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Pradeep Kumar Choudhury*

**Abstract**

While the literature on technology and education is growing in India, specifically after the COVID-19 pandemic, yet there is a lack of evidence to date on understanding the inequalities in access to smartphones and internet and how it determines students learning outcomes. In this paper, using a recent nationwide rural household education survey, we examine socioeconomic inequalities in access to smartphones and internet and how they matter for children's learning level in reading, math and language skills. We find significant socioeconomic variations in access to smartphones and internet among rural households in India - internet use is higher among rich and educated households than poor and less educated counterparts. We also find some evidence suggesting that access to smartphones and internet in the household produces learning gains in reading, math and language skills for children, with considerable variations across households' socioeconomic positions. In a context where technology is increasingly integrated in educational transactions, our results have important policy implications for India and other developing countries. The study contributes novel insights to a nascent body of research in India on the impact of technology on student learning outcomes, as well as to a wider literature concerning technology and educational inequalities.

**Keywords:** smartphone, internet, socioeconomic positions, learning outcomes, rural India

*Assistant Professor of Education and Economics, Zakir Husain Centre for Educational Studies, Jawaharlal Nehru University, New Delhi, India. Email: pradeepchoudhury@jnu.ac.in

## Introduction

Digital technology is clearly integrated with the Sustainable Development Goal (SDG) 4, which aims to ensure inclusive and equitable quality education, new innovations and promote lifelong learning opportunities for all (United Nations, 2015). The 2023 Global Education Monitoring Report (GEM Report) on technology and education has specified the potential role of technology in increasing access, equity, quality, and relevance of both school and tertiary education (UNESCO, 2023). For instance, to reach children in conflict zones and remote areas, access to appropriate technology and necessary infrastructure works as an enabler. Likewise, to increase access to tertiary education, target 4.3 calls on policies and programmes to provide quality distance learning using ICT, including the internet and the provisioning of massive open online courses. More importantly, target 4.c of SDG 4 calls for the provisioning of adequate technological skills for teachers to manage ICT to address the challenges of pupils with special education needs. Furthermore, the COVID-19 pandemic has accelerated the need to apply digital technology in education worldwide, and this has led to the largest-ever movement to online learning (Maity et al., 2022). While the use of digital technology has resulted in many changes in education and learning, yet it is unclear how the technology and remote learning tools have transformed education as many claim (UNESCO, 2023).

Several research studies in the pre-pandemic times have analysed the critical role of technology in educational progress of the society. Kremer et al. (2013) find that while traditional policies like hiring additional teachers or providing textbooks do not appear to have improved student achievement in developing countries, use of Information and Communication Technologies (ICTs) in teaching-learning helps in improving students learning outcomes. In India, several works have found a positive effect of the digital game on learning outcomes of children in math and language at different levels of school education, both in urban and rural settings (Muralidharan, Singh and Ganimian 2019; Banerjee et al. 2017; Kam et al. 2008; Banerjee et al. 2007). Some important channels through which the use of ICT improves students learning include – the provisioning of interactive content that improves students' attention, reducing the lag between students attempting a problem and receiving feedback, analysing patterns of student's errors to precisely target content to clarify specific areas of misunderstanding, and personalising content for each student (Muralidharan, Singh and Ganimian 2019). Further, the National Education Policy 2020 has emphasised the critical role of technology in improving educational process and outcomes in India.

While technology-aided instruction may have a lot of potential to improve students learning, the public provisioning of educational technology is limited in India. Of the country's total elementary schools (schools till grade 8), only about 44 per cent have at least one computer, and less than one-fourth (23.5 per cent) have functional computers. Quite surprisingly, only about 17 per cent of schools have access to the internet (U-DISE, 2020). Furthermore, we find a clear gap in the access to computers and internet between government and private schools. For instance, close to 10 per cent of government schools have access to the internet, while this figure is 30 per cent for privately managed schools in India. The digital divide became glaringly evident during the pandemic, with many students lacking the necessary devices and internet connectivity for remote learning. In India, the National Statistical Office (NSO) data reveals that only about 18.3 per cent of students in overall education have a computer (including desktop, laptop, palmtop, notebook, netbook, tablets, etc.) at home with considerable unequal access between the poor and rich and between rural and urban households (NSO, 2020). The availability of computers at home ranged from 9 per cent to 32 per cent between rural and urban areas and 4.5 per cent to 47.2 per cent between poor and rich households. Only 24.6 per cent of all students aged five years and above were able to operate computers, and the figure further diminishes in case of those from rural areas and low-income families. Likewise, share of students who accessed internet in last 30 days is quite discouraging, i.e., 25.6 per cent – 16.4 among rural students and 11.4 among poor. Only 36.1 per cent of students have internet access at home–ranging from 25.1 per cent to 52.3 per cent between rural and urban India and 13 per cent to 68 per cent between poor and rich households. Only 28.7 per cent of students in India can use internet to search for desired content, and these figures vary widely across socioeconomic groups.

The digital divide is glaringly evident in rural India, with millions of children left behind during the shift to remote learning amid Covid-19 pandemic. The ASER data shows that while smartphone ownership for enrolled children has increased, it varies significantly with households' socioeconomic status. For instance, 52 per cent of families where both parents have completed grade V (low parental education) have at least one smartphone at home, while this figure is 82 per cent in families where both parents have completed at least grade 12 (high parental education) (Pratham, 2021). It is well argued that even when access to digital technology is given to students, their learning from it is likely to vary depending on their personal circumstances such as home environment to study, family pressure to do household chores, the kind of technical support they get from their parents and other household members, and more importantly the social identity of the learners (Rooksby, Weckert, & Lucas, 2002; Alozie and Akpan-Obong 2017). For example, in a patriarchal society such as India, girls often have reduced access to devices and internet and have lower ICT knowledge and skills, limiting their ability to access and benefit from remote learning. Additionally, Indian education system faces significant challenges posed by the lack of digital skills and pedagogical training among educators in rural India (Pratham, 2023).

Technology's problems and successes are rarely due to technology alone — they are more often created by decisions and practices that are political, educational, financial, human, and institutional (Burns, 2021), p. 9). The GEM 2023 report mentions that "the application of digital technology varies by community and socioeconomic level, by teacher willingness and preparedness, by education level and by country income" (UNESCO, 2023, p. V).

The observed growth in enrolment rates in India has not been matched by comparable improvements in learning outcomes. Millions of Indian children cannot read, write or even carry out basic arithmetic (addition and subtraction) despite attending eight years of schooling (World Bank, 2018; MHRD, 2020). For instance, nearly half of all children enrolled in grade 5 cannot read second-grade level text or solve simple two-digit subtraction problems (Pratham, 2019). Similarly, the National Achievement Survey (NAS) 2021 reveals that, on average, a class VIII student could barely answer half of the questions in math, science, and social studies (NCERT, 2021). India ranks second after Malawi in a list of 12 countries wherein a grade II student could not read a single word of a short text (WDR, 2018). Several studies find considerable learning loss for the children of rural India, accessing government schools, girls and poorer children; and an important reason for this is unequal access to digital learning technology during the prolonged school closure amid pandemic (Pratham, 2023; World Bank, 2021; Tilak, 2021). Adopting traditional policies such as improving school infrastructure, hiring additional teachers or providing textbooks does not appear to have improved student learning levels in developing countries (Kremer et al., 2013). In turn, new approaches to improving school performance, such as Information and Communication Technologies (ICTs), specifically internet access that has important pedagogical uses in developing countries have gained increasing interest (Lakdawala et al., 2023).

