Market disruption and unintended welfare gains: Effects of affordable Internet on access to maternal and child healthcare in India.

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ABSTRACT

The entry of Reliance Jio in the Indian Telecom market in 2016 with predatory pricing for high-speed Internet has dramatically distorted the marketplace dynamics and compelled the competing firms to follow similar pricing strategy. In this study, relying on the mechanism that internet penetration can accelerate the dissemination of knowledge and information, we hypothesize that the market disruption has some unintended consumer welfare gains in form of increase in access to maternal and child healthcare (MCH). Based on nationally representative pre-post cross sectional data set, our Local Average Treatment Effect (LATE) estimates using the instrumental variable (IV) strategy shows that market disruption in the Indian telecom has increased internet penetration and improved access to ante-natal care, facility-based childbirth and modern contraceptive usage but has a negative effect on child immunization. The difference-in-difference (DD) estimates for the intent-to-treat-effects (ITT) confirm similar findings. Average-treatment-effect-on-the-treated (ATT) and Average Treatment Effects (ATE) are computed to demonstrate that the results are robust to alternate model specifications and estimation strategies. Heterogeneity analysis shows that the Internet has profound impact among socioeconomically disadvantaged cohorts. Our study

findings implies that affordable Internet access can potentially reduce healthcare access disparities in low- and middle-income country settings.

Keywords: Market disruption; Internet diffusion; Maternal and child healthcare services; instrumental variable

JEL codes: L8, I12, L11

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1. Introduction

Telecommunication, particularly cell phone services and Internet, is one of the fastest growing industry across the global south. Evidence from the developed world shows that late entrants to the market often act as 'disruptors' to capture the market share and maximize profit (Berne, et al. 2019). The new entrants disruptive behaviors consist of several strategies such as introducing new a product or services, and aggressive predatory pricing (Berne, et al. 2019; Ofcom, 2016). On the one hand, such disruptive behavior distorts the market dynamics in terms of market concentration due to the market exit of some of the firms, and merging and acquisition. Principals of microeconomics suggest that, in the long run, such market concentration might reduce social welfare as imperfectly competitive markets are known for the deadweight loss, that is, the loss of consumer surplus and producer surplus and the output produced below the social optimum. On the other hand, studies have demonstrated that entry of 'disruptors' was associated with enhanced innovative activity that results in all companies in a market improving their services with regards to price and quality, often leading to increased consumer welfare (OECD.2015; Ofcom 2016). For instance, Ofcom (2016) has reported that prices in countries with disruptive mobile operators were between 10.7% and 12.4% lower than countries with no disruptive operators. Reduction of competition may increase consumer

welfare in the long run if increased arrival rate of innovations compensates for the welfare loss that results from static price effects (Aghion et al., 2005, Marshall et al., 2019).

In September 2016, the entry of Jio, a late entrant, in the Indian telecom market witnessed a disruptive entry and resulting market distortion. Reliance Jio introduced unlimited data, voice, and other OTT (over-the-top) services at extremely low prices. Data prices witnessed a secular decline from Rs.180 per GB in 2016 to 6.98 per GB in 2019.[1] The price shock adversely impacted the competitive position of other service providers and triggered financial distress in the sector. The Herfindahl-Hirschman Index as measured by share in the subscriber base has jumped from 1608 in 2009 to 2791 in 2019. Average revenue of the industry (Table 1) declined from 9.5% in 2014 to 2.5% in 2016 post Jio, which further fell to -2.8% in 2019 (Competition Commission of India, 2021). While Jio emerged as a market leader, most incumbent operators struggled with technology adoption and high costs related to 4G spectrum acquisitions. The sector consolidated into a highly concentrated and competitive market with only 8 operators in 2019 from the 21 operators in 2016. To ensure survival, small players were acquired by large companies. The sector also saw the merger of two telecommunications giants, Vodafone, and Idea. Bharti Airtel Ltd., who was the dominant player in the market, emerged as Jio's strongest competitor. The Return of Equity (RoE) for Airtel fell from roughly 17% in March 2015 to -9.8% post the disruption. The RoE further declined to -35.7% in March 2020 (Table 2). While the market squeezed in terms of the number of service providers and revenues, Internet consumption grew substantially (Figure 1). As seen by India's expanding Internet user base and data usage, the low tariffs and 4G introduction ushered in a mobile data revolution in India.. Wireless data usage per subscriber jumped from 0.35 GB in 2015 to 4.13 GB. It further climbed to 9.85 GB in 2019.

[1] Source: TRAI Performance Indicator Reports.

Year	Wireless data usage per subscriber per month	Average revenues
2019	9.85	-2.82
2018	7.6	-29.19
2017	4.13	-10.55
2016	1.16	2.51
2015	0.35	12.68
2014	0.23	9.59

Table 1. Wireless data usage per subscriber per month and Average revenues for Telecommunication firms (2014-2019). Source: TRAI Performance Indicator Reports and Competition Commission of India Report 2021

Financial year ending in	RoE for Bharti Airtel Ltd.
Mar-20	-35.7
Mar-19	-1.9
Mar-18	0.07
Mar-17	-9.8
Mar-16	6.96
Mar-15	16.86

Table 2. Bharti Airtel Ltd. RoE for Financial years ending in March 2015-March 2020. Source: www.moneycontrol.com

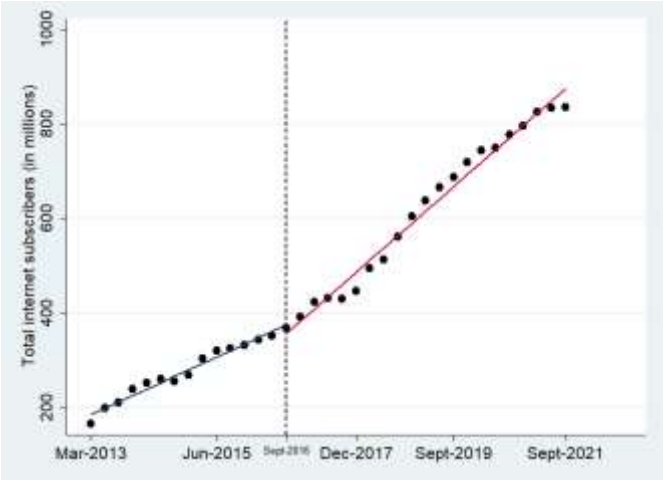

Figure 1. Change in growth of Internet subscribers (in millions) (pre vs post Jio intervention)

Literature has argued that Internet expansion is often welfare enhancing. The United Nations Sustainable Development Goals stressed on affordable and universal Internet access by 2020 (Sustainable Development Goals, Target 9. C). Growing Internet penetration globally and current user base of more than 5 billion worldwide makes it the prime medium to search and share information.[2] Romer's endogenous growth model proposes that knowledge spillover at large scale drives economic growth (Choi & Hoon Yi, 2009; Romer, 1990). An innovative General Purpose Technology (GPT) like the Internet influences numerous dimensions of an economy (Harris, 1996). Internet expansion boosts economic growth through directly enhancing labour market outcomes and quality of human capital (Akerman et al., 2015; Atasoy, 2013). Internet improves educational outcomes and promotes health literacy and healthy behavior (Derksen et al., 2022; Bessière et al., 2010; Jiang & Beaudoin, 2016; Oh & Lee, 2012; Takahashi et al., 2011; Trotter & Morgan, 2008; Webb et al., 2010; Wellman et al., 2001; Xavier et al., 2013).

The paper focuses on the united impact of the market distortion by Jio on certain aspects of societal-wellbeing through increased Internet coverage. Specifically, we draw attention to how

[2] World Internet Users Statistics and 2023 World Population Stats, 2023.

the market domination and predatory pricing by Jio accidentally may have a positive impact on Health outcomes of the population. The United Nations Sustainable Goal-3 (SDG-3) aims to ensure healthy lives and promote well-being for all, at all ages. The SDGs have emphasized improving health outcomes regardless of gender, however, it is an important determinant of health, particularly in LMICs (Fikree & Pasha, 2004; Iqbal et al., 2018). Target 3.1 and 3.2 of SDGs focuses on reducing the maternal mortality ratio to less than 70 per 100,000 live births and neonatal mortality rate to 12 per 1000 live births by 2030 respectively. Concentrated global efforts have led to a consistent decline in both these indicators. India has performed better than the world average in controlling maternal and child deaths. Researchers are pursuing plausible explanations that identify the decline in MMR and the rise in MCH services utilization. Numerous factors influence the demand for MCH services access. Access to healthcare can be defined as a 'degree of fit' between a patient's expectations and characteristics and those of the healthcare services providers. The degree of fit is measured across five dimensions, accessibility, availability, acceptability, affordability, and adequacy (Penchansky and Thomas, 1981; Saurman, 2016). The sixth dimension focuses on enhancing the health literacy of the patients through improved communication between healthcare providers and consumers. Evidence from previous studies indicated that sharing information and enhancing patient's health knowledge is essential for expanding healthcare access. Information asymmetries exist between healthcare providers and consumers (Arrow, 1978; Mooney, 1994). The Internet is considered an essential source of information and people frequently use it to access vital health services, understand health issues and learn about their treatment, which has been shown to have positive and significant effects on their health outcomes (X. Wang et al., 2021; Javanmardi et al., 2018; Sayakhot & Carolan-Olah, 2016).

The paper will examine how increased information and awareness through Internet affects Indian women's access to maternal and child healthcare services (MCH). MCH services we

consider in the study are early ANC, full ANC, skilled birth attendance, modern contraceptive use and full immunization. We specifically consider these services because of their importance in the continuum of care for Maternal Neonatal & Child Health (MNCH) as seen in their use by Countdown 2030. The primary objective of this paper is to investigate the causal impact of household Internet access on the demand for maternal and child healthcare services for Indian women. Research work very recently has started focusing on how the Internet influences women's well-being outcomes. Golin (2022) found that more intense use of broadband Internet adversely impacts the ability to cope with emotional problems for women but not for men. Effects are mostly concentrated among younger cohorts. DiNardi et al. (2019) argue that greater social media interactions due to increased broadband coverage increases BMI, obesity rate, smoking and drinking for white women in the United States. Billari et al., (2019), demonstrated that Internet via multiple channels led to an increase in fertility for highly educated, 25-45-year-old women in Germany. Guldi and Herbst (2017) argued that an increase in information and awareness through increased use of Internet has led to a decrease in teen fertility in the United States from 1999 to 2007. The literature regarding disruptive operators is still limited to European countries only. Several authors have studied their disruptive impacts while remaining focused on the telecommunication industry (Mesnard, 2011; Whalley et al., 2012; Berne et al., 2018).

The current study contributes to the existing strand of literature in the following ways: first, our study assessed the welfare impacts of a telecommunication market disruption in Indian context. Second, it studies the causal impact of Internet use on demand for maternal and child healthcare services of in India, where high-speed affordable Internet is a relatively recent phenomenon. Third, the study exploits 2SLS estimation using a novel instrument variable to address potential endogeneity concerns. We use data from the latest two waves of the National Family Health Survey (NFHS), NFHS-4 (2015-2016) and NFHS-5 (2019-2021) for our

analysis. The dataset serves the purpose of the study because the NFHS provides vital data on variables related to health and family welfare. It also has information on whether the household has Internet access in any form. However, certain identification issues arise due to the potential endogeneity of Internet access, when assessing the impact of information via the Internet on the consumption of healthcare services. After accounting for these endogeneity concerns, the results indicate that household Internet access is positively related to the demand for MCH services such as ANC utilization, skilled birth attendance, institutional deliveries, and modern contraceptive usage, while negatively associated with full immunization of children.

The paper is structured as follows. Section 2 provides a brief account of Internet and MCH services in India. Section 3 outlines the conceptual framework that illustrates the pathways through which household Internet access may influence the demand for maternal and child healthcare services. Section 4 discusses the endogeneity concerns related to our research question, data source and key variables of the study as well as an empirical strategy to address potential endogeneity concerns. Section 5 reports the main results of the paper. Section 6 conducts a series of robustness tests to validate our results. Section 7 analyses the heterogeneity effects. Section 8 explores the potential mechanisms that are driving our results. Section 9 presents the limitations of the study. Section 10 concludes and suggests policy implications.

2. Background

2.1 Internet in India

In August 1995, government monopoly Videsh Sanchar Nigam Limited (VSNL) introduced the Internet only in four major metropolitan cities in India. Due to policy changes in 1998, the entry of private actors and widespread user adoption accelerated Internet provision. The number of Internet users in India increased to 10 million by the year 2000.[3] The National

[3] The Economic Impact of Internet in India | Times of India, 2021

Broadband Plan was formulated by the Indian government in 2004 as a policy initiative to increase broadband subscriptions in India. However, the country's inadequate landline infrastructure slowed the spread of broadband. The number of Internet subscribers in India increased after the government auctioned the 3G spectrum, followed by the 4G spectrum. The market for mobile Internet services is extremely competitive, with numerous private participants. The low Herfindahl Index value of this sector is hypothesized to be the reason why more than 90 percent of Internet subscribers in India access the Internet via mobile devices. India had more than 330 million Internet subscribers by the end of 2015. The majority were wireless Internet subscriptions (Mani & Sridhar, 2015).

The growth of internet in India remained low until Reliance Jio entered the Indian telecommunication market with its mobile internet services. Prior to the intervention only 11% of the households had access to internet, after September 2016. The percentage has jumped to 55%. Figure A.1.6 in the appendix shows how district level household internet access has evolved post Jio intervention. Majority of the total districts in the country had internet in less than 20% of the households. Less than 40 districts had moderate level of diffusion with only 20%-60% households with internet access. Almost a negligible number of districts had more than 60% of households with internet access. Internet penetration improved drastically post the intervention. All districts surveyed had at least 20% of households with Internet access. More than 300 of the districts served had at least 40% percent of households with Internet access. Roughly around fifty districts had Internet access in more than 80% of the households. It can therefore be argued that the introduction of Jio 4G services at low prices has increased Internet diffusion in India.[4] Appendix presents additional figures that shows how household internet access has intervention has increased for different states. The figures are drawn comparing the data from NFHS 4 with NFHS 5. NFHS 4 ended in 2016, 3 months after the jio intervention.

[4] *Source: Authors' calculations*

NFHS 5 provides data for households surveyed between 2019-2021 giving sufficient time for the Indian market to react to the reduced prices. Figure 1 illustrates that Internet subscribers in India are growing at faster pace post September 2016. Figure A.1.7 shows that for every Indian state there is a drastic jump in household Internet diffusion from 2016 to 2021. In figure A.1.7 darker areas correspond to higher level of household Internet diffusion. Figures A.1.2, A.1.3 and A.1.4 show that after September 2016 there has been a rise in internet appears to be higher for socially disadvantaged groups (rural cohorts, Muslims and, SCs/STs/OBCs).

53% of Indian women are aware of mobile Internet, the lowest among South Asian countries. In 2020, however, the number of women in India who reported using mobile Internet and owning a smartphone grew rapidly, even faster than the number of men. 25% of Indian women reported owning a smartphone in 2020, compared to 14% in 2019, and 30% of Indian women reported using mobile Internet in 2020, compared to 21% in 2019. For Indian men, these trends have not changed (GSMA – Connected Women – The Mobile Gender Gap Report, 2021). Based on these trends, It can be contended that the gender digital divide is narrowing in the average Indian household. Internet accessibility has increased for women in recent years.

2.2 Maternal and child healthcare in India

Globally, From 1990 to 2015, MMR declined by 44% to 216 per 100,000 live births (World Health Organization, 2015) and neonatal mortality reduced by 46% to 20 per 1000 live births. In this regard, India has performed better than the global average. During the same period MMR and neonatal mortality fell by 69% (Registrar General of India, 2018) and 53% (CME Info - Child Mortality Estimates, 2023) correspondingly. However, India contributed almost one-fifth to the global burden of maternal and neonatal deaths in absolute terms (World Health Organization, 2012; CME Info - Child Mortality Estimates, 2023).The majority of maternal and neonatal fatalities are preventable since the treatments to manage pregnancy complications are well-known. Literature suggests that increasing access to maternal and child healthcare

(MCH) services can reduce the burden of preventable maternal and neonatal deaths (Lee et al., 123 C.E.; O'Dair et al., 2022; Singh et al., 2014; Upadhyay et al., 2012; World Health Organization, 2015). In India, early ANC checkups, skilled birth attendance and full immunization have risen by 11%, 8% and 14% respectively in the last 5 years. 70% of mothers had early antenatal care checkups, 89% of births occur in health centres, 76% of children (12-23 months) were fully immunized[5].

3. Conceptual Framework

Based on the existing literature, the study formulates a theory of change that links increased household Internet usage triggered by Jio's predatory pricing and MCH healthcare access in three phases. Phase 1 focusses on how the market disruption by Jio led to a dramatic increase in internet diffusion in India. Phase 2 explains the role of the Internet in making health information on the internet more accessible. Phase 3 delves into the effect of rapid internet expansion induced health information surge on MCH service utilization.

