Appendix A. Analytical Procedures, Regression Results, and Supplementary Figures

Following Ai and Norton (2003), this study distinguishes between the coefficient of the interaction term and the interaction effect. In nonlinear models such as logistic regression, the interaction coefficient alone may not accurately represent how the effect of one variable varies across levels of another variable in terms of predicted probabilities (Ai & Norton, 2003; Mize, 2019). As emphasized by Mize (2019), the interpretation of nonlinear interaction effects should focus on the model's predicted probabilities rather than on interaction coefficients.

Therefore, following the analytical recommendations of Mize (2019), this study proceeds by first presenting plots of predicted probabilities, followed by a table format suggested by Mize (2019) that reports first differences, second differences, and their associated statistical significance tests to evaluate interaction effects. In this study, first differences represent the average marginal effects (AMEs) of education within each disability group, whereas second differences represent differences in AMEs between disability groups, indicating whether the effect of education differs significantly by disability status.

All analyses were conducted using Stata 18, and the coding procedures for estimating and presenting nonlinear interaction effects were adapted from the publicly available example codes provided in Mize (2019).

In general, the findings of this study indicate that educational attainment has significant effects on all stages of digital access, as reflected in the significant first differences. The second differences are also statistically significant across most dimensions of digital access (including the mental, material, skills, financial, and government service dimensions), suggesting that the digital access gap between persons with and without disabilities widens at higher levels of education. However, the second differences for social usage and healthcare usage are not statistically significant, implying that the effect of education on these dimensions of digital access is relatively similar between the two groups. The following sections present and discuss these results in detail.

Ai, C., & Norton, E. C. (2003). Interaction terms in logit and probit models. *Economics letters*, *80*(1), 123-129.

Mize, T. D. (2019). Best practices for estimating, interpreting, and presenting nonlinear interaction effects. *Sociological Science*, *6*, 81-117.

Table A1-1. Regression Results of Mental Access.

Mental Access	**OR (SE)**	**95%CI**
Interaction: Education*Disability (base: Low Education)		
Disability* High Education	0.66 (0.07)***	[0.54, 0.81]
Education (base: Low Education)		
High Education	3.98 (0.11)***	[3.77, 4.19]
Disability Status (base: Without Disabilities)		
With Disabilities	0.84 (0.07)*	[0.72, 0.99]
Gender (base: Male)		
Female	1.13 (0.03)***	[1.08, 1.18]
Generation (base: Older Generation)		
X Generation	2.00 (0.05)***	[1.89, 2.11]
Y Generation	4.77 (0.16)***	[4.47, 5.09]
Z Generation	2.74 (0.09)***	[2.58, 2.92]
Employment (base: Unemployed)		
Employed	1.07 (0.03)**	[1.02, 1.12]
Region (base: Northern)		
Central	0.84 (0.03)***	[0.79, 0.89]
Southern	0.78 (0.02)***	[0.74, 0.82]
Eastern	0.85 (0.03)***	[0.78, 0.92]
Outlying Islands	0.75 (0.03)***	[0.70, 0.81]
Survey Year (base: 109)		
111	1.39 (0.04)***	[1.31, 1.48]
112	1.03 (0.03)	[0.97, 1.09]
113	1.09 (0.03)**	[1.03, 1.15]
Constant	0.34 (0.01)***	[0.32, 0.36]
Model fitting		
Log likelihood	-27249.952	

