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Digital Literacy and Vulnerability to Misinformation: Evidence from Facebook Users in Pakistan

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Lack of digital literacy can be a major barrier towards improving the informational well-being of Internet users. Using a field survey of 674 Facebook users in urban Pakistan, we find significant differences in individuals' ability to use common Facebook features. We find that digital literacy is lower among older, less educated, lower income and female users, which points to barriers faced by different demographic groups in improving their digital literacy. Moreover, lower digital literacy is associated with worse truth discernment, lower sharing of true news, emotional reactions to online content, but not more confirmation bias.

Keywords: *digital literacy, misinformation, beliefs, truth discernment*

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In 2021, the number of social media users grew by nearly 490 million globally and much of this growth occurred in emerging markets. For example, Pakistan, Bangladesh, and India witnessed 24.3%, 25%, and 21.2% growth in the number of social media users, respectively, between 2020 and 2021 (DataReportal, 2021). This growth has brought many new users online who might lack the necessary skills to navigate digital spaces and understanding of the processes through which information is generated and spread. These relatively inexperienced technology users are joining social media in a complex landscape in which misinformation is prevalent. As a result, these less digitally literate users might also be worse at discerning between truth and falsehood, and thus more vulnerable to misinformation.

In this paper, we use a field sample of 674 Facebook users drawn randomly from low and middle income neighborhoods in Pakistan to describe the distribution and correlates of digital literacy, and then examine its association with truth discernment, sharing intentions, emotional reactions, and confirmation bias. Pakistan is the fifth most populous country in the world with a median age of 22.8 years. It ranked eighth in terms of growth in social media use in 2021 (DataReportal, 2021). We focus on Facebook as it is the most popular social media platform globally with over 2.7 billion users and was the second most popular platform in Pakistan at the time of the survey.

Understanding the correlates of digital literacy and its association with vulnerability to misinformation can help in (i) identifying social media users that are most susceptible to misinformation and therefore most important to target with interventions, and (ii) shedding light on the channels through which digital literacy might improve discernment such as moderating emotional reactions and confirmation bias. As a result, these descriptive insights can potentially inform future research and policy interventions for countering misinformation in developing countries.

Although the association between digital literacy and truth discernment[1]—which is the ability of respondents to distinguish between true news and false news stories—seems plausible there is mixed evidence in support of the view. For example, Sirlin et al. (2021) found digital literacy to be associated with truth discernment among American social media users. On the

[1]Truth discernment is defined as the average accuracy ratings for true news minus average accurate ratings for false news (Pennycook and Rand, 2019; Sirlin et al., 2021; Rosenzweig et al., 2021).

other hand, Jones-Jang et al. (2021) found that digital literacy—defined as the self-reported recognition of Internet-related terms—did not predict ability to identify fake news stories in a representative sample of US adults. In the context of developing countries, Guess et al. (2020) found that a digital media literacy intervention in which individuals were provided with tips to spot fake news improved truth discernment among high digital literacy users in India (and U.S.) but not in a rural sample with low social media familiarity. Badrinathan (2021) found no effect of an in-person media literacy training on truth discernment in a low digital literacy sample in India. Ali and Qazi (2021) found that video-based messages aimed at teaching people how to spot fake news augmented with personalized feedback improved accuracy of beliefs about fake news among low digital literacy users in Pakistan.

In this paper, we aim to shed further light on the relationship between digital literacy and vulnerability to misinformation in the context of social media users in a developing country. A novel feature of our study design is that we conduct a field survey of social media users to ensure representation of low digital literacy populations, who are not well represented on online platforms such as MTurk (Hargittai and Shaw, 2020).[2] Specifically, we draw a random sample of households from low and middle income neighborhoods in the city of Lahore, and survey individuals who are above 18 years of age and use social media applications. We choose to focus on low and middle income areas, as in this context Internet and technology use rises with incomes (Jamil, 2021). Thus, our study by design aimed to include users at the lower end of the digital literacy spectrum.

Our digital literacy measure is based on the conceptualization of digital literacy as the possession of digital skills required to effectively find information online (Hargittai, 2005). Specifically, our digital literacy measure, which is the self-reported ability of individuals in carrying out a set of digital literacy related tasks, is based on questions about basic digital skills, such as the ability to use a search engine, as well as literacy about Facebook application features (e.g., privacy settings), which requires knowledge and understanding about how content is generated, curated, and can be managed by a user. These questions aim to capture both the knowledge and skills associated with understanding, accessing, and using information online.

[2]Recent works have also highlighted concerns related to inattentiveness of survey-takers and data quality on online survey platforms, such as Lucid (Ternovski and Orr, 2022), MTurk (Arechar and Rand, 2021), and Prolific (Charalambides, N., 2019).

While we do not know the extent to which participants may have overestimated their abilities, this measure is consistent with prior work, which found that familiarity with Internet-related terms and functions are good predictors of actual digital literacy (Hargittai, 2009) and that survey measures should include questions that can detect variation among people with lower levels of digital literacy (Guess and Munger, 2022). Questions focusing on Facebook features—which draw motivation from Newman et al. (2018)—seem particularly relevant for identifying susceptibility to misinformation on social media; after all if people are unaware of social media application features (e.g., sponsored vs. non-sponsored posts), it seems likely that they would be less skeptical of low-quality news content.

Our results show that older individuals, females, less educated, and people with lower household expenditures are significantly more likely to be less digitally literate. While studies with literate populations in developed countries have found age to be a key moderator for digital literacy (Grinberg et al., 2019; Hargittai et al., 2018; Guess and Munger, 2022; Brashier and Schacter, 2020), we find that in a developing country context a larger set of user characteristics are correlated with digital literacy. This reflects that in addition to age, literacy, gender, and income are important correlates of digital literacy of a growing number of new Internet users who are joining the digital space (Vashistha et al., 2019; Qazi et al., 2021).

We find that digital literacy is positively associated with truth discernment. The association is driven by greater accuracy ratings for false news. It is similar in size to the association between truth discernment and other measures of digital literacy (familiarity with Internet-related terms, understanding of the Facebook newsfeed algorithm, and procedural news knowledge) reported in earlier works (Sirlin et al., 2021; Amazeen and Bucy, 2019). Our work complements the growing body of literature—albeit in the context of a developing country—which highlights that digital literacy is predictive of truth discernment.

We also ask whether digital literacy is associated with non-neutral emotional reactions to news headlines. Understanding this relationship is important because non-neutral emotional responses may cloud one's judgement and inhibit discernment (Greenstein and Franklin, 2020; Han et al., 2020; Rosenzweig et al., 2021). Considering a highly educated sample of Facebook users in Nigeria, 76% of which had received some university education, Rosenzweig et al. (2021) found that non-neutral emotions (e.g., happiness and surprise) are associated with greater

belief and sharing of false, relative to true, COVID-19 headlines. Anger has been shown to increase susceptibility to misinformation among a sample of South Korean adults (Han et al., 2020). However, there is little empirical evidence to date about the relationship between digital literacy and emotional responses to news headlines. We find that less digitally literate users are more likely to express non-neutral emotional reactions to news. This is consistent with a digital media literacy intervention, which reduced non-neutral emotional reactions to news headlines in a randomized experiment in Pakistan (Ali and Qazi, 2021). However, we did not find a statistically significant association between digital literacy and confirmation bias, that is, whether people consider a headline to be true or false due to its alignment with their prior beliefs.[3]

Finally, we find digital literacy to be correlated with sharing discernment; the tendency to share true news more than false news, similar to an earlier study on Facebook users in Nigeria (Rosenzweig et al., 2021). However, this is in contrast to earlier works that have found a disconnect between truth discernment and sharing (Sirlin et al., 2021; Pennycook et al., 2020), i.e., the ability to distinguish between truth and falsehood does not necessarily translate into sharing discernment. One reason that could in part explain greater sharing discernment in our study is accuracy priming, i.e., asking respondents about whether a news item is true or false before asking about sharing intentions primes them to think about accuracy (Pennycook et al., 2020). Another reason could be that more extreme emotional responses by low digital literacy users in our study might in part be driving greater sharing discernment. Finally, the results may also be attributable to differences in the digital literacy of our study sample and samples considered in earlier studies. After all, accuracy priming may not be of much use if respondents are not digitally literate enough to contextually understand and effectively find information online. However, further research is needed to distinguish between these explanations and determine whether there exist multiple pathways that affect sharing discernment.

