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Research Article

Examining the Correlation between Internet Usage Frequency and Cognitive Function in India's Elderly Population

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Abstract

Introduction: Research suggests a robust relationship between frequent internet use and enhanced cognitive function, particularly among elderly users.
Objective: This study aims to delve deeper into the impact of Internet use on the cognitive abilities of the elderly, further emphasizing the need for digital inclusion strategies for this age group.
Method: Utilizing quantitative research methods, the internet usage and cognitive function of 671 elderly internet users, aged 60 and above, were examined.
Results: Within the cohort, cognitive impairment prevalence stood at 21.91% (147/671). Notably, significant disparities were found in age, gender, depressive symptoms, and internet use frequency between the cognitively healthy and impaired groups ($p<0.05$), even after adjusting for confounding variables.
Discussion: Our results suggest a potential connection between the frequency of Internet use and cognitive function among the elderly, warranting further research across broader demographics.
Implications: Healthcare professionals, including nurses and mental health practitioners, should consider the potential benefits of regular internet use in mitigating the adverse effects of cognitive decline in the elderly.

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1. Introduction

The increasing number and proportion of the elderly population has global implications, especially as age-related cognitive impairment diseases gain prominence. These conditions impact the daily lives of elderly individuals and significantly augment the demand for care. This leads to a pronounced burden on the health system and economy, positioning it as a public health issue of worldwide concern (Dua *et al.*, 2017; Frankish & Horton, 2017; Prince, Wimo, Guerchet, Ali, & Prina, 2015) [16][28].

Efforts to mitigate the detrimental effects of cognitive impairment focus on the exploration and development of preventative measures and interventions, as emphasized by (Fadzil *et al.*, 2022 and Gavelin *et al.*, 2021) [17]. The importance of this approach is heightened in lower-income countries, which house a significant portion of the elderly population suffering

from cognitive disorders. The scarcity of medical resources in these regions hinders the implementation of large-scale cognitive function screenings among community populations (Bateman *et al.*, 2017; Heo & Park, 2021)[4][20]. Contrastingly, in other regions, an increase in healthcare provisions has been noted, including early screening and interventions for elderly individuals with cognitive impairment (Diniz *et al.*, 2020; Erhag, Ahlner, Sterner, Skoog, & Bergstrm, 2019)[8][11]. It is crucial to analyze the disparity in resource allocation and accessibility of cognitive care across various economic landscapes and understand how it affects the trajectory of cognitive decline in elderly populations. This analysis can guide strategic planning and interventions, with the potential to improve health outcomes and reduce associated burdens. The growing disparities in internet usage skills and the types of internet activities engaged in have posed significant challenges to the effective provision of medical care for elderly individuals with cognitive impairments (Quialheiro *et al.*)[2]. the relationship between internet use and cognitive function in the elderly is attracting increasing scholarly attention due to the potential implications for care and treatment (Krug, d'Orsi, & Xavier, 2019; Slegers, van Boxtell, & Joles, 2009)[23][32]. Even though factors such as age, gender, and education level are commonly recognized as primary risk determinants for cognitive impairment (Sullivan, Anderson, Turner, Spreng, & Alzheimers Dis Neuroimaging, 2019)[33], a potential link between internet use and cognitive function has been suggested within the biomedical-social model (Gondim *et al.*, 2017)[18]. A comprehensive examination of this relationship, particularly among the elderly who use the internet, is necessary. There is a growing body of research suggesting that internet use could have cognitive-stimulating effects. For example, Aq *et al.* (2021) posited that an increased frequency of internet use during the early stages of cognitive impairment in the elderly could potentially slow, halt, or even reverse cognitive decline. However, given the diverse nature of activities encompassed by the term 'internet use', no consensus has been reached regarding the relationship between the type and frequency of internet use and cognitive abilities. In an attempt to address this, many community-based studies are employing the internet as a tool for cognitive function training, screening, and intervention (Baumgart *et al.*, 2015; Brown *et al.*, 2019) [5]. These activities suggest that elderly individuals may need to possess a certain level of internet literacy and possibly engage in internet use at a specific frequency for optimal cognitive outcomes. Among the interventions for cognitive decline, the frequency of Internet use is emerging as a potentially crucial factor (Guo, Yang, Hu, Li, & Lee, 2019) [19]. The significance of this factor, however, still requires robust evidence derived from extensive population studies. Understanding this relationship more fully can help inform targeted interventions and policies to support cognitive health among the aging population. Although internet usage among the elderly has traditionally been limited, advancements in the digital age have begun to narrow the digital divide for this demographic (Ball *et al.*, 2019; Diniz *et al.*, 2020) [3][8]. Consequently, the exploration of internet use among the elderly has progressively become a research area of interest across multiple disciplines. However, it's important to note that most existing research has primarily been conducted in high-income economies (Aggarwal, Xiong, & Schroeder-Butterfill, 2020; Erhag *et al.*, 2019)[11], leaving a knowledge gap regarding internet use among elderly populations in different social and cultural contexts. For instance, the situation of elderly internet users in India, where the number of such users is increasing but still comparatively lower than in Western countries (Dy & Dgf, 2020)[10], is largely underexplored. In order to counteract prevailing age discrimination in healthcare and the digital age, it is essential to instigate broad technological changes. Such efforts could dispel misconceptions about the low internet usage among the elderly and foster a more positive and realistic perspective on ageing. Therefore, this study advantages data from the fourth wave of a nationally representative longitudinal cohort of Indian individuals aged 60 and above. This data encompasses both internet use and cognitive function assessment. The primary objective of this study is twofold. Firstly, it seeks to probe into the relationship between the type and frequency of internet use and the cognitive function of India's elderly internet users. In particular, the research investigates the link between various forms of internet usage - chatting, reading news, watching videos, playing games - and cognitive function, while considering the impact of usage frequency.

