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ICT Inclusion and Women's Empowerment in India: Evidence from a Nationally Representative Survey

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Abstract

Digital technologies are increasingly shaping women's access to information, financial services and social opportunities, yet evidence on their relationship with multidimensional women's empowerment in India remains limited. This study examined the association between ICT inclusion and women's empowerment among currently married/in-union women using nationally representative National Family Health Survey-5 data (2019–21). The analysis included 75,389 women aged 15–49 years. Women's empowerment was measured using a composite index covering household decision-making, economic empowerment and gender attitudes, while ICT inclusion was assessed using mobile phone ownership, internet use and mobile financial transactions. Survey-weighted linear regression models were used to estimate adjusted associations, followed by domain-specific analysis, assessment of urban–rural heterogeneity, and sensitivity analyses using alternative additive and principal component analysis (PCA)-derived indices. ICT inclusion was positively associated with women's empowerment in the fully adjusted model (β = 0.340; 95% CI: 0.307–0.374; $P < 0.001$). Adjusted predicted WEI increased from 8.45 among women with no ICT access to 9.47 among those with high ICT inclusion, representing a 1.02-point difference. The association was stronger for economic empowerment (β = 0.172; 95% CI: 0.158–0.186) and household decision-making (β = 0.147; 95% CI: 0.128–0.167), whereas no significant association was observed with gender attitudes. The association remained significant among both urban and rural women, with no significant urban–rural heterogeneity. Findings were also consistent across alternative index-construction methods. Greater ICT inclusion was associated with higher women's empowerment, particularly in economic and household decision-making domains. However, digital access alone may be insufficient to influence deeply embedded gender attitudes. Further research should examine how digital literacy, purpose of use and social norms shape the translation of digital inclusion into meaningful empowerment.

1. Introduction

Digital technologies have become increasingly embedded in the social and economic lives of individuals, reshaping how people access information, communicate, obtain financial services and participate in economic and social activities [1–3]. For women, access to mobile phones, the internet and digital financial services can potentially expand opportunities that have traditionally been constrained by limited mobility, restricted access to information and unequal control over resources [2, 4, 5]. Mobile phones, for example, can facilitate communication beyond the immediate household, strengthen access to information and social networks, and potentially enhance women's bargaining position within the household [1, 2]. Evidence from India has linked mobile phone use with greater physical mobility and selected indicators of women's autonomy, suggesting that digital connectivity can form an important component of women's social and economic agency [1]. Evidence from other South Asian settings similarly indicates that mobile phone use can be associated with improvements in women's empowerment and household economic outcomes [4]. At the same time, digital access is not distributed equally. Research from India has documented economic and sociocultural barriers to women's mobile-phone ownership and use [6], while recent NFHS-5 evidence demonstrates substantial socioeconomic

and spatial inequalities in women's internet use [7–10]. These patterns indicate that the expansion of digital infrastructure does not necessarily translate into equal opportunities for women to access, control, and meaningfully use digital technologies

The relationship between digital inclusion and women's empowerment is particularly relevant because empowerment is a multidimensional process involving agency, access to resources and participation in decisions affecting women's lives [11]. Digital technologies may contribute to these dimensions through several pathways. Access to online information can improve women's knowledge of education, health, employment, government programmes and rights, while digital financial services can reduce barriers to formal financial participation and facilitate greater control over financial transactions [12, 13]. Evidence from India suggests that digital financial inclusion has considerable potential for strengthening women's financial and social autonomy, although gender gaps in access and use remain [14, 15]. Evidence from other Asian settings similarly indicates that digital financial-service adoption can be associated with improvements in women's empowerment, particularly through greater financial inclusion and control over resources [16]. More recent research further indicates that women's uptake of digital financial services is shaped not only by individual characteristics but also by community-level peer behaviour and gender norms, highlighting the importance of the social environment in determining whether women can benefit from digital technologies [17]. Thus, ICT inclusion should be understood not simply as access to technology, but as an enabling resource whose potential benefits depend on women's capacity and opportunity to use digital technologies meaningfully [12, 17, 18].

The Indian context is particularly important in this regard. India has experienced rapid expansion of mobile connectivity, internet services and digital financial infrastructure, creating new opportunities for digital participation. However, significant inequalities persist in women's access to and use of these technologies [19–21]. NFHS-5-based evidence indicates substantial inequalities in women's internet use according to education, household wealth and place of residence, while recent research shows that women's mobile phone use may remain constrained by digital literacy, household permission, monitoring and broader sociocultural norms [22, 23]. These constraints are important because access to a device or an internet connection does not necessarily imply autonomous or purposeful use. Digital financial inclusion has similarly expanded in India, but evidence indicates that gender parity has not necessarily accompanied this expansion [15]. The policy relevance of this issue is reflected in the Sustainable Development Goals: SDG Target 5.b explicitly calls for enhancing the use of enabling technology, particularly ICT, to promote women's empowerment, with mobile-phone ownership by sex included as its official indicator [24]. Understanding whether greater ICT inclusion is associated with broader dimensions of women's empowerment is therefore important for assessing the social implications of India's continuing digital transformation.