Our findings have important implications for policymakers, social media platforms, academics, and practitioners interested in countering misinformation. First, our results highlight the importance of digital literacy in identifying populations who are vulnerable to misinformation and thus important targets for interventions. For example, our study shows that older

[3]Confirmation bias is the tendency to interpret information in a way that confirms or supports one's prior beliefs.

individuals, females, less educated, and people with lower household expenditures are likely to have low digital literacy and thus are potential targets for digital literacy programs in the context of developing countries. Second, our insights may help inform the design of digital literacy improvement interventions that can also improve truth discernment. For example, the positive association between higher digital literacy and neutral emotional reactions suggest that digital literacy trainings could include techniques to spot emotionally evocative posts, which may also help regulate emotional responses to news headlines. This may be particularly relevant during public health crises, such as the COVID-19 pandemic, or national events such as elections, where emotions may be particularly intense.

The remainder of the paper is structured as follows: section 1 describes the empirical methodology and data; section 2 presents the mains results, which includes description of the distribution of digital literacy, demographic correlates of digital literacy, and relationship between digital literacy and truth discernment, emotional reactions, confirmation bias, and sharing intentions; and section 3 concludes.

Methods

From May to June in 2019, we conducted a field survey of Facebook users drawn randomly from low and middle income neighborhoods in Lahore[4], Pakistan to understand the relationship between digital literacy and truth discernment, sharing intentions, emotional reactions and confirmation bias among low digital literacy populations. Our final dataset included a total of 674 individuals: mean age = 28.2, 32.3% female, mean monthly household expenditure[5] = PKR 40,933 (USD 255 in 2019), and median education level = grade 12.

Our survey included questions about demographic characteristics, social media use, and digital literacy. In addition, we measured the perceived accuracy of news on social media by asking a series of questions about a set of actual true and fake news stories drawn from social media. While all participants viewed the same set of news stories, they were presented in a random order to each participant. Participants were shown three false and three true news

[4]See Appendix C for details about sample selection. While our study focuses on social media users, it will be interesting to explore the relationship betwen digital literacy and truth discernment among non-social media users.

[5]We collected this data using the question, "What is the monthly expenditure for this household?"

stories, which cover general interest topics and current events.[6] While the set of news stories we used were drawn from social media, they were subsequently fact-checked and verified as either true or false by major news outlets in Pakistan including DAWN and The Express Tribune.

The news stories were shown in the form of screenshots of posts or messages, similar to how users would typically receive news on social media. Some of the news stories were in English only, while others were partially or completely in Urdu, the national language of Pakistan. It is common for people to receive news in English because a large fraction of social media content is in English (Fan, A, 2020). To ensure that participants understood the content, they were first asked to carefully view a printed version of the screenshot of the news and then asked to listen to an audio recording of the news. If the news was in English, the audio translated it into Urdu. Participants were not allowed to search the Internet but the screenshots included clues for spotting true or fake news stories, such as the source of news and a blue tick indicating a verified user or entity in case of a tweet or a facebook page.

After viewing and hearing each news story, we ask whether they recalled seeing the news before. We then ask questions related to their beliefs about whether the news is true or not ("Right now, do you think that this statement is true?") and their sharing intentions ("Will you share this news on social media?"). Both the questions had binary yes/no response options. For capturing emotional reactions, they responded to "When you saw this news how did you feel?" using a slider scale 0 (*neutral*), 1 (*positive or negative*) and 2 (*very positive or very negative*).

Then they completed a question about the reason for believing a news story to be true or false that asked, "Why do you think the news is True?"[7] The response options were *Aligns with my political beliefs; Aligns with my religious beliefs; It has the right source (link/report/video/article); It uses professional language; The picture is real; It is not biased; and Other*. To measure confirmation bias, we construct a variable for each respondent, which

[6]The screenshots of all news stories shown to the participants are available in Appendix F.

[7]For false news, we asked a similar question, "Why do you think the news is false?" and the response options were: *Does not align with my political beliefs; Does not align with my religious beliefs; It does not have the right source (link/report/video/article); It does not have the right quality of language; The picture is edited/fake; It is biased; and Other*.

is the proportion of news items for which the respondent indicated prior belief (i.e., either of the first two response options) as a reason for believing a news headline to be true or false.

Given the survey nature of our work and the privacy concerns related to tracking individuals on Facebook especially among female users (Younas et al., 2020), we were unable to observe the actual sharing behavior of participants on social media platforms. Moreover, we do not observe other actual online and offline decisions people may make (e.g., asking a friend, carrying out a search online) before forming beliefs about true and false news. While this is an important limitation, recent works suggest that there is some reason to expect that the relationships we find may extend to actual behavior. For example, Pennycook et al. (2020) found that an accuracy-nudge intervention—developed using sharing intentions as the outcome—was effective when deployed in a field experiment on Twitter and using item-level analysis Mosleh et al. (2020) found that self-reported willingness to share an article is correlated with the number of actual shares received on Twitter.

We measured the digital literacy of respondents in our sample using a survey of 12 questions. These questions included four basic digital literacy questions (i.e., *Can you connect to WiFi and/or mobile data; can you use social media without assistance, can you use Google search; can you read English on social media*[8]) and eight questions related to use of common Facebook features[9] (Can you use the following features? *Create Post, Like, Share, Comment, Privacy Setting, Report, Hide, Sponsored vs. Non-sponsored posts*). We find that questions about the use Facebook features are better able to separate individuals at the higher end of digital literacy as they require knowledge and understanding of (i) how content is generated (e.g., sponsored vs. non-sponsored content), (ii) how content can be kept private (e.g., using privacy settings) and reported by a user (e.g., using the report feature) and (iii) ways to limit exposure to certain types of content (e.g., using the *Hide post* feature). This is consistent with prior work that recommends having different measures for capturing variations at the low end

[8]While this question is more related to literacy than digital literacy, it becomes relevant in the latter case because a large fraction of social media content is in English. For example, Muda et al. (2021) found that individuals are worse at detecting fake news in their foreign language.

[9]Earlier works have used social media platform features to measure digital literacy. For example, Badrinathan (2021) measured digital literacy through eight (self-reported) ratings of degree of understanding of WhatsApp-related items.

and the high end of digital literacy (Guess and Munger, 2022). We take the sum of the 12 binary indicators (normalized to 1) as our measure of digital literacy score. The mean digital literacy score was 0.77 with a standard deviation of 0.19.

In the figures, we report the mean values of our outcomes by four quartiles of the digital literacy score along with 95% confidence intervals. In the text, we report the regression coefficient, p-value, and 95% confidence interval of the estimated coefficient from a regression of the outcome on a continuous measure of the digital literacy score after controlling for age, gender, education and household expenditure.

Results

Distribution of Digital Literacy

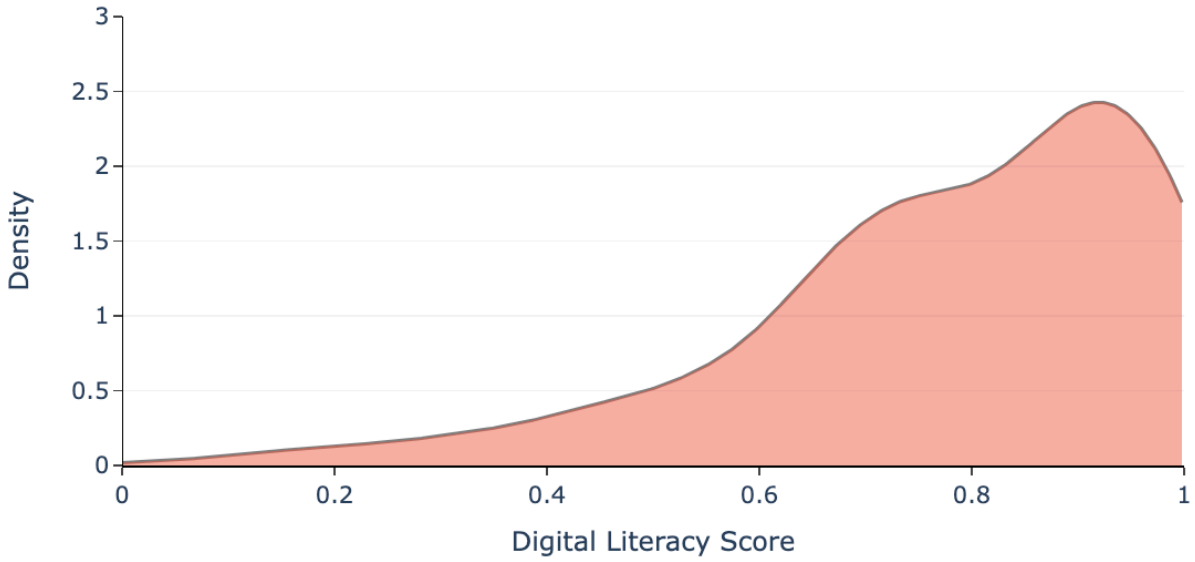

Figure 1. Distribution of digital literacy scores of our sample ($N = 674$).