While the literature on technology and education is growing in India, specifically after the COVID-19 pandemic, yet a few studies to date have examined the socioeconomic inequalities in access to digital learning tools in rural India, an important and widely used mechanism to continue teaching-learning during school closures and being continued after that. How useful are mobile phones and smartphones for education? Moreover, despite the potential of the internet to improve learning levels (Belo et al., 2014; Gibson and Oberg, 2004; Goolsbee and Guryan, 2006; Machin et al., 2007; Vigdor et al., 2014), there has been relatively little research on how it impacts on student performance in developing countries (Lakdawala et al., 2023), and probably no such study in India, and more precisely in rural India. So far, not many studies have rigorously evaluated how the access and use of smartphones and internet bring variations in learning levels for students living in considerably different socioeconomic and educational settings. It is not yet clearly understood how internet on its own influences children's learning outcomes in rural India. Using the Annual Status of Education Report (ASER) 2022 data, this paper studies the socioeconomic gap in access to smartphones and internet among rural households in India. Additionally, we investigate how household's access to smartphones and internet is associated with children's learning outcomes. We hypothesise that there is considerable inequality in access to digital technology (specifically access to smartphones and internet) among households of different socioeconomic settings, and this results in increasing inequalities and growing gaps in learning outcomes among students during the prolonged school closure amid Covid 19 pandemic in rural India. The two questions that guided this study are:

1. What is the extent of inequality in access to smartphones and internet in rural India? How do individual and household factors matter while making smartphones and internet available for the children at the household level for study purposes?

2. To what extent does the family's access to smartphones and internet and its use by the children improve their learning levels? How does the association between smartphone/internet access and students' learning levels in reading, math, and English vary with the family's socioeconomic positions and the type of school students attend?

We find significant socioeconomic variations in access to smartphones and internet among rural households in India - internet use is higher among rich and educated households than poor and less educated counterparts. We also find some evidence suggesting that access to smartphones and internet in the household produces learning gains in reading, math and language skills for children, with considerable variations across household's socioeconomic positions. Our work contributes to at least three strands of literature. First, we contribute to a nascent body of research on digital divide, particularly to the post-pandemic discourses on inequality in access and use of smartphones and internet by students at the household level. Second, this study contributes to the discussion on the potential of the internet to improve learning and its impacts on student performance, an area lacking rigorous empirical evidence, specifically in developing countries contexts. Third, it contributes to the growing literature on connecting students' socioeconomic positions and their use of educational technology, thereby understanding its influences on learning. In a context where technology is increasingly integrated in educational transactions, our results have important policy implications for India and other developing countries.

## Data & Empirical Specification

We use the Annual Status of Education Report (ASER) 2022 data[1], a nationally representative household survey data in rural India. It has a two-stage sample design. In the first stage, villages are randomly selected from the Census village directory for each rural district. Therefore, the coverage of ASER is the population of rural India. Villages are selected using the probability proportional to size (PPS) sampling method. This method allows villages with larger populations to have a higher chance of being selected in the sample. Households in the sampled villages are randomly selected in each of the villages selected in the first stage. This sampling strategy generates a representative picture of each district. All rural districts are surveyed. The estimates obtained are then aggregated at the division, state, and all-India levels. To summarise, ASER 2022 employs a two-stage clustered design. In the first stage, 30 villages are sampled from the Census 2011 village directory for each district using probability proportional to size (PPS). In the second stage, 20 households with resident children in the age group of 3-16 years are surveyed in each sampled village, giving a sample size of 600 households per district. ASER survey started in 2005 and is done every year except in 2020 and 2021 due to covid-19 pandemic.

The purpose of ASER is twofold: (i) to obtain reliable estimates of the status of children's schooling and foundational learning (reading and math ability) and (ii) to measure the change in these basic learning and school statistics over time. For currently enrolled children in the age 3-16, the data is collected on enrolment status, while basic learning status on reading, math and English is collected for the children in the age group of 5-16. Every year, a core set of questions regarding schooling status and basic learning levels remains the same. However, new questions have been added to explore different dimensions of schooling and learning at the elementary stage. For instance, unlike earlier ASER rounds, the 2022 dataset has information on smartphone access and internet penetration at the household level. ASER collects several socioeconomic indicators of the household members, including the school-going children in the age group of 3 to 16 — for example, gender, age, household wealth, school type, access to digital technology, etc. Additionally, every year, ASER surveyors visit a government primary or upper primary school in each sampled village. The school information is recorded based either on direct observation (such as attendance or usability of facilities) or information provided by the school (such as grants information). ASER also collects data on facilities at the village level like the availability of basic and school facilities. For details on the ASER 2022 survey, visit https://asercentre.org/aser-2022/.

[1] Data availability Statement: This data was made available for the researcher from the ASER Data Centre, New Delhi, with a written permission to carry out this specific study. While ASER reports are publicly available in its website (www.asercentre.org), to access the unit-level data, a researcher generally needs to send a request to the data team, mentioning the need for the data.

The survey collects four indicators of remote learning at the household level – household has a mobile phone, household has a smartphone, number of smartphones in the household and internet availability on smartphones. The questions asked to the respondent (often to the head of the household) in the household survey sheet of ASER 2022 survey are: (a) "Mobile in the household (yes/no)" (b) If yes, is any mobile a smartphone? (yes/no) (c) if yes, how many smartphones in a household? (d) If there is a smartphone, then was there internet access today? Besides, the data is also collected on access to electricity at home, availability of TV at home, computer at home etc.

The learning level of the children is captured at three levels:

Reading: The original math code in the survey is: Code: 1 = beginner, 2 = child can identify letters, 3 = child can read words, 4 = child can read a para, 5 = child can read a story. For our analysis, we recoded as: 1 = beginner, 2 = child can identify letters or can read words, 3 = child can read a para, 4 = child can read a story.

Math: The original math code in the survey is: 1 = beginner, 2 = child can recognise numbers 1-9, 3=child can recognise numbers 11-99, 4=child can do subtraction, and 5=child can do division. For our analysis, we recoded as: 1 = beginner, 2 = child can recognise numbers 1-99 (here, we combined original codes 2 and 3), 3= child can do subtraction; 5=child can do division.

English Language: The original English code in the survey is: 1 = beginner, 2 = child can identify capital letters, 3 = child can identify small letters, 4 = child can read words, 5 = child can read a sentence. for our analysis, we recoded as: 1 = beginner, 2 = child can identify capital or small letters, 3 = child can read words, 4 = child can read a sentence.

Codes for reading, Math and English represent the learning levels in order as the learning difficulty levels are coded in ascending order i.e. 1 to 4.

We use the Ordered logistic regression model due to the ordinal nature of reading, math and English assessment score outcome variables to find out how unequal access to and use of mobile phones, smartphones and internet at the household level results in learning inequality among children[2].

[2] Given the data limitation in ASER 2022 survey, this paper attempts to examine the potential determinants of socioeconomic inequality in access to smartphones and internet in rural India, and how does its access is associated with the children's' learning outcome. We do not attempt to establish causality in this study.

The econometric specification is:

$$Y = \alpha + \beta(\text{internet access}) + \gamma\,(\text{Father Education}) + \delta\,(\text{Mother Education}) + \eta\,(\text{Age}) + \theta X + \varepsilon$$

Where Y takes the code values for reading, math and English, and $\theta X$ = potential confounding factors. We have estimated *three ordered logit regression equations*, one each for reading, math and English.

Results of the ordered logistic regression is presented in Table 10.

This study has also calculated the predicted probabilities of reading, math and English assessment scores at different levels of ‘child’s age, ‘father’s education’ and ‘mother’s education’. Results are presented as figures (see Figs. 1–9). They have been calculated using the *margins* command in Stata, as suggested by Karaca-Mandic et al. (2012). Also, to simplify the analysis, the predicted probabilities were calculated only for the lowest and highest ordinal values of reading, math, and English assessment scores.

The factors determining access to mobile phones and smartphones is estimated using OLS model, and the results are given in Table 8 and 9.