LR chi²	9582.84
Prob > chi²	<0.001
Pseudo R²	0.1495

Note: *p < 0.05 **P < 0.01 ***P < 0.001

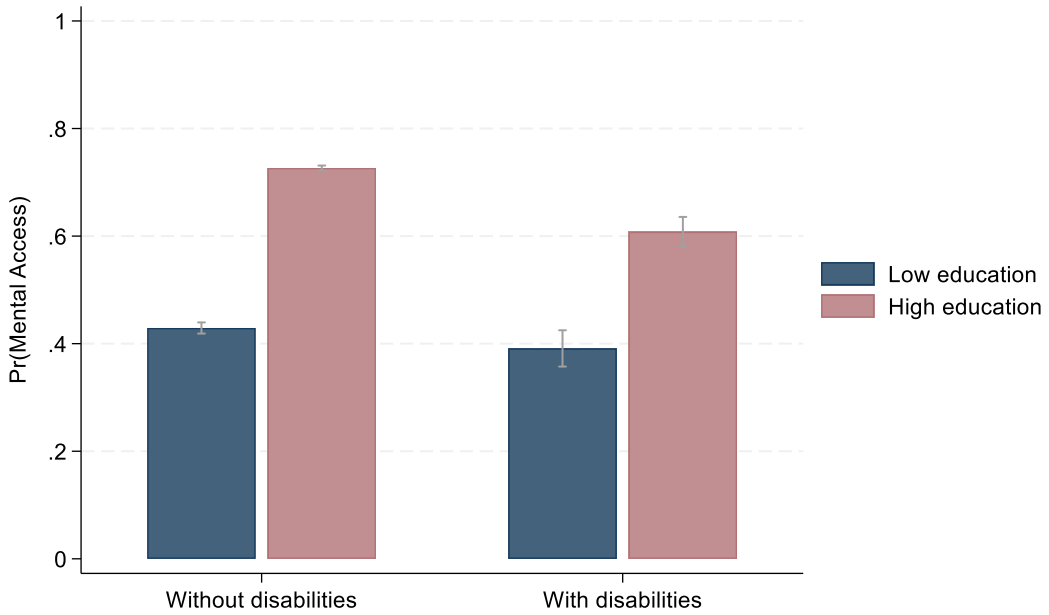

Figure A1. Probability of Mental Access by Disability Status and Education (Bar Chart).

Table A1-2. Probability of Mental Access by Disability Status and Education with Tests of Interaction Effects.

Group	Pr(Mental Access)	First Differences	Second Difference
Without disabilities, Low education	0.429 (0.005)	0.727 − 0.429 = 0.297***	0.297 − 0.217 = 0.081***
Without disabilities, High education	0.727 (0.002)		
With disabilities, Low education	0.391 (0.017)	0.608 − 0.391 = 0.217***	
With disabilities, High education	0.608 (0.014)		

Notes: Standard errors of the predicted probabilities are reported in parentheses. *** p<0.001, ** p<0.01, * p<0.05, two-tailed tests.

Figure A1 presents the predicted probabilities of mental access. The bars represent predicted probabilities derived from the logistic regression model, while the error bars indicate confidence intervals around the estimates. Within each disability group, the difference between the low-education and high-education bars reflects the first difference. A larger gap between the two bars indicates a stronger effect of educational attainment on mental access.

The comparison of these educational gaps across disability groups reflects the second difference, which captures whether the effect of education differs by disability status. In this figure, predicted probabilities increase substantially with higher educational attainment for both groups. However, the increase is larger among individuals without disabilities than among persons with disabilities, suggesting that higher educational attainment widens the disparity in mental access between the two groups.

Table A1-2 further reports the predicted probabilities in detail, first differences, and second differences for mental access. Among individuals without disabilities, the predicted probability of mental access increases from 0.429 for those with low education to 0.727 for those with high education, corresponding to a first difference (AME) of 0.297 ($p < 0.001$). Among persons with disabilities, the predicted probability increases from 0.391 to 0.608, corresponding to a first difference of 0.217 ($p < 0.001$). These findings indicate that higher educational attainment significantly improves mental access for both groups.

Also, the second difference is statistically significant (0.081, $p < 0.001$), indicating that the magnitude of the educational effect differs significantly by disability status. Specifically, the effect of education on mental access is approximately 8.1 percentage points larger among individuals without disabilities than among persons with disabilities. This suggests that although education improves mental access for both groups, higher educational attainment is associated with a widening disparity in mental access between persons with and without disabilities.

Notably, the remaining figures and tables in this appendix are interpreted using the same logic. Overall, the results consistently show that educational attainment increases digital access across most dimensions, while the digital gap between persons with and without disabilities tends to widen at higher educational levels. However, social and healthcare usage present different patterns, where educational effects remain relatively similar across disability groups.

Table A2-1. Regression Results of Material Access.