We begin by investigating the distribution of digital literacy scores in our sample shown in Figure 1. We find the distribution to be skewed to the right with a median score of 0.83. Thus, 50% of the respondents answered at least 10 (out of 12) questions in the affirmative. However, we also find a significant fraction of lower-skill individuals. For instance, 25% of the

respondents in our sample answered less than 8 (out of 12) questions in the affirmative whereas 10% answer only up to 6 questions in the affirmative.

Examining individual questions, we find that a large fraction of respondents were able to connect to WiFi and/or mobile data (98.5%), use social media without assistance (92%) and like (98.5%), share (95.5%), and comment (95%) on a Facebook post. However, a significant fraction of respondents did not have the ability to read English on social media (65.7%), and the ability to use more advanced Facebook features such as hiding a post (57.7%), reporting a post (51.2%), and differentiating between sponsored and non-sponsored posts (27%).[10] It is the latter questions that allow us to capture most of the variation in the digital literacy of individuals in our sample.

Taken together, these results demonstrate the existence of significant gaps in the self-reported ability of individuals in carrying out a set of digital literacy related tasks.

[10]See Table G.7 in Appendix G for descriptive statistics about individual digital literacy questions.

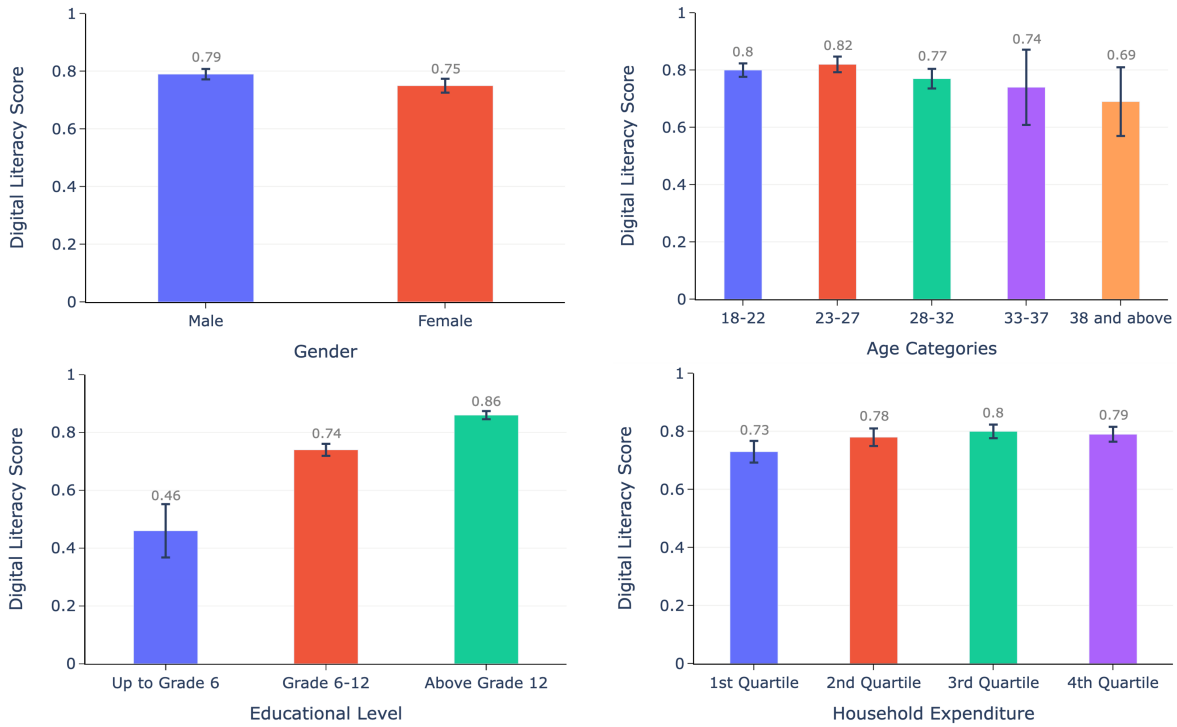

Figure 2. Relationship of digital literacy with gender, age, education level, and household expenditures. Shown are the mean digital literacy scores across males and females (top left plot), different age groups (top right plot), education levels (bottom left plot) and the four expenditure quartiles (bottom right plot) in our sample. Error bars indicate 95% confidence intervals.

Digital literacy and Demographic Correlates

We now analyze the relationship between digital literacy and several demographic characteristics including age, educational level, gender, and household expenditure (a proxy for household income). Understanding this relationship can help with identifying population groups that are most vulnerable to misinformation and thus important targets for interventions.

Gender. We find a negative relationship between digital literacy and gender in our sample as female respondents had a lower digital literacy than the male respondents on average; see

Figure 2.[11] The association between digital literacy and gender was statistically significant at the 5 percent level. In part, this association is suggestive of the digital gender divide that exists in several developing countries. In a study conducted across 10 low- and middle-income countries, women were 1.6 times more likely than men to report lack of skills as a barrier to Internet use (Web Foundation, 2015). For example, currently Pakistan ranks the highest in the world in terms of the gender gap in Internet access between men and women (65%) and mobile phone ownership (51%) EIU (2021). Several ethnographic studies indicate that patriarchal cultures often prevent women and girls from developing digital skills (Naseem et al., 2020). Women and girls may struggle to access public ICT facilities due to unsafe roads, limits on their freedom of movement, or because the facilities themselves are considered unsuitable for women (Cheema et al., 2022). Additionally, women may not have the financial independence needed to pay for Internet connectivity. Fears concerning safety and harassment—both online and offline—also inhibit many women and girls from benefiting from or even wanting to use ICTs (Mustafa et al., 2019).

Age. We find a negative relationship between digital literacy and age, i.e., older participants were more likely to have lower digital literacy; see Figure 2. This is consistent with recent evidence, which found that a similar relationship between age and Web-use and Internet skills in U.S. and European samples (Hargittai et al., 2018; Guess and Munger, 2022). From a theoretical perspective, earlier works posit that this relationship can be explained by differences in socioeconomic status and autonomy of use (Hargittai et al., 2018; van Dijk, 2005).

Our findings are also related to the mixed pattern of results between age and truth discernment among U.S. samples. For example, based on the analysis of social media data, Grinberg et al. (2019) and Brashier and Schacter (2020) found a negative relationship between discernment and age whereas Rosenzweig et al. (2021) found a positive relationship. One possible explanation for the mixed pattern could be differences in the demographic characteristics of the samples used in these studies. For example, Rosenzweig et al. (2021) studied a highly educated sample from Nigeria (76% of the respondents had received some university education) recruited via Facebook ads whereas Grinberg et al. (2019) used a sample of Twitter users who

[11]The respondents were asked about their gender without specifying any predefined categories or options. For our analysis, we created a dummy variable for gender equal to 1 if the respondent was a female and 0 for males.

were found to exhibit little demographic bias compared to a nationally representative sample of registered U.S. voters that were Twitter users.

Educational Attainment. We find a positive correlation between digital literacy and educational attainment, i.e., more educated participants were more likely to have higher digital literacy; see Figure 2. This is consistent with earlier findings on a sample of social media users in the United States where understanding of Facebook newsfeed and self-reported Internet familiarity were found to be correlated with having a college-level degree (Sirlin et al., 2021). Prior work on digital inequality has also shown that differences in educational attainment impact both technology adoption and use (Vroman et al., 2015).

Household Expenditures. Finally, we find a positive correlation between digital literacy and household expenditures; see Figure 2. This correlation is suggestive of the barriers faced by low-income populations in obtaining regular access to the Internet due to affordability considerations (Qazi et al., 2021) as well as due to limited opportunities for improving their digital literacy. Hargittai et al. (2018) find that income is linked to autonomy of use (i.e., the freedom to use the technology when and where one wants), which has been found to be an important correlate of Internet skills.

Taken together, these results show that digital literacy was lower amongst females, older individuals, less educated, and low-income individuals in our sample.

