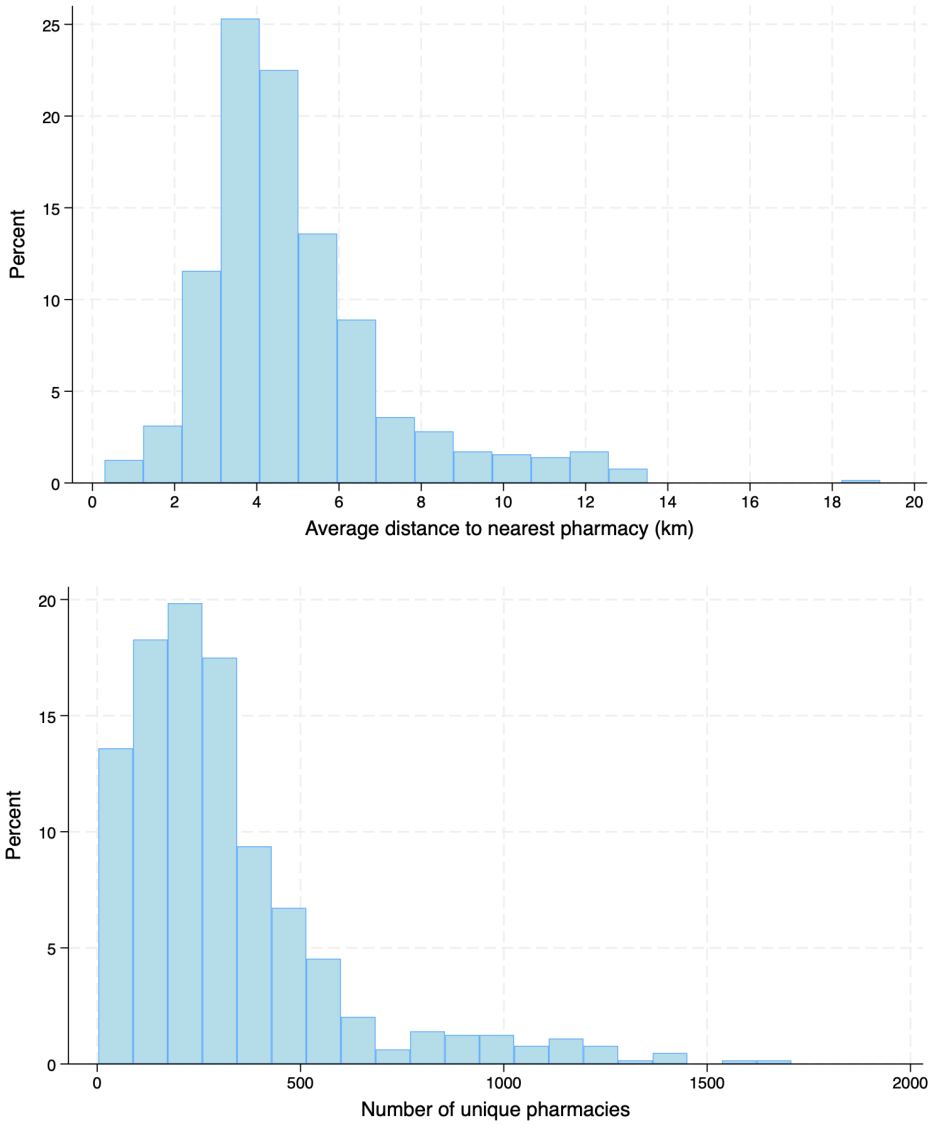


Figure 8: Event-study estimates of the effects of e-pharmacy access on births. The graph plots the dynamic treatment effects for births, with event time normalized to the year before e-pharmacy entry. Estimates are shown for four specifications. Points represent coefficient estimates and vertical bars indicate 95% confidence intervals. The estimates indicate a short-lived decline in births following e-pharmacy entry but nopersistent effect.