Material Access	**OR (SE)**	**95%CI**
Interaction: Education*Disability (base: Low Education)		
Disability* High Education	0.42 (0.05)***	[0.34, 0.52]
Education (base: Low Education)		
High Education	14.05 (0.46)***	[13.18, 14.97]
Disability Status (base: Non-disabled)		
Disability	0.83 (0.05)**	[0.73, 0.94]
Gender (base: Male)		
Female	1.12 (0.04)**	[1.05, 1.20]
Generation (base: Older Generation)		
X Generation	5.50 (0.29)***	[4.97, 6.09]
Y Generation	20.36 (2.40)***	[16.15, 25.65]
Z Generation	1.42 (0.05)***	[1.33, 1.52]
Employment (base: Unemployed)		
Employed	2.04 (0.08)***	[1.89, 2.21]
Region (base: Northern)		
Central	0.71 (0.03)***	[0.65, 0.77]
Southern	0.60 (0.02)***	[0.56, 0.64]
Eastern	0.64 (0.03)***	[0.58, 0.70]
Outlying Islands	0.61 (0.03)***	[0.55, 0.67]
Survey Year (base: 109)		
111	1.21(0.05)***	[1.11, 1.31]
112	0.93 (0.04)	[0.85, 1.01]
113	1.00 (0.04)	[0.93, 1.08]
Constant	0.68 (0.03)***	[0.63, 0.74]
Model fitting		
Log likelihood	-16239.129	

LR chi²	22192.32
Prob > chi²	<0.001
Pseudo R²	0.4059

Note: *p < 0.05 **P < 0.01 ***P < 0.001

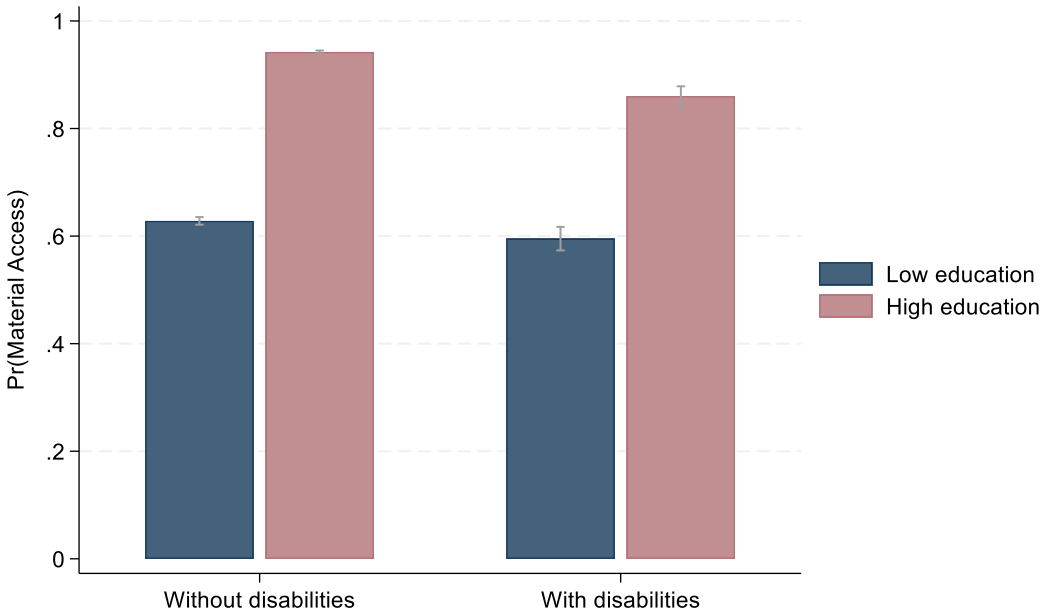

Figure A2. Probability of Material Access by Disability Status and Education (Bar Chart).

Table A2-2. Probability of Material Access by Disability Status and Education with Tests of Interaction Effects.

Group	Pr(Material Access)	First Differences	Second Difference
Without disabilities, Low education	0.628 (0.004)	0.942 − 0.628 = 0.314***	0.314 − 0.265 = 0.049***
Without disabilities, High education	0.942 (0.001)		
With disabilities, Low education	0.595 (0.011)	0.860 − 0.595 = 0.265***	
With disabilities, High education	0.860 (0.009)		

Note: *p < 0.05 **P < 0.01 ***P < 0.001

Table A3-1. Regression Results of Skills Access.