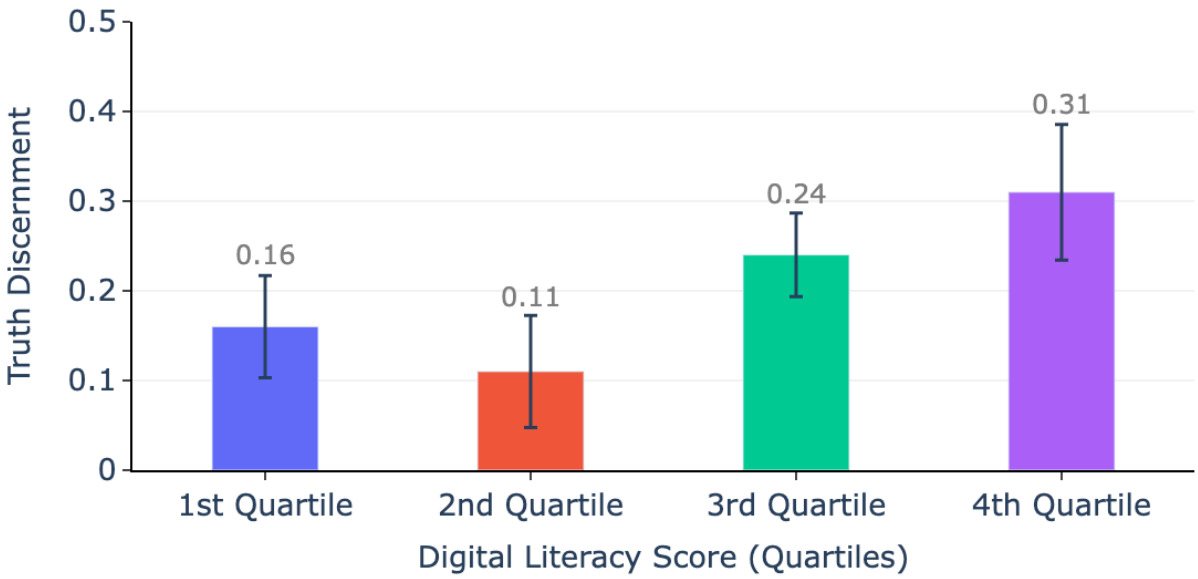

Figure 3. Relationship of digital literacy with truth discernment (defined as average accuracy ratings for true news minus average accurate ratings for false news). For example, if a participant rated 50% of the true headlines as accurate and 10% of false headlines as accurate, their level of truth discernment would be $0.5 - 0.1 = 0.4$. Thus, discernment values can range from -1 to 1. Shown are the mean values for truth discernment across the four quartiles of digital literacy scores. Error bars indicate 95% confidence intervals.

Digital literacy and Truth Discernment

Next, we examine the relationship between digital literacy and truth discernment. We find that truth discernment—defined as average accuracy ratings for true news minus average accurate ratings for false news—is positively associated with digital literacy; see Figure 3. In particular, respondents in the first quartile of digital literacy exhibited 1.5× and 1.9× worse truth discernment compared to respondents in the third and fourth quartiles, respectively. The latter respondents answered at least 11 (out of 12) digital literacy questions in the affirmative, which is suggestive of their greater knowledge of Facebook features and basic digital competencies.

We find that the association between truth discernment and digital literacy is robust to

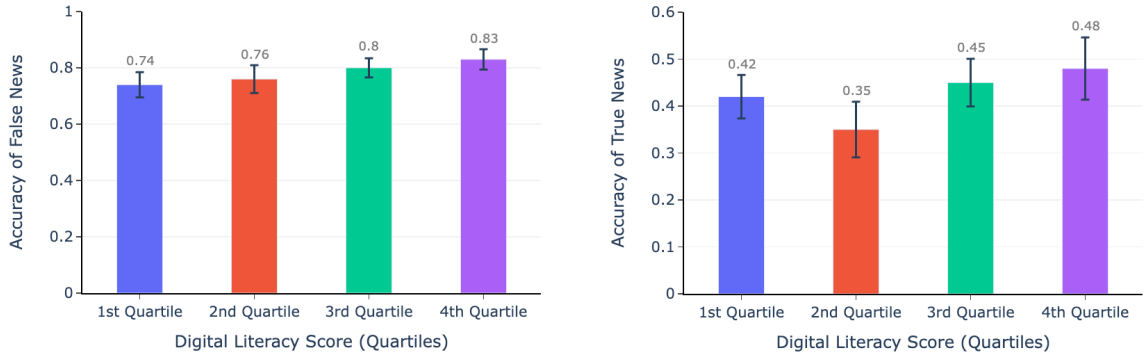

Figure 4. Relationship of digital literacy and accuracy of false headlines (left plot) and accuracy of true headlines (right plot). Shown are the mean values of the outcome variable across the four quartiles of digital literacy scores. Error bars indicate 95% confidence intervals.

adding demographic controls for age, gender, education level, and household expenditure ($\beta = 0.244$, 95% CI = [0.067, 0.421], $p = 0.007$), which suggests that the association does not simply reflect differences in demographic characteristics.[12]

To unpack whether truth discernment is driven by greater accuracy of true news or false news, we consider accuracy of false news and true news separately. We find a positive and statistically significant relationship between digital literacy and the ability of participants to correctly identify false news; see Figure 4. This association is also robust to adding controls for age, education, gender, and household expenditure ($\beta = 0.206$, 95% CI = [0.084, 0.327], $p < 0.001$); see Appendix Table B.2. On the other hand, we do not find a statistically significant relationship between digital literacy and the accuracy ratings of true news items; see Figure 4.[13]

Finally, our robustness checks in Appendix E show that the association between digital literacy and accuracy of beliefs is robust to adding news headline fixed effects (see Appendix Table E.6) and that our results are not driven by a particular news headline (see Appendix

[12] All regression tables are provided in Appendix B.

[13] A regression of the accuracy of true news on a continuous measure of the digital literacy score after controlling for age, gender, education, and household expenditure results in the following estimate of the regression coefficient: ($\beta = 0.038$, 95% CI = [-0.115, 0.192], $p = 0.627$).

Figure E.3).[14]

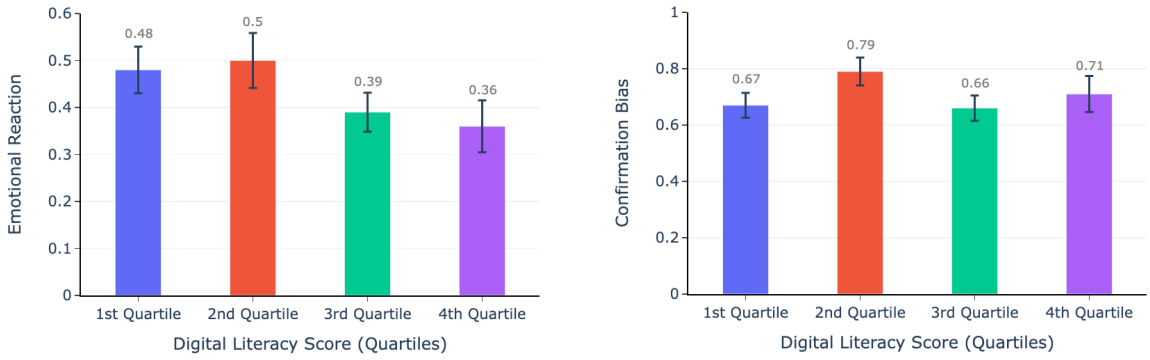

Figure 5. Relationship of digital literacy with emotional reactions (left plot) and confirmation bias (right plot). Shown are the mean values for emotional reactions (left plot, bars indicate a normalized score of three emotions: very positive/very negative (2), positive/negative (1), neutral (0)) and confirmation bias (right plot, bars correspond to the fraction of responses in which respondents indicated prior belief as the reason for believing a news item to be true or false) across the four quartiles of digital literacy scores. Error bars indicate 95% confidence intervals.

Digital literacy, Emotions and Confirmation Bias

We now examine the relationship between digital literacy, emotional reactions and reasons for stated beliefs about the accuracy of news headlines.

Prior work shows that when respondents have an emotional reaction to a news story (e.g., anger, happiness, and surprise), they are more likely to believe, want to read, and share that news, regardless of whether it is true or false (Han et al., 2020; Greenstein and Franklin, 2020). Moreover, emotional reactions have also been found to be associated with worse truth discernment (Rosenzweig et al., 2021). Are less digitally literate users more likely to have non-neutral emotional reactions to news? In our sample, we find that digital literacy is negatively associated with self-reported emotional reactions as shown in Figure 5. Thus, less digitally literate users are more likely to have non-neutral reactions to news stories. For example, users

[14]While we drew our set of true and false new stories—which cover general interest topics and current events—directly from social media, they may not be representative of all or most of fake news on social media. Thus, it is important for future work to examine how our results generalize to a larger and more diverse set of news stories as well as to users from other developing countries.

in the fourth quartile of digital literacy had a 25% lower score compared to respondents in the first quartile of digital literacy in terms of emotional reactions.

The negative association we find between digital literacy and emotional reactions is robust to the inclusion of demographic controls for age, gender, education level, and household expenditure (β = -0.222, 95% CI = [-0.379, -0.646], $p = 0.006$); see Appendix Table B.1. These results suggest that digital literacy may have a emotion regulating role when consuming news on social media. Thus, future work should explore whether the association we observe between digital literacy and emotional reactions is causal. This is also relevant because fact-checking websites often advocate for regulating emotions as a way to counter misinformation (Rosenzweig et al., 2021).