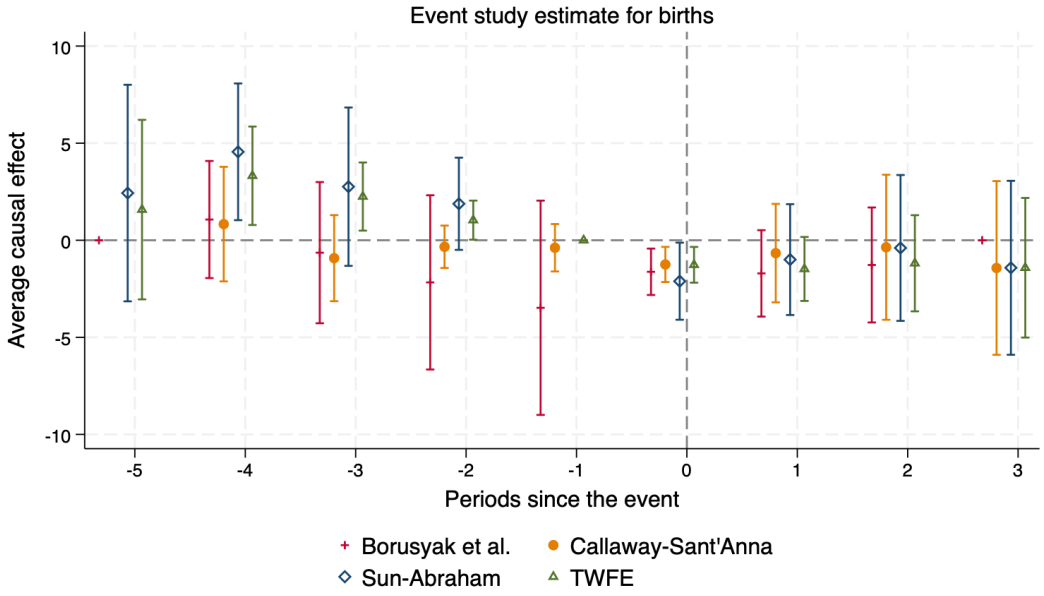


Figure 9: Event-study estimates of the effects of e-pharmacy access on abortions. The graph plots the dynamic treatment effects for abortions, with event time normalized to the year before e-pharmacy entry. Estimates are shown for four specifications. Points represent coefficient estimates and vertical bars indicate 95% confidence intervals. There is a delayed but persistent reduction in abortions, with no strong evidence of pre-trends for the outcome.

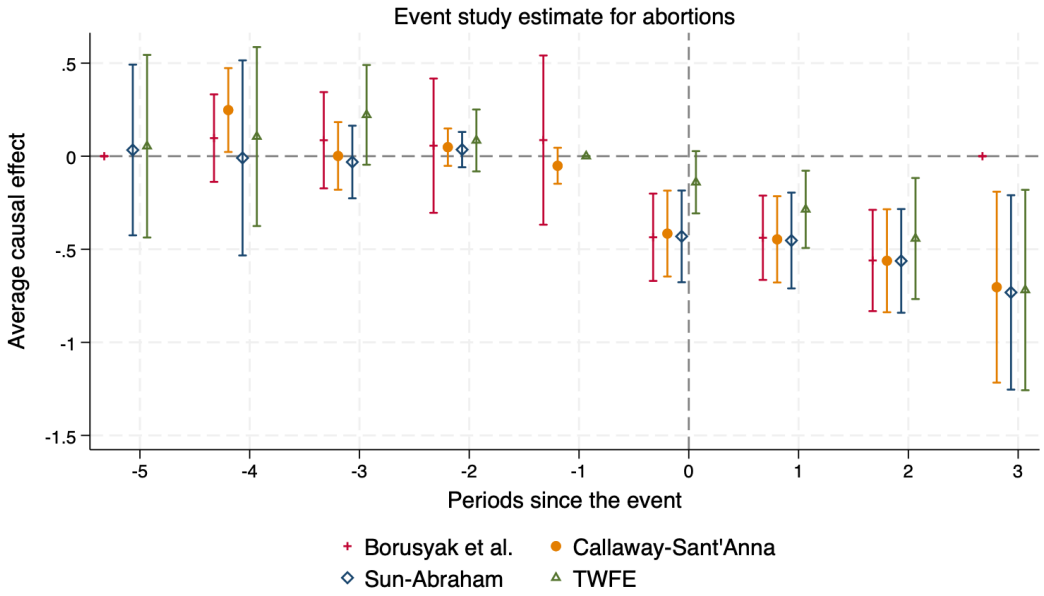


Table 1: Descriptive estimates for the survey data

Summary statistics		
Variable	Mean	SD
Main outcomes		
Current contraceptive use	0.432	0.495
Used contraceptive to delay pregnancy	0.537	0.499
Independent decision to use contraceptive	0.092	0.29
Awareness of method	0.983	0.131
Characteristics		
Marital status	0.711	0.453
Residence (1=urban)	0.269	0.443
Age	30.183	9.823
Years of education	3.105	2.312
Sample (N)		1,329,752

Notes: The table reports means and standard deviations for key reproductive health outcomes and individual characteristics using nationally representative NFHS survey data for the sample period.