Despite growing interest in the digital gender divide and digital financial inclusion, an important gap remains in the empirical literature. Existing Indian studies have largely examined digital access or internet use as outcomes, or have focused on specific dimensions such as financial inclusion, mobility, health-related access or particular forms of autonomy [1, 17, 22, 23]. Other studies have examined the

relationship between digital financial inclusion and women's empowerment, but often within specific populations, geographical settings, or particular dimensions of empowerment, but nationally representative evidence linking broader ICT inclusion with a multidimensional measure of women's empowerment remains comparatively limited [10, 12, 25]. Moreover, the potential relationship may not be uniform across different dimensions of empowerment: digital technologies may be more closely related to economic resources and household decision-making than to deeply embedded gender attitudes and norms [12, 17, 19]. There is therefore a need for a national-level analysis that considers multiple components of ICT inclusion together and examines their relationship with women's empowerment as a multidimensional construct, while also assessing whether the association varies across domains and place of residence. Addressing this gap can provide a more comprehensive understanding of the social implications of women's digital inclusion in contemporary India.

Against this background, the present study examines the association between ICT inclusion and women's empowerment among currently married/in-union women in India using nationally representative NFHS-5 (2019–21) data. Women's empowerment is conceptualized through three domains, household decision-making, economic empowerment and gender attitudes, while ICT inclusion incorporates mobile phone ownership, internet use and mobile financial transactions. The study has four specific objectives: (i) to examine the association between ICT inclusion and overall women's empowerment after accounting for demographic, socioeconomic and household characteristics; (ii) to assess whether the association differs across the three dimensions of women's empowerment; (iii) to examine potential heterogeneity in the ICT–empowerment association between urban and rural women; and (iv) to determine whether the observed association persists under alternative additive and PCA-based approaches to constructing the ICT and empowerment indices. By bringing these dimensions together, the study seeks to contribute empirical evidence on the relationship between digital inclusion and women's empowerment in India and to inform the broader discussion on technology-enabled progress towards gender equality and the Sustainable Development Goals.

2. Materials and Methods

2.1 Data source and study design

This study utilized data from the fifth round of the National Family Health Survey (NFHS-5), conducted during 2019–2021 under the stewardship of the Ministry of Health and Family Welfare, Government of India. NFHS-5 is a nationally representative household survey implemented by the International Institute for Population Sciences (IIPS), Mumbai, with technical assistance from the DHS Program. The survey employed a stratified two-stage sampling design in rural areas and a stratified three-stage sampling design in urban areas to generate representative estimates at the national, state, and district levels [26].

The present study was based on the Individual Recode (IR) dataset, which contains information for women aged 15–49 years. As the Women's Empowerment Index included indicators on household decision-making that were collected only from women currently married or living with a partner, the

analytical sample was restricted to women currently in union (v502 = 1). Women with missing information on any of the four decision-making variables (v743a, v743b, v743d, and v743f) were excluded. After applying these eligibility criteria and data cleaning procedures, the final analytical sample comprised 75,389 currently married women with complete information on all variables included in the multivariable analyses. The sample selection process is illustrated in Fig. 1.

2.2 Variable description

2.2.1 Outcome variable: Women's Empowerment Index

The outcome variable for the present study was women empowerment index (WEI) which was conceptualized as a multidimensional construct encompassing women's autonomy in household decision-making, economic empowerment, and gender-equitable attitudes [11, 27]. A composite WEI score was developed using twelve indicators derived from three conceptual domains (Table S1) [28].

The household decision-making domain included women's participation in decisions regarding their own healthcare, major household purchases, visits to family or relatives, and the use of their husband's earnings. Responses indicating that the woman decided either alone or jointly with her husband/partner were coded as 1, while decisions made solely by the husband or another household member were coded as 0 [29].

The economic empowerment domain comprised ownership of a bank or financial institution account, ownership of a house (alone or jointly), and ownership of agricultural land (alone or jointly). Women possessing each asset or financial resource received a score of 1, otherwise 0 [29].

The gender attitudes domain assessed women's rejection of intimate partner violence using five standard NFHS questions on whether wife beating is justified if a wife goes out without informing her husband, neglects the children, argues with her husband, refuses sexual intercourse, or burns the food. Women rejecting each justification were assigned a value of 1, whereas acceptance of wife beating received a value of 0 [27].

The additive WEI was computed by summing all twelve binary indicators, yielding a total score ranging from 0 to 12, with higher values indicating greater empowerment. Detailed descriptions of the variables used in constructing the index are provided in Supplementary Table S1, while the domain structure and scoring scheme are presented in Supplementary Table S2.

To evaluate the robustness of the index construction, Principal Component Analysis (PCA) was additionally performed using the same indicators. The additive and PCA-derived indices demonstrated a high degree of agreement (Pearson correlation = 0.888). Internal consistency and index validation statistics are reported in Supplementary Table S3.

2.2.2 Exposure variable: ICT Inclusion Index

The primary exposure variable was an ICT Inclusion Index constructed to capture women's access to and use of digital technologies [30]. The index comprised three indicators: ownership of a mobile phone, ever use of the internet, and use of a mobile phone for financial use [31, 32].

Each indicator was dichotomized, with affirmative responses coded as 1 and negative responses coded as 0. The additive ICT Inclusion Index was calculated by summing the three indicators, resulting in a score ranging from 0 to 3, where higher scores represented greater ICT inclusion.

As a sensitivity analysis, a PCA-derived ICT index was also developed. The additive and PCA-based ICT indices were highly correlated (Pearson correlation = 0.997), indicating that the simpler additive score adequately represented the underlying construct. The variables used in constructing the ICT Inclusion Index are described in Supplementary Table S1, while the scoring system and validation statistics are presented in Supplementary Tables S2 and S3, respectively.