Skills Access	**OR (SE)**	**95%CI**
Interaction: Education*Disability (base: Low Education)		
Disability* High Education	0.48 (0.07)***	[0.36, 0.63]
Education (base: Low Education)		
High Education	5.28 (0.18)***	[4.94, 5.66]
Disability Status (base: Without Disabilities)		
With Disabilities	1.07 (0.13)	[0.85, 1.35]
Gender (base: Male)		
Female	0.90 (0.02)***	[0.86, 0.95]
Generation (base: Older Generation)		
X Generation	3.67 (0.11)***	[3.46, 3.88]
Y Generation	7.93 (0.27)***	[7.41, 8.48]
Z Generation	2.71 (0.09)***	[2.54, 2.90]
Employment (base: Unemployed)		
Employed	1.08 (0.03)**	[1.03, 1.14]
Region (base: Northern)		
Central	0.75 (0.02)***	[0.71, 0.80]
Southern	0.72 (0.02)***	[0.68, 0.76]
Eastern	0.78 (0.03)***	[0.72, 0.85]
Outlying Islands	0.79 (0.03)***	[0.72, 0.86]
Survey Year (base: 109)		
111	1.39 (0.05)***	[1.30, 1.49]
112	1.12 (0.04)**	[1.05, 1.19]
113	1.11 (0.03)**	[1.04, 1.17]
Constant	0.17 (0.01)***	[0.16, 0.18]
Model fitting		
Log likelihood	-23538.272	

LR chi²	10885.68
Prob > chi²	<0.001
Pseudo R²	0.1878

Note: *p < 0.05 **P < 0.01 ***P < 0.001

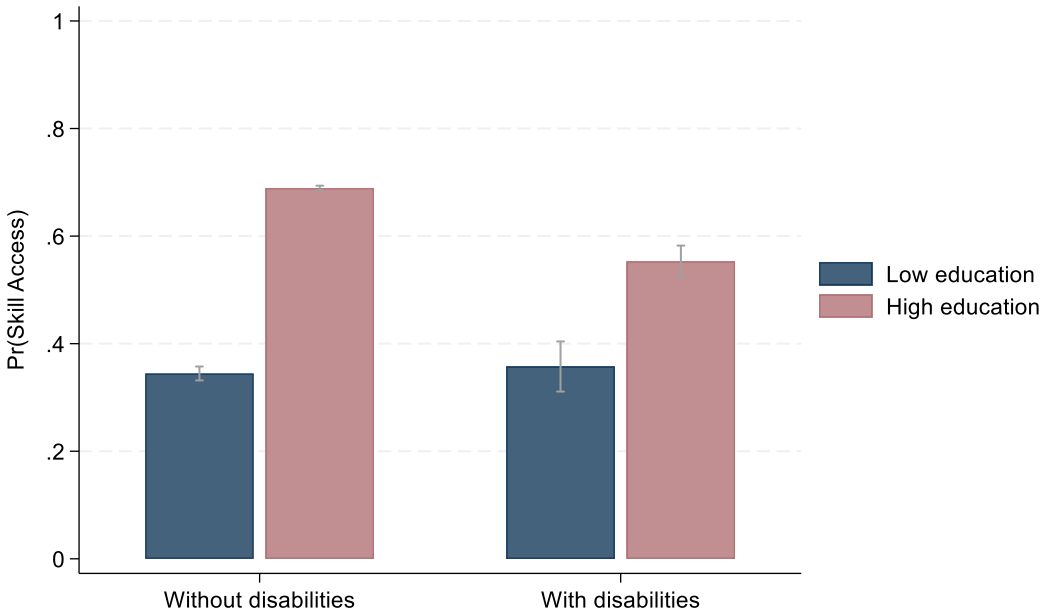

Figure A3. Probability of Skills Access by Disability Status and Education (Bar Chart).

Table A3-2. Probability of Skills Access by Disability Status and Education with Tests of Interaction Effects.

Group	Pr(Skills Access)	First Differences	Second Difference
Without disabilities, Low education	0.345 (0.007)	0.689 − 0.345 = 0.345***	0.345 − 0.195 = 0.149***
Without disabilities, High education	0.689 (0.002)		
With disabilities, Low education	0.358 (0.024)	0.553 − 0.358 = 0.195***	
With disabilities, High education	0.553 (0.015)		

Note: *p < 0.05 **P < 0.01 ***P < 0.001

Table A4-1. Regression Results of Usage Access (Social).