Table 2: Average socio-economic characteristics of the districts

Summary Statistics as per 2011 census of India			
Variable	Not yet treated	Treated	Balance Test
Growth rate	19	17	.48
% urban population	20	25	.17
Sex ratio	931	946	.2
Overall literacy rate	72	73	.63
Female literacy	65	65	.75
Male literacy	79	81	.1
Area (sqkm)	5,650	4,998	.46
Population density	262	916	.24
Total population	6,76,856	1980973	0.001*
Sample (N=711)	28	683	

Notes: The table reports average district-level socio-economic characteristics from the 2011 Population Census, separately for districts that received access to e-pharmacies during the study period and those not yet treated. With the exception of total population size, treated and untreated districts appear broadly similar across observable baseline characteristics, suggesting limited systematic differences prior to the roll-out of e-pharmacies.

Table 3: Effect of e-pharmacy access on births and abortions

Panel A: TWFE				
	(1)	(2)	(3)	(4)
DV (per 1000 women)	Births		Abortions	
Sample	Baseline	Exclude Forbiddens	Baseline	Exclude Forbiddens
Treated	-1.117***	-1.142***	-0.094	-0.083
	[0.409]	[0.429]	[0.094]	[0.100]
Observations	4,114	4,074	4,114	4,074
R squared	0.946	0.945	0.761	0.757
Panel B: Stack DID				
Treated	-1.983***	-2.081***	-0.239***	-0.256***
	[0.607]	[0.643]	[0.068]	[0.072]
Observations	3,096	2,922	3,096	2,922
R squared	0.961	0.960	0.786	0.782
Mean	34.22	34.21	1.441	1.438
Year and District FE	Yes	Yes	Yes	Yes

Notes: The table reports difference-in-differences estimates of the effect of access to e-pharmacies on births and abortions measured per 1,000 women at the district–year level. Panel A presents estimates from a two-way fixed effects (TWFE) and Panel B presents estimates from a stacked difference-in-differences design that restricts the comparison group to districts that do not receive access to an e-pharmacy during the study period (2014–2019). There is a significant decline in birth across both specifications and decline in abortions in the stacked estimate. All specifications include district and year fixed effects. Standard errors, clustered at the district level, are reported in parentheses. '***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Effect of intensity of e-pharmacy exposure on births and abortions

Panel A: TWFE				
	(1)	(2)	(3)	(4)
DV (per 1000 women)	Births		Abortions	
Sample	Baseline	Exclude Forbiddens	Baseline	Exclude Forbiddens
Share Treated	-0.132	-0.111	0.002	0.009
	[0.439]	[0.450]	[0.075]	[0.077]
Observations	4072	4032	4072	4032
R squared	0.946	0.945	0.761	0.757
Panel B: Stack DID				
Share Treated	-0.206	-0.195	-0.224**	-0.229**
	[0.852]	[0.865]	[0.114]	[0.115]
Observations	2970	2838	2970	2838
R squared	0.96	0.959	0.785	0.781
Mean	34.22	34.21	1.441	1.438
Year and District FE	Yes	Yes	Yes	Yes

Notes: The table reports difference-in-differences estimates using treatment intensity as a the independent variable. The dependent variables are births and abortions per 1,000 women at the district–year level. Panel A presents estimates from a two-way fixed effects (TWFE) and Panel B reports estimates from a stacked difference-in-differences design. Coefficients capture the marginal effect of an increase in treatment intensity. The estimates highlight that higher e-pharmacy penetration is associated with a larger and statistically significant reduction in abortions, while effects on births remain small and insignificant. All specifications include district and year fixed effects. Standard errors, clustered at the district level, are reported in parentheses. '***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively

Table 5: Heterogeneity in the effects of e-pharmacy access by district characteristics

Heterogeneity results				
	(1)	(2)	(3)	(4)
DV (per 1000 women)	Births			
	Female literacy		Villages	
Treated	-0.533	-2.357**	-1.645**	-0.579
	[0.428]	[0.948]	[0.637]	[0.574]
Observations	2,048	2,026	2,151	1,923
Mean	34.21	34.21	34.21	34.21
DV	Abortions			
Treated	-0.106	-0.189*	-0.242***	-0.000
	[0.152]	[0.105]	[0.093]	[0.160]
Observations	2,048	2,026	2,151	1,923
Mean	1.438	1.438	1.438	1.438
Year and District FE	Yes	Yes	Yes	Yes
Compared to mean	High	Low	High	Low