**Results & Discussion**

***Descriptive Evidence***

We summarise the descriptive evidence on gender, socioeconomic and regional inequality[3] in access to mobile phones, smartphones and internet in rural India (Table 1 to 6) and how children's learning is associated with internet access (Table 7). We find that around 20% of households in rural India do not have access to smartphones and 5% do not have mobile phones (see Table 1). In 2022, almost every rural household (95.8%) had a mobile phone, as against 90.2% in 2018. In the last four years (between 2018 and 2022), households with smartphones have doubled, with a few states (Gujarat, Kerala, Punjab, Telangana) going above 90% (Chavan, 2023; Pratham, 2023). Of the households with a smartphone, almost 90% had internet connection, with significant variations among states, 80.8% in Jharkhand to 97.7% in Kerala (Table 6). Access to mobile phones, particularly smartphones and internet connection in smartphones has increased considerably in rural India during the COVID-19 pandemic – a new normal for rural families in

[3] Caste (social group) is an important indicator of identity and cultural background of Indians. However, ASER 2022 data does not collect caste information.

India. The key question raised in this study is: How useful are mobile phones, smartphones and internet for children's learning? In 2021, ASER found that of the children who had smartphones at home, 26% could not access them for studies, 47% had some access and the rest (27%) had access all the time (Chavan, 2023).

We do not find a significant gender gap in access to mobile phones and smartphones, though the share of access to these digital devices is marginally higher among male students. For instance, availability of smartphones is 80.3% for male students and 79.5% for female students. We also find marginal variations in internet access between male (89.4%) and female (89.1%) students (Table 1). We also looked at the association of parental education with access to mobile phones, smartphones and internet. Results reveal a positive linkage between fathers' education and access to mobile phones, smartphones and internet. Among the students whose fathers have not received any formal schooling, 91.1% have access to mobile phones and 66.5% have smartphones (Table 2). These figures are relatively higher in case of those whose fathers have attained above secondary education, i.e., 98.7% and 91.2%, respectively. Similarly, around 83% of the students whose fathers have not received any formal schooling have internet access (conditional upon having a smartphone), compared to 92.5% in case of those whose fathers have attained above secondary education (Table 2). Further, we note a similar association between mother's education and access to mobile phones, smartphones and internet in rural households in India. Among the students whose mothers have not received any formal schooling, only 69.3% have access to smartphones, while this is 93% for those whose mothers have attained above secondary education (Table 3). These figures for internet access are 85.3% and 92.8% respectively.

We also find some variations in access to mobile phones, smartphones and internet by household type (pucca, half-pucca and kaccha[4]) and school type (Government, Private, Madrassa and Convent[5]) in rural India. Children living in pucca houses have better access to mobile phones, smartphones and internet than those living in half-pucca and kaccha houses. For instance, access to smartphones are 85.6% and 67.1% for Pucca and Kaccha households, and internet access figures are 91.5% and 84.6%, respectively (Table 4). To some extent, this also reveals the association between household wealth and access to gadgets and internet in India, as rich

[4] In India, there are three major types of houses - pucca, half-pucca and kaccha. Pucca houses are made from durable materials like cement concrete, burnt bricks, timber or stone; kutcha houses are made of clay, bamboo, flax, grass, crop residues, mulch and unburnt bricks; and half-pucca is the middle of these two.

[5] There are three different 'school management types' in India: government schools, private-aided (also referred to as government-aided schools), and private-unaided (i.e., private) schools. Besides these three broad categories, there are also private-unaided schools that are "unrecognized" and do not comply with basic government regulations for being a school. Madrassa and Convent schools are private schools with some association with religious communities.

households usually live in pucca houses and the poor live in kaccha houses. We also find inequalities in access to mobile phones, smartphones and internet for the children accessing private and government schools (Table 5). There is suggestive evidence that children from private schools had a better learning gain during COVID-19 pandemic than government school-going children, and this connects to better availability of gadgets and internet among households who send their children to private schools (Pratham, 2021).

Table 7 suggests a trend where, in general, a higher percentage of households with internet access corresponds to higher reading levels. For example, in reading level 4 (the highest learning level in reading i.e. a child can read a story), 91.41% of households have internet access, which is higher than the overall percentage of households with internet access (89.19%). The data indicates a potential association between higher reading levels and households with internet access – internet access is highest for reading level 4 (a child can read a story) and lowest for reading level 1 (a beginner). In reading level 1, 86.61% of households have internet access, while for reading level 4, this figure is 91.41%. Similar to the reading levels, a higher percentage of households with internet access corresponds to higher arithmetic levels. For example, in arithmetic level 4 (a child can do division), 91.29% of households have internet access while this figure is 85.79% for arithmetic level 1 (beginner). A similar positive trend is observed between households' internet access and children's English learning. The internet access for learning level 4 (a child can read a sentence) among rural households is 92.4% while it is 86.28% for learning level 1 (beginner). While studies connecting internet access and children's learning is limited in India, a few studies in developed countries and in some developing countries find a positive impact of internet on students learning (Belo et al., 2014; Gibson and Oberg, 2004; Goolsbee and Guryan, 2006; Machin et al., 2007; Vigdor et al., 2014; Lakdawala et al., 2023). In Peru, internet access has a moderate, positive short-run impact on school-average standardised math scores, and more importantly, this effect grows over time (Lakdawala et al., 2023).

**Table 1.** Access to Mobile Phones, Smartphones & Internet in Rural India by Gender

| | Mobile Phones | | | Smartphones | | | Internet (If having a Smartphone) | | |
|---|---|---|---|---|---|---|---|---|---|
| | No | Yes | Total | No | Yes | Total | No | Yes | Total |
| Male | 4.85 | 95.15 | 100 | 19.72 | 80.28 | 100 | 10.6 | 89.4 | 100 |
| Female | 4.95 | 95.05 | 100 | 20.45 | 79.55 | 100 | 10.86 | 89.14 | 100 |
| Total | 4.9 | 95.1 | 100 | 20.08 | 79.92 | 100 | 10.73 | 89.27 | 100 |

**Table 2.** Access to Mobile Phones, Smartphones & Internet in Rural India by Father Education

| | Mobile Phones | | | Smartphones | | | Internet (If having a Smartphone) | | |
|---|---|---|---|---|---|---|---|---|---|
| | No | Yes | Total | No | Yes | Total | No | Yes | Total |
| No Schooling | 8.88 | 91.12 | 100 | 33.53 | 66.47 | 100 | 16.90 | 83.10 | 100 |
| 1 to 5 | 5.59 | 94.41 | 100 | 27.33 | 72.67 | 100 | 13.05 | 86.95 | 100 |
| 6 to 8 | 3.93 | 96.07 | 100 | 21.92 | 78.08 | 100 | 11.16 | 88.84 | 100 |
| 9 to 10 | 2.57 | 97.43 | 100 | 16.39 | 83.61 | 100 | 9.61 | 90.39 | 100 |
| Above 10 | 1.23 | 98.77 | 100 | 8.73 | 91.27 | 100 | 7.46 | 92.54 | 100 |
| Total | 4.23 | 95.77 | 100 | 20.08 | 79.92 | 100 | 10.75 | 89.25 | 100 |

**Table 3.** Access to Mobile Phones, Smartphones & Internet in Rural India by Mother Education

| | Mobile Phones | | | Smartphones | | | Internet (If having a Smartphone) | | |
|---|---|---|---|---|---|---|---|---|---|
| | No | Yes | Total | No | Yes | Total | No | Yes | Total |
| No Schooling | 7.49 | 92.51 | 100 | 30.65 | 69.35 | 100 | 14.70 | 85.30 | 100 |
| 1 to 5 | 4.72 | 95.28 | 100 | 24.38 | 75.62 | 100 | 11.97 | 88.03 | 100 |
| 6 to 8 | 3.17 | 96.83 | 100 | 19.53 | 80.47 | 100 | 10.40 | 89.60 | 100 |
| 9 to 10 | 2.1 | 97.9 | 100 | 13.64 | 86.36 | 100 | 9.02 | 90.98 | 100 |
| Above 10 | 0.9 | 99.1 | 100 | 7.05 | 92.95 | 100 | 7.13 | 92.87 | 100 |
| Total | 4.28 | 95.72 | 100 | 20.06 | 79.94 | 100 | 10.71 | 89.29 | 100 |