Phase 1 – Reliance Jio and Internet diffusion

Apart from higher prices and poor internet speed the low levels of internet adoption in India before 2016 can be attributed to several shortcomings of the previous government programs. The National e-Governance Plan (NeGP) (initiaited in 2006) covered a wide range of domains viz. agriculture, land records, health, education, passports, police, courts, municipalities, commercial taxes and treasuries, etc. However, NeGP failure to leverage emerging technologies like mobile and cloud and integrate databases couldn't foster a digital environment in the country. Therefore in 2015, the Indian Government announced its flagship program 'Digital India' which stimulated the use of Internet in governance and healthcare. Digital India reflected the state's emphasis in coordinating digital technologies and development. The program consists of three vision areas:

[5] Source: Authors' calculations

digital infrastructure as a core utility to every citizen; governance and services on demand; and digital empowerment of citizens. However, the ambitious program did not have a huge impact on internet connectivity because of low levels of digital literacy and inability to use mobile smartphones in the country.[6]

Several demand and supply side constraints rendered the government-led initiatives ineffective. Market-based intervention like the entry of Reliance Jio signified an inflection point in growth of internet subscriber base in India. In the third quarter of 2016, Jio, a new private service provider, enabled 4G services for mobile devices in most regions of India. The Jio intervention has brought significant changes in the structure of the Indian telecommunication market through its predatory pricing. Currently, the market is dominated by two major telecommunication operators – Reliance Jio and Bharti Airtel. This contrasts with 2015, when a dozen operators had a presence in the market. It has been argued that with these structural changes, India's Telecommunication market is rapidly moving towards an effective duopoly (Ghosh, 2021). Rapid innovation in the form of affordable high speed 4G internet triggered by intense competition in the industry led to an Internet boom in the country. To address the demand side constraints, Jio employed a 'puppy-dog strategy' by providing its services for the first three months at no cost to its customers, capturing a significant market share. The other operators had to follow the price to survive in the market. Three months after the disruption the services were at data prices which were the lowest in the world. The market intervention enabled Indians to become the largest per-capita data consumers in the world. This resulted in a rise in data usage and a surge in country's Internet subscriber growth (Gupta et al., 2019). TRAI data indicates that as of the end of the third quarter of 2016, there were 367.48 million Internet subscribers. According to TRAI's September 2021 report, India has 834,29 million Internet subscribers. India

[6] (PM Modi's Digital India Will Fail without Mass IT Awareness Programmes - Hindustan Times, 2017.)

currently has the largest number of Internet users in the world only after China.[7] To tackle limitations on the supply side, Jio made substantial infrastructural advancements, focused on expanding spectrum capacity by erecting cellular towers, and enhancing fiber optics networks. It introduced high speed 4G internet in the country which improved the quality of Internet service (Mukherjee, 2019). Moreover, Jio also addressed the issue of limited digital literacy by launching mobile feature phones that allowed first time internet users to access internet through a technology that they were already familiar with (Ghosh, 2021). The potential of emerging digital technologies also brought significant foreign investment to the country. Facebook invested $5.7 billion for a minority stake in Reliance Jio (Dasgupta, 2022). There also have been indications of favoritism by the current Indian government in favor of Reliance Jio.[8]

Phase 2 – Internet and health information

We also borrow from the theory of change from Dwyer & Liu (2013) which studies the impact of consumer health information on the number of physician and emergency room visits. Their work builds on (Grossman, 1972)'s human capital model which also forms the basis our conceptual framework. Individuals optimize their utility over health and other goods with respect to their budget and production constraints. Individual's well-being increases from being healthy and greater efficiency of consumption and leisure associated with improved health. Health is a stock that is initially dependent on genetics and later can be acquired using health inputs.

Healthcare markets are characterized by uncertainty about choices of treatment alternatives and effectiveness of treatments. Kenneth Arrow, in his seminal article recognized that the asymmetric nature of information between providers and users of healthcare services is a crucial aspect of medical markets (Arrow, 1963). In this principal-agent framework, medical professionals' goal to maximize their own profit function may offset the objective of patients' utility maximization

[7] (Internet Top 20 Countries - Internet World Users, 2019)
[8] (How Reliance Jio Is Monopolising the Telecom Sector, 2019.)

hampering social welfare. The uncertainty in these markets makes information a valuable commodity since it helps individuals make efficient decisions. (Haas-Wilson, 2001) states that Individuals find three types of health information: diagnostic information, treatment information and physician-specific quality information.

Niche Theory and the theory of users and gratifications explain the evolution of information seeking habits due to media displacement effects between traditional and new media (Dimmick et al., 2009). Internet allows users to watch TV, read newspapers, and listen to radio making it a centralized system for information seeking (Heersmink, 2016). The Internet offers its users access to a vast repository of information and knowledge at lower search costs relative to other sources (Bakos, 1997; Dubowicz & Schulz, 2015; Jepsen, 2007). Ratchford et al., (2014) present a theoretical model which demonstrates that access to Internet and proficiency in internet use will increase the total amount of information acquired owing to decreased search costs. Conventional information sources lack the immediacy, searchability and interactivity of Internet-based information (Harrison et al., 2006).

Online health information seeking ranks among the most popular Internet activity and individuals frequently cite Internet as the primary source of health information (Amante et al., 2015; Hesse et al., n.d.; Kummervold et al., 2008). Medical professional's websites and health blogs on the Internet are well-established platforms for production of patient knowledge (Bert et al., 2013; Bjelke et al., 2016a; Serçekuş et al., 2021a).The existence of social media allows knowledge generation through users interacting in a digital space (Antheunis et al., 2013; Korda & Itani, 2013). Health Forums and Online Health Communities (OHCs) facilitate collaborative construction of knowledge by synthesizing evidence from experiences of patients with similar health conditions (Bellander et al., 2018). In addition to being an experiential knowledge sharing system, OHCs also provide space for peer-support among patients themselves (Bernardi, 2022; Sendra et al., 2019; Smailhodzic et al., 2016). Support from OHCs

can be defined in terms of four dimensions, information, advice, confirmation, and empathy (Carlsson et al., 2016).

Evidence in the literature shows pregnant women are increasingly relying on the Internet to address the information asymmetry between providers and themselves (Powell et al., 2003). Specifically, during pregnancy, women are constrained in terms time to acquire information (Coll et al., 2017; Cramp et al., 2009). Women seek information about subjects like foetal development, nutrition, and childbirth (Bjelke et al., 2016b; Rahmawati et al., 2021; Sayakhot & Carolan-Olah, 2016b; Serçekuş et al., 2021b). Women also engage in forums online to create contact, provide and seek social support and exchange experiences of other pregnant women (Carlsson et al., 2016). Information provided during ANC visits is often directed at women which makes fathers uncertain about childbirth. Consequently, they are dependent on internet for their informational requirements (Deave & Johnson, 2008; Fenwick et al., 2012; Oscarsson et al., 2018; Premberg et al., 2006).

However, information seeking is complex. Marchionini and Komlodi (1998) argued, "Information-seeking is a special case of problem-solving. It includes recognizing and interpreting the information problem, establishing a plan of search, conducting the search, evaluating the results, and if necessary, iterating through the process again." According to Sutcliffe and Ennis (1998) information seeking involves four cognitive activities: problem identification, need articulation, query formulation and result evaluation. Information seeking on the Internet isn't straightforward. It is acknowledged that owing to limits on ability to acquire information, consumers experience variations in cost and benefits of the information (Klein & Ford, 2003). Key cognitive skills are essential for successful information seeking (Sharit et al., 2008). While Internet today is a primary source of information for patients, it is unregulated (Fahy et al., 2014; Wu & McCormick, 2018). It serves as a medium for the spread of misinformation and disinformation (Betsch, 2011; Grimes et al., 2020). Additionally, social

media acts as a global propagator for false information (Larson, 2018). Research shows that pregnancy related information shared on OHC which bypass the control of credentialled experts remains unchallenged (Betts et al., 2014). Therefore, given the cognitive abilities of the users, the knowledge shared on the Internet heightens the risk of unreliable information dissemination. The role of cognitive skills of internet users to make use of online health information can be explained by the framework proposed by Jiang and Beaudoin (2016). The framework employs the Cognitive Mediation Model (CMM) and Uses and Gratifications theory (U&G) as originally postulated by the Derivative Model by (Beaudoin, 2008). They suggested six integral pathways that describe the interplay of cognitive skills and health inforamation seeking. First, motivation for health-related Internet use to health-related Internet use: Motivation can be conceived as an impetus of action (Deci & Ryan, 1985). Park et al. (2009) demonstrated that motivation to use Internet is positively associated with email, blog and social media use. Motivation to obtain health information has been considered a strong predictor of adoption of social networking sites to improve quality of life (Omar et al., 2014). Second, motivation for health-related Internet use to perceived health information overload: A situation where the amount of information available to them hampers an individual's efficiency in using information (Bawden et al., 1999). Petty & Cacioppo (1986) found motivation can aid in such situations in helping reduce information overload through issue-relevant thinking. Third, health-related Internet use to perceived health information overload: Exposure to excessive social media content on the web can potentially lead to information overload given users' limited cognitive abilities (Lang, 2000). Fourth, health-related Internet use to health literacy: Internet use can help improve people's health literacy, which is defined as a person's ability to obtain, interpret, and use information to improve health (USDHHS, 2001) . A study showed that patients who regularly browsed health information from an Internet-based patient portal had 1.4 times higher health literacy than non-users (Sarkar et al., 2010). Fifth, perceived

health information overload to health literacy: If Information supply exceeds one's information-processing capacity, the individuals tend to make inaccurate decisions (Eppler & Mengis, 2004). Sixth, motivation for health-related Internet use to health literacy: research indicates that motivation for media use predicts knowledge development (Kwak, 1999; McLeod & McDonald, 1985). The above pathways suggest that the quality of user-media interaction through several channels has the potential to influence MCH services seeking behaviour of women. The next phase of the conceptual framework focuses on these channels.

Phase 3 – Health information and MCH services utilization

The impact of health information on MCH services utilization is complex. Kenkel (1990) argued that ill-informed consumers underestimate the marginal product of medical care. The potential increase in online information seeking through increased household Internet can increase the size of an average consumer's information set (Javanmardi et al., 2018; Sayakhot & Carolan-Olah, 2016; Rice, 2006; McKay et al., 2002). As suggested by the first, second, fourth and the sixth pathways, existence of basic cognitive skills to process the information and increased Internet access may lead to an increase in the health literacy in the users. Accordingly, we hypothesize that authentic information can act as a complement to medical care and increase MCH utilization through increased health literacy. Information on the Internet is often misleading, inaccurate and potentially dangerous (Suarez-Lledo & Alvarez-Galvez, 2021; Sharma et al., 2017; Eysenbach et al., 2002; Berland et al., 2001). Third and fifth pathway of the framework by Jiang and Beaudoin (2016) posits that users may lack the cognitive skills to differentiate between accurate and inaccurate information. Henceforth, misinformation can make consumers misjudge the benefits of MCH and have an adverse impact on its demand. The third and the fifth pathways also suggest that individual's lack of cognitive skills to process correct internet health information can further negatively affect MCH services demand. In contrast, Suziedelyte (2012) also argued that lack of key cognitive

skills and potential misinformation on the internet can increase dependence on health professionals to transform medical information on the internet into knowledge. As a result, increased health information may act as a complement and have a positive effect on MCH services usage. Lastly, highly informed individuals may substitute formal medical care with self-care. Such a situation may arise in a setting where trust in doctor-patient relationships and health-insurance coverage is low, and the time cost of visits is high. We argue in such a scenario health information may act as a substitute for MCH service utilization. The theory of change suggests that consumer health information can act as both a complement and substitute to MCH utilization and can have a positive and a negative effect repectively. The causal pathways outlined below (Figure. 1) suggest that the effect of Internet health information on Indian women's demand for maternal and child healthcare services is a priori uncertain.

Apart from the information channel, Internet may influence MCH utilization through several other pathways. As noted by, Bellou (2015), the Internet may decrease search costs, increase the rate of partnership offers and improve compatibility with a partner by giving women a larger pool to choose from. Women who experience intimate partner violence are less likely to utilize MCH services (Paul & Mondal, 2021). Increased compatibility with a prospective partner through a rise in Internet diffusion may increase the likelihood of women using MCH services. Increased Internet coverage is also found to be positively associated with female labour force participation rates and the labour productivity of women (Akerman et al., 2015; Atasoy, 2013). Assuming that MCH services are a normal good, favorable job market conditions for women can potentially increase the demand for MCH services.

In the Indian context, there is evidence of a gender digital divide (Antonio & Tuffley, 2014). In the average Indian household, Internet is more accessible to men than to women. The Facebook -Cambridge Analytica scandal revealed how Facebook was accused of collecting information regarding users' data and Internet activity to run targeted advertisements that display users

what they want to see opposed to what they ought to see[9]. The Internet is infamous for its gender bias algorithms that promote conservative patriarchal ideas which merely are a result of more men than women in the pool of total Internet users (Lambrecht & Tucker, 2019; Schroeder, 2021). These gender-biased algorithms may have an adverse impact on the demand for maternal and child healthcare services.

Channels not based on health related information can also influence the utilization of these services in opposite directions. The net effect of the Internet is ambiguous because the mechanisms that positively impact MCH services utilization can dominate the negative impact or vice-a-versa. It is also possible that positive and negative effects cancel out each other leaving the net effect to be insignificant. Therefore, the paper is focused on providing empirical content to our research question. We determine the direction of the net effect of the Internet on MCH service utilization, if any. We further highlight potential explanations for our findings and what implications we can derive from them.

[9] Facebook sued over Cambridge Analytica data scandal - BBC News https://www.bbc.com/news/technology-54722362

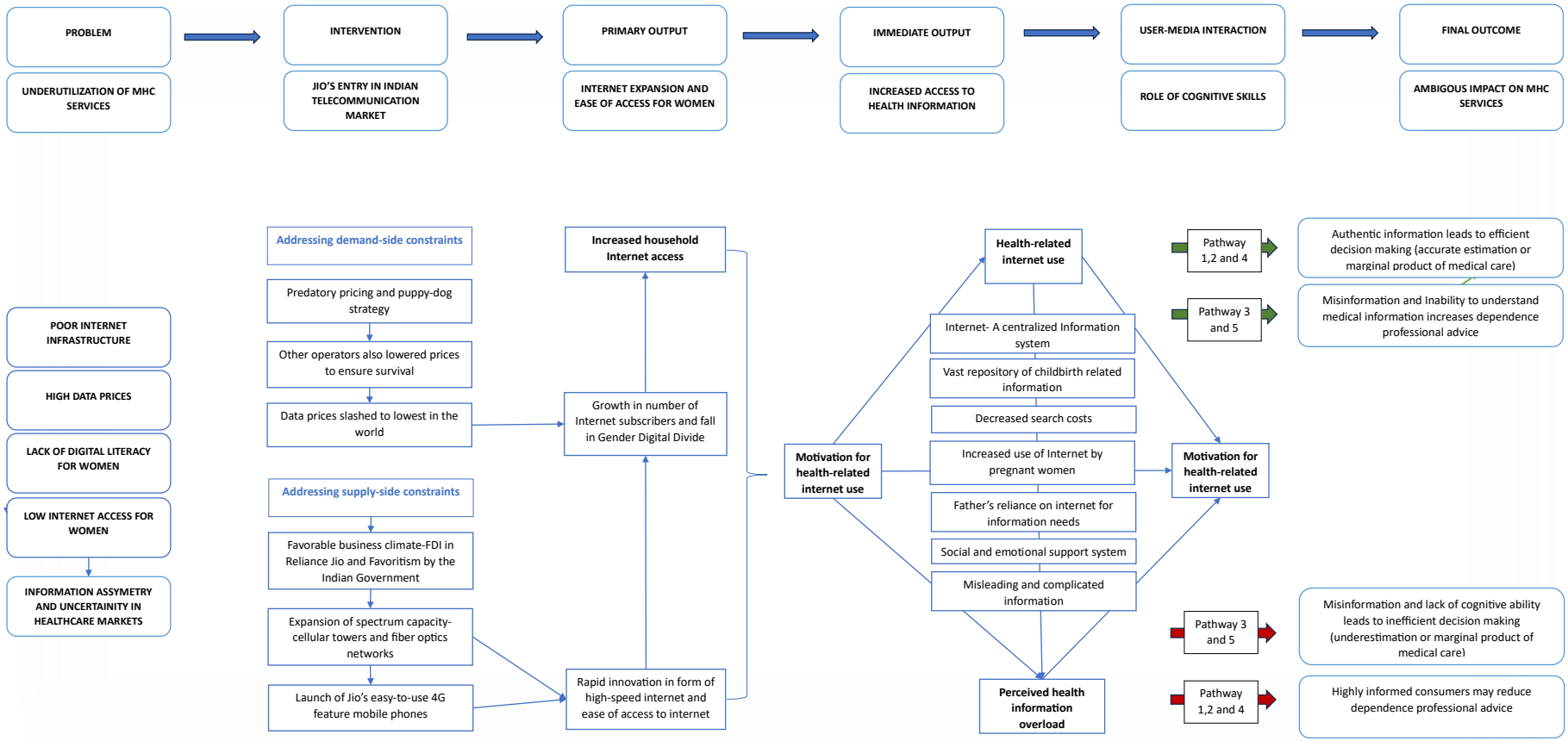

Figure 2. Conceptual framework

4. Data and Methods

4.1 Data Source

Through our primary empirical methodology and a series of robustness tests, we determine the impact of household Internet access on Indian women's use of MCH services. After a comprehensive literature review, we identify two instrumental variables that can be used to calculate the LATEs and ATTs in the context of the current study. The results are validated deriving ITT effects and ATEs from DiD and IPW techniques, respectively. The study utilizes nationally representative secondary data for women of reproductive age (15-49 years) from all the states and union territories of India. The data for the study is drawn from the fourth and fifth waves of The National Family Health Survey (NFHS). NFHS is a large-scale, multi-round survey conducted on a representative sample of households throughout India under the stewardship of Ministry of Health and Family Welfare (MoHFW), Government of India. MoHFW designated the International Institute for Population Science (IIPS), Mumbai, as the nodal agency for the survey. The survey is a rich source of information about an individual's lifestyle including many health and non-health variables along with household access to the Internet. The survey also provides reliable data on MCH services utilization and child immunization. The sample was selected using a stratified two-stage sampling design. In the first stage, clusters were selected using probability proportional to cluster size. In the second stage, 22 households from each cluster were selected with an equal opportunity systematic selection from the household listing. NFHS 4 and NFHS 5 interviewed a nationally representative set of 6,99,686 and 7,24,115 women of reproductive age, respectively. Data from the wave 2 of the Indian Human Development Survey (IHDS) conducted in 2011-12 is used to validate the findings of the IV estimates by conducting falsification tests to support the parallel trends assumptions of DID estimates.

The NFHS 4 survey lacks data on households headed by the 'others' gender. To calculate the causal effects we restrict the sample to only those households which were headed by a male or a female so that data the two waves of the NFHS is comparable. The restriction leaves 699,686 and 724,107 observations from each wave. The control and treatment groups for our DID estimates are based pre and post the intervention district level treatment intensity. To calculate the ITTs using a DiD technique we restrict our sample at two stages. First, we exclude those observations from the NFHS 4 for which data was collected after August 2016 to obtain precise estimates of district treatment intensity pre and post the intervention. Second, Due to paucity of comparable data, our sample from NFHS 4 and NFHS 5 is confined only to those districts that were included in the both the waves of the survey. Similarly, we restrict the sample from wave 2 of the IHDS for the placebo tests only to those NFHS 4 districts for which the treatment intensity estimates can be calculated. We limit our analysis to women aged 15-49 years. The restrictions reduce samples of the IHDS to 12,703 women, the NFHS 4 to 601,821 women, and the NFHS 5 to 594,458 women.