Notes: This table reports heterogeneity estimates from the baseline difference-in-differences specification, estimated separately across districts grouped by socioeconomic characteristics. Columns (1) and (2) split districts by female literacy levels (above and below the sample mean), while columns (3) and (4) split districts by the share of villages (above and below the sample mean). All specifications include district and year fixed effects and are weighted by district population. Treatment effects are concentrated in more rural and lower–female-literacy districts, indicating that e-pharmacies are most impactful where social constraints are likely to be more binding. Standard errors, clustered at the district level, are reported in parentheses. '***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6: Effects of e-pharmacy access on delaying pregnancy and decision-making to use contraceptive

	(1)	(2)	(3)	(4)
DV	Tried to delay pregnancy		Decision to use	
Sample	Baseline	Exclude Forbiddens	Baseline	Exclude Forbiddens
Treated	0.031*	0.031*	0.027***	0.024***
	[0.016]	[0.018]	[0.008]	[0.008]
Observations	1329752	1326562	553039	551925
R squared	0.402	0.402	0.010	0.010
Mean	0.537	0.537	0.0924	0.0924
Year and State FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: This table reports estimates using NFHS survey data. Dependent variables include indicators for use of contraception to delay or avoid pregnancy and independent decision-making regarding contraceptive use. All specifications include year and state fixed effects and control for age, education, marital status, and residence type. District fixed effects are not included due to the pooled cross-sectional nature of the data. Estimates highlight that e-pharmacy access is associated with higher contraceptive use to delay pregnancy and a statistically significant increase in women's independent decision-making, indicating improved ability to act on fertility preferences. Standard errors are clustered at the district level. '***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7: Effects of e-pharmacy access on awareness and usage of contraceptives

	(1)	(2)	(3)	(4)
DV	Using Contraceptive		Knowledge of method	
Sample	Baseline	Exclude Forbiddens	Baseline	Exclude Forbiddens
Treated	0.028*	0.031*	0.011*	0.01
	[0.016]	[0.017]	[0.006]	[0.007]
Observations	1,329,752	1326562	1,329,752	1326562
R squared	0.320	0.32	0.030	0.03
Mean	0.432	0.433	0.983	0.983
Year and State FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

Notes: This table reports estimates using NFHS survey data. The dependent variables include indicators for awareness and actual current use of contraceptive methods. All specifications include year and state fixed effects and control for age, education, marital status, and residence type. District fixed effects are not included due to the pooled cross-sectional nature of the data. The results highlight that e-pharmacy entry increases the use of contraceptive methods without affecting knowledge, suggesting that privacy, not information are the potential binding constraints. Standard errors are clustered at the district level. '***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 8: E-pharmacy access and contraceptive behaviour by marital status

	(1)	(2)	(3)	(4)	(5)	(6)
DV	Tried to delay pregnancy		Using contraceptive		Knowledge of Method	
Sample	Married	Single	Married	Single	Married	Single
Treated	0.038*	0.009	0.033	0.009***	0.005	0.026*
	[0.023]	[0.008]	[0.023]	[0.003]	[0.004]	[0.014]
Observations	945,775	383,977	945,775	383,977	945,775	383,977
R squared	0.111	0.369	0.110	0.299	0.010	0.025
Mean	0.717	0.0946	0.585	0.0554	0.993	0.957
Year and State FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Each column reports estimates separately for married and unmarried women. The dependent variables are indicators for whether the respondent has tried to delay pregnancy, is currently using any contraceptive method, or reports knowledge of modern contraceptive methods. The treatment variable equals one if an e-pharmacy operates in the respondent's district at the time of interview. All specifications include year and state fixed effects and control for individual characteristics, including age, education and residence. Standard errors are clustered at the district level. The results show that e-pharmacy access enhances autonomy-related contraceptive behaviors among married women, while for unmarried women it significantly raises both contraceptive use and knowledge, indicating that digital platforms relax different binding constraints across marital status.'***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively

Table 9: Relation between distance to physical pharmacies and online sales of reproductive care products

	(1)	(2)	(3)
DV (in per 1000 capita)	Total sales	Female products	Male products
Distance to physical pharmacy (km)	-0.259	-0.261	-0.259
	[0.197]	[0.182]	[0.198]
Observations	606	607	613
R-squared	0.028	0.030	0.027
Control	Yes	Yes	Yes
Mean	0.001	0.0008	0.0013

Notes: This table reports the correlation between physical access to brick-and-mortar pharmacies and online sales of reproductive care products at the district level. The dependent variables are average of total online sales per 1000 population, sales of female-oriented products per 1000 women and sales of male-oriented product per 1000 men (columns 1–3). The key explanatory variable is the average distance (in km) to the nearest licensed physical pharmacy within a district. All specifications control for total population, district area and pharmacy density (pharmacies per capita). The sample is restricted to the treated districts with sales post 2020. Robust standard errors are reported in parentheses. '***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively.