**Table 4.** Access to Mobile Phones, Smartphones & Internet in Rural India by House Type

| | Mobile Phones | | | Smartphones | | | Internet (If having a Smartphone) | | |
|---|---|---|---|---|---|---|---|---|---|
| House Type | No | Yes | Total | No | Yes | Total | No | Yes | Total |
| Pucca | 2.28 | 97.72 | 100 | 14.35 | 85.65 | 100 | 8.46 | 91.54 | 100 |
| Half-Pucca | 4.87 | 95.13 | 100 | 22.04 | 77.96 | 100 | 12.96 | 87.04 | 100 |
| Kaccha | 9.23 | 90.77 | 100 | 32.82 | 67.18 | 100 | 15.35 | 84.65 | 100 |
| Total | 4.3 | 95.7 | 100 | 20.08 | 79.92 | 100 | 10.71 | 89.29 | 100 |

**Table 5.** Access to Mobile Phones, Smartphones & Internet in Rural India by School Type

| | Mobile Phones | | | Smartphones | | | Internet (If having a Smartphone) | | |
|---|---|---|---|---|---|---|---|---|---|
| School Type | No | Yes | Total | No | Yes | Total | No | Yes | Total |
| Government | 5.05 | 94.95 | 100 | 23.37 | 76.63 | 100 | 12.37 | 87.63 | 100 |
| Private | 1.7 | 98.3 | 100 | 11.12 | 88.88 | 100 | 7.17 | 92.83 | 100 |
| Madrassa | 5.56 | 94.44 | 100 | 31.36 | 68.64 | 100 | 11.81 | 88.19 | 100 |
| Convent | 4.18 | 95.82 | 100 | 9.94 | 90.06 | 100 | 9.22 | 90.78 | 100 |
| Total | 4.16 | 95.84 | 100 | 19.75 | 80.25 | 100 | 10.65 | 89.35 | 100 |

**Table 6.** Access to Mobile Phones, Smartphones & Internet in Rural India by Major States

| | Mobile Phones | | | Smartphones | | | Internet (If having a Smartphone) | | |
|---|---|---|---|---|---|---|---|---|---|
| State | No | Yes | Total | No | Yes | Total | Total | Yes | Total |
| AP | 2.44 | 97.56 | 100 | 13.16 | 86.84 | 100 | 10.27 | 89.73 | 100 |
| ASSAM | 6.15 | 93.85 | 100 | 25.15 | 74.85 | 100 | 9.03 | 90.97 | 100 |
| BIHAR | 3.44 | 96.56 | 100 | 34.07 | 65.93 | 100 | 10.58 | 89.42 | 100 |
| GUJARAT | 1.2 | 98.8 | 100 | 4.03 | 95.97 | 100 | 12.38 | 87.62 | 100 |
| HARYANA | 1.47 | 98.53 | 100 | 11.22 | 88.78 | 100 | 7.92 | 92.08 | 100 |
| JHARKHAND | 7.76 | 92.24 | 100 | 33.24 | 66.76 | 100 | 19.15 | 80.85 | 100 |
| KARNATAKA | 2.29 | 97.71 | 100 | 13.31 | 86.69 | 100 | 12.25 | 87.75 | 100 |
| KERALA | 0.29 | 99.71 | 100 | 2.21 | 97.79 | 100 | 2.30 | 97.70 | 100 |
| MP | 7.21 | 92.79 | 100 | 27.94 | 72.06 | 100 | 10.91 | 89.09 | 100 |
| MAHARASHTRA | 4.8 | 95.2 | 100 | 12.80 | 87.20 | 100 | 11.17 | 88.83 | 100 |
| ODISHA | 8.7 | 91.3 | 100 | 29.83 | 70.17 | 100 | 10.37 | 89.63 | 100 |
| PUNJAB | 1.63 | 98.37 | 100 | 7.33 | 92.67 | 100 | 2.36 | 97.64 | 100 |
| RAJASTHAN | 3.25 | 96.75 | 100 | 19.77 | 80.23 | 100 | 6.25 | 93.75 | 100 |
| TAMIL NADU | 2.73 | 97.27 | 100 | 13.32 | 86.68 | 100 | 14.54 | 85.46 | 100 |
| TELANGANA | 1.8 | 98.2 | 100 | 9.04 | 90.96 | 100 | 14.94 | 85.06 | 100 |
| UP | 4.78 | 95.22 | 100 | 29.92 | 70.08 | 100 | 15.97 | 84.03 | 100 |
| UTTARAKHAND | 2.09 | 97.91 | 100 | 19.16 | 80.84 | 100 | 7.57 | 92.43 | 100 |
| WEST BENGAL | 3.45 | 96.55 | 100 | 32.47 | 67.53 | 100 | 15.03 | 84.97 | 100 |
| Total | 4.31 | 95.69 | 100 | 20.08 | 79.92 | 100 | 10.72 | 89.28 | 100 |

Note: AP – Andhra Pradesh, MP = Madhya Pradesh, UP = Uttar Pradesh

**Table 7.** Access to Internet in Rural India and Students Learning Levels

| | % of Households without Internet | % of Households with Internet | Total |
|---|---|---|---|
| Reading level of the child | | | |
| 1 | 13.39 | 86.61 | 100 |
| 2 | 12.36 | 87.64 | 100 |
| 3 | 12.03 | 87.97 | 100 |
| 4 | 8.59 | 91.41 | 100 |
| Total | 10.81 | 89.19 | 100 |
| Arithmetic level of the child | | | |
| 1 | 14.21 | 85.79 | 100 |
| 2 | 11.55 | 88.45 | 100 |
| 3 | 10.03 | 89.97 | 100 |
| 4 | 8.71 | 91.29 | 100 |
| Total | 10.79 | 89.21 | 100 |
| English level of the child | | | |
| 1 | 13.72 | 86.28 | 100 |
| 2 | 12.19 | 87.81 | 100 |
| 3 | 10.87 | 89.13 | 100 |
| 4 | 7.62 | 92.38 | 100 |
| Total | 10.7 | 89.3 | 100 |

Note: 1 = lowest performance, 4 = highest performance

***Determinants of Access to Mobile Phones, Smartphones and Internet: Empirical Results***

Two sets of empirical results are estimated: (a) determinants of inequality in access to mobile phones, smartphones and internet for all households (table 8) (b) how access to mobile phones, smartphones and internet for those households whose children enrolled in schools (table 9). We find that child and family characteristics play a critical role in determining the access to mobile phones, smartphones and internet access among households. For instance, female children are six percentage points and two percentage points less likely to get access to smartphones and internet, respectively for all households (table 8). These figures are 21 percentage points and 18 percentage points respectively for households with children enrolled in schools. This clearly supports the World Bank (2021) results on gender inequality in access to digital devices in low- and middle-income countries - girls often have reduced access to digital technology and internet at home amidst school closures due to COVID-19 pandemic. Also, it is argued that girls have lower digital knowledge and skills, limiting their ability to access and benefit from remote learning. In a patriarchal society such as India, existing social norms in the family and communities create inequalities for girls in accessing and using digital devices. Likewise, educated and rich households have greater access to digital devices and internet than less educated and poor households (table 8 and 9). Results show that access to mobile phones, smartphones and internet in households (all households and households with children enrolled in schools) increases with parental education. For example, households with fathers above secondary education level have access to internet by 36 percentage points while this is 21 percentage points in households where fathers' education level is primary. Interestingly, we find that children accessing English medium and private schools have better access to mobile phones and internet than those attending non-English medium and public/government schools in India (Table 9). In both estimations, we find considerable state-wise variations in access to mobile phones, smartphones and internet – households from richer and more urbanised states like Delhi, Punjab and Gujarat have significantly higher access to digital devices and internet than that of less urbanised and poor states like Bihar, Odisha and Jharkhand. Overall, our results show a considerable gender, regional and socioeconomic inequality in access to digital learning tools (mobile phones, smartphones and internet) in rural India, and more importantly, this inequality widens for households with children enrolled in schools.