4.2 Variable description

4.2.1 Outcome Variables

We focus on the utilization of the following five maternal health care services during the most recent birth by creating the following dummy variables with 1 if the woman is treated, 0 otherwise. (i) Early Antenatal Care: The woman is treated if she had her first antenatal visit during the first trimester of the pregnancy (ii) Full Antenatal care: A woman is considered treated if she made at least four ANC visits, at least on tetanus toxoid injection and iron and folic acid tablets or syrup taken for 100 or more days. (iii) Skilled birth Attendance: Whether the last birth was assisted by a doctor, nurse, LHV, ANM or other health personnel. (iv) Modern contraceptive use: Whether the woman reports the use of at least one modern contraceptive method: male or female condoms, pills, injectables, implants, intrauterine

devices, male or female sterilization, female diaphragms and Lactational Amenorrhea Method. (v) Full immunization: The woman is considered treated if the last child is fully immunized with the following vaccines: BCG, measles, 3 doses of polio and 3 doses of DPT.

4.2.2 Control Variables

To capture the impact of internet access we construct a dummy variable which takes a value 1 if the woman's household has internet access in any form, 0 otherwise. In addition to the variable of interest, we control for several individual woman characteristics such as age, education, employment status, mobility variables like whether the woman is permitted to go to the market, hospital or outside the village alone, wealth percentile (lowest, lower, middle, richer, richest). The study also considers whether the woman's social or religious background (Hindu, Muslim, Scheduled Caste, Scheduled Tribe, Other Backward classes). We control for services availed from ASHA/ANM workers or cash transfers received under the Janani Suraksha Yojana (JSY). We further factor in several household specific characteristics like total number of family members, number of 15–49-year-old females, area of residence (rural/urban), gender of the household head.

4.3 Identification Strategy: Local average treatment effect (LATE)

Table A.2.1 in the appendix provides the Ordinary Least Squares (OLS) estimates of internet access on MCH services utilization. The findings demonstrate a significant positive association between household internet access and MCH services such as early ANC, complete ANC, and modern contraceptive use. OLS results also show that household internet access is associated with reduced likelihood of fully immunized children. The baseline results for skilled birth attendance are insignificant. Due to possible endogeneity issues OLS estimates may produce inconsistent results. Endogeneity may arise through two potential channels. First, unobservable omitted variables may confound the causal estimates: the decision to have Internet in the household may be correlated with unobservable characteristics like customs of the households,

individual beliefs etc., which may simultaneously also influence the demand for maternal health care services. Second, simultaneity issue resulting from reverse causality: health conditions arising from demand from MCH services, could affect preferences regarding leisure activities, which in turn can influence the demand for household Internet. In the subsequent sections, the study addresses these potential endogeneity concerns. We compute the LATE using a novel IV in context of the current study.

The study estimates the average impact of internet access on the demand for MCH services. We use the Jio intervention as an instrument variable for household internet access. Since Reliance Jio was launched nationwide on 5th September 2016, all the individuals who were interviewed after August 2016 were exposed to Jio's dramatically decreased internet prices. This decrease in the data prices is expected to increase the probability of having internet in the household. It is likely that some individual households may not acquire internet services even after the Jio intervention. As suggested by (Angrist & Krueger, 2001) if the IV is associated with heterogeneous treatment effects. The parameter thus identified gives us the Local average treatment effect (LATE). The LATE is the estimate of the causal impact of internet access on the demand for MCH services for the complier sub-population. Compilers in our sample are the cohorts which obtained internet connectivity in their households after the Jio intervention.

Our estimation technique takes the form of a two-stage-least-squares (2SLS) IV strategy. In the first stage we estimate the impact of the instrument on the endogenous variable. Consider the following first-stage equation,

$$Internet_{id} = \beta Jio_i + X_i + \lambda_d + \epsilon_{id}, \qquad (2)$$

where $Internet_{id}$ is the binary indicator of internet access in individual's household in district d, Jio_i is takes a value 1 if I was interviewed after August 2016, 0 otherwise. X_i is a vector of

observable control variables for individual i, λ_d are district level fixed effects, and ϵ_{id} is the error term.

The general form of second stage estimation is,

$$Y_{id} = \beta \widehat{Internet}_{id} + X_i + \lambda_d + \epsilon_{id}, \qquad (3)$$

where, Y_{id} is the binary indicator of woman i from district d availing a particular MCH service. $\widehat{Internet}_{id}$ is obtained from the first stage equation.

IV estimates are only valid if they satisfy the assumptions of 'relevance' and 'exclusivity'. Graph A.1.1. in the appendix shows how the households that were exposed to the Jio intervention were more likely to have internet access for the whole sample. Graph A.1.8 illustrates how percentage of households with internet access has changed for Indian states after in response to market structure modifications due to Jio. The IV is assigned 1 if the observation in the dataset was interviewed after August 2016 is and 0 otherwise. It can be argued that the plausible variation in the IV is positively correlated with Internet access therefore it satisfies the 'relevance' assumption. The exclusivity assumption is supported by the fact that Jio only impacts internet access in households and cannot directly affect maternal health-seeking behaviour. We run a robustness check on our external instrument (Jio) as a precaution against any possible threat to the exclusivity assumption. We use the Lewbel (2012) approach which combines our external instrument with internally generated instruments. Lewbel (2012) proposes an identification approach based on the heteroskedastic covariance restriction. An advantage of Lewbel 2SLS estimates is that they do not rely on satisfying the exclusivity assumption. It is widely accepted in the literature as a robustness check for external instrumental variables.

5. Results

Table 3 provides descriptive statistics for several socioeconomic and domestic characteristics of the individuals considered in the study. The first panel shows the average level of MCH services utilization by individual women. Services like Early ANC and Skilled birth attendance report higher levels of utlization: 73% and 87% respectively. In contrast, full ANC, Modern contraceptive use and full immunization rates remain relatively low in the country. The second panel provides descriptive statistics for household characteristics. Average family size in the sample is 6 members including 2 women of reproductive age (15-49 years). 85% of the households are headed by a male member. 34% of individuals are residents of urban areas. The third panel illustrates several individual aspects. 81% of the women practice Hinduism while 14% are Muslim. Employment remains low with on 30% of the women have jobs. Roughly around 50% of the women in the sample have autonomy in mobility. Roughly 75% of the women belong to socially disadvantaged castes (SCs/STs/OBCs). The National Health Mission service utlization remains low in the country with only 34% of the women availing cash transfers from the Janani Suraksha Yojna. Roughly around 9% and 10% women availed ASHA and ANM services respectively.

Variables	(1) Mean	(2) Std. Dev.	(3) Min	(4) Max
MCH services (0= did not avail the MCH service, 1=Availed the MCH service)				
Early ANC	0.726137	0.44594	0	1
Full ANC	0.484157	0.49975	0	1
Skilled birth attendance	0.868907	0.337502	0	1
Modern contraceptive use	0.39583	0.489029	0	1
Full immunization	0.476885	0.499466	0	1
Household characteristics				
Household Internet access	0.33857	0.473224	0	1
Family size	5.574871	2.586625	1	41
Number of eligible males in the family	1.807976	0.957413	1	12
Area of residence (0= rural, 1= urban)	0.335372	0.472121	0	1
Gender of the household head (0= female, 1= male)	0.851742	0.355389	0	3
Wealth Index (1= poorest, 5= richest)	3.060987	1.397093	1	5
Individual characteristics				
Age	30.20061	9.842251	15	49
Years of education	7.252564	5.249383	0	20
Employment status (0=unemployed, 1= employed)	0.298916	0.457784	0	1
Allowed to go to the market alone (0= Not allowed, 1= allowed)	0.552254	0.497263	0	1
Allowed to go to the health facility alone (Not allowed, 1= allowed)	0.507057	0.499951	0	1
Allowed to go outside the village alone (0= Not allowed, 1= allowed)	0.489342	0.499888	0	1
Religion				
Hindu (0= other, 1= Hindu)	0.809736	0.39251	0	1
Muslim (0= other, 1= Muslim)	0.136294	0.343101	0	1
Social group				
Scheduled Caste (0= other, 1= Scheduled caste)	0.211478	0.408356	0	1
Scheduled Tribe (0= other, 1= Scheduled tribe)	0.092293	0.289439	0	1
Other Backward Classes (0= other, 1= Other backward class)	0.431676	0.49531	0	1
NHM services				
Availed any ASHA service (0=no, 1= yes)	0.09406	0.291912	0	1
Availed any ANM service (0=no, 1= yes)	0.106737	0.308778	0	1
Availed JSY transfer (0=no, 1= yes)	0.346975	0.476009	0	1

Table 3. Descriptive Statistics

Prior to presenting the regression analysis results, we report preliminary evidence of a positive association between household Internet access and MCH service utilization. The figures 3-7 below illustrate the relation between Internet diffusion and demand for several maternal and child healthcare services at the district level. The left panel in figures exhibit a positive relation between district level internet diffusion (percentage of households with internet in the district) and early ANC, full ANC, skilled birth attendance and modern contraceptive use rates in the district. The relationship appears to be inconclusive for the percentage of children fully immunized a priori. The histograms in the right panel also display a similar picture: higher the level of internet diffusion, higher the demand for MCH services in the districts. Figures A.1.8 to A.1.32 in the appendix aids in visualizing that women from households with internet connectivity were more likely to avail these services. The pattern is consistent for women with different socio-economic backgrounds. The correlation appears to hold true for urban/rural cohorts and various social, religious and wealth groups. The effect appears to be more pronounced for the marginalized groups.

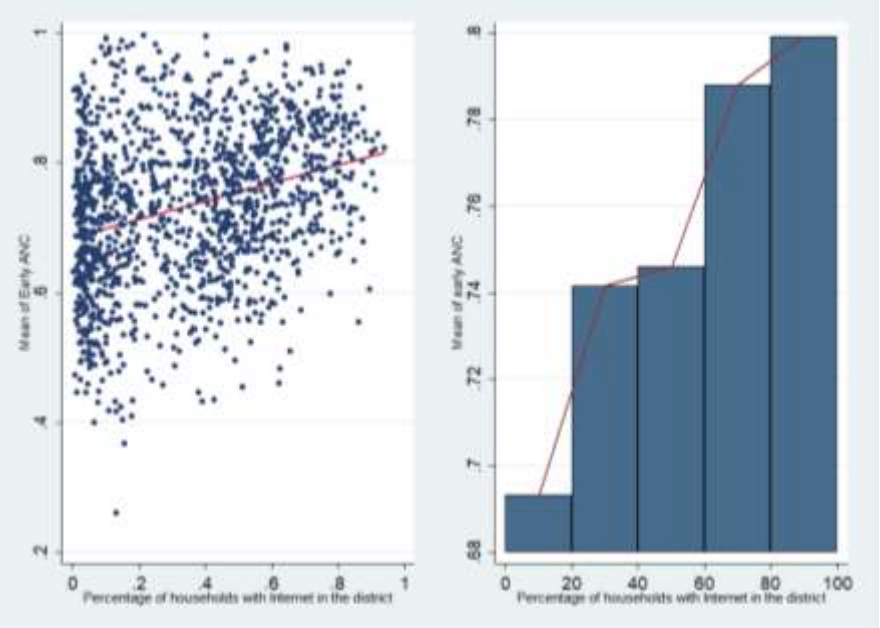

Figure 3. Early ANC utilization rate and Internet diffusion at the district level.

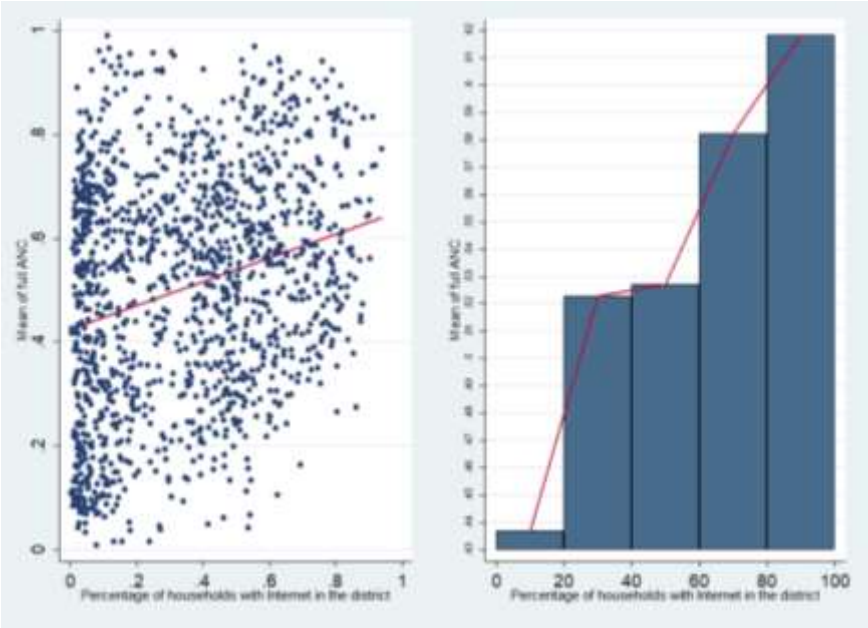

Figure 4. Full ANC utilization rate and Internet diffusion at the district level.

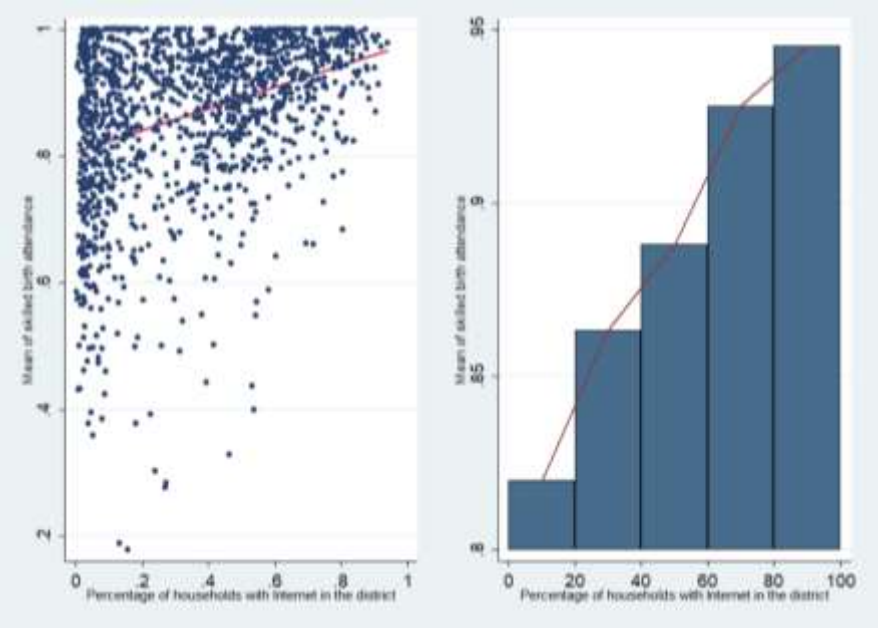

Figure 5. Skilled birth attendance rate and Internet diffusion at the district level.

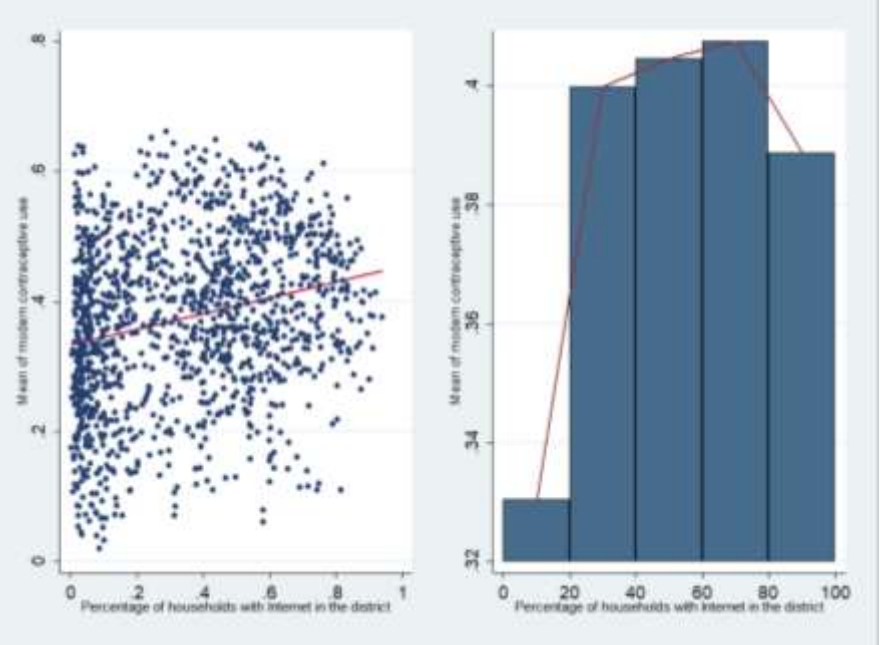

Figure 6. Modern contraceptive utilization rate and Internet diffusion at the district level.

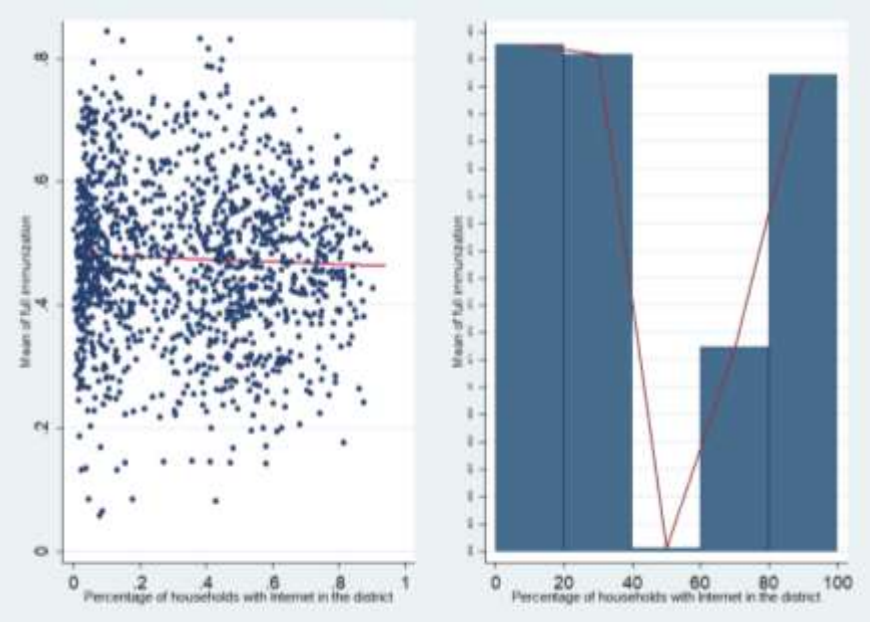

Figure 7. Full immunization rate and Internet diffusion at the district level.