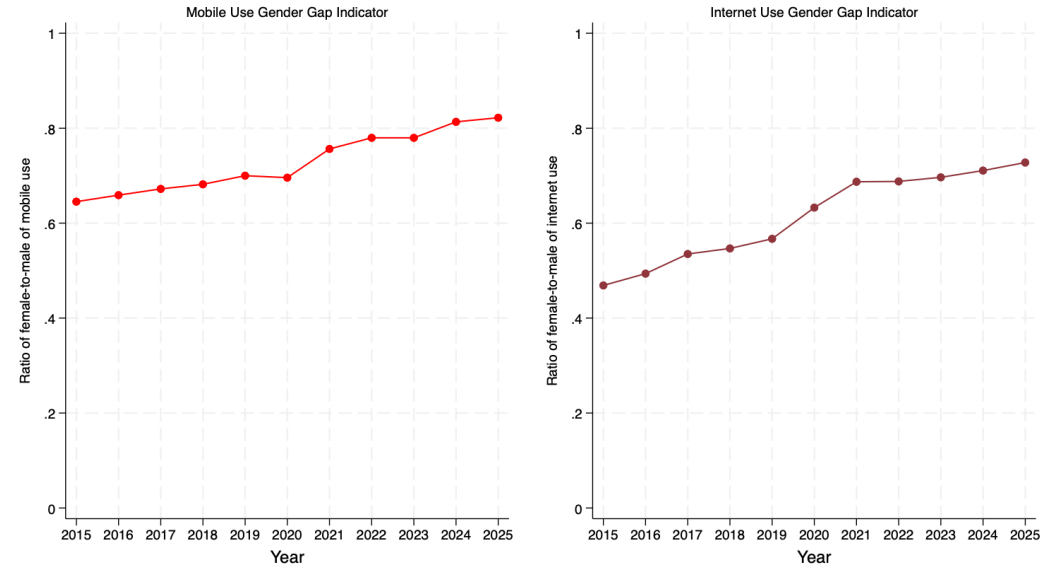
Table 10: Distance to physical pharmacies and effect on reproductive outcome

Third Difference				
	(1)	(2)	(3)	(4)
DV (per 1000 women)	Births		Abortions	
Sample	Baseline	Exclude Forbiddens	Baseline	Exclude Forbiddens
Treated	-1.323**	-1.339**	-0.118	-0.107
	[0.524]	[0.549]	[0.114]	[0.120]
Treated x High Distance	0.349	0.346	0.075	0.075
	[0.467]	[0.468]	[0.089]	[0.089]
Observations	3,834	3,800	3,834	3,800
R squared	0.946	0.945	0.761	0.757
District and Year FE	Yes	Yes	Yes	Yes
Mean	35.61	35.57	1.505	1.501

Notes: This table reports estimates from an extended difference-in-differences specification that interacts e-pharmacy access with an indicator for districts having above-mean distance to the nearest physical pharmacy. The interaction term captures whether treatment effects differ by physical access. All specifications include district and year fixed effects and are weighted by district population. Standard errors, clustered at the district level, are reported in parentheses. The results show that the effects of e-pharmacy access on births and abortions do not vary with distance to physical pharmacies, ruling out physical access as the primary channel.'***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively.

A. Appendix

Figure A1: Internet and mobile use gender gap in India: The figure plots the female-to-male ratio of mobile phone use and internet use in India between 2015 and 2025, where values closer to one indicate a smaller gender gap. In 2015, the internet use ratio was approximately 0.47 (implying a 53% gap, or about 47 women online for every 100 men), increasing to around 0.73 by 2025 (a 27% gap). At the same time, the mobile use ratio rose from roughly 0.65 (35% gap) to about 0.82 (18% gap), indicating a substantial narrowing of digital gender disparities over time.