Secondly, it aims to examine the regulatory aspects of these types of internet use. To this end, we have utilized data from the Longitudinal Ageing Study in India (LASI). By undertaking a comprehensive analysis of this data, we hope to add to the existing body of knowledge in this field and provide actionable insights that can inform policy and interventions.

2. Materials and Methods

2.1. Sample and Data Collection

The data for this research was obtained from the Longitudinal Ageing Study in India (LASI), a comprehensive national longitudinal survey focusing on India's population aged 45 and older, as well as their spouses. The survey uses a cluster sampling technique, which involves selecting community residents from 150 districts and 450 villages across 28 provinces of India. The fourth wave of this national survey, carried out from July 2020 to March 2021, garnered a total participation of 17,708 individuals. The LASI has received approval from the ethics review committee of the respective institution, ensuring the survey upholds necessary ethical standards. The data from LASI can be accessed and utilized by researchers via the official website: LASI Publications. In order to create a relevant and focused dataset for our study, we established specific inclusion criteria. We selected individuals who: (1) were aged 60 years and above; (2) had complete data across all critical variables, including gender, education level, marital status, prevalence of chronic diseases, and self-rated health status; and (3) had used the internet in the previous month. Following these criteria, we curated a sample size of 671 observations for our analysis.

The chosen criteria ensure the sample accurately represents the elderly internet-using population, thereby enabling an in-depth examination of the relationship between internet usage type,

frequency, and cognitive function among this group. The strict inclusion criteria also ensure the data is as complete and accurate as possible, thereby enhancing the validity of our findings and conclusions.

2.2. Variables

2.2.1. Independent Variable

For this study, we identified internet use as the independent variable. The survey participants were queried, "Have you used the internet in the past month?" Only participants who responded affirmatively were included in the subsequent data analysis. It is worth noting that a minority of the overall participants - 3.79% (671 out of 17,708) - reported using the internet. We further dissected the dimension of internet usage into two distinctive components: frequency and content.