Table 4 reports the 2SLS model results. The odd numbered columns present the first stage IV estimates. The results indicate a highly significant positive relation between Jio and household Internet access. The F statistics values show that our instrument is not weakly correlated with

Internet access. The even number columns show that Household internet access has a positive and statistically significant impact on early ANC, full ANC, modern contraceptive use and full immunization. The result is insignificant for skilled birth attendance. From the IV estimates we argue that endogeneity causes a considerable downward bias in our OLS results because the corresponding 2SLS estimates in higher than the results obtained in table appendix. The Lewbel 2SLS estimates (Table A.2.2) are also consistent with the baseline and conventional IV estimates. The results provide evidence in favor of a positive causal impact of the Internet on MCH utlization.

	Early ANC		Full ANC		Skilled birth attendance		Modern contraceptive use		Full immunization	
	First stage	Second Stage	First stage	Second Stage	First stage	Second Stage	First stage	Second Stage	First stage	Second Stage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Jio	0..4262123***		0.4238105***		0.4213173***		0.4213173***		0.4187618***	
	(.0064535)		(0.0061518)		(0.0061342)		(0.0061342)		(0.0068924)	
Household Internet access		**0.1239535*** **		**0.1628931*** **		**-0.0070883**		**0.2588274*** **		**-0.097813*** **
		(0.0148187)		**(0.0181849)**		**(0.0048669)**		**(0.0167541)**		**(0.0201617)**
Constant	-0.2954914***	0.7955609***	-0.2783217***	0.6149444***	-0.2813176***	-0.967072***	-0.2813176***	-0.0259605	-0.2503259***	0.2490594***
	(.0499827)	(0.0496417)	(0.048932)	(0.0585412)	(0.0485083)	(0.0175602)	(0.0485083)	(0.0174818)	(0.05126)	(0.0666126)
Observations	45802		48743		49697		49697		41068	
Controls	Yes		Yes		Yes		Yes		Yes	
District fixed effects	Yes		Yes		Yes		Yes		Yes	
C-D Wald F statistic	11720.70		12815.49		12901.17		12901.17		10617.93	
K-P Wald rk F statistc	4361.71		4746.14		4717.45		4717.45		3691.43	

Notes: This table reports IV regression results. Column 1 and 3 shows the first stage regression with access in the household as the dependent variable. Columns 2 and 4 show the second-stage regression results with early ANC and full ANC as the dependent variables, respectively. Internet diffusion at the cluster/PSU level has been used as an instrument for household internet access. The sample has been taken from NFHS 4 and NFHS 5. Each regression controls for, area of residence (rural/urban), wealth of the household, whether state of residence is EAG, gender of head of the household, family size, number of women in a family, age, education, caste, religion, marital status, if individual allowed to go to market, hospital and outside village, whether received JSY assistance or availed any service/advice from ASHA and ANM. The F statistics values imply the rejection of the null hypothesis of weak instrument. *, ** and *** represent 10%, 5% and 1% levels of significance, respectively. Standard errors are reported in parentheses.

Table 4. IV estimates (Jio)- Internet and MCH services (LATE)

6. Robustness checks

6.1 Robustness check 1: IV estimation: Average-treatment-effect-on-the-treated (ATT)

To validate the LATEs, the study employs another instrumental variable to address the endogeneity concern between household internet access and MCH services use. Following the methodology of Gong et al., (2020) and Chunfang et al., (2022), we use Internet penetration rate in a cluster/PSU (percentage of households in the cluster with Internet) as an instrumental variable. Internet penetration in the cluster reflects the information facilities and level of internet infrastructure both of which are directly related to household's internet use behavior. However, cluster level internet is an objective value and unrelated to individual's healthcare seeking behaviour. To assure exogeneity the paper by Gong et al., (2020) lags the IV by four years. Due to lack of data availability, we use the approach suggested by He et al., (2022).

The IV is calculated as follows,

$$ClusterInternet_{-icd} = \frac{\sum_1^n Internet_{icd} - Internet_{icd}}{n-1}$$

$ClusterInternet_{-ic}$ indicates the average Internet penetration rate of other households living in the same cluster c in district d, excluding household of individual i, $Internet_{icd}$ iis the binary indicator of individual i's household internet access. N represents the total number of households in cluster c.

Consider the following first-stage equation.

$$Internet_{icd} = \beta ClusterInternet_{icd} + X_i + \lambda_d + \epsilon_{id}, \qquad (4)$$

The second-stage equation is

$$Y_{icd} = \beta \widehat{Internet}_{icd} + X_i + \lambda_d + \epsilon_{id}, \qquad (5)$$

where, Y_{icd} is the binary indicator of woman i from a cluster c in district d availing a particular MCH service. $\widehat{Internet}_{icd}$ is obtained from the first stage equation. The standard errors are clustered at the cluster level.

The results of the 2SLS IV model are presented in table A.2.3. The first stage estimation results are reported in the odd numbered columns, whereas the even numbered columns show the regression output of the second stage estimation. The first stage results illustrate that the instrument 'cluster Internet penetration' is positively and significantly associated with household internet access. Cragg-Donald Wald F statistic and Kleibergen-Paap Wald rk F statistic values suggest that cluster internet penetration is not a weak instrumental variable. Given the above IV specification, the causal impact of Internet on skilled birth attendance and full immunization is insignificant. The results for early ANC, full ANC, modern contraceptive use are similar to the main empirical findings of the paper indicating that our results are robust.

6.2 Robustness check 2: DiD estimation: Intention-to-treat effect (ITT)

To estimate the impact of Internet access on MCH services, we treat the Jio intervention as a natural experiment. We study Jio as an internet expansion program in a quasi-experimental design using three pooled correctional surveys: IHDS wave 2, NFHS 4 and NFHS 5. We apply a DiD technique following the approach of Havnes and Mogstad (2011b) to estimate the effect of the expansion of household internet access on MCH services. The paper exploits the fact that the internet supply shocks were larger in some areas than others. The identification strategy is the following: We compare the MCH utilization outcomes of interest before and after the Jio intervention, from districts where household internet connectivity expanded a lot (treatment group) and districts where internet expansion was relatively less (comparison group).

The pre-intervention cohort consists of women whose data was collected in the period 2011–2012 from the IHDS 2 and January 2015 -August 2015 from the NFHS 4. We regard 2016–

2019 as the internet expansion period. Using MCH service utilization data of women in 2019-2021 as post-intervention cohort provides the telecommunication market in districts some time to adjust to the disruption by Jio. Using the data from the NFHS 4 and NFHS 5, we rank districts according to the percentage point increase in household internet penetration rate from 2016 to 2019 to determine treatment and control groups. The sample is then divided at the median. The upper half constitutes the treatment districts and the lower half the comparison districts.

The DiD regression model, estimated by the Ordinary-least-squares (OLS) is defined as

$$Y_{idt} = Post_t + \beta(Treat_{id} * Post_t) + X_i + \lambda_d + \epsilon_{idt}, \qquad (6)$$

Y_{idt} is the binary indicator MCH utilization for a woman i from district d in year t. $Treat_{id}$ takes a value 1 if i is from treatment district d. $Post_t$ equals to 1 if t > 2019.

Following the approach of M. Baker et al., (2008), β can be interpreted as an intention-to-treat effect (ITT) since our regression model estimates the reduced form impacts on all women from post-reform cohorts who reside in the treatment districts. An advantage of the ITT parameter is that it captures peer effects, if any, on women who did not have internet access. The ITT parameters obtained in Table A.2.4 show a positive impact of Jio on early ANC, full ANC and full immunization.

A crucial identifying assumption for the DiD estimates is the parallel trends assumption. The assumption states that the trends in the MCH services should not systematically change in the absence of the program. The graphs below plot the pre-trends of MCH services utilization based on the Indian Human Development Survey (IHDS) 2. The figures below depict graphical evidence that a common trend was observed in Antenatal Care utilization. To enhance confidence in our results, we conduct a placebo test by omitting observations post 2015 from our analysis. To assess the impact of the Jio intervention we consider 2011-12 as the baseline and 2015 as the

post-intervention period. As Jio was not available between 2011-2015, insignificant DiD estimates in table A.2.5 suggest a common trend of MCH service utilization between the treatment and the control districts. A drawback of these results arises because data for modern contraceptive use and skilled birth attendance cannot be compared due to differences in the coding of these variables in the IHDS and NFHS. Further, estimates of the placebo test compare 601,821 women in the treatment group to just 12,703 women in the control group. The values in the parallel trends for 2011-2012 are based on the average of 12,703 women only compared to 601,821 and 590,458 women in NFHS 4 and NFHS 5 respectively.

6.3 Robustness check 3: IPW estimation: Average treatment effect (ATE)

To calculate the ATE we follow the approach suggested by Hernán & Robins, (2020) and estimate the inverse probability weighted regressions which are based on two stages. In the first stage the probability of having internet access is estimated based on the based on all observed covariates. In the second stage we weight the individuals based on the inverse of the probability of treatment selection. We cluster the standard errors at the PSU/cluster level and also include state-fixed effects. The results are presented table A.2.6 and are consistent with our previous estimates.

7. Heterogeneous effects

Prior research indicates substantial heterogeneity in MCH service access. Studies demonstrate limited utilization of these services among socioeconomically disadvantaged cohorts. Inequalities may also persist due to distinct social norms in diverse communities (Allendorf, 2010; Pallikadavath et al., 2004a, 2004b; Say & Raine, 2007; Sridharan et al., 2018; Sunil et al., 2006; Viegas Andrade, Noronha, Singh, Guimar, et al., 2012; Viegas Andrade, Noronha, Singh, Rodrigues, et al., 2012). We return to our main specification and consider heterogeneous effects.

Table A.2.7 presents results for rural-urban strata. The results suggest that the LATEs for early ANC, full ANC and modern contraceptive use are higher for rural women. The effect is positive and highly significant for urban and rural areas for these services. In rural areas, the impact of internet access on skilled birth attendance is negative and significant at 0.05 level. In contrast, the effect turns out to be positive and significant at 0.10 level in urban areas. The results indicate that the average effects on skilled birth attendance for the entire population masks the heterogeneous effects by area of residence. Internet has a greater negative impact on full immunization in urban areas relatively.

Table A.2.8. illustrates the heterogeneity in Internet's impact by religion. The table contrasts the outcomes for Hindu and Muslim cohorts. Internet has a positive and highly significant effect on early ANC for Hindu women. The effect turns out to be negligible for Muslims. The effect on full ANC is positive across religion, however, the level of significance decreases for Muslims. Internet adversely affects skilled birth attendance for Hindu women but has no influence on Muslims. The estimates do not yield any notable differences between the two groups for modern contraceptive use. The negative impact on full immunization is more pronounced for Muslims than Hindus.

Table A.2.9. reveals some evidence for a caste gradient in the causal impact of internet on MCH services. The results suggest a similar pattern for Scheduled castes and Scheduled tribes for all the outcomes. The positive impact on early ANC, full ANC and modern contraceptive use is higher for OBCs than SC/STs. The detrimental effect on skilled birth attendance for OBCs is more than SC/STs. The estimates for early ANC, modern contraceptive use and full immunization are similar for OBCs and other higher castes. In contrast to their socioeconomically disadvantaged counterparts, estimates for higher castes appear to be lower.

Table A.2.10 we provide an analysis of heterogeneous effects based on wealth quintiles. The lowest two quintiles "poorest' and "poorer" are classified into "poor" category. Similarly, the

top two quintiles ("richer" and "richest") are considered to be the "rich" cohort. The effect appears to be more concentrated among poor women for most outcomes. The negative impact on full immunization increases as ascend the wealth ladder. Outcomes do not appear to be significant for the middle wealth quintile except for full ANC.

8. Discussion

The study proposes and tests the potentially ambiguous influence of increased Internet diffusion in India on the rising demand for maternal and child healthcare services through a novel IV. Our findings empirically argue that household Internet access is positively and significantly associated with the use of modern contraceptives, early and full ANC checkups. The estimates are consistent across different methodologies opted as robustness checks. The study argues that the role of awareness through increased Internet coverage becomes crucial in the Indian context. Building on the existing literature, the potential mechanism through which Internet penetration leads to a rise in demand for MCH services is the increased health information seeking associated with internet use (Ajayi et al., 2023; Bjelke et al., 2016c; Dobransky & Hargittai, 2012; Gao et al., n.d.; H. A. Grimes et al., 2014; Shieh et al., 2009). Women may not always perceive the information to be reliable but still (somewhat) useful (Slomian et al., 2017). Web-derived health information yields enhanced communication between physician and patients, shared decision making, and more efficient use of clinical time (Wald et al., 2007).

The study also highlights a significant adverse impact of increasing misinformation and promotion of patriarchal ideas on the immunization of children. Our results indicate that increased household Internet access has negatively and adversely impacted the immunizations and preventive vaccination of children in India (Carrieri et al., 2019; Hill & Allen, 2021; Murtiningsih et al., 2017; Ołpiński, 2012; Verdonk et al., 2009). Heterogenous effects on skilled birth attendance demonstrate contrasting effect of Internet on rural vs urban subsamples,

which results in a net insignificant impact on the entire sample. These results are in sharp contrast to what one would argue intuitively. Inaccurate information and a gender digital divide in the Indian cyberspace can potentially hinder women' access to healthcare. Increased Internet coverage for women can potentially reduce the impact of biased algorithms and contribute to large-scale health programs in the country.

Heterogeneity analysis reveals that the effect of Internet on MCH service utilization for socioeconomically disadvantaged women is more than their well-off counterparts. The result may be a consequence of the Internet becoming more accessible after the dramatic fall in prices post-September 2016. The heterogeneity in our results is not surprising since Jio's gave a relatively larger boost to Internet access for the impoverished groups. Thus, a bigger local average treatment effect in outcomes is expected for the disadvantaged women. The findings indicate Internet penetration can potentially reduce healthcare access disparities between the privileged and the under-privileged.

9. Limitations of the study

This paper contributes to the understanding of how the recent Internet expansion in India impacts MCH access. However, it is essential to take note of the limitations of the study. First, the study uses Internet access at the household level due to lack of data. Individual use of the Internet may provide more precise causal estimates. The paper further uses cross-sectional data sets. Using panel data in the future would more accurately account for individual heterogeneity and selection issues. Due to data collection issues, size of the control group and possible nonexistence of parallel trends, DiD estimates should be interpreted with caution. Although we also examine heterogeneous effects of Internet access, we believe a detailed investigation in this regard is still needed. It would also be useful to consider other model specifications for causal inference if suitable instruments can be found. Future research can concentrate on the impact of Internet diffusion on other aspects of women well-being.

10. Conclusion

Utilization of MCH services is critical in reducing MMR, particularly in LMICs like India. Targeted programs that raise awareness can potentially encourage women to seek formal healthcare and minimize pregnancy complications. Our results suggest that household Internet access can increase access to pregnancy healthcare however can potentially reduce the likelihood getting their children immunized. The misinformation through biased algorithms and gender digital divide thus can reduce the gains generated from increased Internet usage. Increasing Internet adoption for women can mitigate potential drawbacks of Internet by making it a more inclusive space.

11. Appendix

11.1 Additional Graphs

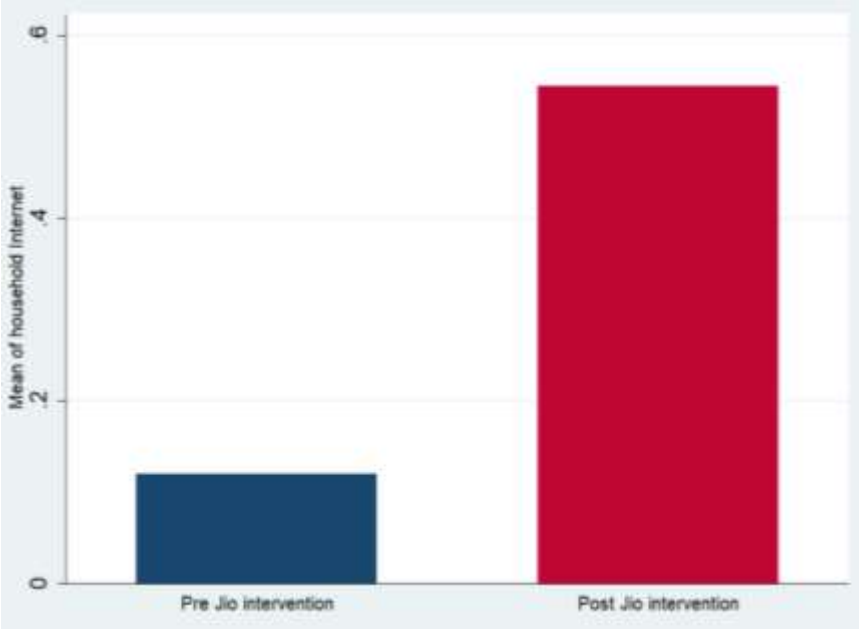

Figure A.1.1. Household Internet penetration (pre vs post Jio intervention) (Authors' calculation)

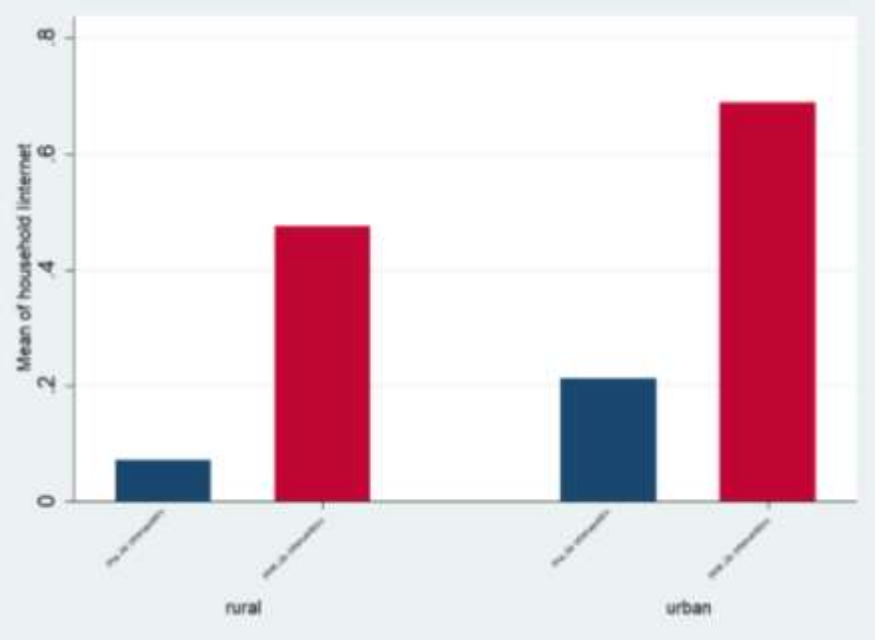

Figure A.1.2. Area-wise household Internet penetration (pre vs post Jio intervention) (Authors' calculation)