Social Usage	**OR (SE)**	**95%CI**
Interaction: Education*Disability (base: Low Education)		
Disability* High Education	0.77 (0.15)	[0.53, 1.13]
Education (base: Low Education)		
High Education	2.27 (0.12)***	[2.05, 2.51]
Disability Status (base: Without Disabilities)		
With Disabilities	0.82 (0.12)	[0.62, 1.08]
Gender (base: Male)		
Female	0.90 (0.05)*	[0.81, 0.99]
Generation (base: Older Generation)		
X Generation	2.21 (0.13)***	[1.97, 2.48]
Y Generation	6.37 (0.57)***	[5.34, 7.60]
Z Generation	2.05 (0.14)***	[1.80, 2.33]
Employment (base: Unemployed)		
Employed	1.19 (0.06)**	[1.07, 1.32]
Region (base: Northern)		
Central	0.83 (0.05)**	[0.73, 0.94]
Southern	0.89 (0.05)*	[0.79, 0.99]
Eastern	0.86 (0.07)	[0.73, 1.01]
Outlying Islands	0.93 (0.08)	[0.79, 1.10]
Survey Year (base: 109)		
111	0.78 (0.06)**	[0.68, 0.90]
112	0.56 (0.04)***	[0.49, 0.64]
113	0.59 (0.04)***	[0.52, 0.67]
Constant	8.47 (0.62)***	[7.34, 9.77]
Model fitting		
Log likelihood	-8115.7613	

LR chi²	1528.55
Prob > chi²	<0.001
Pseudo R²	0.0861

Note: *p < 0.05 **P < 0.01 ***P < 0.001

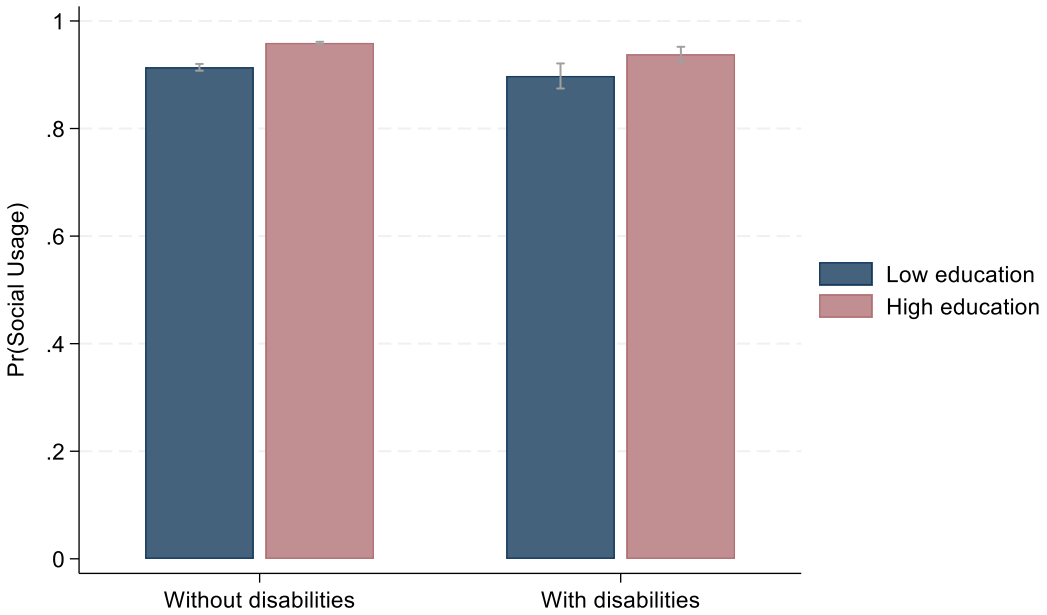

Figure A4. Probability of Social Usage by Disability Status and Education (Bar Chart).

Table A4-2. Probability of Social Usage by Disability Status and Education with Tests of Interaction Effects.

Group	Pr(Social Usage)	First Differences	Second Difference
Without disabilities, Low education	0.914 (0.003)	0.959 − 0.914 = 0.045***	0.045 − 0.040 = 0.005
Without disabilities, High education	0.959 (0.001)		
With disabilities, Low education	0.898 (0.012)	0.938 − 0.898 = 0.040**	
With disabilities, High education	0.938 (0.007)		

Note: *p < 0.05 **P < 0.01 ***P < 0.001

Table A5-1. Regression Results of Usage Access (Financial).