2.2.3 Covariates

Covariates were selected based on previous literature examining women's empowerment and digital inclusion in low- and middle-income countries [25, 28, 33–35]. The analyses adjusted for respondent's age (years), age squared (to account for potential non-linear associations), place of residence (urban/rural), educational attainment (no education, primary, secondary, and higher), household wealth quintile (poorest to richest), social group (Scheduled Caste, Scheduled Tribe, Other Backward Class, and Others), religion (Hindu, Muslim, and Others), current employment status (working/not working), and number of children ever born. These variables represent key demographic, socioeconomic, and household characteristics that may confound the relationship between ICT inclusion and women's empowerment.

2.3 Statistical analysis

Descriptive statistics were computed to summarize the characteristics of the study population according to levels of ICT inclusion. Categorical variables were presented as weighted frequencies and percentages, while continuous variables were summarized using weighted means and standard deviations. Differences across ICT Inclusion Index categories were evaluated using survey-adjusted Wald tests.

The association between ICT inclusion and WEI was examined using survey-weighted linear regression models accounting for the complex sampling design of NFHS-5, including sampling weights, clustering, and stratification. Three sequential models were estimated. Model 1 examined the unadjusted association between the ICT Inclusion Index and the WEI. Model 2 additionally adjusted for demographic and socioeconomic characteristics. Model 3 further incorporated a quadratic term for age to account for potential non-linear relationships.

To identify which dimensions of empowerment were most strongly associated with ICT inclusion, separate survey-weighted linear regression models were estimated for each domain of the WEI, namely

household decision-making, economic empowerment, and gender-equitable attitudes.

Potential heterogeneity by place of residence was examined for the association between the ICT Inclusion Index and WEI after adjustment for the study covariates and result were presented in Table S5. Sensitivity analyses were also conducted to examine whether the observed association persisted under alternative methods of index construction. First, the additive WEI was replaced with a PCA-derived WEI while retaining the additive ICT Inclusion Index. Second, alternative combinations of additive and PCA-derived indices for both the exposure and outcome were examined. The consistency of the association across these alternative specifications indicates that the observed ICT–WEI association was not confined to a particular method of index construction.

All analyses incorporated the survey design variables provided by NFHS-5 using the svy estimation framework in Stata version 17. Statistical significance was assessed at the 5% level using two-sided tests.

3. Result

3.1 Characteristics of the study population and WEI status

The analysis sample included 75,389 currently married/in-union women, with an overall mean WEI of 8.98 ± 2.32 (Table 1). ICT inclusion was limited for a substantial share of women: 40.7% had no ICT access, while 31.7% had low, 18.8% moderate, and only 8.8% had high ICT inclusion. A clear difference in women's empowerment was evident across these groups. Mean WEI rose steadily from 8.66 ± 2.46 among women with no ICT access to 9.62 ± 2.06 among those with high ICT inclusion (survey-adjusted $P < 0.001$).

Rural women accounted for 76.1% of the sample and had a slightly lower mean WEI than urban women (8.95 ± 2.37 vs. 9.06 ± 2.19; $P < 0.001$). WEI also differed significantly across age groups, education levels, household wealth, social groups, religious groups, and number of living children (all survey-adjusted $P < 0.001$). Mean WEI increased from 8.55 ± 2.45 among women aged 15–24 years to 9.13 ± 2.28 among those aged 35–49 years. Educational differences were more pronounced: women with higher education had a mean WEI of 9.41 ± 2.01, compared with 8.80 ± 2.47 among women with no education.

Differences by household wealth were smaller but remained statistically significant. Mean WEI was highest among women in the richest households (9.26 ± 2.13) and ranged from 8.90 to 8.94 across the poorest through richer groups. Across social groups, Scheduled Tribe women had the highest mean WEI (9.31 ± 2.25), while Scheduled Caste women had the lowest (8.84 ± 2.37). Mean WEI was also lower among Muslim women (8.62 ± 2.45) than among Hindu women (8.96 ± 2.32) and women belonging to other religions (9.51 ± 2.12).

In contrast, working status showed no statistically significant difference in WEI (P = 0.302). Mean WEI was 9.03 ± 2.29 among working women and 8.96 ± 2.34 among those not working. WEI differed significantly by number of living children, with mean values ranging from 8.63 ± 2.43 among women with no living children to 9.05 ± 2.41 among women with three or more children (survey-adjusted P < 0.001).

Table 1. Characteristics of the study population and WEI among currently married women in India, NFHS-5 (2019–21)

Characteristics	n (%)	WEI (Mean ± SD)	Survey-adjusted *P*-value
ICT Inclusion Index			**<0.001**
No ICT access	30,707 (40.7)	8.66 ± 2.46	
Low ICT inclusion	23,902 (31.7)	9.03 ± 2.27	
Moderate ICT inclusion	14,168 (18.8)	9.29 ± 2.09	
High ICT inclusion	6,612 (8.8)	9.62 ± 2.06	
Place of residence			**<0.001**
Urban	18,004 (23.9)	9.06 ± 2.19	
Rural	57,385 (76.1)	8.95 ± 2.37	
Age group (years)			**<0.001**
15–24	12,014 (15.9)	8.55 ± 2.45	
25–34	28,717 (38.1)	8.99 ± 2.30	
35–49	34,658 (46.0)	9.13 ± 2.28	
Educational attainment			**<0.001**
No education	21,437 (28.4)	8.80 ± 2.47	
Primary	10,617 (14.1)	8.92 ± 2.34	
Secondary	34,781 (46.1)	9.01 ± 2.29	
Higher	8,554 (11.3)	9.41 ± 2.01	
Household wealth quintile			**<0.001**
Poorest	15,568 (20.7)	8.92 ± 2.44	
Poorer	16,727 (22.2)	8.94 ± 2.39	
Middle	15,778 (20.9)	8.90 ± 2.33	
Richer	14,502 (19.2)	8.93 ± 2.26	
Richest	12,814 (17.0)	9.26 ± 2.13	
Social group			**<0.001**
Scheduled Caste	14,343 (19.0)	8.84 ± 2.37	
Scheduled Tribe	13,833 (18.4)	9.31 ± 2.25	
Other Backward Class	29,706 (39.4)	8.89 ± 2.33	
Others	17,507 (23.2)	9.00 ± 2.32	