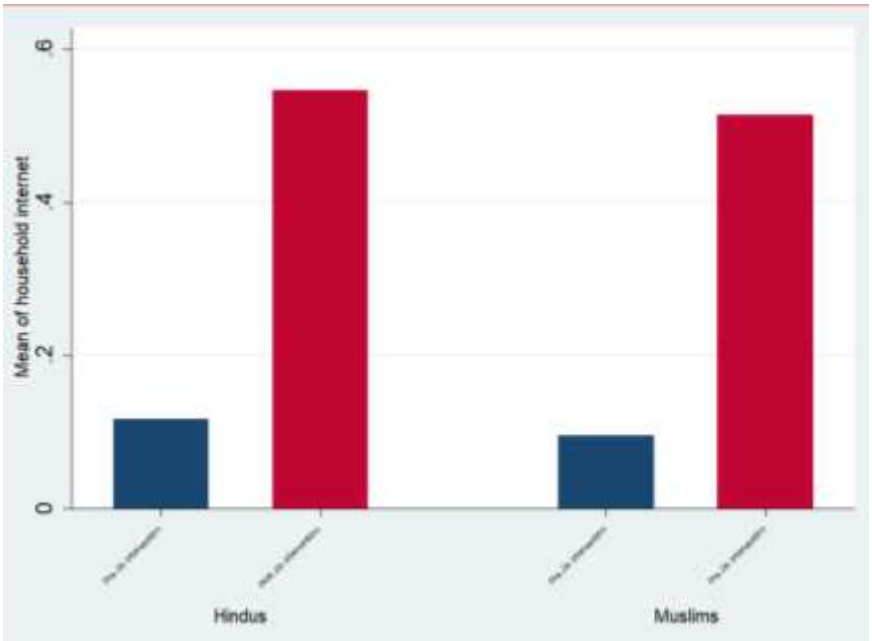

Figure A.1.3. Religion-wise household Internet penetration (pre vs post Jio intervention) (Authors' calculation)

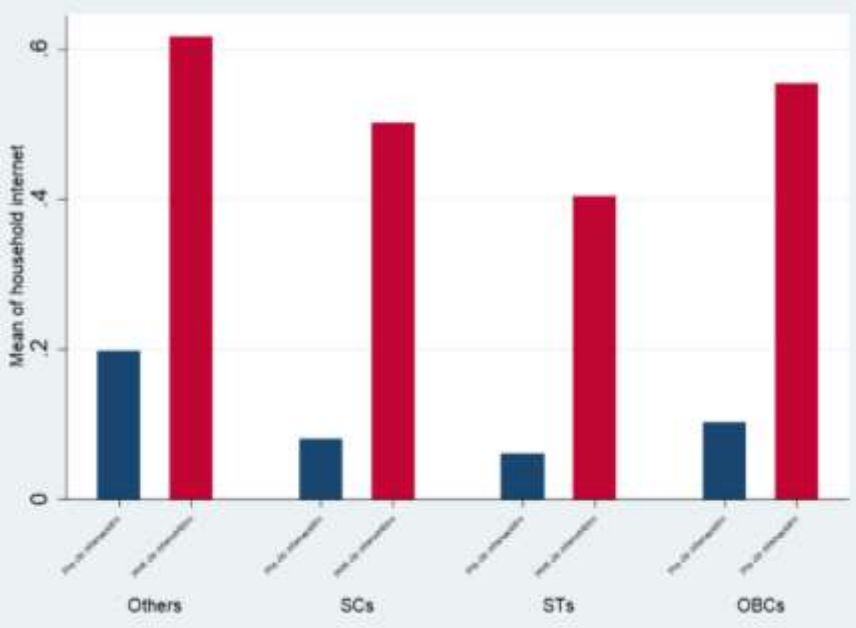

Figure A.1.4. Social group-wise household Internet penetration (pre vs post Jio intervention) (Authors' calculation)

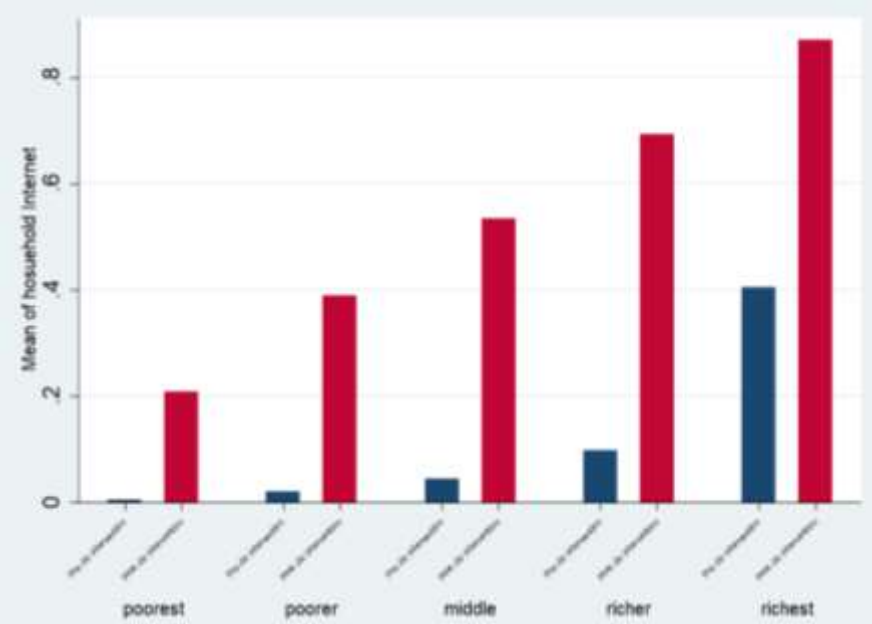

Figure A.1.5. Wealth group-wise household Internet penetration (pre vs post Jio intervention) (Authors' calculation)

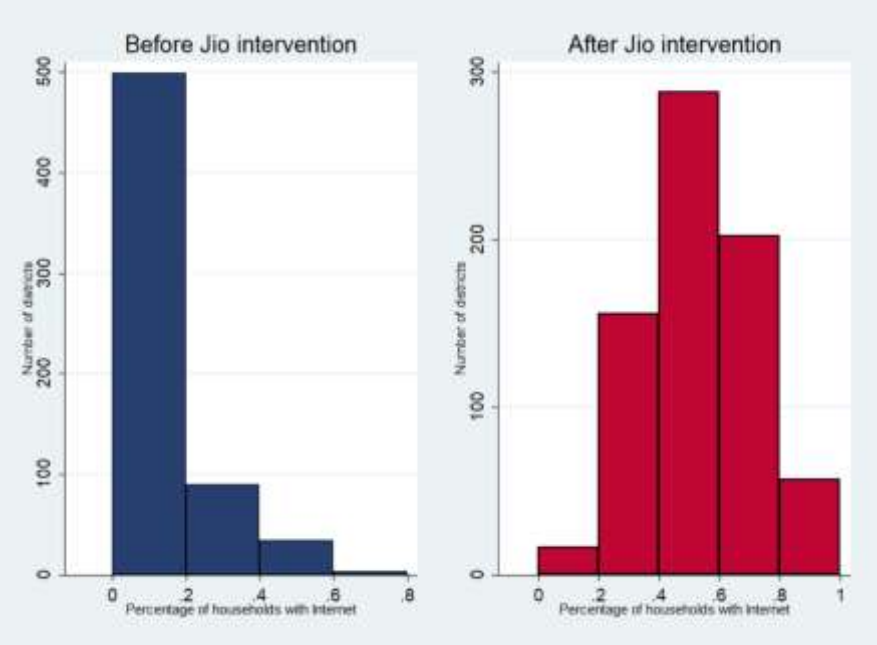

Figure A.1.6. Number of districts with different levels of Internet penetration (pre vs post Jio intervention) (Authors' calculation)

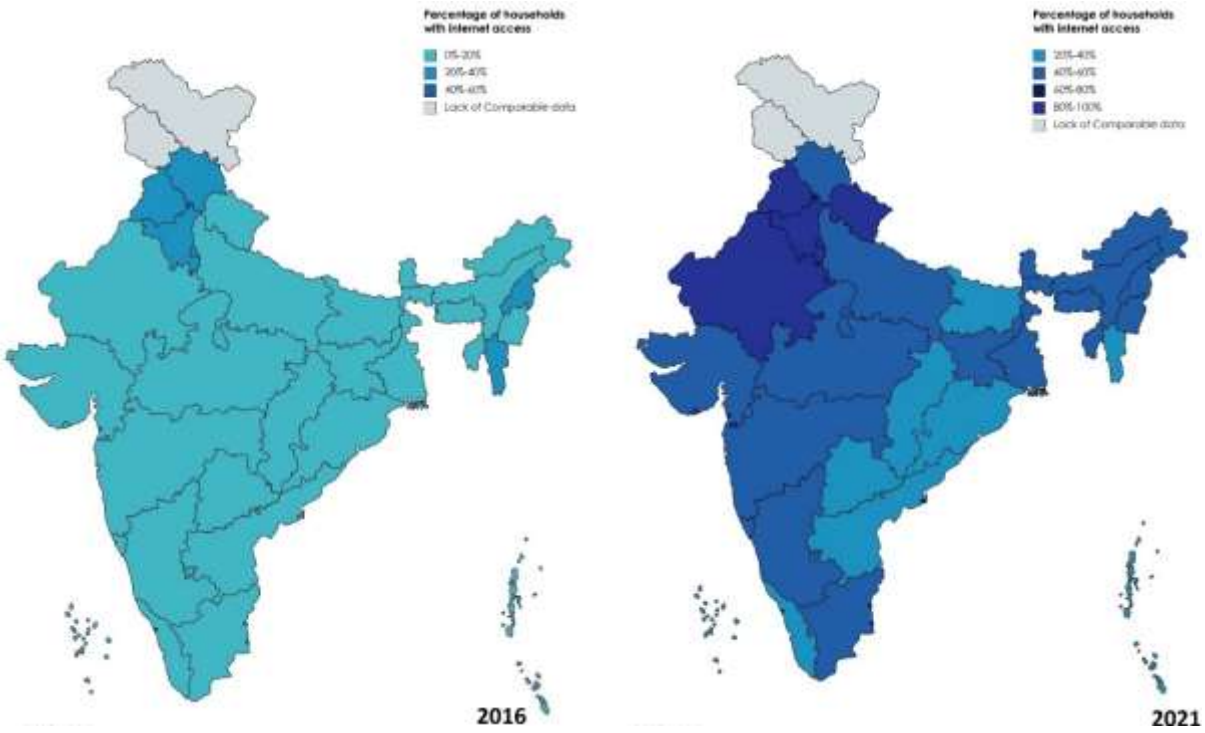

Figure A.1.7. State-wise household Internet penetration (pre vs post Jio intervention) (Authors' calculation)

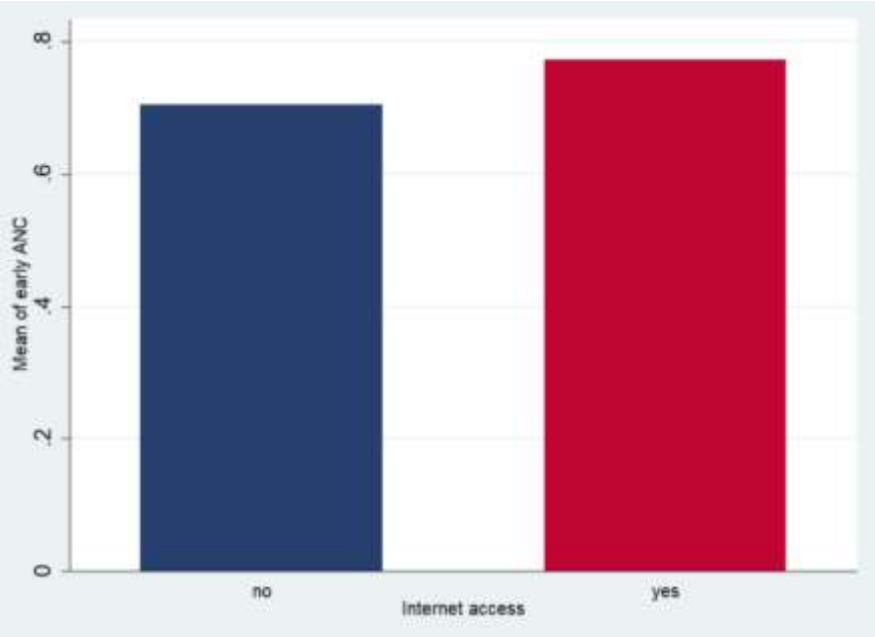

Figure A.1.8. Mean of early ANC for households with and without Internet (Authors' calculation)

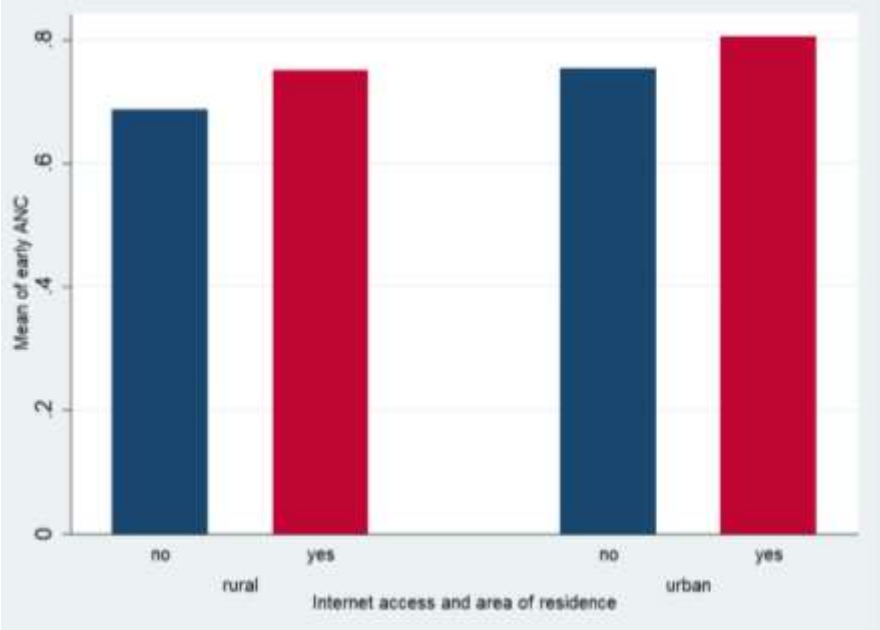

Figure A.1.9. Area of residence-wise mean of early ANC for households with and without Internet (Authors' calculation)

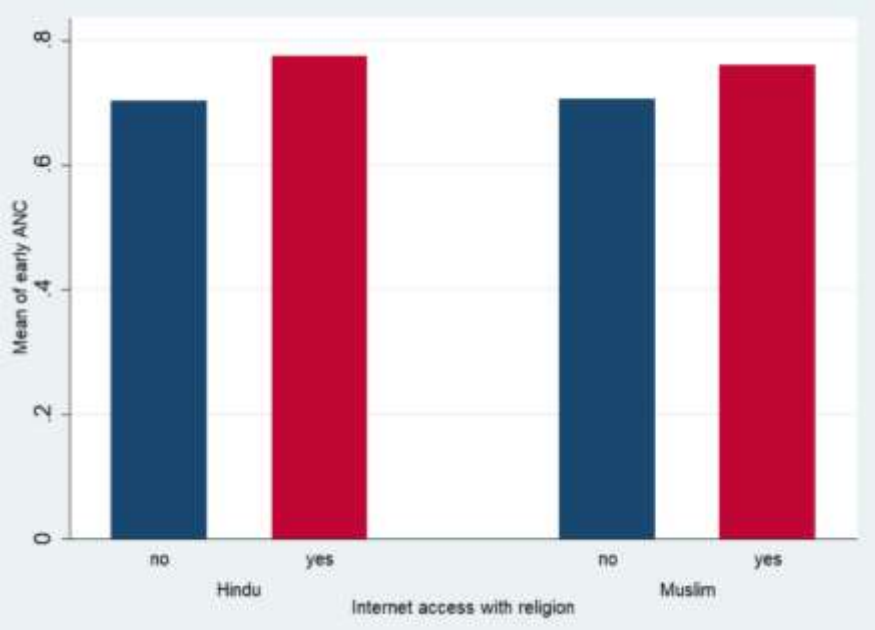

Figure A.1.10. Religion-wise mean of early ANC for households with and without Internet (Authors' calculation)

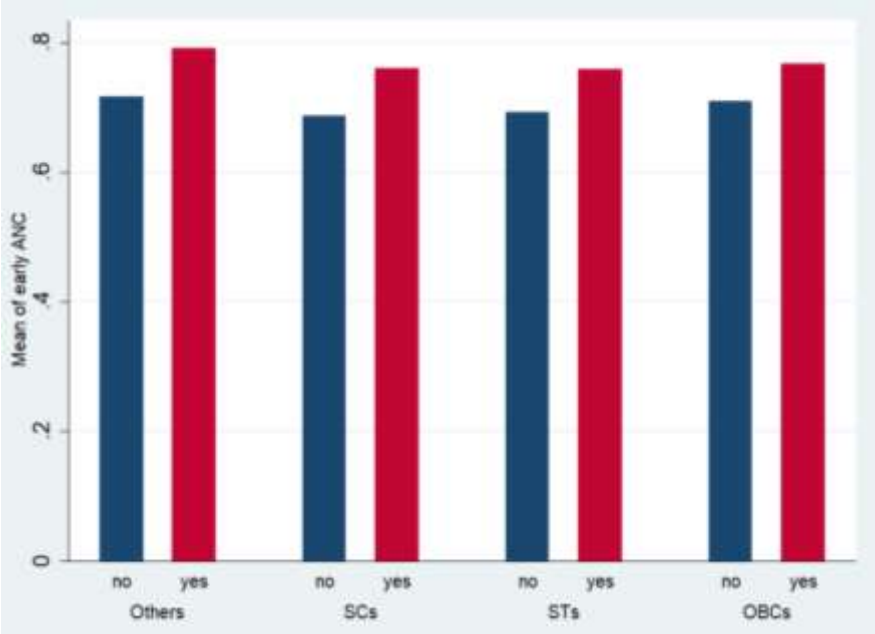

Figure A.1.11. Social group-wise mean of early ANC for households with and without Internet (Authors' calculation)