Financial Usage	**OR (SE)**	**95%CI**
Interaction: Education*Disability (base: Low Education)		
Disability* High Education	0.35 (0.07)***	[0.24, 0.50]
Education (base: Low Education)		
High Education	10.21 (0.51)***	[9.27, 11.26]
Disability Status (base: Without Disabilities)		
With Disabilities	1.15 (0.20)	[0.82, 1.63]
Gender (base: Male)		
Female	0.94 (0.02)**	[0.89, 0.98]
Generation (base: Older Generation)		
X Generation	3.25 (0.10)***	[3.06, 3.45]
Y Generation	7.33 (0.24)***	[6.87, 7.81]
Z Generation	1.57 (0.06)***	[1.46, 1.69]
Employment (base: Unemployed)		
Employed	1.22 (0.03)***	[1.17, 1.29]
Region (base: Northern)		
Central	0.68 (0.02)***	[0.64, 0.72]
Southern	0.62 (0.02)***	[0.59, 0.65]
Eastern	0.59 (0.03)***	[0.54, 0.64]
Outlying Islands	0.73 (0.03)***	[0.67, 0.79]
Survey Year (base: 109)		
111	1.79 (0.06)***	[1.68, 1.91]
112	1.26 (0.04)***	[1.19, 1.34]
113	1.55 (0.05)***	[1.46, 1.64]
Constant	0.05 (0.00)***	[0.04, 0.05]
Model fitting		
Log likelihood	-23952.942	

LR chi²	13035.24
Prob > chi²	<0.001
Pseudo R²	0.2139

Note: *p < 0.05 **P < 0.01 ***P < 0.001

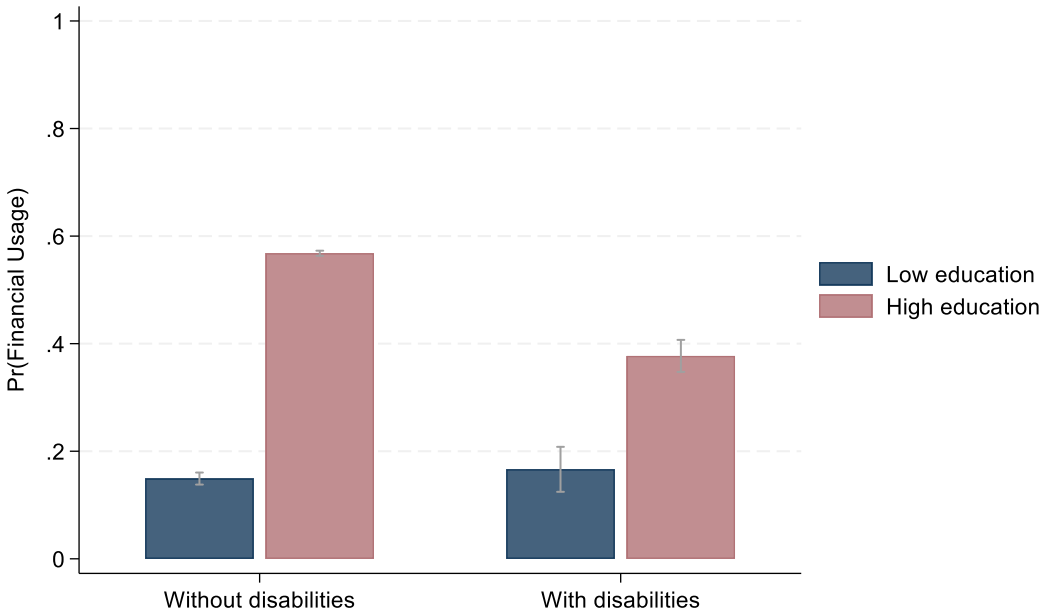

Figure A5. Probability of Financial Usage by Disability Status and Education (Bar Chart).

Table A5-2. Probability of Financial Usage by Disability Status and Education with Tests of Interaction Effects.

Group	Pr(Financial Usage)	First Differences	Second Difference
Without disabilities, Low education	0.149 (0.006)	0.568 − 0.149 = 0.419***	0.419 − 0.211 = 0.208***
Without disabilities, High education	0.568 (0.002)		
With disabilities, Low education	0.167 (0.021)	0.377 − 0.167 = 0.211***	
With disabilities, High education	0.377 (0.015)		

Note: *p < 0.05 **P < 0.01 ***P < 0.001

Table A6-1. Regression Results of Usage Access (Healthcare).