1. With respect to frequency, the participants were asked, "How often did you surf the internet last month?" The available responses ranged from regular usage ("almost every day") to more sporadic usage ("almost every week" and "not often"). This allowed us to evaluate the possible relationship between the frequency of internet use and cognitive function.
2. In terms of internet content, the participants were probed about specific activities: chatting, watching news, watching videos, and playing games. Each of these activities was framed as a binary question with "Yes" or "No" as possible answers. This enabled us to capture a broad spectrum of internet activities and assess how different types of internet use might correlate with cognitive function.

2.2.2. Dependent Variable

In our study, the dependent variable is cognitive function, which we measured using the Mini Mental State Examination (MMSE). The MMSE is a widely recognized tool developed by Folstein *et al.* [14] specifically for the evaluation of cognitive function in elderly individuals (Folstein, Folstein, & McHugh, 1975) [14].
It encompasses five cognitive domains: orientation, immediate recall, attention, calculation, and language.
The MMSE scoring system ranges from 0 to 30, with a higher score indicating a better cognitive function. The instrument has been used in large-scale, multicentre studies and is suitable for a nationally representative dataset of India's elderly population. For the purposes of this study, we utilized the version of the scale that's adapted for Indian context. The classification of cognitive impairment was determined based on education levels and corresponding MMSE scores: For individuals with no formal education (illiteracy), an MMSE score of 17 or less was categorized as cognitively impaired. For those with primary school education (up to 6 years of education), an MMSE score of 20 or less indicated cognitive impairment. For individuals who had a secondary school education or higher (more than 6 years of education), an MMSE score of 24 or less defined cognitive impairment. These thresholds are tailored to the varying educational backgrounds of the participants, acknowledging that education level can influence MMSE scores. Such stratification allows a more nuanced interpretation of the MMSE scores and the corresponding cognitive function of the individuals.
By analyzing both frequency and content of internet use, we aim to provide a comprehensive perspective on the habits of elderly internet users. This dual-axis approach can reveal nuanced patterns and relationships that could be missed when considering frequency or content in isolation.

2.2.3. Control Variables

This study includes several potential confounding variables. These comprise demographic characteristics, such as age, gender, educational attainment, marital status, and place of residence. Age is categorized into specific age groups: 60-64, 65-70, 70-74, and 75 years and older. Gender is designated as '1' for male and '0' for female. Education level is denoted as '1' for illiterate (no formal education), '2' for primary school level (up to 6 years of education), and '3' for secondary school level or higher (more than 6 years of education). Marital status is represented as '1' if the participant has a spouse and '0' if not. Place of residence is coded as '1' for urban and '0' for rural.
Health status encompasses aspects like chronic diseases, mental health, and self-rated health.

Chronic Diseases: This includes any of the 14 listed chronic diseases (such as hypertension, dyslipidaemia, diabetes, cancer, arthritis, asthma, etc.) that the respondents reported having.

Mental Health: Depression was evaluated using the 10-item Center for Epidemiological Studies Depression Scale (CESD-10). Participants scoring higher than 10 on the CESD-10 were identified as having depressive symptoms (Evans *et al.*, 2019).

Self-rated Health: Participants were asked to rate their health by responding to the question, "What do you think of your health?" The responses, ranging from 'very poor' to 'very good', were scored on a scale of 1-5. A higher score indicated better self-rated health

2.3. Statistical Analysis

Our analysis utilized Stata 16.0 to eliminate missing data points and outliers across all selected variables. Quantitative data are expressed in both relative frequency (in percentage) and absolute frequency (N). To scrutinize the relationship between the type and frequency of internet use and cognitive function, we used cognitive impairment as the dependent variable. For comparisons, the chi-square test and Mann–Whitney U test were employed. To further analyze, we utilized a binary logistic regression model, with three different models presented in our study. Model 1 took into account gender, age, education level, marital status, and residence (urban or rural). Model 2 expanded upon Model 1 by including the health determinants of the respondents. Model 3 built upon Model 2 by integrating types and frequencies of internet use. Additionally, each type of internet use and its frequency were also incorporated into the logistic regression model for separate analyses. For this analysis, we used SPSS 26.0. The outcomes from the logistic regression

model are presented as Odds Ratios (OR), with 95% Confidence Intervals (CI), and p-values deemed statistically significant when less than 0.05.