**Table 8. OLS Regression: Predictors of access to mobile phones, smartphones and internet access for all households**

| | (1) Mobile Phones | (2) Smartphones | (3) Internet |
|---|---|---|---|
| Female Child | -0.000636 | -0.00693*** | -0.00220** |
| | (0.000539) | (0.000994) | (0.000945) |
| Child Age | 0.00224*** | 0.00434*** | 0.00157*** |
| | (0.000109) | (0.000183) | (0.000182) |
| Father Age | 0.000260** | -0.00180*** | 0.000119 |
| | (0.000104) | (0.000179) | (0.000178) |
| Mother Age | 6.70e-06 | 0.000556*** | -0.000388** |
| | (0.000110) | (0.000184) | (0.000177) |
| Father Education (Ref.- Zero) | | | |
| 1 to 5 | 0.0323*** | 0.0161*** | 0.0213*** |
| | (0.00228) | (0.00363) | (0.00363) |
| 6 to 8 | 0.0420*** | 0.0390*** | 0.0298*** |
| | (0.00201) | (0.00332) | (0.00330) |
| 9 to 10 | 0.0419*** | 0.0560*** | 0.0336*** |
| | (0.00186) | (0.00323) | (0.00328) |
| Above 10 | 0.0400*** | 0.0678*** | 0.0366*** |
| | (0.00183) | (0.00330) | (0.00340) |
| Mother Education (Ref.- Zero) | | | |
| 1 to 5 | 0.0189*** | 0.00671** | 0.00686** |
| | (0.00171) | (0.00309) | (0.00302) |
| 6 to 8 | 0.0268*** | 0.0175*** | 0.0151*** |
| | (0.00149) | (0.00288) | (0.00274) |
| 9 to 10 | 0.0271*** | 0.0335*** | 0.0182*** |
| | (0.00147) | (0.00283) | (0.00272) |
| Above 10 | 0.0258*** | 0.0441*** | 0.0204*** |
| | (0.00142) | (0.00292) | (0.00297) |
| HH Type (Ref.- Kaccha) | | | |
| Pucca | 0.0263*** | 0.0663*** | 0.0277*** |
| | (0.00163) | (0.00315) | (0.00325) |
| Semi-Pucca | 0.0237*** | 0.0292*** | 0.00350 |
| | (0.00186) | (0.00322) | (0.00336) |
| 4 Wheeler Motor Vehicle | -0.000983 | 0.0269*** | 0.00531** |
| | (0.000786) | (0.00184) | (0.00221) |
| 2 Wheeler Motor Vehicle | 0.0335*** | 0.122*** | 0.0301*** |
| | (0.00106) | (0.00221) | (0.00223) |
| HH has Electricity | 0.0950*** | 0.0314*** | 0.127*** |
| | (0.00604) | (0.00673) | (0.00984) |
| HH has TV | 0.0280*** | 0.0877*** | 0.0102*** |
| | (0.00128) | (0.00258) | (0.00266) |
| Constant | 0.722*** | 0.556*** | 0.674*** |
| | (0.00795) | (0.0113) | (0.0135) |
| Observations | 586,590 | 554,415 | 436,613 |
| R-squared | 0.092 | 0.172 | 0.047 |

Clustered (Village level) standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.10

**Table 9. OLS Regression: Predictors of access to mobile phones, smartphones, and internet access for households with children enrolled in schools**

| | (1) | (2) | (3) |
|---|---|---|---|
| | Mobile Phones | Smartphones | Internet |
| School Type (Ref.-Government) | | | |
| Private | 0.00509*** | 0.0217*** | 0.0189*** |
| | (0.000918) | (0.00199) | (0.00239) |
| Madrassa | 0.00985 | 0.0129 | 0.0327** |
| | (0.00907) | (0.0193) | (0.0158) |
| Convent | 0.00227 | 0.0270 | 0.0385 |
| | (0.0126) | (0.0207) | (0.0293) |
| Medium of Instruction (Ref.-Hindi) | | | |
| English | -0.00594*** | 0.0246*** | 0.0167*** |
| | (0.00132) | (0.00302) | (0.00324) |
| Other Language | -0.00403** | 0.0174*** | 0.00989** |
| | (0.00191) | (0.00378) | (0.00436) |
| Private Tuition | 0.00896*** | 0.0109*** | 0.00794*** |
| | (0.00102) | (0.00201) | (0.00211) |
| Female Child | -0.000307 | -0.00459*** | -0.000948 |
| | (0.000552) | (0.00103) | (0.000980) |
| Child Age | 0.00215*** | 0.00423*** | 0.00153*** |
| | (0.000114) | (0.000194) | (0.000195) |
| Father Age | 0.000221** | -0.00177*** | 0.000148 |
| | (0.000103) | (0.000182) | (0.000180) |
| Mother Age | 6.74e-06 | 0.000538*** | -0.000384** |
| | (0.000108) | (0.000187) | (0.000177) |
| Father Education (Ref.- Zero) | | | |
| 1 to 5 | 0.0290*** | 0.0160*** | 0.0208*** |
| | (0.00223) | (0.00369) | (0.00368) |
| 6 to 8 | 0.0375*** | 0.0392*** | 0.0281*** |
| | (0.00197) | (0.00338) | (0.00336) |
| 9 to 10 | 0.0373*** | 0.0538*** | 0.0307*** |
| | (0.00186) | (0.00329) | (0.00334) |
| Above 10 | 0.0357*** | 0.0641*** | 0.0323*** |
| | (0.00182) | (0.00337) | (0.00345) |
| Mother Education (Ref.- Zero) | | | |
| 1 to 5 | 0.0176*** | 0.00603* | 0.00711** |
| | (0.00170) | (0.00314) | (0.00307) |
| 6 to 8 | 0.0250*** | 0.0138*** | 0.0141*** |
| | (0.00149) | (0.00292) | (0.00278) |
| 9 to 10 | 0.0256*** | 0.0285*** | 0.0156*** |
| | (0.00147) | (0.00289) | (0.00279) |
| Above 10 | 0.0247*** | 0.0353*** | 0.0148*** |

| | | | |
|---|---|---|---|
| | (0.00144) | (0.00299) | (0.00302) |
| Constant | 0.742*** | 0.533*** | 0.661*** |
| | (0.00775) | (0.0116) | (0.0139) |
| Observations | 534,784 | 507,322 | 401,536 |
| R-squared | 0.085 | 0.173 | 0.048 |

*** p<0.01, ** p<0.05, * p<0.1; figures in the parentheses are robust standard errors.

***What Determines students learning in reading, math and English in rural India?***

We find a positive and statistically significant association between access to internet in the household and children's learning outcomes in reading, math and English. Children accessing internet are 26.6 percentage points more likely to perform better in reading, 13.3 percentage points in math and 22.9 percentage points in English skills (Table 10). Besides, our results confirm some of the established findings in the literature on learning inequality in India. For example, children accessing private schools perform better in all three domains (reading, math and English) than those attending public schools. Several recent works in India find better learning outcomes and cognitive abilities of children attending private schools than public school counterparts (Singhal and Das, 2019; Kumar and Choudhury, 2022). The other significant factors determining children's learning are parental education, household wealth, villages with early childhood education centres, etc. Results show that the learning levels of reading, arithmetic and English for a girl child are less than a boy. In India, gender inequality in learning outcomes is well evident in the literature (White et al., 2016; Alcott & Rose, 2017; Singhal & Das, 2019), and this inequality has increased over time in favour of boys (Jain, 2019). Kumar and Choudhury (2022) find that male children have significantly higher math scores than their female counterparts, and this difference decreases with the increase in parental education and household assets. We also found a positive association between access to mobile phones/smartphones and students learning outcomes.