Religion			**<0.001**
Hindu	57,417 (76.2)	8.96 ± 2.32	
Muslim	9,218 (12.2)	8.62 ± 2.45	
Others	8,754 (11.6)	9.51 ± 2.12	
Currently working			**0.302**
No	55,095 (73.1)	8.96 ± 2.34	
Yes	20,294 (26.9)	9.03 ± 2.29	
Number of living children			**<0.001**
0	6,590 (8.7)	8.63 ± 2.43	
1–2	39,521 (52.4)	8.99 ± 2.28	
3–4	22,942 (30.4)	9.05 ± 2.33	
≥5	6,336 (8.4)	9.05 ± 2.41	
Overall	**75,389 (100.0)**	**8.98 ± 2.32**	—

Abbreviations: SD, standard deviation; ICT, Information and Communication Technology.

Note: Values are presented as number (percentage) for categorical variables and mean ± standard deviation (SD) for the WEI (range: 0–12). Survey-adjusted *P*-values were obtained using design-based linear regression accounting for the NFHS-5 complex sampling design (sampling weights, clustering, and stratification).

3.2 Association between ICT inclusion and WEI

In the present study, three survey-weighted regression models were estimated to examine the association between ICT inclusion and women's empowerment. Model 1 estimated the unadjusted association between the ICT Inclusion Index and WEI. Model 2 included the full set of sociodemographic and household covariates, while Model 3 additionally incorporated a squared age term to examine whether the relationship between age and WEI departed from linearity.

ICT inclusion was positively and significantly associated with WEI in all three models. In the unadjusted model, a one-unit increase in the ICT Inclusion Index was associated with a 0.333-point higher WEI (95% CI: 0.305–0.361; $P < 0.001$). The association remained statistically significant after adjustment, with coefficients of 0.349 (95% CI: 0.315–0.383; $P < 0.001$) in Model 2 and 0.340 (95% CI: 0.307–0.374; $P < 0.001$) in Model 3 (Table 2).

The adjusted predictive margins further demonstrated a clear stepwise increase in WEI across the four levels of ICT inclusion (Figure 2). Predicted WEI increased from 8.45 (95% CI: 8.40–8.50) among women

with no ICT access to 8.79 (95% CI: 8.76–8.83) among those with low ICT inclusion, 9.13 (95% CI: 9.09–9.18) among those with moderate ICT inclusion, and 9.47 (95% CI: 9.40–9.55) among those with high ICT inclusion. The difference between the lowest and highest ICT inclusion levels corresponded to an increase of approximately 1.02 points in predicted WEI.

Table 2. Survey-weighted association between ICT Inclusion Index and WEI among currently married women in India, NFHS-5 (2019–21)

Variables	Model 1Crude	Model 2Adjusted	Model 3Fully adjusted
ICT Inclusion			
ICT Inclusion Index	0.333***	0.349***	0.340***
	[0.305, 0.361]	[0.315, 0.383]	[0.307, 0.374]
Demographic characteristics			
Place of residence (Ref: Urban)			
Rural	—	0.015	0.025
		[-0.074, 0.103]	[-0.063, 0.113]
Age (years)[#]			
Age	—	0.024***	0.114***
		[0.021, 0.028]	[0.089, 0.139]
Age²	—	—	−0.001***
			[-0.002, −0.001]
Socioeconomic characteristics			
Educational attainment (Ref: No education)			
Primary	—	0.074	0.063
		[-0.007, 0.156]	[-0.018, 0.145]
Secondary	—	0.160***	0.159***
		[0.087, 0.232]	[0.086, 0.231]
Higher	—	0.429***	0.413***
		[0.321, 0.536]	[0.305, 0.520]
Household wealth quintile (Ref: Poorest)			
Poorer	—	−0.058	−0.060
		[-0.150, 0.035]	[-0.152, 0.033]
Middle	—	−0.158**	−0.164***
		[-0.254, −0.062]	[-0.260, −0.068]
Richer	—	−0.212***	−0.220***

		[-0.317, −0.108]	[-0.324, −0.116]
Richest	—	−0.084	−0.093
		[-0.204, 0.037]	[-0.213, 0.027]
Social characteristics			
Social group (Ref: Scheduled Caste)			
Scheduled Tribe	—	0.271***	0.266***
		[0.162, 0.380]	[0.157, 0.375]
Other Backward Class (OBC)	—	0.062	0.057
		[-0.011, 0.134]	[-0.015, 0.129]
Others	—	0.077	0.072
		[-0.009, 0.163]	[-0.014, 0.158]
Religion (Ref: Hindu)			
Muslim	—	−0.365***	−0.354***
		[-0.469, −0.261]	[-0.458, −0.249]
Others	—	0.088	0.083
		[-0.034, 0.210]	[-0.038, 0.204]
Household characteristics			
Employment status (Ref: Not currently working)			
Currently working	—	−0.062*	−0.080**
		[-0.121, −0.002]	[-0.139, −0.020]
Number of living children[#]	—	0.095***	0.081***
		[0.075, 0.115]	[0.061, 0.101]
Constant	8.459***[8.414, 8.504]	7.359***	5.955***
		[7.183, 7.535]	[5.514, 6.395]
Model statistics			
Observations	75,389	75,389	75,389
R^2	0.019	0.038	0.040
Survey design	Yes	Yes	Yes

Notes: Values are β coefficients with 95% confidence intervals (CI) estimated from survey-weighted linear regression models accounting for sampling weights, clustering, and stratification in NFHS-5. Model 1 presents the crude association between ICT Inclusion Index and the WEI. Model 2 adjusts for several socio-demographic covariates. Model 3 additionally includes a quadratic age term (Age²) to account for non-linearity. Age, and number of living children was used as continuous variable. Reference categories are shown in parentheses. *$p < 0.05$; ***$p < 0.01$; ***p < 0.001. #: used as continuous variable.