Healthcare Usage	**OR (SE)**	**95%CI**
Interaction: Education*Disability (base: Low Education)		
Disability* High Education	0.76 (0.11)	[0.58, 1.01]
Education (base: Low Education)		
High Education	4.19 (0.16)***	[3.90, 4.51]
Disability Status (base: Without Disabilities)		
With Disabilities	1.23 (0.15)	[0.96, 1.57]
Gender (base: Male)		
Female	0.91 (0.02)***	[0.87, 0.95]
Generation (base: Older Generation)		
X Generation	1.59 (0.04)***	[1.51, 1.68]
Y Generation	1.37 (0.04)***	[1.30, 1.44]
Z Generation	0.70 (0.02)***	[0.66, 0.75]
Employment (base: Unemployed)		
Employed	0.94 (0.02)**	[0.90, 0.98]
Region (base: Northern)		
Central	0.74 (0.02)***	[0.70, 0.78]
Southern	0.76 (0.02)***	[0.73, 0.81]
Eastern	0.87 (0.03)***	[0.80, 0.94]
Outlying Islands	0.79 (0.03)***	[0.74, 0.86]
Survey Year (base: 109)		
111	0.95 (0.03)	[0.90, 1.01]
112	0.83 (0.02)***	[0.79, 0.88]
113	0.88 (0.02)***	[0.83, 0.92]
Constant	0.26 (0.01)***	[0.24, 0.28]
Model fitting		
Log likelihood	-28364.905	

LR chi²	4451.96
Prob > chi²	<0.001
Pseudo R²	0.0604

Note: *p < 0.05 **P < 0.01 ***P < 0.001

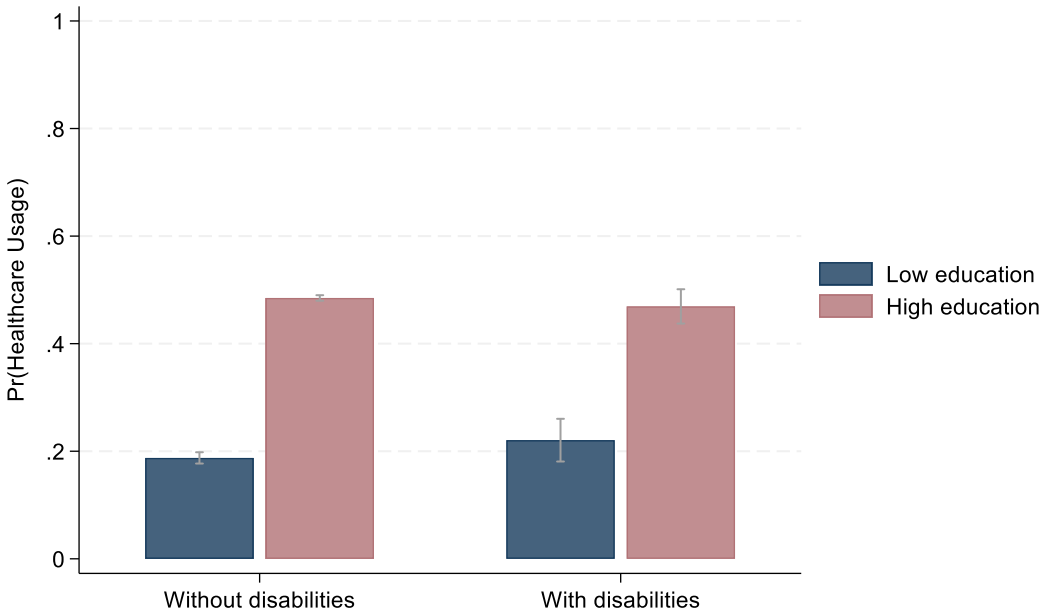

Figure A6. Probability of Healthcare Usage by Disability Status and Education (Bar Chart).

Table A6-2. Probability of Healthcare Usage by Disability Status and Education with Tests of Interaction Effects.

Group	Pr(Healthcare Usage)	First Differences	Second Difference
Without disabilities, Low education	0.188 (0.005)	0.485 − 0.188 = 0.297***	0.297 − 0.249 = 0.049
Without disabilities, High education	0.485 (0.003)		
With disabilities, Low education	0.221 (0.020)	0.469 − 0.221 = 0.249***	
With disabilities, High education	0.469 (0.016)		

Note: *p < 0.05 **P < 0.01 ***P < 0.001

Table A7. Regression Results of Usage Access (Government service).