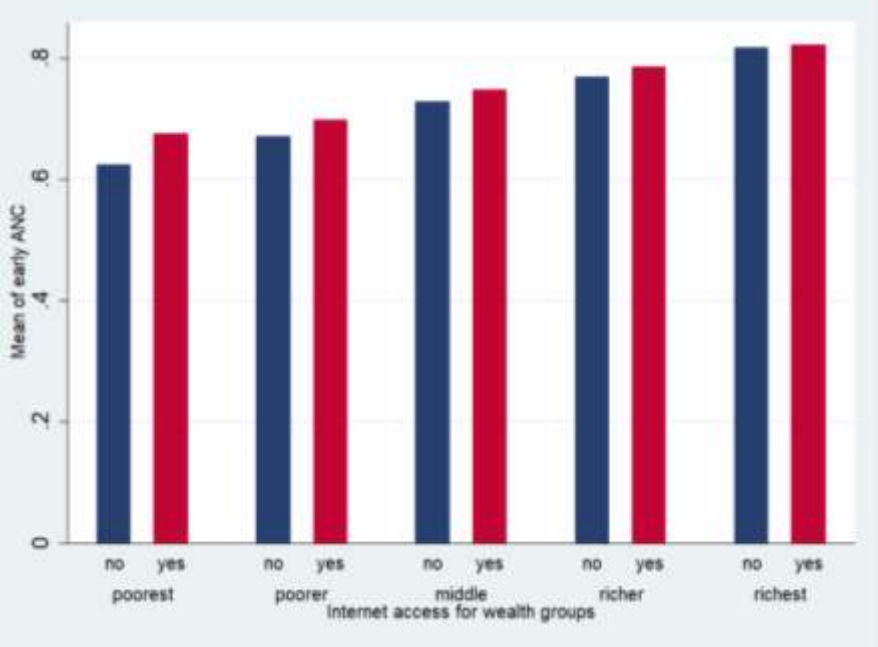

Figure A.1.12. Wealth group-wise mean of early ANC for households with and without Internet (Authors' calculation)

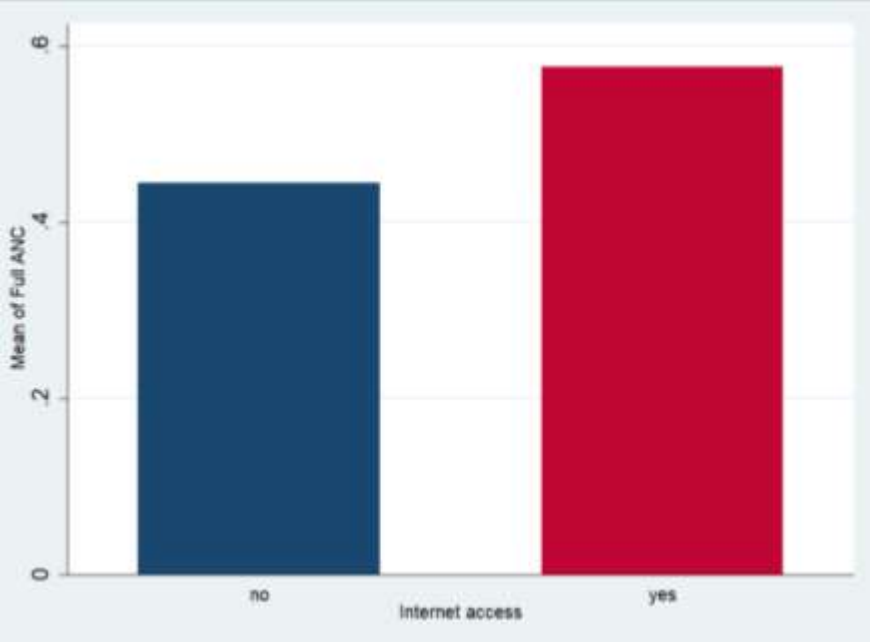

Figure A.1.13. Mean of full ANC for households with and without Internet (Authors' calculation)

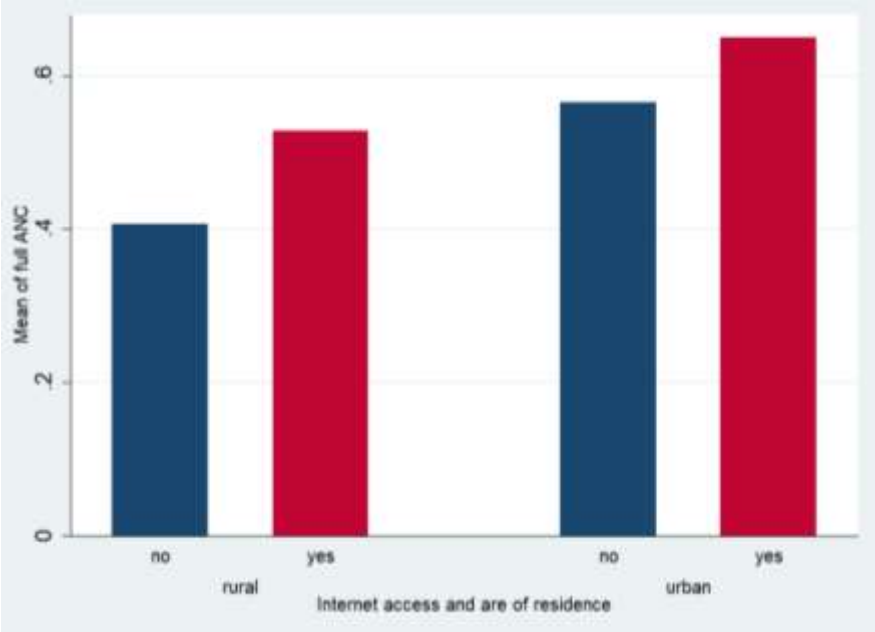

Figure A.1.14. Area of residence-wise mean of full ANC for households with and without Internet (Authors' calculation)

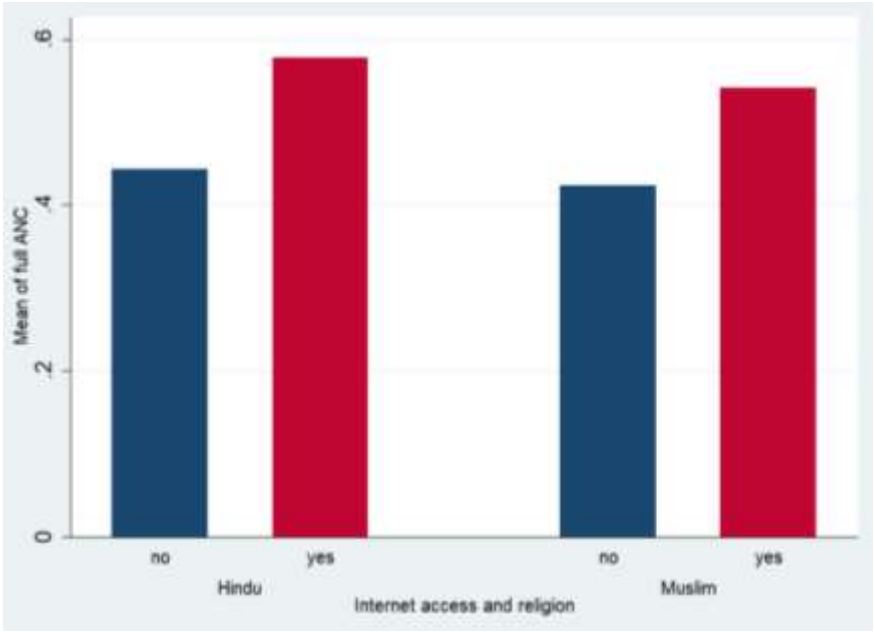

Figure A.1.15. Religion-wise mean of full ANC for households with and without Internet (Authors' calculation)

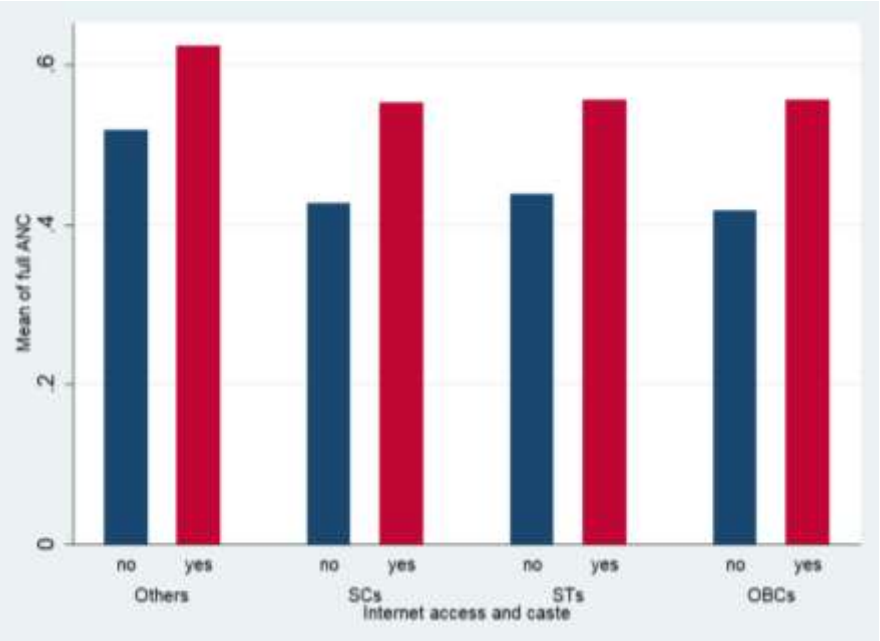

Figure A.1.16. Social group-wise mean of full ANC for households with and without Internet (Authors' calculation)

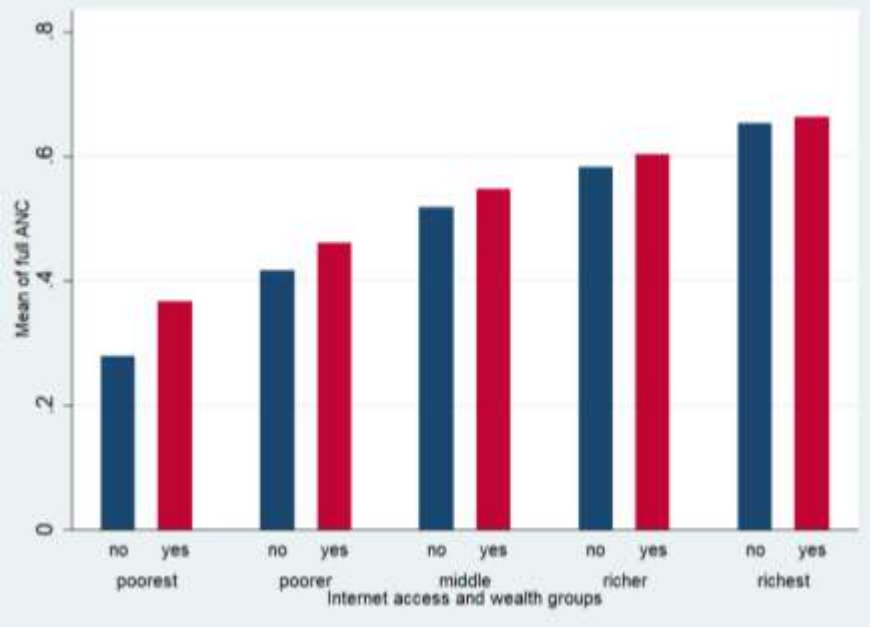

Figure A.1.17. Wealth group-wise mean of full ANC for households with and without Internet (Authors' calculation)

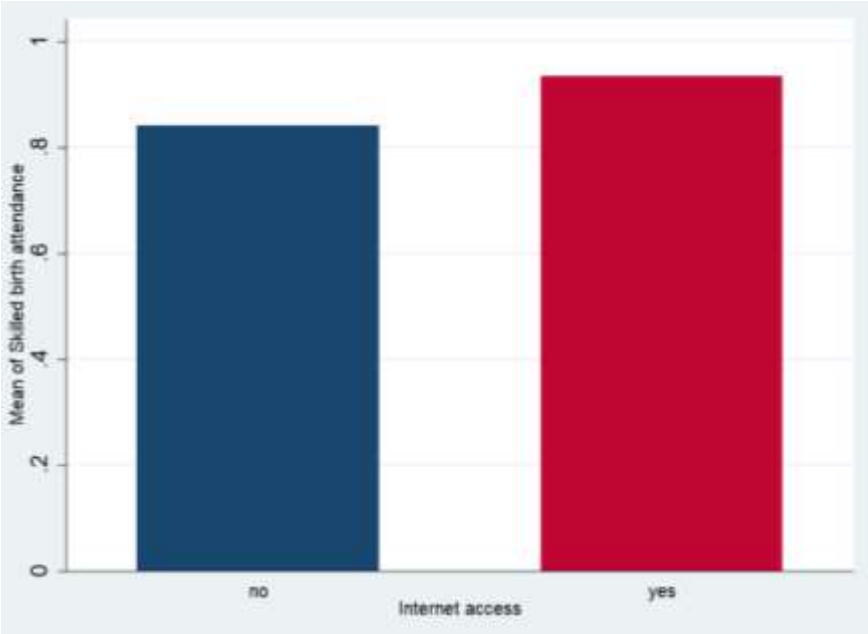

Figure A.1.18. Mean of skilled birth attendance for households with and without Internet (Authors' calculation)

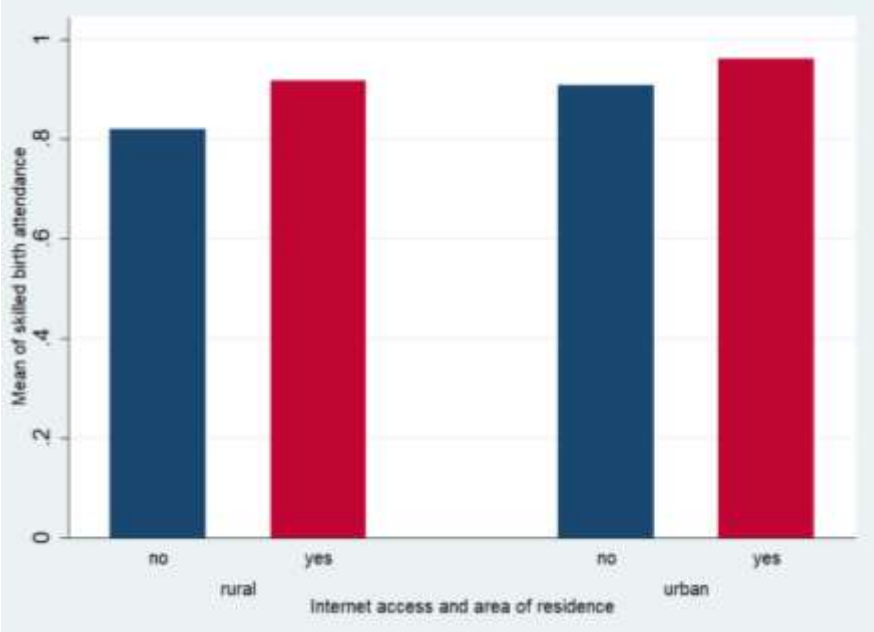

Figure A.1.19. Area of residence-wise mean of skilled birth attendance for households with and without Internet (Authors' calculation)

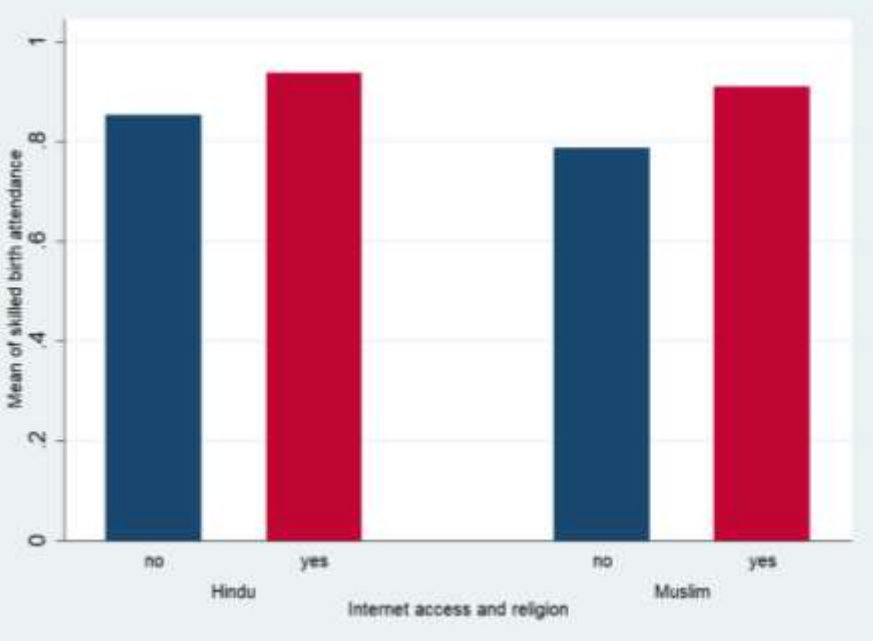

Figure A.1.20. Religion-wise mean of skilled birth attendance for households with and without Internet (Authors' calculation)