We find no statistically significant relationship between digital literacy and citing prior beliefs as the reason for the perceived accuracy of a news headline, even though the regression coefficient is positive ($\beta = 0.078$, 95% CI = [0.077, 0.233], $p = 0.325$); see Figure 5. In other words, the observed difference in citing prior beliefs as a reason for believing a news story to be true might simply be due to chance.

Digital Literacy and Sharing Intentions

Next, we analyze the relationship between digital literacy and sharing discernment, which is the propensity of participants to share true news more than false headlines (defined as average sharing probability for true news minus average sharing probability for false news). We find a positive association between digital literacy and sharing discernment as shown in Figure 6. This association is robust to adding demographic controls for age, gender, education level, and household expenditure ($\beta = 0.124$, 95% CI = [0.022, 0.226], $p = 0.017$); see Appendix Table 6.

To unpack whether sharing discernment is driven by greater sharing of true news or less sharing of fake news, we consider sharing intention for false news and true news separately. We find no statistically significant relationship between digital literacy and the intention of participants to share false news; see Figure 7. However, we find that the intention of participants to share true news is positively associated with digital literacy (see Figure 7) and this relationship is robust to adding demographic controls ($\beta = 0.143$, 95% CI = [0.039, 0.247], $p = 0.007$); see Appendix table B.4. Observe that while the perceived accuracy of true news does

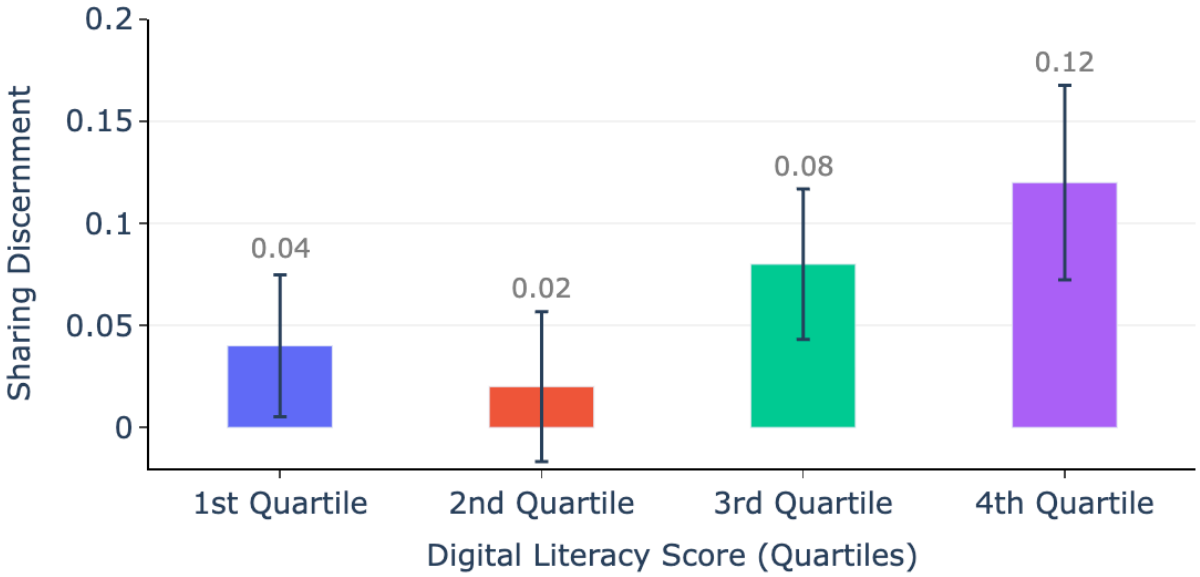

Figure 6. Relationship of digital literacy with sharing discernment (right plot, defined as average sharing probability for true news minus average sharing probability for false news). The discernment values can range from -1 to 1. Shown are the mean values of sharing discernment across the four quartiles of digital literacy scores. Error bars indicate 95% confidence intervals.

not improve with digital literacy in our sample (improvement comes mainly from false news), sharing discernment is driven by greater sharing of true news by higher digital literacy users. Thus, accuracy priming—as a result of asking respondents about whether a news item is true or false (Pennycook et al., 2020)—may not fully explain the association we observe between digital literacy and sharing discernment.

Conclusion

The ability to competently navigate digital spaces and effectively find information online is important for one's informational well-being. Yet there is a dearth of empirical evidence in this area, particularly from developing countries. Using data of 674 Facebook users gathered through a face-to-face field survey in Pakistan, we examined the demographic correlates of digital literacy and its association with truth discernment, emotional responses to misinformation,

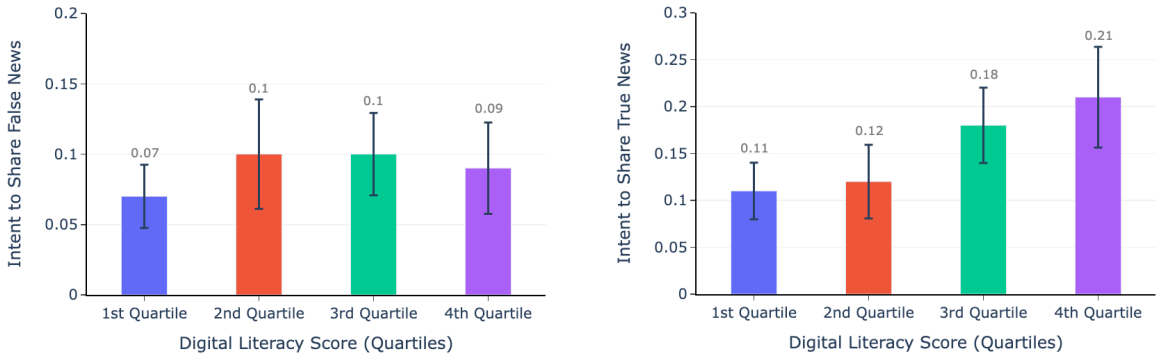

Figure 7. Relationship of digital literacy and the probability of sharing false headlines (left plot) and true headlines (right plot). Shown are the mean values of the outcome variable across the four quartiles of digital literacy scores. Error bars indicate 95% confidence intervals.

confirmation bias, and sharing intentions. We find that in our sample, digital literacy was lower among females, less educated, older, and lower income users, which points to potential barriers faced by these groups in improving their digital literacy. We found that digital literacy was associated with better truth discernment, greater intent to share true news but not false news, less extreme emotions, but no less confirmation bias when assessing the veracity of headlines.

Our findings have implications for policymakers, social media platforms, academics, and practitioners interested in countering misinformation. First, our results suggest that digital literacy may be useful in identifying social media users who are susceptible to believing misinformation and thus important targets for interventions. Second, our results can potentially inform the design of future digital literacy interventions. For example, the positive association between higher digital literacy and neutral emotional reactions to misinformation suggest that digital literacy trainings could include techniques to spot emotionally evocative posts, which may also help regulate emotional responses to news headlines. This may be particularly relevant during public health crises, such as the COVID-19 pandemic, or national events such as elections, where emotions might be particularly intense.

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Appendix

Regression Results

A.1 OLS model with controls for age, education, gender, and household expenditure

In the text, we report the regression coefficient, p-value, and 95% confidence interval of the estimated coefficient from a regression of the outcome on a continuous measure of the digital literacy score. For this analysis, we use ordinary least squares regression (OLS) with controls for age, gender, education, and household expenditure (proxy for household income). We estimate the following respondent-level model:

$$Y_i = \beta_0 + \beta_1 dl\_score_i + \beta_2 age_i + \beta_3 inc_i + \beta_4 gen_i + \beta_5 e1_i + \beta_6 e2_i + \epsilon_i \quad (1)$$

where dl_score_i, inc_i, age_i, gen_i, $e1_i$, and $e2_i$ represent the digital literacy score, age, household expenditure, gender (equal to 1 for females, and 0 otherwise), dummy equal to 1 if education is between primary and grade 12, and a dummy equal to 1 if education is above grade 12 for each respondent i. We use the model for all of the results mentioned within the text. We use the above model for each of our outcomes of interest (Y_i): *truth discernment, sharing discernment, intent to share true news, intent to share false news, emotions and confirmation bias.* The results are reported in Table B.1 and Table B.2.