**Table 10. Determinants of students learning in reading, math and English in rural India: Ordered Logistic Regression Results**

| Explanatory Variables | Coefficients (Reading) | Coefficients (Arithmetic) | Coefficients (English) |
|---|---|---|---|
| Child goes to which type of school (1= private) | 0.244*** | 0.184*** | 0.299*** |
| | (0.011) | (0.011) | (0.011) |
| Child's Gender (1 = female) | -0.236*** | -0.120*** | -0.136*** |
| | (0.009) | (0.008) | (0.008) |
| Child's age | 0.592*** | 0.493*** | 0.540*** |
| | (0.002) | (0.002) | (0.002) |
| Father's schooling level | 0.046*** | 0.053*** | 0.039*** |
| | (0.002) | (0.002) | (0.002) |
| Mother's schooling level | 0.049*** | 0.054*** | 0.083*** |
| | (0.002) | (0.002) | (0.002) |
| Child attends a private tuition (1 = yes) | 0.430*** | 0.588*** | 0.519*** |
| | (0.010) | (0.010) | (0.010) |
| English medium school (1 = yes) | -0.013 | 0.326*** | 1.098*** |
| | (0.011) | (0.011) | (0.011) |
| Type of Household (1=pucca/semi pucca) | 0.168*** | 0.229*** | 0.263*** |
| | (0.013) | (0.012) | (0.012) |
| Household has electricity (1 = yes) | 0.297*** | 0.189*** | 0.493*** |
| | (0.031) | (0.032) | (0.031) |
| Household have members who has completed standard 12 other than mother/father of the child (1 = yes) | 0.028*** | 0.042*** | -0.060** |
| | (0.010) | (0.010) | (0.010) |
| Household has a motor vehicle (1 = yes) | -0.069*** | -0.067*** | 0.053*** |
| | (0.011) | (0.011) | (0.011) |
| Household has newspaper (1 = yes) | 0.045*** | 0.020 | 0.012 |
| | (0.016) | (0.015) | (0.016) |
| Household has reading material other than newspaper (1 = yes) | 0.043*** | 0.061*** | 0.042** |
| | (0.018) | (0.017) | (0.018) |
| Household has member who can use a computer (1 = yes) | 0.225*** | 0.117*** | 0.302*** |
| | (0.012) | (0.011) | (0.011) |
| Household has access to internet (1 = yes) | 0.267*** | 0.135*** | 0.229*** |
| | (0.015) | (0.015) | (0.015) |
| Village has an Angandwadi (1 = yes) | 0.097*** | 0.044*** | 0.048* |
| | (0.019) | (0.019) | (0.020) |
| Village has a pucca road (1 = yes) | -0.046*** | 0.001 | -0.110*** |
| | (0.015) | (0.015) | (0.015) |
| Constant cut1 | 4.461 | 3.516 | 4.987 |
| | (0.045) | (0.045) | (0.045) |
| Constant cut2 | 7.097 | 7.007 | 7.756 |
| | (0.047) | (0.047) | (0.047) |
| Constant cut3 | 8.070 | 8.330 | 9.029 |
| | (0.048) | (0.048) | (0.048) |
| N | 237,566 | 237,611 | 236,668 |
| Pseudo- $R^2$ | 0.2484 | 0.2057 | 0.2414 |
| Prob. > $(Chi)^2$ | 0.000 | 0.000 | 0.000 |

*** p<0.01, ** p<0.05, * p<0.1; figures in the parentheses are robust standard errors.

***Interaction effect of access to internet and children's learning outcome by Child's age, father's education and mother's education***

Overall, access to internet at home is positively associated with children's learning outcomes in reading, math and English in rural India. Here, we have estimated the marginal predicted probabilities between internet access and children's learning outcomes (for the lowest and highest ordinal values of reading, math and English assessment scores) by child's age and parent's education. We find a few interesting results from our analysis. First, access to internet has differential effect on children's learning outcomes in reading, math and English by their age – Children from higher age group (likely to be enrolled in the higher grades) benefit more in accessing internet than their younger counterparts (figure 1 to 3). It may be the case that children in higher grades use the internet more effectively for their learning, which helps them perform well. With the increase in child's age, for the highest ordinal values in reading, math and English assessment scores, the predicted probabilities are increasing for children both with and without internet access, while they are decreasing for the lowest ordinal values in all three assessments. However, the marginal effect of a child's age on learning outcomes is higher for students with internet access for the highest ordinal values i.e. the top curves in figures 1 to 3. This shows the net positive effect of children's access to internet on their learning assessment scores and how this differs for younger and older children, a proxy to grade levels. Second, we analysed the changing effect of parent's education (father's year of schooling and mother's year of schooling) on children's reading, math and English scores for children with and without access to internet in their households. The predicted probabilities of internet access and without internet access at different levels of fathers schooling are presented in figure 4, 5 and 6 for reading, math and English scores, respectively. The predicted probabilities for mothers schooling are presented in Figs. 7. 8 and 9. For the highest ordinal value in the case of all three assessment scores (figure 4 to 9) clearly shows that the predicted probabilities increase with the increase in fathers and mothers years of schooling, true for both 'with internet access' and 'without internet access' groups, while they are decreasing for the lowest ordinal value. However, our results by 'status of internet access at household' show that the marginal effect of 'with internet access' is higher and the difference in predicted probabilities curves between 'with internet access' and 'without internet access' widens with the increase in the fathers and mothers educational attainment. It indicates that access to internet in the household helps more in assessment scores for educated parents. However, the magnitude of the marginal effect is higher for reading and English scores than math scores.

**Fig. 1.** Predicted probabilities of reading level (outcome=1 and 4) for households with (=1) and without (=0) internet at different levels of child's age

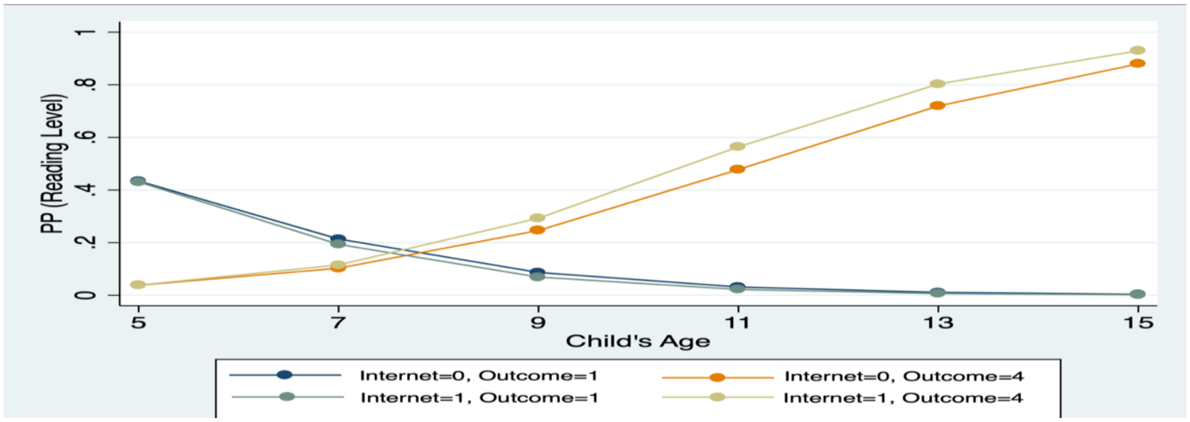



**Fig. 2.** Predicted probabilities of math level (outcome=1 and 4) for households with (=1) and without (=0) internet at different levels of child's age