Government Service Usage	OR (SE)	95%CI
Interaction: Education*Disability (base: Low Education)		
Disability* High Education	0.65 (0.08)***	[0.51, 0.82]
Education (base: Low Education)		
High Education	9.80 (0.29)***	[9.24, 10.38]
Disability Status (base: Without Disabilities)		
With Disabilities	0.77 (0.08)*	[0.63, 0.94]
Gender (base: Male)		
Female	1.18 (0.03)***	[1.12, 1.23]
Generation (base: Older Generation)		
X Generation	3.08 (0.09)***	[2.92, 3.26]
Y Generation	4.14 (0.13)***	[3.90, 4.40]
Z Generation	1.42 (0.04)***	[1.33, 1.51]
Employment (base: Unemployed)		
Employed	1.32 (0.03)***	[1.26, 1.38]
Region (base: Northern)		
Central	0.78 (0.02)***	[0.74, 0.83]
Southern	0.74 (0.02)***	[0.70, 0.78]
Eastern	0.72 (0.03)***	[0.67, 0.78]
Outlying Islands	0.62 (0.02)***	[0.58, 0.67]
Survey Year (base: 109)		
111	2.35 (0.08)***	[2.20, 2.50]
112	1.26 (0.04)***	[1.19, 1.34]
113	1.02 (0.03)	[0.96, 1.08]
Constant	0.09 (0.00)***	[0.08, 0.09]
Model fitting		
Log likelihood	-27731.806	

LR chi²	21026.92
Prob > chi²	<0.001
Pseudo R²	0.2749

Note: *p < 0.05 **P < 0.01 ***P < 0.001 (Source: this study)

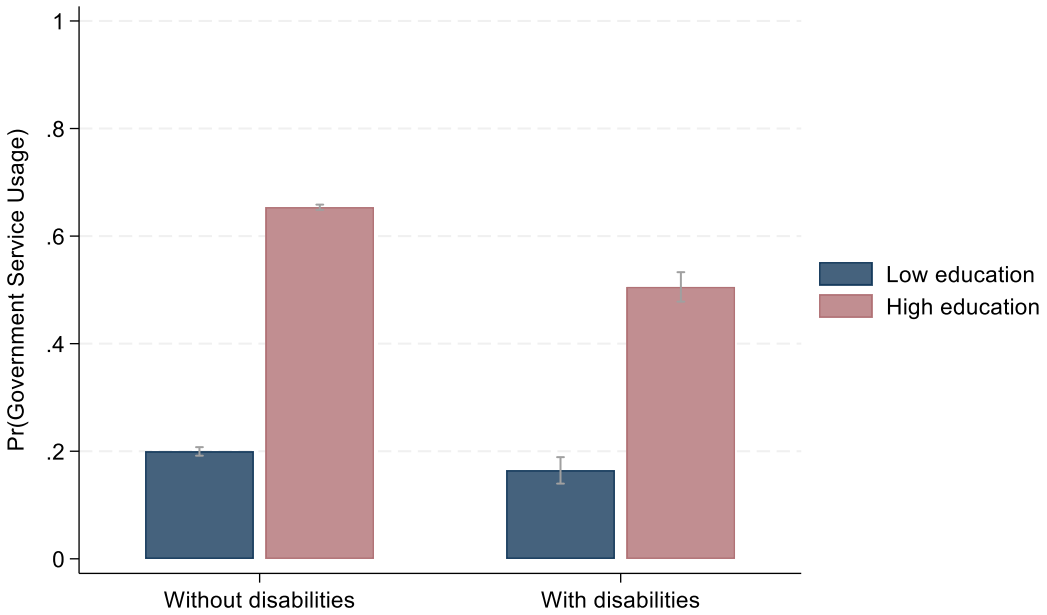

Figure A7. Probability of Government Service Usage by Disability Status and Education (Bar Chart).

Table A7-2. Probability of Government Service Usage by Disability Status and Education with Tests of Interaction Effects.

Group	Pr(Government Service Usage)	First Differences	Second Difference
Without disabilities, Low education	0.200 (0.004)	0.654 − 0.200 = 0.454***	0.454 − 0.341 = 0.113***
Without disabilities, High education	0.654 (0.002)		
With disabilities, Low education	0.164 (0.013)	0.506 − 0.164 = 0.341***	
With disabilities, High education	0.506 (0.014)		

Note: *p < 0.05 **P < 0.01 ***P < 0.001