Data Source: Digital Gender Gaps

Figure A2: Evolution of treatment intensity across districts. The figure plots the average share of treated pincodes within districts between 2014 and 2024, where treatment intensity is defined as the proportion of pincodes with access to at least one e-pharmacy. Treatment intensity rises sharply between 2015 and 2017 and stabilizes thereafter, indicating that most within-district expansion occurred early in the roll-out and closely mirrors the timing of district-level adoption.

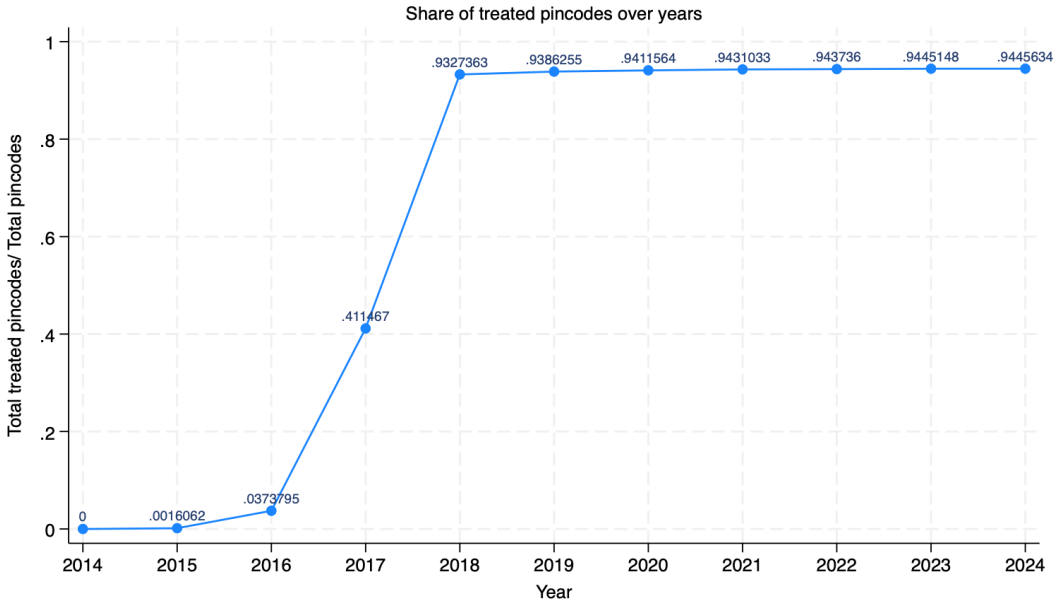


Figure A3: Spatial distribution of treated and untreated districts. The map shows the treatment status of Indian districts during the study period, where treated districts are those that gained access to at least one e-pharmacy between 2014 and 2019, and never treated districts are those that receive access only after 2019. The spatial dispersion of untreated districts across regions suggests no strong geographic clustering in treatment assignment, supporting the assumption that selection into treatment is not driven by systematic regional characteristics.