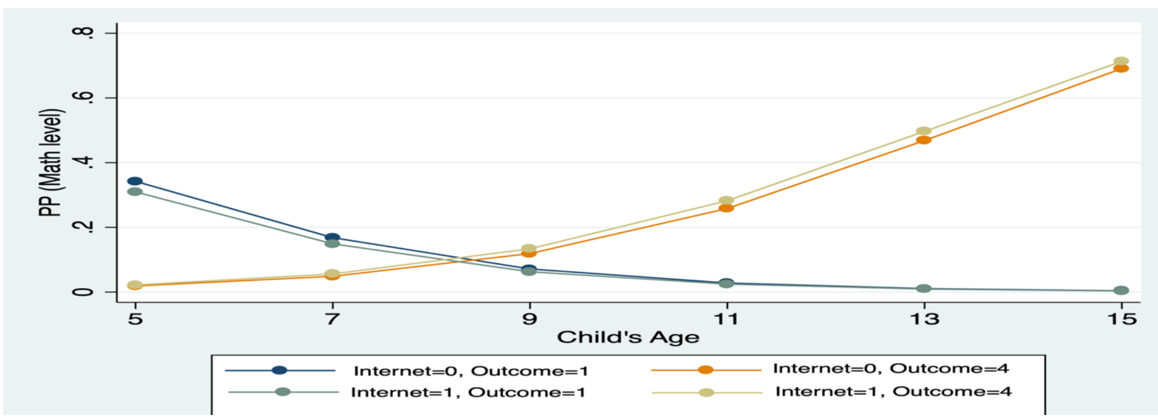



**Fig. 3.** Predicted probabilities of English level (outcome=1 and 4) for households with (=1) and without (=0) internet at different levels of child's age

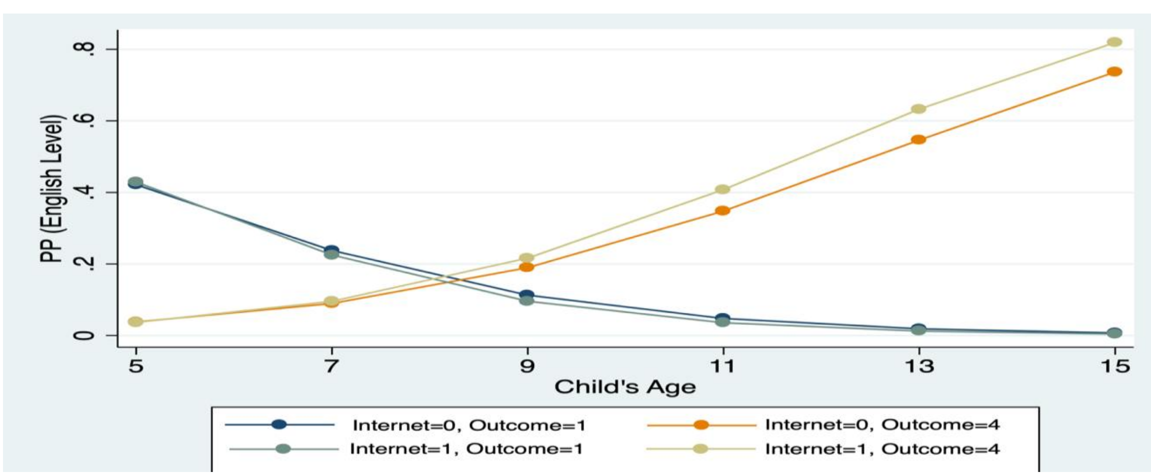


**Fig. 4.** Predicted probabilities of reading level (outcome=1 and 4) for households with (=1) and without (0) internet at different levels of father's education

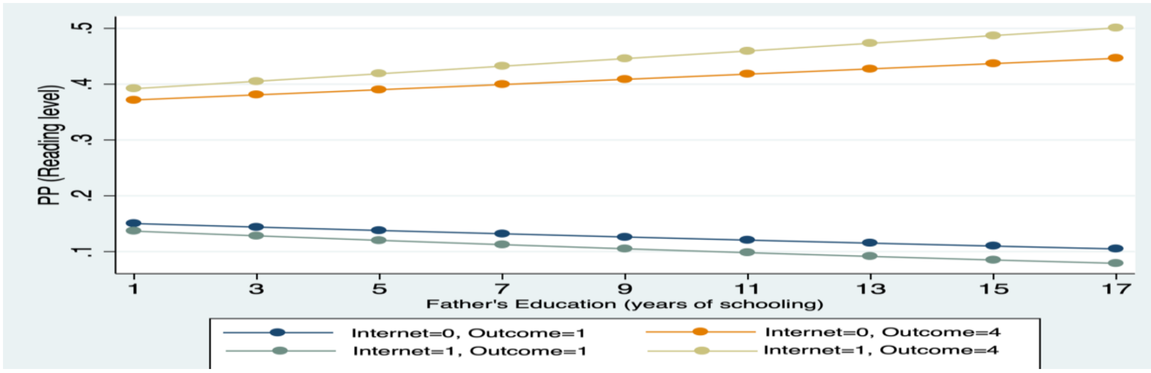



**Fig. 5.** Predicted probabilities of math level (outcome=1 and 4) for households with (1) and without (=0) internet at different levels of father's education

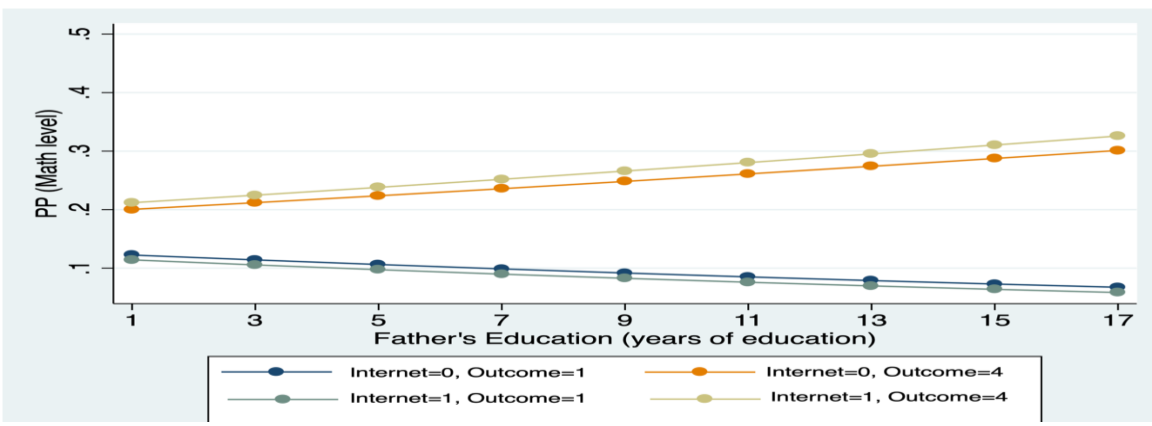


**Fig. 6.** Predicted probabilities of English level (outcome=1 and 4) for households with (=1) and without (=0) internet at different levels of father's education

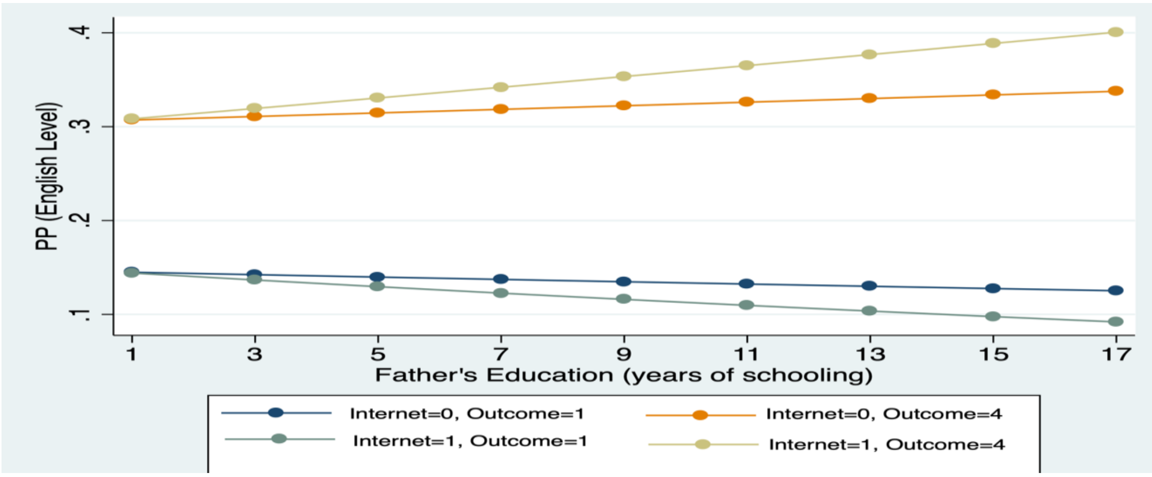



**Fig. 7.** Predicted probabilities of reading level (outcome=1 and 4) for households with (=1) and without (=0) internet at different levels of mother's education