3. Results

3.1. Cognitive Function

A comparison of the MMSE scores between the normal group and the group with mild cognitive impairment was conducted. Table 1 indicates that the average MMSE score for the group with normal cognitive function was 26.82 with a standard deviation of 2.19, while the group with cognitive impairment had an average score of 20.62 with a standard deviation of 4.24. A significant difference was found in the total MMSE scores between these two groups ($P<0.05$). It was observed that the scores across various categories such as orientation, immediate memory, attention, calculation, and language were higher in the group with normal cognitive function compared to those in the group with cognitive impairment.

Table 1: MMSE scores between normal group and cognitive function (M±SD)

MMSE Items	Normal	Cognitive impairment	Full mark	t	P-value
Orientation	9.56 ± 0.73	8.41 ± 1.71	10		
Memory	2.86 ± 0.42	2.47 ± 0.92	3		
Attention and computation	4.24 ± 1.34	1.62 ± 1.45	5		
Recall ability	2.48 ± 0.72	1.76 ± 1.00	3		
Language function	7.79 ± 1.14	6.38 ± 2.00	9		
Total MMSE scores	26.94 ± 2.19	20.61 ± 4.23	30	81.672	<0.001

3.2. Sample Characteristics

The demographic and sociological attributes of the 671 elderly internet users are depicted in Table 2. It was observed that among these users, 51.7% fell into the 60-64 age bracket. The majority were male (60.8%), had attained at least a junior high school education (75.9%), and resided in urban areas (72.4%). It was also found that a significant percentage, 88.8%, were married or had partners. The age and gender distributions among these elderly internet users are graphically represented in Fig.1.

When it comes to health status, 48.1% reported having no chronic diseases and 86.1% had no symptoms of depression. In terms of their self-rated health status, most fell into the 'general' category, comprising 51.7% of the sample.

In terms of internet usage, 30.4% reported using the internet nearly every day. Regarding the type of internet use, the activities ranked from most to least frequent were: reading news, watching videos, chatting, and playing games.

3.2. Sample Characteristics

Table 2 provides a detailed statistical analysis of the 671 elderly internet users sampled in this study. Focusing on the demographic characteristics, we found that the majority (51.7%) were in the 60-64 age group. Men comprised 60.8% of the participants and 75.9% had education levels equivalent to junior high school or above. Urban residents made up 72.4% of the study group, and a considerable proportion (88.8%) were either married or had partners. The study also considered the health status of the participants. We found that 48.1% reported no chronic illnesses and 86.1% showed no signs of depressive symptoms. When asked about their own perception of health status, most (51.7%) rated themselves as being in a 'general' health status. Regarding the internet use, 30.4% of these elderly individuals were using the internet almost daily. In terms of internet activities, the hierarchy from most to least engaged were: reading news, watching videos, chatting, and playing games.

According to MMSE evaluation standards, 147 individuals (representing 21.9% of the sample) were identified with symptoms of cognitive impairment. There were noteworthy differences observed in factors like age, gender, and depressive symptoms among elderly internet users. Notably, cognitive impairment was most prevalent among those aged 60-64 years old (51.7%), with a gradual increase observed as age progressed. Meanwhile, there was no significant difference observed among the types of internet use ($P<0.05$).