In the adjusted model 3, several covariates were significantly associated with WEI. Age was positively associated with WEI (β = 0.114; 95% CI: 0.089–0.139), whereas the negative coefficient for age squared (β = −0.001; 95% CI: −0.002 to −0.001) indicated a non-linear age pattern. Educational attainment showed a clear gradient, with women with secondary education (β = 0.159; 95% CI: 0.086–0.231) and higher education (β = 0.413; 95% CI: 0.305–0.520) having higher WEI than women with no education. Similarly, scheduled Tribe women had higher WEI compared to their counterpart women from Scheduled Caste (β = 0.266; 95% CI: 0.157–0.375). Additionally, the number of living children was also positively associated with WEI (β = 0.081; 95% CI: 0.061–0.101).

A marginal negative association was exhibited across different wealth quintile group. Relative to the poorest wealth group, significant negative associations were observed among women in the middle (β = −0.164; 95% CI: −0.260 to −0.068) and richer (β = −0.220; 95% CI: −0.324 to −0.116) categories, compared to their counterpart from poorest wealth quintile group. Similarly, among religious group Muslim women were negatively associated with ICT exposure and WEI (β = −0.354; 95% CI: −0.458 to −0.249), compared to their counterpart from Hindu women. Additionally, a weak negative association was observed for working women (β = −0.080; 95% CI: −0.139 to −0.020) compared to their counterparts who were not working.

3.3 ICT inclusion and dimensions of women's empowerment

The association between ICT inclusion and women's empowerment differed across the three domains of the WEI: household decision-making, economic empowerment, and gender attitudes (Table 3; Table S4). ICT inclusion was positively associated with both household decision-making and economic empowerment, while the association with gender attitudes was not statistically significant.

The strongest association was observed for economic empowerment, where a one-unit increase in the ICT Inclusion Index was associated with a 0.172-point higher score (95% CI: 0.158–0.186; $P < 0.001$). A positive association was also observed for household decision-making (β = 0.147; 95% CI: 0.128–0.167; $P < 0.001$). Both associations remained statistically significant after adjustment for the covariates included in the fully adjusted model. In contrast, the association between ICT inclusion and gender attitudes was substantially smaller and did not reach statistical significance (β = 0.021; 95% CI: −0.001–0.042; $P = 0.058$).

Table 3. Survey-weighted association between ICT Inclusion Index and different dimensions of women's empowerment among currently married women in India, NFHS-5 (2019–21)

Outcome variable	β coefficient	95% CI	Adjusted R^2
Overall Women's Empowerment Index	0.340***	[0.307 - 0.374]	0.040
Household decision-making	0.147***	[0.128 - 0.167]	0.033
Economic empowerment	0.172***	[0.158 - 0.186]	0.046
Gender attitudes	0.021	[−0.001 - 0.042]	0.024

Notes: Estimates are β coefficients from separate survey-weighted linear regression models examining the association between the ICT Inclusion Index and each empowerment outcome. All models were adjusted for all socio-demographic control used in model 3 of the study, while accounting for the complex sampling design of NFHS-5 (sampling weights, clustering, and stratification). Observations: 75,389 for all models.

3.4 Urban–rural heterogeneity in the association between ICT inclusion and WEI

The association between ICT inclusion and WEI was positive and statistically significant among both urban and rural women. The average marginal association was 0.315 (95% CI: 0.260–0.371; $P < 0.001$) for urban women and 0.359 (95% CI: 0.322–0.396; $P < 0.001$) for rural women. Although the estimated association was slightly higher among rural women, the difference between the two estimates was not statistically significant (adjusted Wald $F(1, 6{,}423) = 1.94$; $P = 0.164$), indicating no significant urban–rural heterogeneity in the ICT inclusion–WEI association (Table S5).

3.5 Sensitivity analysis using alternative index construction

To examine whether the observed association between ICT inclusion and women's empowerment persists under alternative methods of index construction, we estimated fully adjusted models using different combinations of additive and PCA-derived indices (Table 4; Table S6). The association remained positive and statistically significant across all specifications. Using the primary additive indices, the coefficient was 0.340 (95% CI: 0.307–0.374; $P<0.001$), compared with 0.138 (95% CI: 0.112–0.164; $P<0.001$) when the PCA-derived WEI was used with the additive ICT Index.

The association also remained significant when the ICT Index was derived using PCA, both with the additive WEI (β=0.164; 95% CI: 0.131–0.198; $P<0.001$) and the PCA-derived WEI (β=0.028; 95% CI: 0.001–0.055; $P=0.043$). Although the coefficient magnitude varied across specifications, the direction and statistical significance of the association remained consistent. The lower sample sizes in PCA-based ICT models resulted from complete-case analysis due to missing information on the mobile financial transaction indicator. Overall, the findings indicate that the observed association between ICT inclusion and women's empowerment persists across alternative approaches to index construction (Table S6).