A.2 OLS model by quartiles with controls for age, education, gender, and household expenditure

For predictions by quartiles, we estimate the following model in which we add dummy variables to allow for a different slope within each quartile.

$$Y_i = \beta_0 + \beta_1 age_i + \beta_2 inc_i + \beta_3 gen_i + \beta_4 e1_i + \beta_5 e2_i + \beta_6 q2_i + \beta_7 q3_i + \beta_8 q4_i + \epsilon_i \quad (2)$$

where age_i, inc_i, gen_i, $e1_i$, $e2_i$, q_j's represent the age, household expenditure, gender, dummy equal to 1 if education is between primary and grade 12, dummy equal to 1 if education is above grade 12 for each respondent i, and q_js refer to dummy variables ($j \in \{2, 3, 4\}$) equal to 1 for each corresponding quartile (i.e., q_2 is equal to 1 if the dl_score of a respondent is in the second quartile). Note that we do not add q_1 because it would make the sum of q_j's linear dependent with the intercept. We use the above model for each of our outcomes of interest

Table B.1: Association between digital literacy and different outcomes (truth discernment, sharing discernment, emotions, and confirmation bias) with controls.

	(1)	(2)	(3)	(4)
Dependent variable	Truth Discern.	Sharing Discern.	Emotions	Conf. Bias
DL Score	0.244***	0.124**	-0.222***	0.078
	(0.090)	(0.052)	(0.080)	(0.079)
Household Expenditure	-0.000	-0.000	-0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.001	0.002**	-0.001	0.005***
	(0.002)	(0.001)	(0.001)	(0.001)
Female	-0.114***	-0.047**	-0.019	-0.018
	(0.033)	(0.018)	(0.028)	(0.028)
Edu: Grade 6-12	0.033	0.018	0.045	-0.033
	(0.071)	(0.051)	(0.093)	(0.060)
Edu: >Grade 12	0.066	0.034	0.054	-0.087
	(0.077)	(0.056)	(0.097)	(0.065)
Constant	-0.005	-0.087	0.670***	0.413***
	(0.092)	(0.061)	(0.110)	(0.085)
Observations	674	674	674	631
R-squared	0.039	0.028	0.041	0.105

Note. Robust standard errors in parentheses. Mean (standard deviation) of Digital Literacy (DL) Score is 0.78 (0.19). Education below grade 6 is omitted as the base category. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table B.2: Association between digital literacy and accuracy of true news, accuracy of false news, and sharing intentions for true and false news with controls.

Dependent variable	(1) Accuracy of True News	(2) Accuracy of False News	(3) Intent to Share True News	(4) Intent to Share False News
DL Score	0.038	0.206***	0.143***	0.019
	(0.078)	(0.062)	(0.053)	(0.043)
Household Expenditure	-0.000***	0.000**	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Age	-0.001	0.002*	0.000	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Female	-0.087***	-0.027	-0.113***	-0.066***
	(0.030)	(0.022)	(0.019)	(0.015)
Edu: Grade 6-12	0.118	-0.085	0.037	0.019
	(0.078)	(0.071)	(0.049)	(0.041)
Edu: >Grade 12	0.142*	-0.076	0.033	-0.001
	(0.083)	(0.073)	(0.054)	(0.043)
Constant	0.383***	0.612***	0.032	0.119**
	(0.093)	(0.084)	(0.060)	(0.053)
Observations	674	674	674	674
R-squared	0.030	0.037	0.058	0.033

Note. Robust standard errors in parentheses. Mean (standard deviation) of Digital Literacy (DL) Score is 0.78 (0.19). Education below grade 6 is omitted as the base category. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

(Y_i): *truth discernment, sharing discernment, intent to share true news, intent to share false news, emotions and confirmation bias.* The results are reported in Table B.3 and Table B.4.

Sample Selection and Randomization

Our field survey was conducted in Lahore, the largest city by population (approximately 11 million) in the province of Punjab in Pakistan. Our partner for field data collection was the survey wing of the Institute of Development Alternatives (IDEAS). Our field survey was designed to include a separate experiment for evaluating whether a digital media literacy intervention affects how people evaluate true and false news headlines (Ali and Qazi, 2021). The results of the experiment are examined in a separate study. Due to the horizontal pattern of urban development in Lahore, the dwelling sizes are inversely correlated with income levels, therefore, we use population density as a proxy for income levels as well as to draw our sample of low- and middle-income households. In particular, we use the AsiaPop (2013) satellite data which provides population counts at a spatial resolution of 100m by 100m to identify most densely populated (low and middle income) neighborhoods.

Table B.3: Association between different quartiles of digital literacy scores and outcomes (truth discernment, sharing discernment, emotions, and confirmation bias) with controls.

	(1)	(2)	(3)	(4)
Dependent variable	Truth Discern.	Sharing Discern.	Emotions	Conf. Bias
DL Score 2nd Quartile	-0.017	0.008	-0.010	0.157***
	(0.040)	(0.025)	(0.036)	(0.032)
DL Score 3rd Quartile	0.099**	0.055*	-0.111***	-0.010
	(0.047)	(0.029)	(0.039)	(0.041)
DL Score 4th Quartile	0.115**	0.075**	-0.131***	0.071
	(0.052)	(0.031)	(0.041)	(0.043)
Household Expenditure	-0.000	-0.000	-0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.001	0.002**	-0.001	0.005***
	(0.002)	(0.001)	(0.001)	(0.001)
Female	-0.102***	-0.040**	-0.032	-0.033
	(0.034)	(0.019)	(0.028)	(0.029)
Edu: Grade 6-12	0.073	0.032	0.021	-0.054
	(0.067)	(0.050)	(0.090)	(0.060)
Edu: >Grade 12	0.111	0.047	0.032	-0.108*
	(0.074)	(0.053)	(0.093)	(0.064)
Constant	0.108	-0.035	0.578***	0.434***
	(0.074)	(0.053)	(0.100)	(0.074)
Observations	674	674	674	631
R-squared	0.047	0.034	0.053	0.146

Note. Robust standard errors in parentheses. Mean (standard deviation) of Digital Literacy (DL) Score is 0.78 (0.19). Quartiles are 0-0.67, 0.67-0.83, 0.83-0.92, 0.92-1. Bottom quartile and education below grade 6 are omitted as the base category. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table B.4: Association between different quartiles of digital literacy scores and outcomes with controls.

Dependent variable	(1) Accuracy of True News	(2) Accuracy of False News	(3) Intent to Share True News	(4) Intent to Share False News
DL Score 2nd Quartile	-0.065*	0.048	0.041*	0.033
	(0.036)	(0.030)	(0.024)	(0.021)
DL Score 3rd Quartile	0.021	0.078**	0.078**	0.024
	(0.041)	(0.031)	(0.031)	(0.025)
DL Score 4th Quartile	0.015	0.101***	0.078**	0.002
	(0.044)	(0.032)	(0.033)	(0.025)
Household Expenditure	-0.000***	0.000**	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Age	-0.001	0.002*	0.001	-0.001*
	(0.001)	(0.001)	(0.001)	(0.001)
Female	-0.076**	-0.025	-0.111***	-0.071***
	(0.031)	(0.024)	(0.019)	(0.016)
Edu: Grade 6-12	0.138*	-0.065	0.044	0.012
	(0.076)	(0.071)	(0.048)	(0.039)
Edu: >Grade 12	0.163**	-0.052	0.038	-0.009
	(0.080)	(0.073)	(0.052)	(0.041)
Constant	0.408***	0.701***	0.087	0.122***
	(0.082)	(0.077)	(0.054)	(0.047)
Observations	674	674	674	674
R-squared	0.040	0.036	0.061	0.037

Note. Robust standard errors in parentheses. Mean (standard deviation) of Digital Literacy Score is 0.78 (0.19). Quartiles are 0-0.67, 0.67-0.83, 0.83-0.92, 0.92-1. Bottom quartile and education below grade 6 are omitted as the base category. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