Table 2: Comparison of sample characteristics between normal cognitive group and Cognitive impairment group (n=671)

Variables	**Total**	**Normal**	**Cognitive impairment**	***P-value***
	N (%)	**N (%)**	**N (%)**	
Demographic characteristics **Age, year** 0.014 B				
60-64	347(51.7)	250 (48.7)	97 (61.4)	
65-69	186 (27.7)	154 (30.0)	32 (20.3)	
70-74	78 (11.6)	64(12.5)	14 (8.9)	
75 and above	60 (8.9)	45 (8.8)	14 (9.5)	
Gender				0.024 A
Male	389 (60.8)	324(63.2)	84 (53.2)	
Female	263 (39.2)	189(36.8)	74 (46.8)	
Education level				0.171 B
Illiterate	11 (1.6)	7 (1.4)	4 (2.5)	
Primary school	151 (22.5)	124 (24.2)	27 (17.1)	
Junior school or higher	509 (75.9)	382 (74.5)	127 (80.4)	
Marital status				0.699 A
Married or with partner	596 (88.8)	457(89.1)	139 (88.0)	
Unmarried or partner **Register**	75 (11.2)	56 (10.9)	19 (12.2)	0.268 A
Rural	185(27.6)	136 (26.5)	49 (31.0)	
Urban	486 (72.4)	377 (73.5)	109 (69.0)	
Health status				
Multi-morbidity				0.650 B
No chronic condition	323 (48.1)	244 (47.6)	79(50.0)	
One chronic condition	194 (28.9)	152 (29.6)	42 (26.6)	
Multi-morbidity	154 (23.0)	117 (22.8)	37 (23.4)	
Depression symptom				0.003 A
No	582 (86.7)	456 (88.9)	126 (79.7)	

Note: Significance level $p < 0.05$, A Pearson Chi-square. B Mann–Whitney U-test.

3.3. Internet Use and Cognitive Function

The outcomes of a binary stepwise logistic regression analysis are demonstrated in Table 3, focusing on the influencing factors of internet usage and cognitive functionality. As per Model 1, certain demographic and sociological information, such as education level, marital status, and registration, did not significantly affect cognitive impairment in the elderly population. After accounting for confounding factors, we observed that the frequency of internet usage had a noteworthy influence. The likelihood of cognitive impairment among those who used the internet 'almost every week' was 0.404 times compared to those who used it 'almost every day' (95% CI: 0.206-0.791). Furthermore, it was 0.388 times compared to those who did not use the internet regularly (95% CI: 0.152-0.993). This data suggests a potential correlation between the frequency of internet use and cognitive function among the elderly.

Table 3: Logistic regression analysis of influencing factors of Internet use and cognitive function

Variables	Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95%CI
Demographic characteristics						
Age group						
60-64	1.00	1.00		1.00		
65-69	1.133	0.580-2.214	1.010	0.511-1.996	0.987	0.495-1.968
70-74	0.661	0.320-1.364	0.607	0.292-1.261	0.562	0.268-1.179
75 and above	0.701	0.301-1.628	0.648	0.276-1.522	0.624	0.263-1.480
Gander Male 1.00	1.00	1.00				
Female	1.619	1.099-2.384*	1.567	1.057-2.324*	1.578	1.043-2.389*
Education lavel- Illiterate	1.00		1.00		1.00	
Primary school	1.319	0.369-4.708	1.512	0.416-5.487	1.184	0.295-4.742
Junior school or higher	0.605	0.373-0.981	0.563	0.343-0.923	0.549	0.330-0.913
Marital status						
Married	1.00		1.00		1.00	
Others	1.010	0.562-1.817	0.973	0.558-1.829	0.974	0.533-1.779
Register						
Rural	1.00		1.00		1.00	
Urban	1.383	0.907-2.108	1.341	0.873-2.058	1.257	0.809-1.956
Chronic illness						
No chronic condition	1.00				1.00	
One chronic condition	0.929			0.545-1.584	0.973	0.594-1.596
Multi-morbidity	0.430			0.255-0.723	0.914	0.534-1.563
Depression symptom						
No	1.00				1.00	
Yes	0.430			0.255-0.723*	0.419	0.248-0.708*
Self-perceived health status						
Very good/Good	1.00				1.00	
Fair	1.877			1.007-3.498	1.898	1.012-3.560
Poor /Very poor	1.666			0.945-2.937	1.702	0.962-3.014
Internet use (last month)						
Internet use frequency						
Almost daily	1.00					
Almost every week	0.404					0.206-0.791**
Not regularly	0.388					0.152-0.993
Internet using						
Chatting						
No	1.00					
Yes	1.055					0.702-1.585
Watch news						
No	1.00					
Yes	1.090					0.649-1.833
Watch videos						
No	1.00					
Yes	0.917					0.607-1.385
Play games						
No		1.00				
Yes		1.103				0.719-1.692