Table 4. Sensitivity analysis of the association between ICT Inclusion Index and Women's Empowerment using alternative index construction methods among currently married women in India, NFHS-5 (2019–21)

Outcome measure	ICT measure	β coefficient	95% CI	Observations
Women's Empowerment Index (Additive score)	Additive ICT Index	0.340***	[0.307 - 0.374]	75,389
Women's Empowerment Index (PCA score)	Additive ICT Index	0.138***	[0.112 - 0.164]	73,821

Notes: Estimates are β coefficients obtained from survey-weighted linear regression models adjusted for several socio-demographic covariates. The PCA-derived Women's Empowerment Index was estimated using the same empowerment indicators included in the additive index. The persistence of a positive and statistically significant association indicates that the findings are robust to the method used for constructing the Women's Empowerment Index.

4. Discussion

In present study, we have examined the association between ICT inclusion and women's empowerment among currently married women in India using nationally representative NFHS-5 data. The findings show a consistent positive association between greater ICT inclusion and women's overall empowerment, with women reporting higher levels of ICT inclusion also having higher WEI scores. The association remained significant after adjustment for demographic, socioeconomic and household characteristics, and was evident across alternative approaches to index construction. Importantly, the analysis considered empowerment as a multidimensional construct encompassing household decision-making, economic resources and gender attitudes, rather than relying on a single indicator. This provides a broader assessment of how women's digital inclusion is related to different dimensions of agency in contemporary India. The findings are also directly relevant to SDG 5, particularly Target 5.b, which calls for enhancing the use of enabling technologies, including ICT, to promote women's empowerment.

The foremost finding of the present study is that ICT inclusion is positively associated with women's empowerment, with an increase of 1.02 points in the adjusted predicted WEI between women with no ICT access and those with high ICT inclusion. This association was not confined to a particular method of index construction and remained positive and statistically significant when the WEI, the ICT Index, or both were constructed using PCA rather than additive scoring. Moreover, the association was significant among both urban and rural women, with no statistically significant difference between the two groups. These findings are consistent with earlier evidence from India showing that mobile phone use is associated with indicators of women's autonomy and physical mobility, suggesting that access to digital communication can be related to women's ability to access information and maintain social connections

[1,36]. Recent work on digital financial inclusion in India also emphasizes the importance of mobile-based financial access for women's economic participation and gender relations [12,15].

Several mechanisms may plausibly explain this association, although they were not directly examined in the present cross-sectional analysis. Mobile phones and internet access can reduce information constraints by allowing women to obtain information about education, health, government programmes, financial services and employment opportunities, while digital communication can extend social networks beyond the immediate household [19,37]. These resources may increase women's access to information and strengthen their capacity to participate in household decisions. The financial component of the ICT Index may be particularly relevant because mobile-based financial transactions can provide women with greater opportunities to access and manage formal financial services. Evidence from India indicates that mobile phone use is associated with greater physical mobility and contraceptive use, with information and social networks identified as plausible pathways through which mobile access may strengthen women's autonomy [1,4,23]. At the same time, digital access does not automatically translate into agency; women's ability to convert ICT access into empowerment is likely to depend on digital literacy, control over the device, affordability, household support and prevailing gender norms. Evidence from India also shows that restrictive gender norms and community-level conditions can influence women's adoption and use of digital financial services [17,19].

The domain-specific results provide further insight into the overall association. ICT inclusion was more strongly associated with economic empowerment than with household decision-making, whereas the association with gender attitudes was not statistically significant. The relatively stronger association with economic empowerment may reflect the direct connection between digital access and financial resources included in the ICT measure, particularly mobile-based financial transactions. Access to bank accounts, mobile payments and other digital financial services can reduce transaction barriers and potentially increase women's engagement with formal financial systems [12,15]. The positive association with household decision-making is also consistent with evidence that mobile phones can facilitate communication, access to information and social networks, which may strengthen women's bargaining position within households [1]. In contrast, ICT inclusion was not significantly associated with gender attitudes. This suggests that access to digital technologies may be more closely related to material resources and agency than to deeply embedded beliefs concerning gender relations and violence [19,38]. Evidence from Bangladesh similarly indicates that the relationship between ICT and attitudes towards wife beating varies by type of technology: computer ownership and greater ICT ownership were associated with lower odds of justifying wife beating, whereas not all ICT indicators showed significant associations [39].

The findings also demonstrate that women's empowerment remains closely associated with broader socioeconomic and demographic circumstances. Educational attainment showed one of the clearest positive associations, with secondary and higher education associated with higher WEI than no education. Education may strengthen women's knowledge, confidence and ability to access and interpret information, including information obtained through digital technologies [28,33,34]. The age pattern was

nonlinear: WEI increased with age but at a declining rate, suggesting that empowerment may accumulate through adulthood before the rate of increase diminishes. Recent analysis of NFHS-5 similarly reports that empowerment tends to be highest around the late twenties and thirties, although the specific pattern differs across empowerment dimensions [40,41]. The socioeconomic findings were less uniform. Women in the middle and richer wealth categories had lower WEI than those in the poorest group, while the richest group did not differ significantly from the poorest after adjustment. Although this pattern should not be interpreted as evidence that poverty promotes empowerment, it indicates that household wealth does not necessarily translate directly into women's agency. Previous research from India has likewise shown that the relationship between household economic status and women's empowerment is not always uniform across empowerment measures, suggesting that material resources and women's individual agency may represent related but distinct dimensions of empowerment [42,43]. Similar non-monotonic patterns have been reported in South Asian research, where women in the richest households were not necessarily more empowered than those in poorer households [44]. The negative association observed for current employment also warrants caution because employment status alone does not capture control over earnings, the nature or quality of employment, or autonomy in work-related decisions. Recent evidence from India similarly emphasizes that women's employment and economic agency are distinct dimensions: being employed does not necessarily imply control over one's earnings or greater decision-making power within the household [45,46]. Thus, the observed association may partly reflect the limitations of using current employment status as a broad indicator of women's economic empowerment.