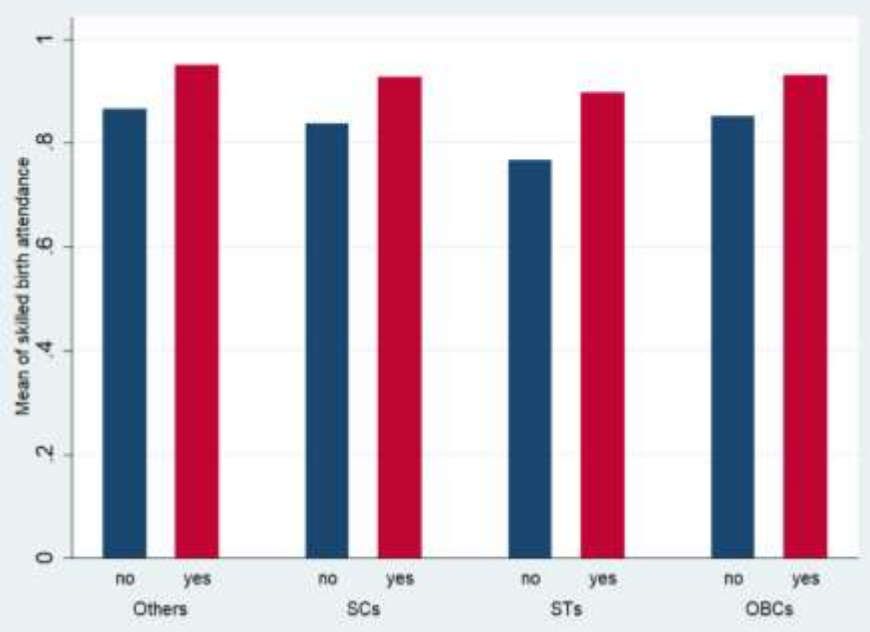

Figure A.1.21. Social group-wise mean of skilled birth attendance for households with and without Internet (Authors' calculation)

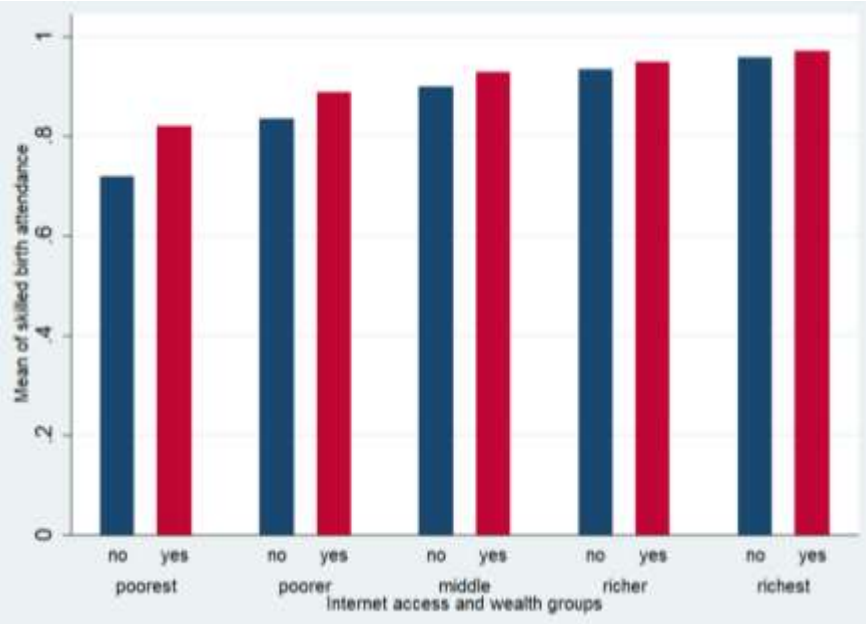

Figure A.1.22. Wealth group-wise mean of skilled birth attendance for households with and without Internet (Authors' calculation)

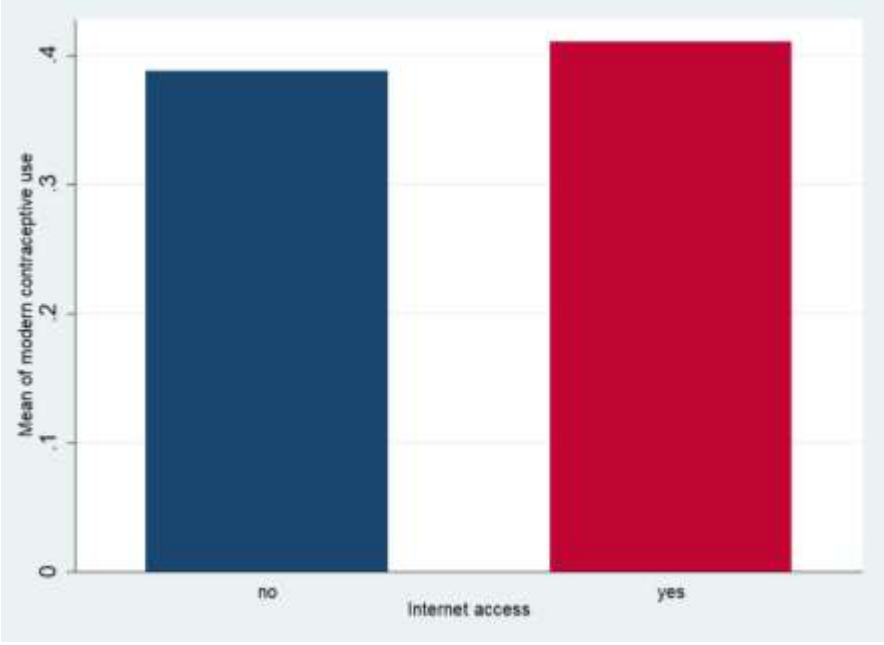

Figure A.1.23. Mean of modern contraceptive use for households with and without Internet (Authors' calculation)

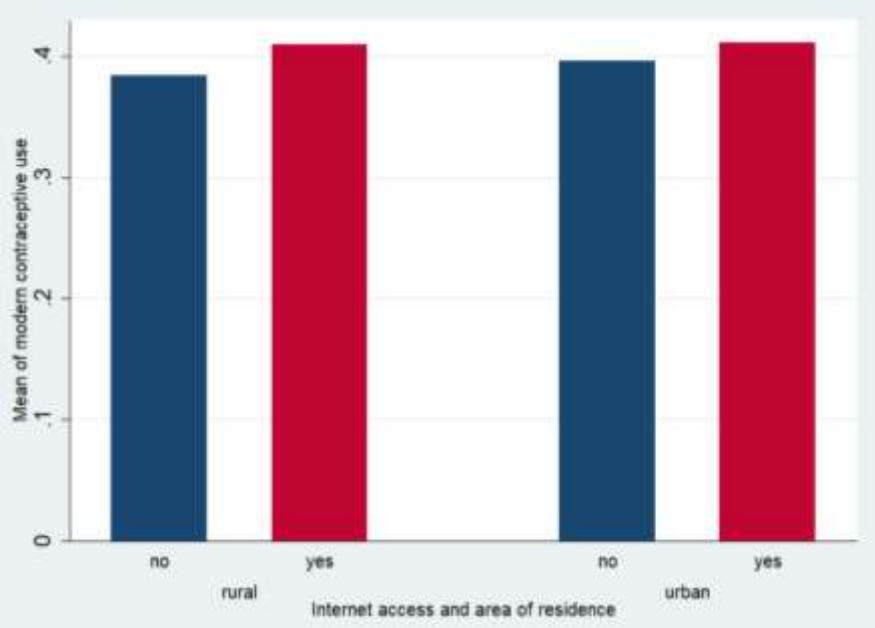

Figure A.1.24. Area of residence-wise mean of modern contraceptive use for households with and without Internet (Authors' calculation)

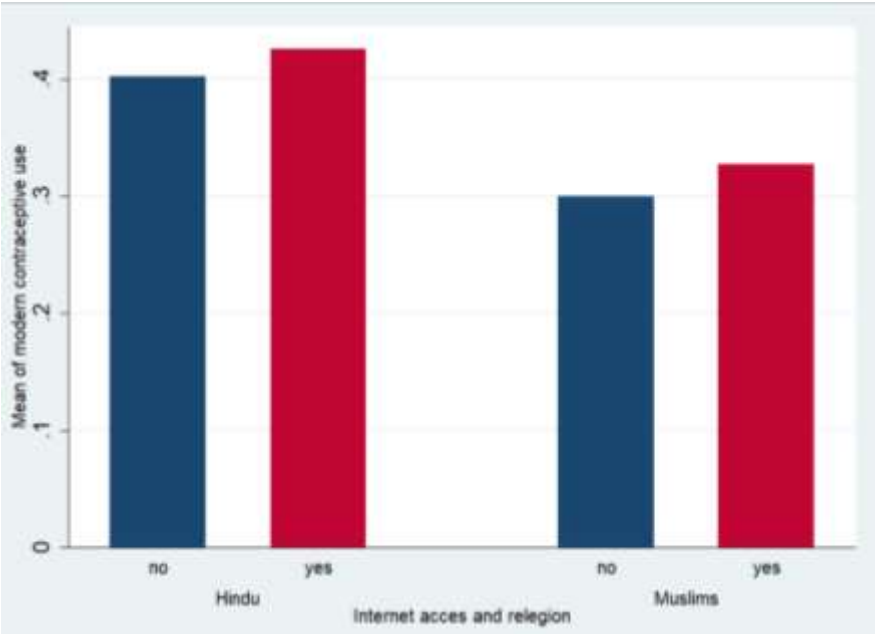

Figure A.1.25. Religion-wise mean of modern contraceptive use for households with and without Internet (Authors' calculation)

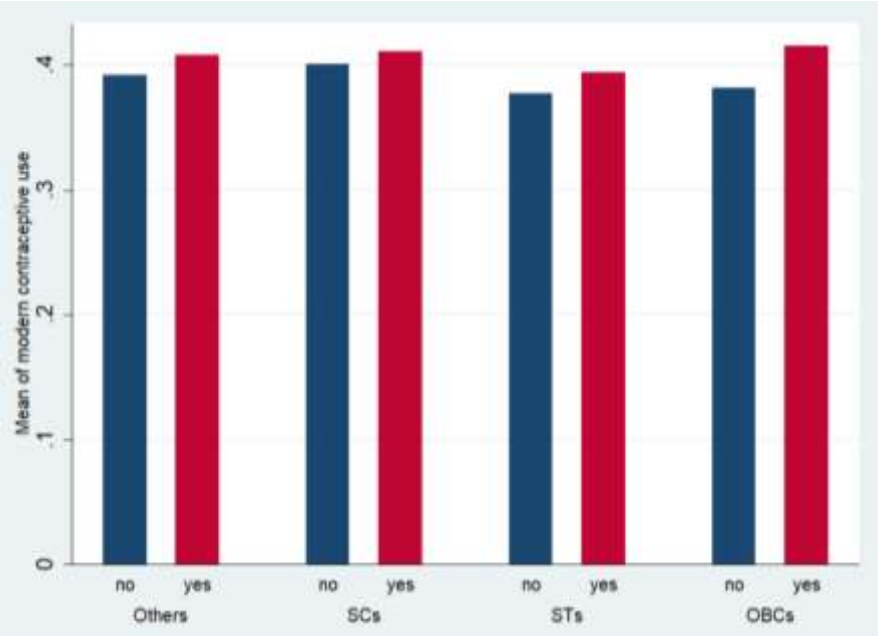

Figure A.1.25. Social group-wise mean of modern contraceptive use for households with and without Internet (Authors' calculation)

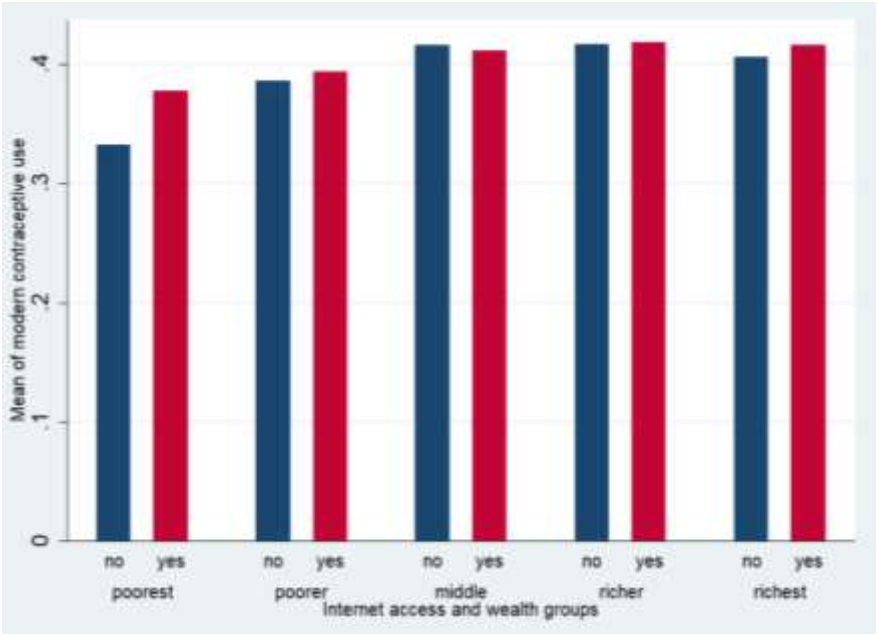

Figure A.1.26. Wealth group-wise mean of modern contraceptive use for households with and without Internet (Authors' calculation)

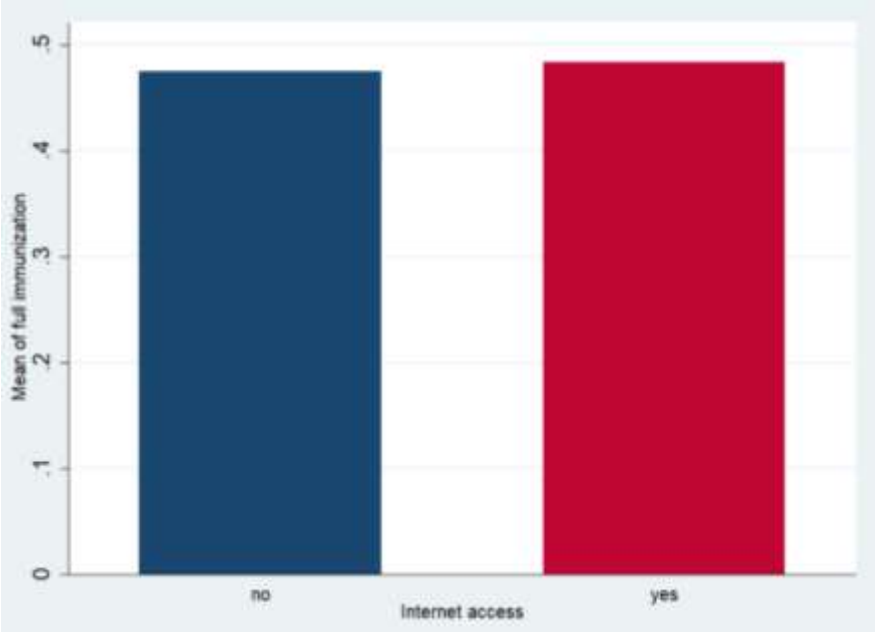

Figure A.1.28. Mean of full immunization for households with and without Internet (Authors' calculation)

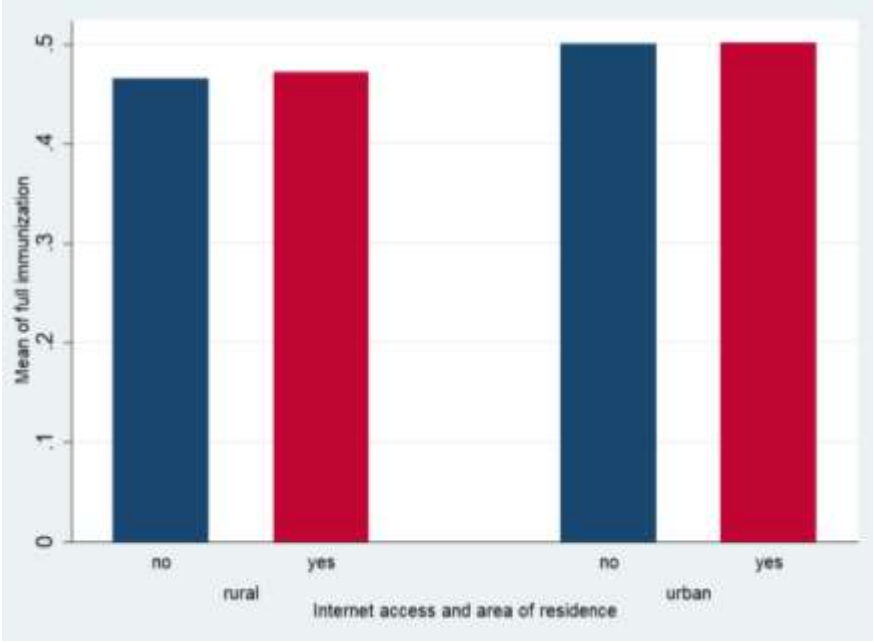

Figure A.1.29. Area of residence-wise mean of full immunization for households with and without Internet (Authors' calculation)

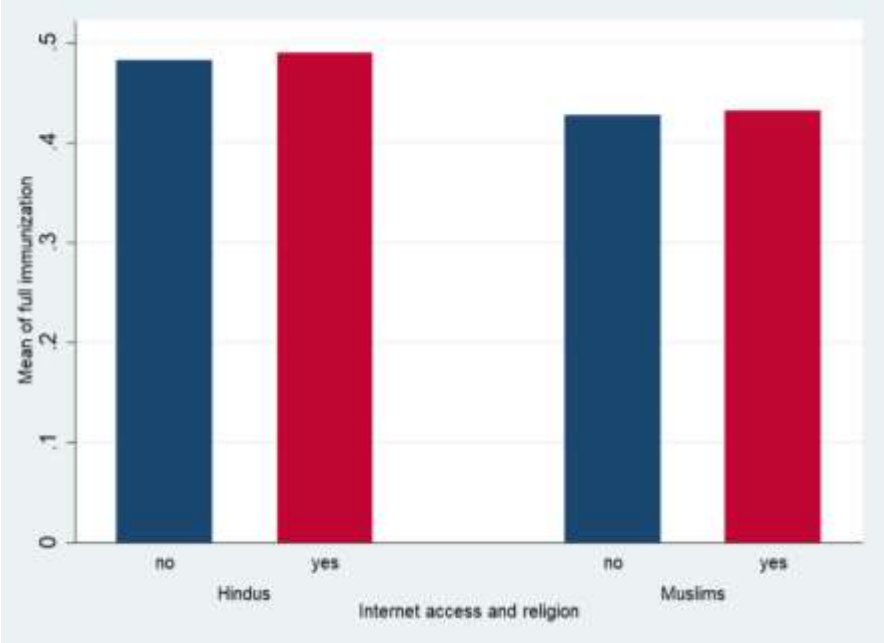

Figure A.1.30. Religion-wise mean of full immunization for households with and without Internet (Authors' calculation)