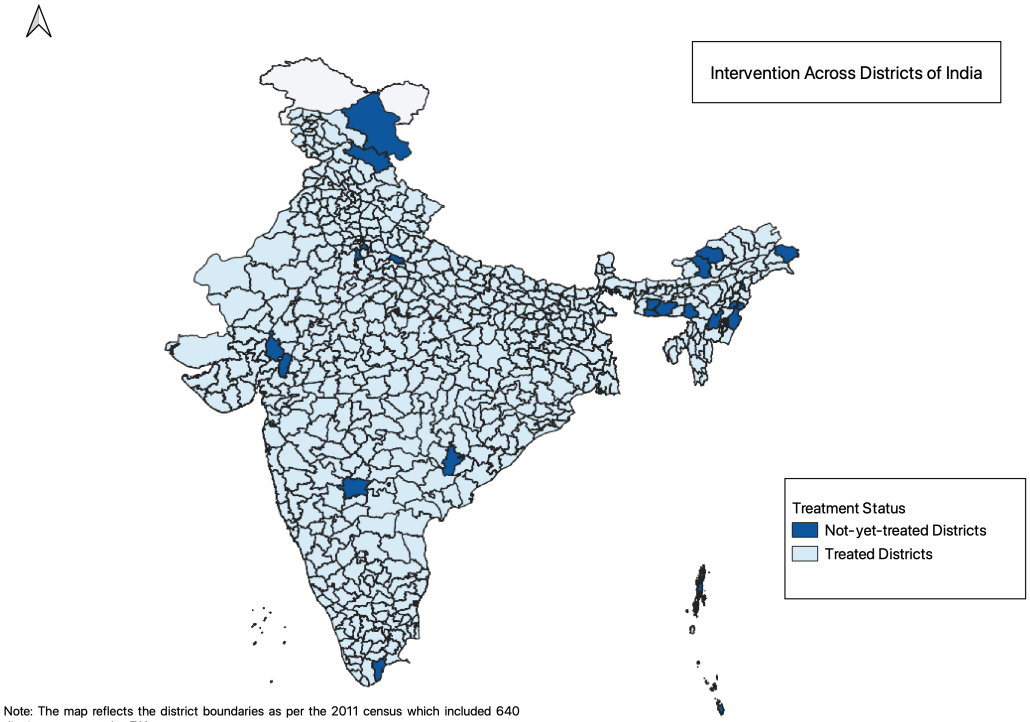


Figure A4: Relation between online sales of female products and reproductive outcome. The figures plot district-specific treatment effects on births and abortions against average per-capita online sales of female reproductive health products, illustrating the relationship between sales intensity and heterogeneity in estimated treatment effects. The figure highlights that higher online sales are weakly associated with larger declines in abortions but show no systematic relationship with treatment effects on births.

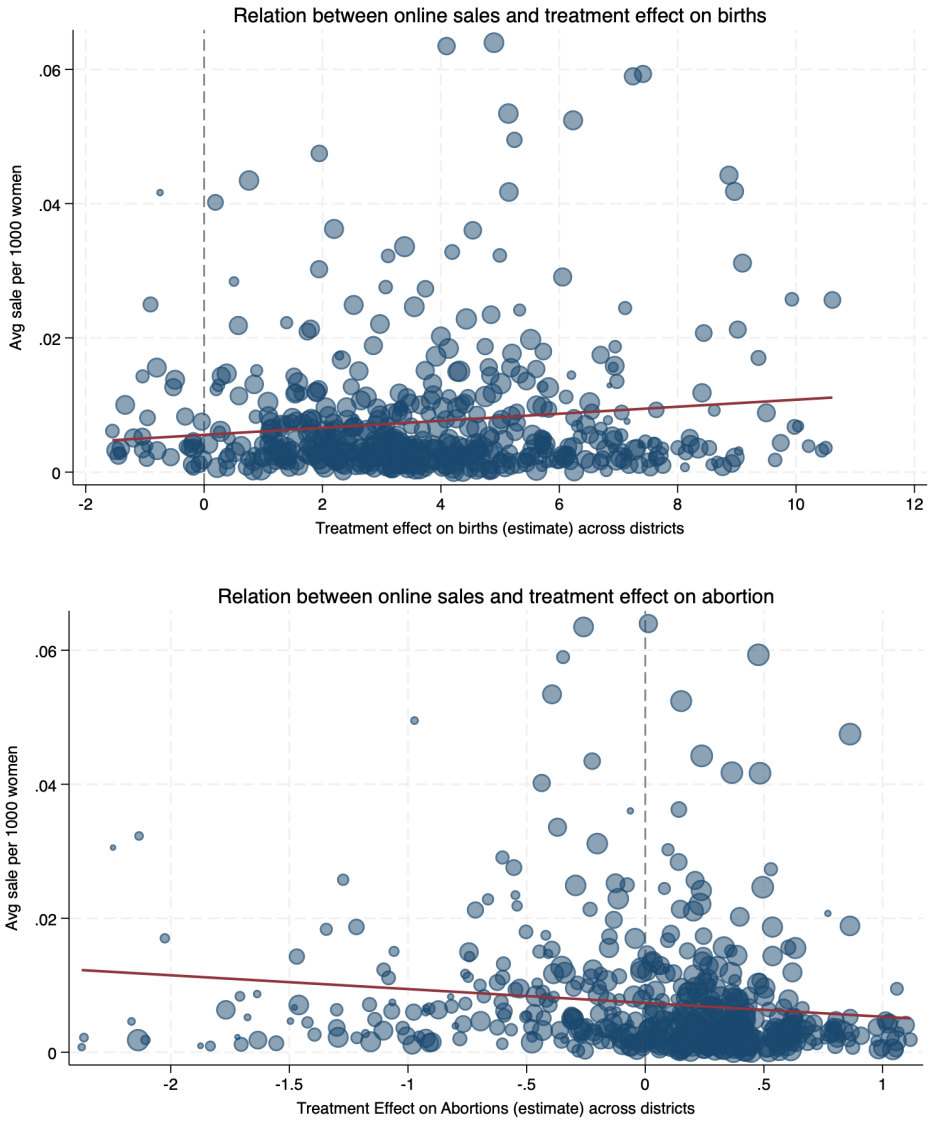


Table A1: Mobile phone ownership and contraceptive use following e-pharmacy entry