This study has several strengths. First, it uses a large nationally representative sample of 75,389 currently married/in-union women and accounts for the complex sampling structure of NFHS-5 through survey-weighted estimation. Second, women's empowerment was assessed through a multidimensional index incorporating household decision-making, economic resources and gender attitudes, allowing the analysis to identify differences across domains rather than treating empowerment as a single outcome. Third, the study examined whether the ICT–WEI association varied by place of residence and found a similar association among urban and rural women. Finally, the use of alternative additive and PCA-based constructions for both indices provide an important methodological check: the direction and statistical significance of the association persisted across the different specifications, although the magnitude of the coefficients varied.

Several limitations should also be considered when interpreting these findings. The cross-sectional nature of NFHS-5 prevents establishing temporal or causal direction, and reverse causality cannot be ruled out; women with greater empowerment may themselves be more likely to obtain and use ICT. Although the analysis adjusted for several important demographic and socioeconomic characteristics, residual confounding from factors such as household gender norms, spousal characteristics, digital literacy, control over mobile devices and quality or purpose of ICT use may remain. The ICT Inclusion Index was based on only three indicators—mobile phone ownership, internet use and mobile financial transactions—and therefore does not capture frequency, intensity, quality or purpose of digital use. Similarly, the WEI does not cover all dimensions of empowerment, such as political participation,

community leadership, psychological agency or freedom of movement. Finally, the analytical sample was restricted to currently married/in-union women because the decision-making indicators required for the index were available for this group, limiting the generalizability of the findings to unmarried, formerly married or widowed women.

5. Conclusion

The study outcome provides evidence of a positive association between ICT inclusion and women's empowerment among currently married women in India. Women with greater ICT inclusion had higher levels of overall empowerment. The association remained positive and statistically significant after adjustment for key demographic, socioeconomic and household characteristics and across alternative additive and PCA-based constructions of the ICT and empowerment indices. The domain-specific findings further showed that ICT inclusion was more strongly associated with economic empowerment and household decision-making, whereas no statistically significant association was observed with gender attitudes. These findings highlight the relevance of digital inclusion to women's empowerment and contribute to the broader objectives of SDG 5 on gender equality, particularly the promotion of enabling technologies for women's empowerment, while also supporting the goals of inclusive access to technology and reduction of inequalities. However, the findings also indicate that access to ICT alone may not be sufficient to influence deeply embedded gender attitudes and social norms. Further research is therefore needed to examine how the type, frequency, purpose and quality of digital use, digital literacy, control over digital devices and access to digital financial services shape different dimensions of women's empowerment. Longitudinal and mixed-method studies are also needed to clarify the pathways underlying these associations and to determine how women translate digital access into meaningful agency and decision-making power. Overall, the findings support the importance of moving beyond basic digital access towards meaningful, equitable and purposeful digital inclusion, alongside educational, economic and gender-transformative interventions, to strengthen women's empowerment and accelerate progress towards the Sustainable Development Goals.

Declarations

Ethics approval and consent to participate

This study used secondary, anonymized data from the fifth round of the National Family Health Survey (NFHS-5), India (2019–2021), obtained from the Demographic and Health Surveys (DHS) Program. The study involved no direct interaction with participants, and no primary data were collected by the authors. Therefore, ethical approval and informed consent from individual participants were not required for the present analysis. The NFHS-5 survey was conducted under established ethical procedures by the responsible survey authorities.

Consent to publish

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AS: Conceptualized the study, conducted the literature review, and prepared the initial draft of the manuscript. AY: Contributed to the conceptualization of the study, conducted the data analysis, and contributed to the review and editing of the manuscript. APS: Supervised the study and contributed to the critical review and editing of the manuscript.

All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Data availability

The data used in the present study is publicly available through the Demographic and Health Surveys (DHS) Program upon registration and approval for data access. The datasets can be obtained from the DHS Program website: https://dhsprogram.com/data/.