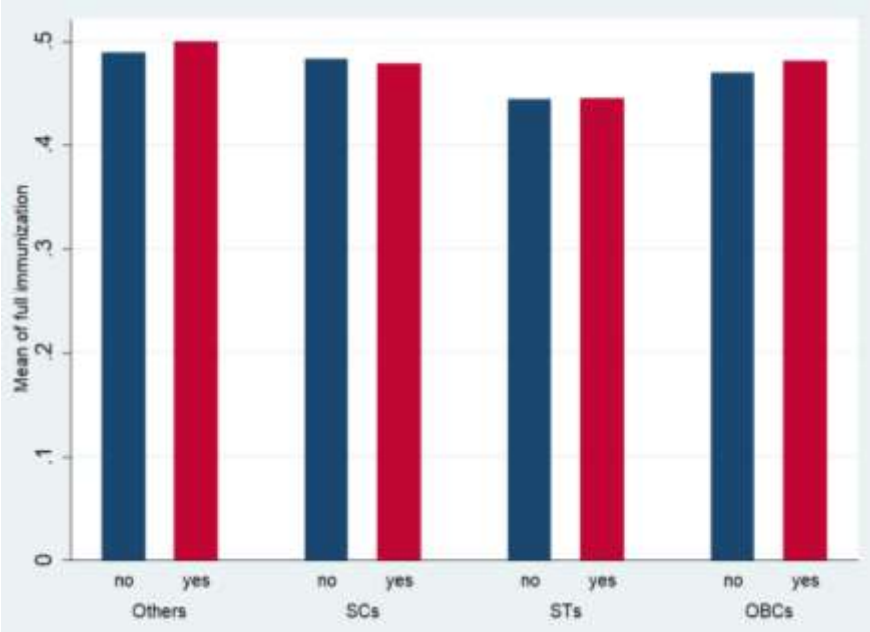

Figure A.1.31. Social group-wise mean of full immunization for households with and without Internet (Authors' calculation)

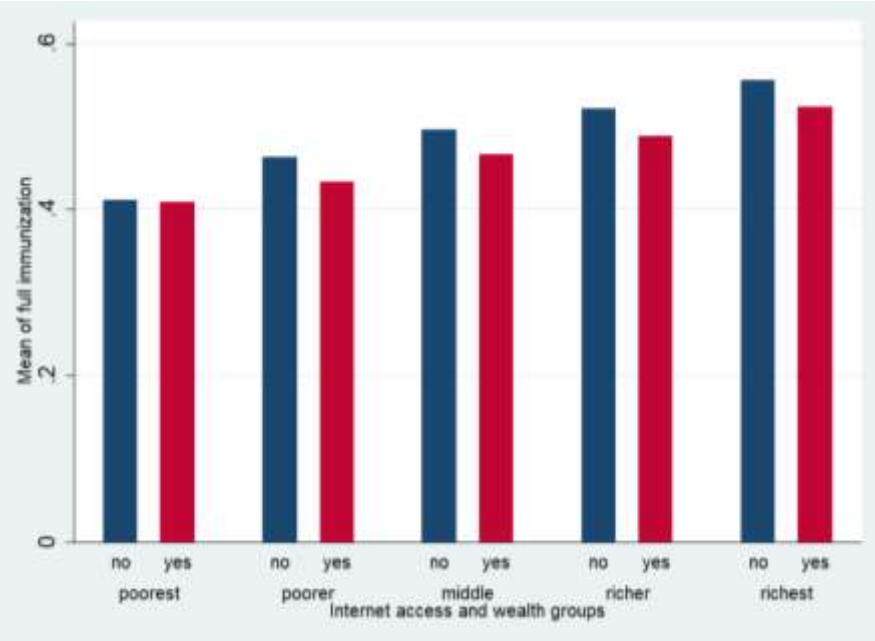

Figure A.1.32. Wealth group-wise mean of full immunization for households with and without Internet (Authors' calculation)

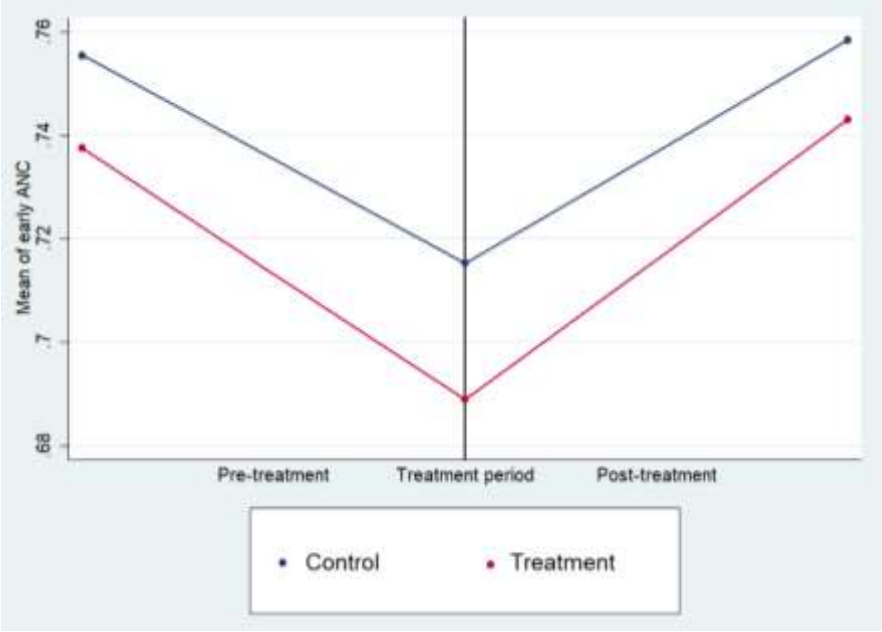

Figure A.1.33. Parallel Trends-early ANC

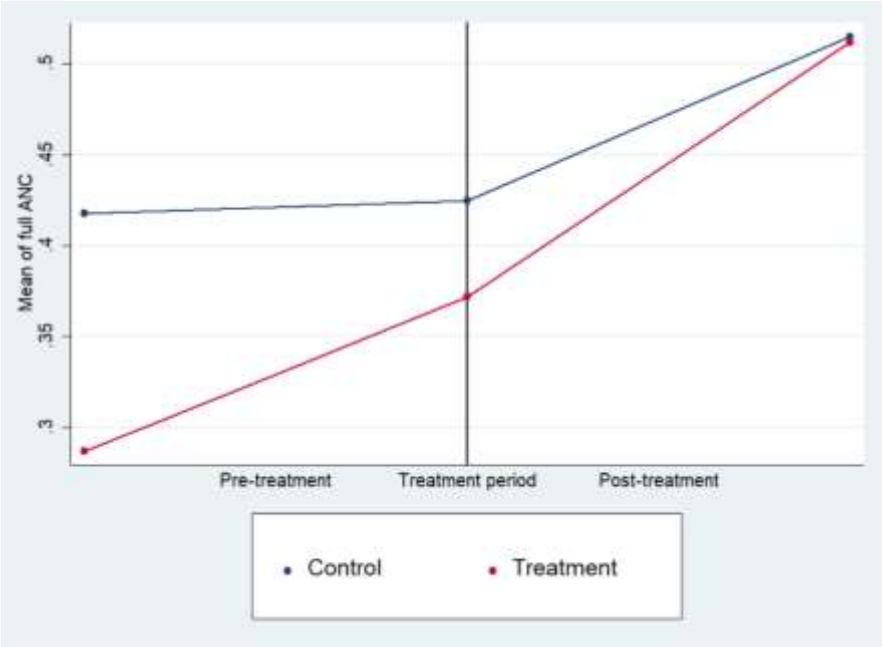

Figure A.1.34. Parallel Trends-full ANC

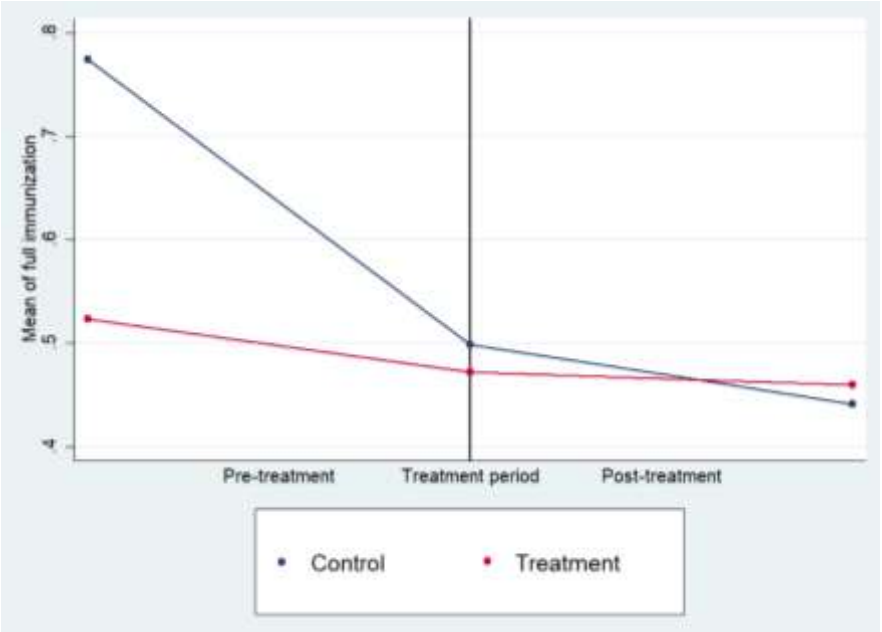

Figure A.1.35. Parallel Trends-full immunization

11.2 Additional tables

	Early ANC	Full ANC	Skilled birth attendance	Modern contraceptive use	Full immunization
	(1)	(2)	(3)	(4)	(5)
Household Internet access	**0.0319905*** **	**0.0505202*** **	**0.0001848**	**0.0567945*** **	**-0.0190469*** **
	(0.0049595)	**(0.0055353)**	**(0.0016119)**	**(0.0053757)**	**(0.006218)**
Constant	0.7365139***	0.5328851***	0.9673342***	-0.0227572	0.3068305***
	(0.0433527)	(0.0585412)	(0.0145154)	(0.0501341)	(0.0586917)
Observations	45802	48743	49697	49697	41068
Controls	Yes	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes	Yes

Table A.2.1. Household Internet access and MCH services (Baseline results)

	Early ANC	Full ANC	Skilled birth attendance	Modern contraceptive use	Full immunization
	(1)	(2)	(3)	(4)	(5)
Household Internet access	**0.0353045*** **	**0.1007112*** **	**0.0082977*** **	**0.083823*** **	**0.024936***
	(0.0112193)	**(0.0141917)**	**(0.0082977)**	**(0.0127998)**	**(0.0145413)**
Constant	0.7400019***	0.4881486***	0.9729767***	0.3976571***	0.0145413***
	(0.0050634)	(0.0071007)	(0.0021251)	(0.0068918)	(0.0079006)
Observations	45802	48743	49697	49697	41068
C-D Wald F statistic	705.094	784.507	803.679	803.679	724.035
K-P Wald rk F statistc	411.407	426.455	437.811	437.811	376.475

Table A.2.2. Household Internet access and MCH services (Lewbel 2SLS results)

	Early ANC		Full ANC		Skilled birth attendance		Modern contraceptive use		Full immunization	
	First stage	Second Stage	First stage	Second Stage	First stage	Second Stage	First stage	Second Stage	First stage	Second Stage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Cluster Internet penetration	0.8194749***		0.8177638***		0.81676***		0.81676***		0.8163033***	
	(0.0097794)		(0.0095423)		(0.0094414)		(0.0094414)		(0.0110228)	
Household Internet access		**0.1002272*** **		**0.1787451*** **		**0.0009544**		**0.1971822*** **		**-0.228676**
		(0.0148187)		**(0.0166601)**		**(0.0040319)**		**(0.0152571)**		**(0.0180352)**
Constant	-0.4115502***	0.7881127***	-0.38916 ***	0.619612***	-0.3906052***	0.9694726***	-0.3906052***	-0.0443805	-0.3792924***	0.2656595***
	(0.0426429)	(0.0496455)	(0.0414415)	(0.0586024)	(0.0412449)	(0.0174818)	(0.0412449)	(0.0586838)	(0.0461696)	(0.0662473)
Observations	45801		48742		49696		49696		410647	
Controls	Yes		Yes		Yes		Yes		Yes	
District fixed effects	Yes		Yes		Yes		Yes		Yes	
C-D Wald F statistic	15098.36		16254.97		15098.38		16475.04		13595.68	
K-P Wald rk F statistic	7021.79		7344.26		7021.81		7483.66		5484.26	

Notes: This table reports IV regression results. Odd numbered columns show the first stage regression with access in the household as the dependent variable. Even numbered columns show the second-stage regression results for the outcome variables. Internet penetration at the cluster/PSU level has been used as an instrument for household internet access. The sample has been taken from NFHS 4 and NFHS 5. Each regression controls for, area of residence (rural/urban), wealth of the household, gender of head of the household, family size, number of women in a family, age, education, caste, religion, if the individual allowed to go to market, hospital and outside village, whether received JSY assistance or availed any service/advice from ASHA and ANM. The F statistics values imply the rejection of the null hypothesis of weak instrument. *, ** and *** represent 10%, 5% and 1% levels of significance, respectively. Standard errors are reported in parentheses.

Table A.2.3. Household Internet access and MCH services (IV [cluster Internet penetration] results) (ATT)

	Early ANC	Full ANC	Full immunization
	(1)	(2)	(5)
Post	0.051798***	0.0804406***	-0.0546591***
	(0.0032867)	(0.0034751)	(0.0036615)
ITT	**0 .0082278***	**0.0505275*****	**0 .0470124*****
	(0.0046186)	**(0.0047324)**	**(0.0049644)**
Constant	0.7358994***	0.5928375***	0.520337***
	(0.0230853)	(0.0590197)	(0.0266663)
Observations	273264	307591	257266
Controls	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes

Table A.2.4. DiD estimates- Jio intervention and MCH services (ITT)

	Early ANC	Full ANC	Full immunization
	(1)	(2)	(5)
Post	0.0248558	-0.18321336***	-0.1807039***
	(0.0032867)	(0.0670989)	(0.0573319)
ITT	**-0.1516066**	**0.0540815**	**-0.1538005****
	(0.0880523)	**(0.0739734)**	**(0.0686378)**
Constant	0.7417331***	0.7451685***	0.6230257***
	(0.0915313)	(0.0761903)	(0.0642994)
Observations	165555	138236	160283
Controls	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes

Table A.2.5. Falsification tests for DiD estimates- Jio intervention and MCH services

	Early ANC	Full ANC	Skilled birth attendance	Modern contraceptive use	Full immunization
	(1)	(2)	(3)	(4)	(5)
Household Internet access	0.0288214***	0.0503828***	0.0011766	0.055264***	0.0153617
	(0.0084946)	(0.0086551)	(0.0032603)	(0.0087274)	(0.0105951)
Observations	45802	48743	49697	49697	41068
Controls	Yes	Yes	Yes	Yes	Yes

Table A.2.6. IPW estimates- Internet and MCH services (ATE)

	Rural	Urban
	(1)	(2)
Early ANC	0.1405333***	0.0948056***
	(0.019702)	(0.0282157)
Observations	33362	12440
Full ANC	0.1933606***	0.091738***
	(0.0189888)	(0.0362525)
Observations	35896	12847
Skilled birth attendance	-0.0164675**	0.0106426*
	(0.0066472)	(0.0055204)
Observations	36524	13173
Modern contraceptive use	0.2668331***	0.2409254***
	(0.0186691)	(0.0323072)
Observations	36524	13173
Full immunization	-0.0797329***	-0.1071744***
	(0.021748)	(0.0408632)
Observations	30135	10933

Table A.2.7. Household Internet access and MCH services (IV results) (Rural vs Urban)

	Hindus	Muslims
	(1)	(2)
Early ANC	0.1392744***	0.0440194
	(0.0179613)	(0.0459554)
Observations	34163	6859
Full ANC	0.1846617***	0.0903268**
	(0.0196372)	(0.0432955)
Observations	36495	7232
Skilled birth attendance	-0.0111793**	0.0100135
	(0.005593)	(0.0102659)
Observations	37106	7401
Modern contraceptive use	0.2544463***	0.2709853***
	(0.0186959)	(0.0433976)
Observations	37106	7401
Full immunization	-0.0689221***	-0.1446438***
	(0.0218839)	(0.0546582)
Observations	30685	6186

Table A.2.8. Household Internet access and MCH services (IV results) (Hindus vs Muslims)

	Scheduled caste	Scheduled tribe	Other backward classes	Others
	(1)	(2)	(1)	(2)
Early ANC	0.1534253***	0.2475332***	0.090485***	0.0977892***
	(0.0329857)	(0.0587409)	(0.0202062)	(0.0359224)
Observations	8559	7808	18148	11287
Full ANC	0.2384328***	0.3481433***	0..2055956***	-0.0157443
	(0.0336364)	(0.0571913)	(0.0225095)	(0.0387249)
Observations	9237	8291	19500	11715
Skilled birth attendance	-0.0075469	-0.0220561	-0.014663**	-0.0029675
	(0.0099126)	(0.0258184)	(0.0064997)	(0.0075138)
Observations	9384	8506	19810	11997
Modern contraceptive use	0.3085573***	0..2766336***	0.2458424***	0.2304383***
	(0.0356978)	(0.0558678)	(0.0222632)	(0.0385569)
Observations	9384	8506	19810	11997
Full immunization	-0.0464113	0.0308024	-0.0865611***	-0.1614313***
	(0.0382133)	(0.0623844)	(0.0256979)	(0.0509777)
Observations	7710	6983	16423	9952

Table A.2.9. Household Internet access and MCH services (IV results) (Social group-wise comparison)

	Poor	Middle	Rich
	(1)	(2)	(2)
Early ANC	0.2862486***	0.0490221*	0.0714995***
	(0.0396952)	(0.0287327)	(0.019196)
Observations	17771	9960	18071
Full ANC	0.3719564***	0.1310764***	0.060085***
	(0.0375114)	(0.0299275)	(0.0233032)
Observations	19891	10409	18443
Skilled birth attendance	-0.0304801**	0.0012088	0.0002142
	(0.0304801)	(0.0090149)	(0.0048267)
Observations	20185	10632	18880
Modern contraceptive use	0.4515442***	0.1846582***	0.1875161***
	(0.0361901)	(0.0294838)	(0.0239817)
Observations	20185	10632	18880
Full immunization	-0.0359164	-0.070028*	-0.1417743***
	(0.0410168)	(0.0369786)	(0.0283352)
Observations	16480	8807	15781

Table A.2.10. Household Internet access and MCH services (IV results) (Wealth group-wise comparison)

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