	(1)	(2)
DV	Current use of contraceptive	
Sample	Baseline	Exclude Forbiddens
Treated x Owns Mobile	0.021***	0.021***
	[0.007]	[0.007]
Observations	216,571	216,061
R-squared	0.324	0.324
Mean	0.432	0.433
Year and State FE	Yes	Yes
Control	Yes	Yes

Notes: The dependent variable is an indicator equal to one if the respondent is currently using any contraceptive method. The main regressor is the interaction between e-pharmacy access in the respondent's district and an indicator for mobile phone ownership. Column (1) reports baseline estimates, while column (2) excludes forbidden groups. All specifications include year and state fixed effects and controls for individual characteristics, including age, education, marital status and residence. Standard errors are clustered at the district level. '***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A2: Robustness to poisson specification

	(1)	(2)	(3)	(4)
	Births		Abortions	
DV (per 1000 women)	Baseline	Exclude Forbiddens	Baseline	Exclude Forbiddens
Treated	-0.033***	-0.036***	-0.140***	-0.130**
	[0.013]	[0.014]	[0.047]	[0.051]
Observations	4,114	4,074	4,114	4,074
District and Year FE	Yes	Yes	Yes	Yes

Notes: This table reports estimates from poisson regression models with births and abortions specified as count outcomes at the district–year level. All specifications include district and year fixed effects. Standard errors are clustered at the district level. '***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A3: Robustness to alternative outcome definitions

Panel A : Outcome winsorised (at 99 percentile)				
	(1)	(2)	(3)	(4)
	Births		Abortions	
DV (per 1000 women)	Baseline	Exclude Forbiddens	Baseline	Exclude Forbiddens
Treated	-1.997***	-2.095***	-0.239***	-0.257***
	[0.607]	[0.643]	[0.068]	[0.072]
Observations	3,096	2,922	3,096	2,922
R-squared	0.961	0.960	0.786	0.782
Panel B : Unadjusted outcome				
Treated	-2.841**	-1.755***	-0.733**	-0.501***
	[1.108]	[0.671]	[0.369]	[0.184]
Observations	3,096	2,922	3,096	2,922
R-squared	0.957	0.956	0.793	0.778
Mean	34.22	34.21	1.441	1.438
Year and District FE	Yes	Yes	Yes	Yes

Notes: This table reports robustness checks using alternative definitions of the main outcome variables. The dependent variables include alternative measures of births and abortions differing from the baseline specification in aggregation. All specifications follow the baseline difference-in-differences design and include district and year fixed effects. Standard errors are clustered at the district level. '***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A4: Robustness to alternative inference with state level clustering

	(1)	(2)	(3)	(4)
	Births		Abortions	
DV (per 1000 women)	Baseline	Exclude Forbiddens	Baseline	Exclude Forbiddens
Treated	-1.117**	-1.142**	-0.094	-0.083
	[0.470]	[0.489]	[0.240]	[0.247]
Observations	4,114	4,074	4,114	4,074
R-squared	0.946	0.945	0.761	0.757
District and Year FE	Yes	Yes	Yes	Yes

Notes: This table reports baseline estimates with standard errors clustered at the state level rather than the district level to account for spatial correlation in treatment timing and outcomes. The underlying specification, treatment definition and sample remain unchanged. Standard errors are clustered at the district level. '***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A5: Effect of intensity of e-pharmacy exposure on births and abortions

	(1)	(2)	(3)	(4)
DV (per 1000 women)	Births		Abortions	
Sample	Baseline	Exclude Forbiddens	Baseline	Exclude Forbiddens
Share Treated	-0.232	-0.216	-0.220*	-0.225*
	[0.877]	[0.892]	[0.116]	[0.118]
Observations	2,970	2,838	2,970	2,838
R squared	0.960	0.959	0.785	0.781
Mean	34.22	34.21	1.441	1.438
District and Year FE	Yes	Yes	Yes	Yes

Notes: The table reports difference-in-differences estimates using treatment intensity as a the independent variable. Intensity is defined using the median share of treated pincodes within each district over the period 2018-2024. All specifications include district and year fixed effects. Standard errors, clustered at the district level are reported in parentheses. '***', '**', and '*' denote statistical significance at the 1%, 5%, and 10% levels, respectively