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Figures

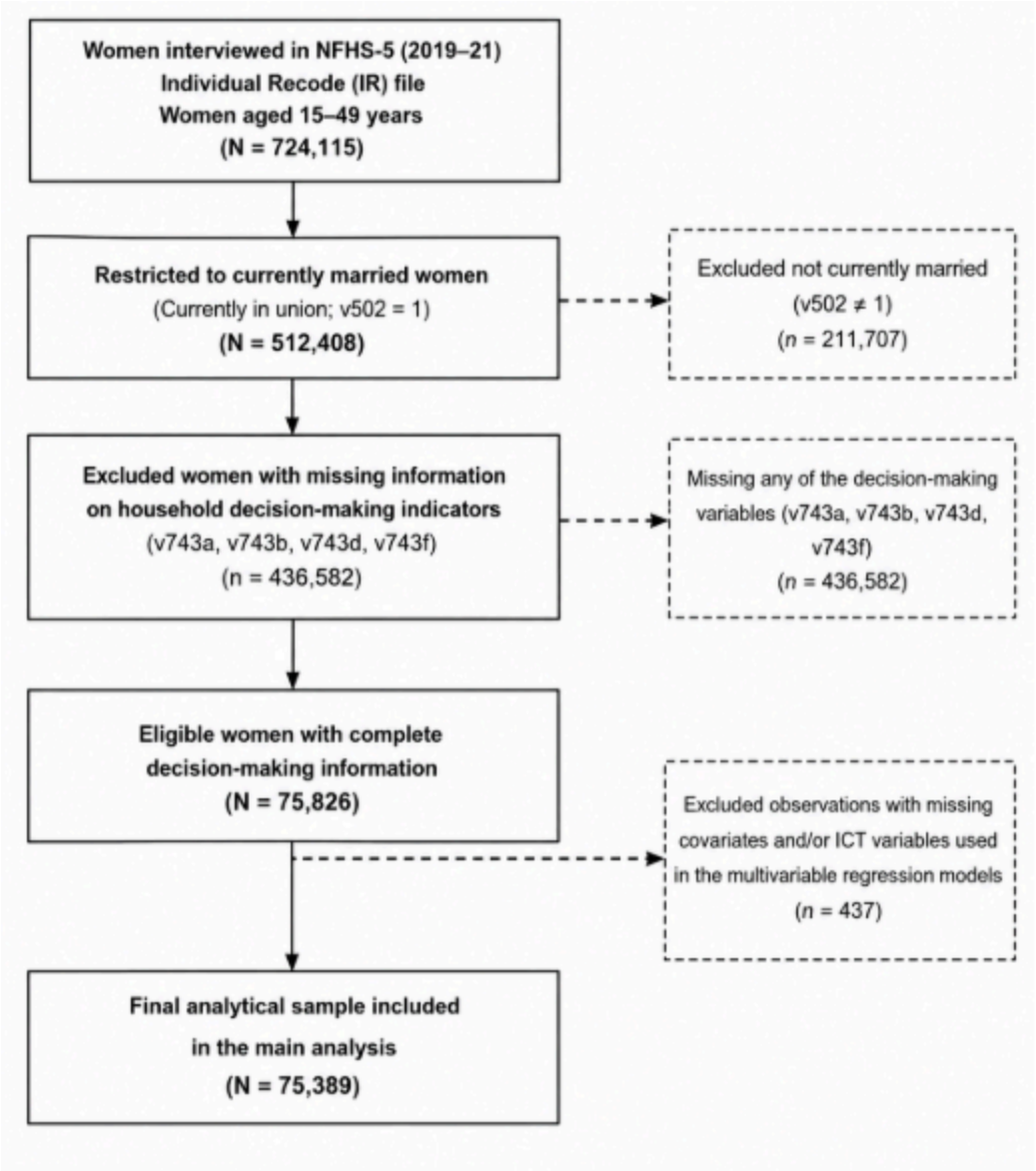


Figure 1

Flowchart illustrating the selection of the analytical sample from the National Family Health Survey (NFHS-5), India, 2019–21.

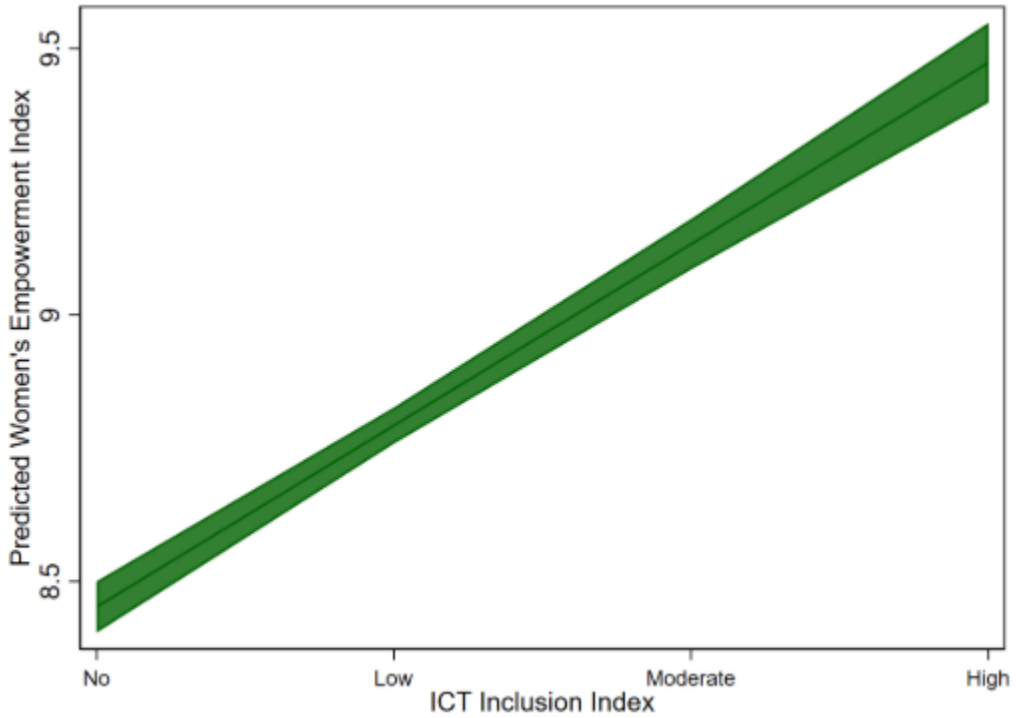


Figure 2

Adjusted predicted probability of WEI by ICT inclusive index

Note: Shaded areas represent 95% confidence intervals. Estimates are derived from the fully adjusted survey-weighted regression model.

Supplementary Files

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