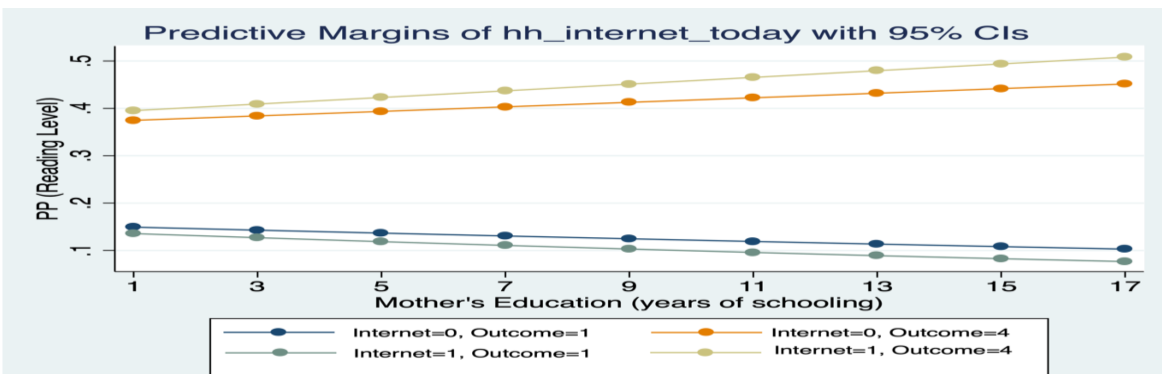



**Fig. 8.** Predicted probabilities of math level for households with (=1) and without (=0) internet at different levels of mother's education

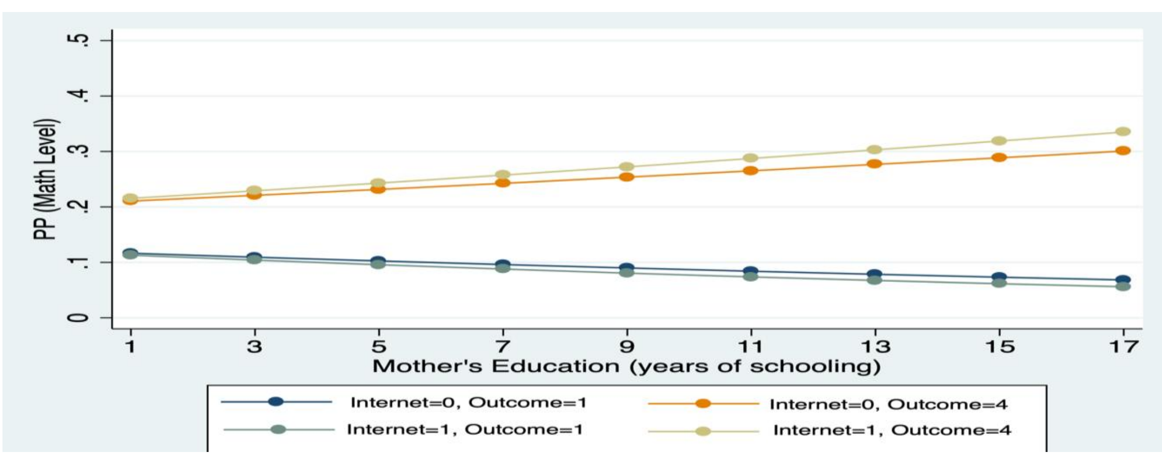
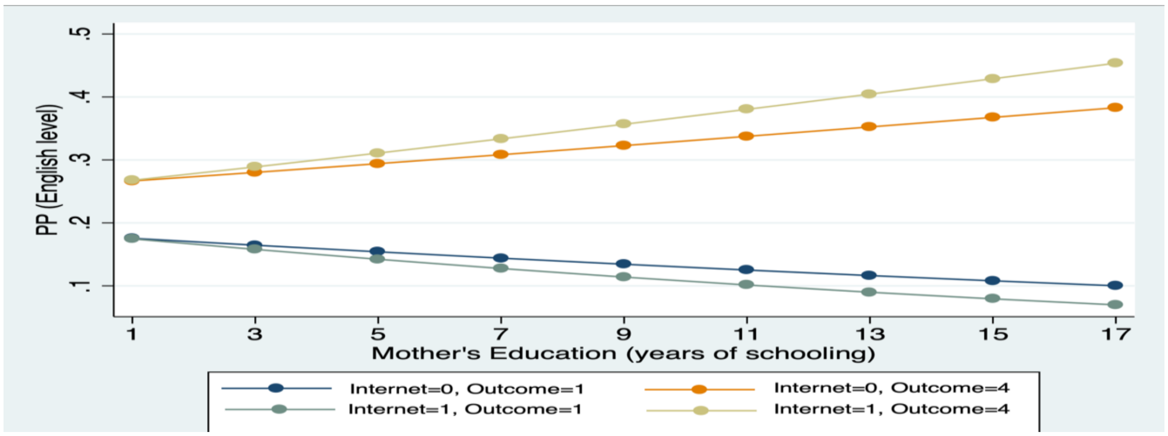


**Fig. 9.** Predicted probabilities of English level (outcome=1 and 4) for households with (=1) and without (=0) internet at different levels of mother's education



## Conclusion

In this study, we examine how access to digital devices vary among households and its association with children's learning outcomes in reading, math and English in rural India. Using ASER 2022 data, the study answers two main questions: (a) What is the extent of inequality in access to mobile phones, smartphones and internet among households living in different socioeconomic and educational positions in rural India? (b) How does the use of smartphones and internet is associated with children's learning levels in reading, math and English? How do family's socioeconomic positions interact with access to smartphones/internet and children's learning outcomes? We find significant socioeconomic variations in access to digital technology for education among rural households in India, with a considerable socioeconomic variation. For instance, internet use for teaching learning is higher among rich and educated households than that of poor and less educated counterparts. We also find that inequality in access to digital technology is associated with children's learning outcomes in reading, math and English. Furthermore, the relationship between access to mobile phones/smartphones/internet and children's learning outcomes vary considerably with household's socioeconomic positions and demographic attributes. For example, access to mobile phones/smartphones/internet is strongly and positively associated with learning outcomes for educated parents and older children, compared to less educated parents and younger children counterparts.

While this study is an initial foray into analysing the socioeconomic inequalities in access to distance learning tools in rural India and how it matters differently for children's learning outcomes, a robust research agenda lies ahead in unfolding more on this issue. For instance, we suggest future research examining regional and state-specific policies and practices in using digital technology in India, specifically to address the challenges rural kids face. Likewise, future research should examine how ed-tech improves children's learning levels. While the broader literature on ed-tech and ICTs typically examines the issue of digital divide and its association with learning inequality, it is not yet clearly understood how ed-tech on its own influences learning. Another important issue that needs immediate attention from researchers is the governance and regulation of ed-tech industries that provide remote learning. The sector is expanding rapidly in India, and parents are exploited due to information asymmetry. While this issue is flagged in the education policy discourse, research evidence is sparse, specifically in the Asia-Pacific region and developing countries.

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or write to communications@gdn.int for more information.

GDN Global Development Network

**INDIA:** 2nd Floor, West Wing ISID Complex, 4,
Vasant Kunj Institutional Area, New Delhi-110070, India

**EUROPE:** 63 Boulevard François Mitterrand - CS 50320,
63009 Clermont-Ferrand Cedex, France

**US:** Clifton Larson Allen LLP, 901 N. Glebe Road,
Suite 200, Arlington, VA 22203, USA