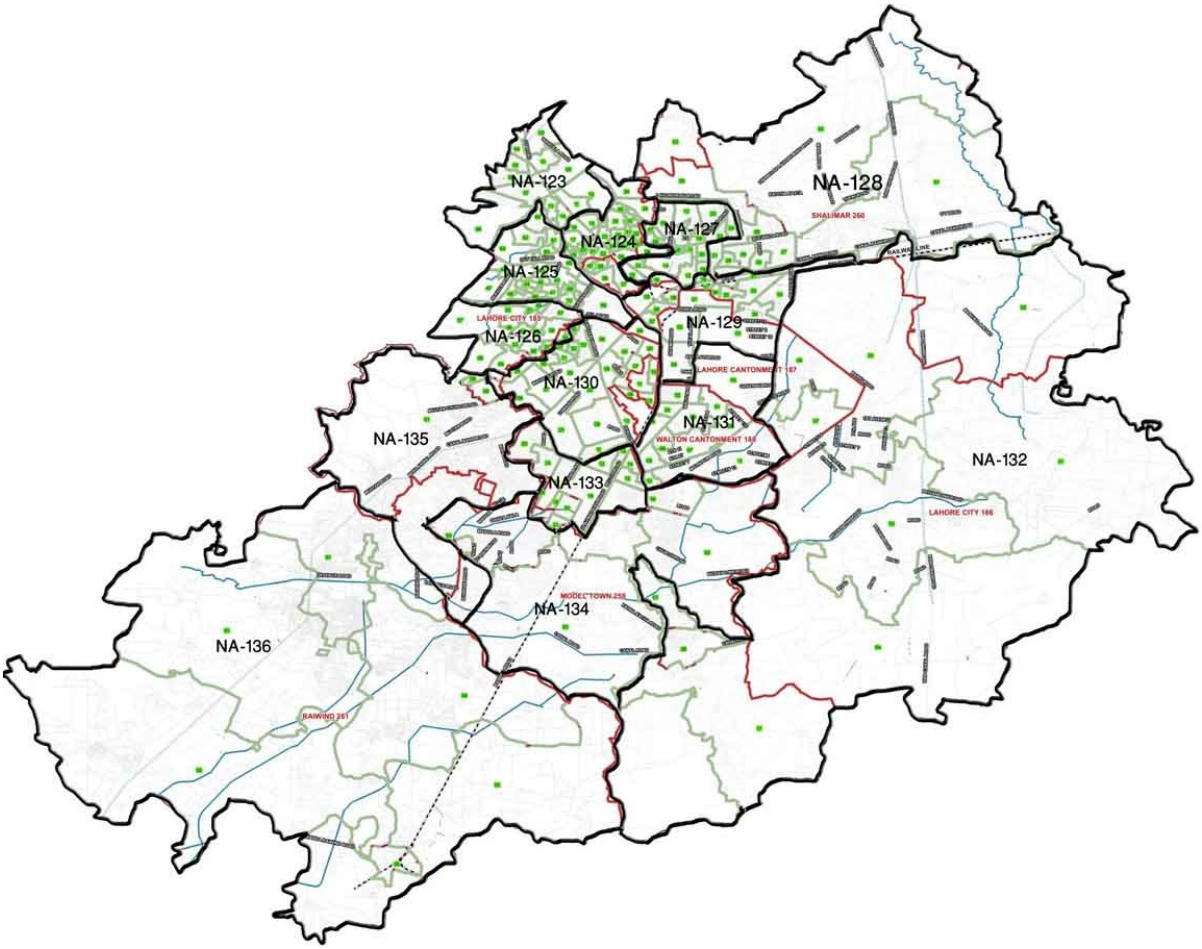

Figure C.1. This map shows the fourteen National Assembly constituencies in the city of Lahore and the red boxes correspond to the ones from where the study sample was drawn. We obtained this map from the Election Commission of Pakistan.

The selected areas we consider in our study account for nearly 35% of the city's total population and cover seven of the fourteen National Assembly constituencies in the city (see Figure C.1). The median population density in the selected areas of our study was 109 persons per 100m by 100m grid whereas the median density in areas not covered by our sample was 28 persons per 100m by 100m grid. We draw a random sample of 200 grids from the selected areas. In order to initiate the data collection within the chosen grids, we randomly dropped a point (x and y coordinate) within the grid. The enumerators arrived at the point and used

the left hand rule to survey, within each grid, five households where at least one social media user was present. The definition of social media user for our survey was that the respondent must be at least 18 years of age and use a social media application. Our total sample included 1000 households, 1470 social media users out of which 674 users are Facebook users. We also verify in Figure C.2 below that household expenditures (a proxy of income) is indeed declining in population density.

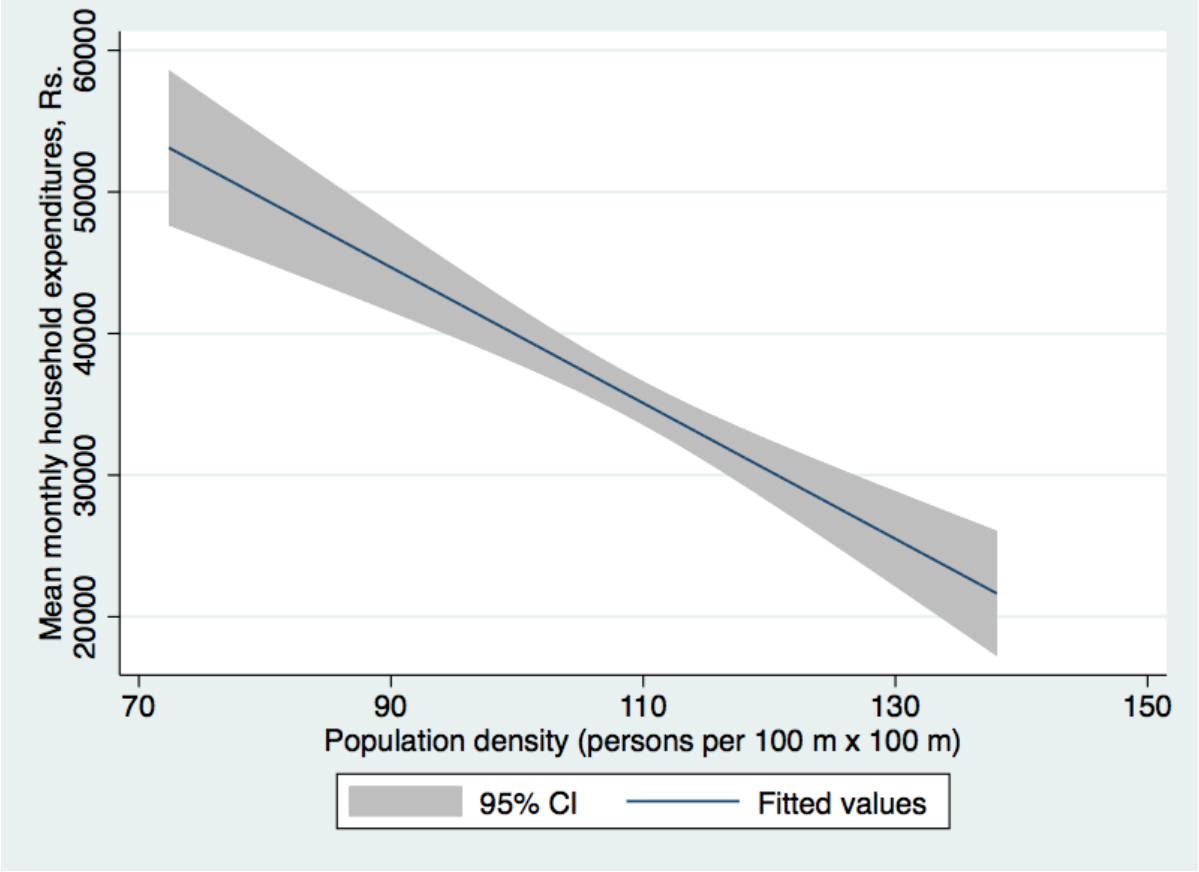

Figure C.2. This figure shows a fitted line with 95% confidence interval, between population density (per 100 m x 100 m) and monthly household expenditures reported in our survey.

Descriptive Statistics

Table D.5 provides descriptive statistics of our sample.

Table D.5: Descriptive statistics for the sample.

Variable	N	Mean	SD	Min	Median	Max
Age	674	28.21	9.34	18	26	70
Female	674	0.32	0.47	0	0	1
Education level	674	2.37	0.54	1	2	3
Household Expenditure (PKR. '000s)	674	40.93	26.50	0.003	35	350
Users with a WhatsApp account	674	0.92	0.28	0	1	1
Users with a Facebook account	674	1	0	1	1	1
Digital Literacy Score	674	0.78	0.19	0	0.83	1

Note. Education level was coded as 1 (if the attained education was below grade 6), 2 (if between grade 6 and 12) and 3 (if above grade 12). Female is a variable equal to 1 if the respondent was a female, 0 for male. Except age and monthly household expenditure (which were quantitative variables with no pre-specified category), the other remaining variables were binary (1 if the respondent had an account on the specific social media platform, 0 otherwise).

Comparison with the National Demographic Distribution

67.7% of participants in our study were males whereas 32.3% were females. 64% of the participants were below the age of 29 (median age was 26 years) and 34.3% were between 33–55, and the maximum age was 70 years. The age distribution in our sample is comparable to the national distribution in Pakistan where 64% of citizens are estimated to be below the age of 29 and nearly 28% were between 30-55 (compared to 34.3% in our sample). The national median age is 22.5 years (Najam and Bari, 2018). While 8% of the national population is estimated to be older than 55 years, our sample had 1.6% of respondents from this category.

1.6% of our sample received up to primary education and 30% received between grade

6 and grade 12 education. 29% of Pakistan's population is non-literate (i.e., they received no formal education) whereas 65% received education between grade 1 and grade 12 (compared to 30.6% in our sample). Thus, our sample have a greater education level compared to the national distribution

The median monthly household expenditure in our sample was PKR 40,933. According to the Household Integrated Economic Survey 2018-19 conducted by the Pakistan Bureau of Statistics, the median monthly household expenditure in urban areas in Pakistan was estimated to be PKR 31,031. After adjusting for inflation, we estimate this amount to be PKR 41,987 in 2022 Pakistani Rupees, which is similar to the median household expenditure in our sample.

Robustness Checks

C.1 Correlation of digital literacy score with the probability of correctly identifying news items

We run separate regressions to predict the probability of correctly answering whether a news item is true or false, separately for each news item, based on the digital literacy score with controls for age, education, gender, and household expenditure. We see that the results are not driven by a particular headline.

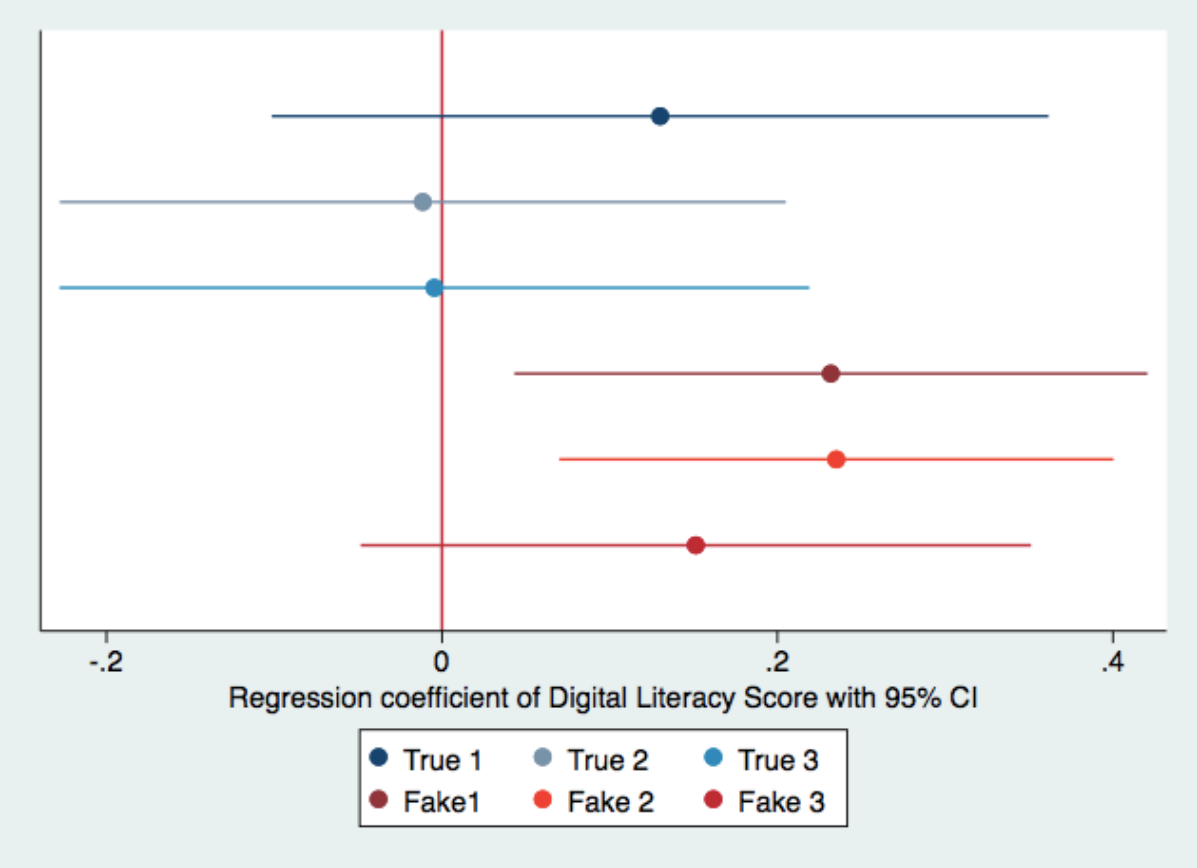

Figure E.3. Regression coefficients of digital literacy score for individual news items with controls for age, gender, education, and household expenditure. Dependent variable is equal to 1 if the respondent correctly identifies a news item as true or fake, and 0 otherwise. Regressions include all controls.

C.2 OLS results for the probability of correctly identifying a news item with news fixed effects

For robustness, we check whether the digital literacy score predicts the probability of correctly identifying each news item separately with news fixed effects and controls for age, education, gender, and household expenditure. News fixed effects allow us to flexibly control for any idiosyncratic features of the news items that might be driving our results. The results are reported in Column 1 of Table E.6. We find that digital literacy is positively associated

with accuracy of beliefs about news items after controlling for news fixed effects. Moreover, we run separate regressions for each news headline in Columns 2 to 7. As we can see, the digital literacy score is positively associated with correctly identifying most news items.

Table E.6: Association between digital literacy scores and accuracy (probability of correctly answering each news item) with news fixed effects and controls.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DV:	Correctly identify news as true or false						
	All	True-1	True-2	True-3	False-1	False-2	False-3
DL Score	0.122***	0.130	-0.011	-0.005	0.232**	0.235***	0.151
	(0.042)	(0.118)	(0.110)	(0.114)	(0.096)	(0.084)	(0.102)
HE	-0.000	-0.000**	-0.000	-0.000**	0.000	0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.000	0.000	-0.002	-0.001	0.003*	0.001	0.002
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
Female	-0.057***	-0.025	-0.137***	-0.099**	-0.055	-0.037	0.012
	(0.016)	(0.044)	(0.040)	(0.042)	(0.039)	(0.031)	(0.035)
Grade 6-12	0.017	-0.083	0.232***	0.205*	-0.080	-0.046	-0.129
	(0.042)	(0.119)	(0.088)	(0.109)	(0.093)	(0.090)	(0.095)
$>$ Grade 12	0.033	-0.090	0.321***	0.195*	-0.121	-0.070	-0.037
	(0.044)	(0.126)	(0.096)	(0.116)	(0.098)	(0.093)	(0.100)
Constant	0.498***	0.529***	0.244**	0.377***	0.548***	0.628***	0.661***
	(0.053)	(0.146)	(0.114)	(0.142)	(0.124)	(0.111)	(0.122)
Observations	4,044	674	674	674	674	674	674
R-squared	0.145	0.016	0.029	0.020	0.018	0.032	0.025

Note. Regression in column 1 includes news fixed effects. Robust standard errors in parentheses. Mean (standard deviation) of Digital Literacy (DL) Score is 0.78 (0.19). The variables 'HE', 'Grade 6-12', and '>Grade 12' stand for household expenditure, education between grade 6 and grade 12, and education above grade 12, respectively. 'True-1', 'True-2', and 'True-3' stand for true news items 1, 2, and 3, respectively. 'False-1', 'False-2', and 'False-3' stand for false news items 1, 2, and 3, respectively. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

News Headlines

Figures F.4 and F.5 show the snapshot of false news and true news items used in our study.

False Headline 1

False Headline 2

False Headline 3

Figure F.4. False News Headlines

True Headline 1

True Headline 2

True Headline 3

Figure F.5. True News Headlines

Summary Statistics of Digital Literacy Scores

Table G.7 shows the average score and the standard deviation for each question in our digital literacy measure.

Table G.7: Descriptive statistics of individual digital literacy questions.

Basic Digital Literacy Questions	Mean (SD)
1. Are you able to connect to WiFi and/or mobile data?	0.985 (0.121)
2. Can you use social media without assistance?	0.920 (0.272)
3. Can you use social media without assistance?	0.868 (0.339)
4. Can you use social media without assistance?	0.657 (0.475)
Questions about Facebook Features: *Can you use the following features on Facebook?*	
5. Like a post	0.985 (0.121)
6. Share a post	0.955 (0.206)
7. Comment	0.950 (0.219)
8. Create post	0.872 (0.333)
9. Update privacy settings of your account	0.714 (0.452)
10. Report a post	0.512 (0.500)
11. Hide a post	0.577 (0.494)
12. Identify sponsored vs non-sponsored posts	0.270 (0.444)

Note. Column 2 shows the average score for each of the 12 digital literacy related questions across the respondents along with the standard deviation in the brackets. All response options were binary - Yes (1); No (0).