Note: ***P<0.001, **P<0.05, *P<0.1

3.4. Examination of Interactive Effects

Table 4 presents the outcomes related to the impact of the frequency and types of internet usage on cognitive function. After adjusting for demographic characteristics and health status variables, we included an interaction term between internet usage frequency and types into the logistic regression model for an interaction analysis. This was conducted in Models 4 through 7, where we explored the interactive effects among various categories of internet use content such as chatting, news watching, video watching, and gaming. Our statistical analysis showed that there was no significant interaction effect between the types and frequency of internet use ($P > 0.05$).

Variables	Model 4		Model 5		Model 6		Model 7	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Chat × Almost daily	1.00							
Chat ×Almost every week	0.754	0.186-3.052						
Chat ×Not regularly	0.593	0.087-4.037						
Watch news× Almost daily			1.00					
Watch news ×Almost every								
week			3.652	0.830-16.069				
Watch news× Not regularly			1.783	0.240-13.248				
Watch videos ×Almost daily					1.00			
Watch videos ×Almost every					2.762	0.731-10.444		
week								
Watch videos × Not regularly			2.612			0.358-19.073		
Play games × Almost daily							1.00	
Play games × Almost every week							0.775	0.165-3.630
Play games ×Not regularly							1.403	0.178-11.056

Note: All models were controlled for Demographic characteristics, Age, Gender, Education year, marital status, Register, Multi-morbidity, Depression symptom, Self-perceived health status.

4. Discussion

This research, the first of its kind in India, explores the association between the frequency and type of internet use, and cognitive function in elderly Indian internet users. Additionally, it investigates how demographic factors and health status influence these relationships. The key findings indicate that cognitive impairment remains high among elderly internet users, with frequency of internet usage having a considerable impact on cognitive function. Interestingly, depressive symptoms also emerged as a potential influence on cognitive function among elderly internet users, highlighting the importance of focusing on cognitive health in seniors and leveraging digital health technology to monitor and intervene in cognitive decline. Previous epidemiological studies predominantly used the MMSE scale to assess cognitive function in the elderly (Markwick, Zamboni, & de Jager, 2012) [24]. While this measure has proven useful, it is not comprehensive in large-sample community screenings. We found that cognitive impairment's incidence in our study was 24.30%, consistent with other findings in India (Rao *et al.*, 2018, Nie *et al.*, 2011)[31][25], but slightly higher than in other countries (Ward, Arrighi, Michels, & Cedarbaum, 2012)[36]. This discrepancy may be due to varying degrees of population aging and economic conditions in different countries. India has a high elderly population and low education and income levels, risk factors for cognitive impairment. Our research uniquely investigated the relationship between internet usage frequency and type, and cognitive function in elderly internet users. We analysed the effects of four common internet usage types: chatting, watching news and videos, and gaming. Our findings indicated a positive correlation between these activities and cognitive function. Interestingly, we did not find a significant difference in the cognitive impact across different types of use, possibly due to our participants' education level and income. Regular internet use is linked to a reduced risk of cognitive impairment and dementia (Huang & Zhou, 2013; Krug *et al.*, 2019)[21][23]. However, we found that frequency of use did not significantly moderate the relationship between internet use and cognitive function. This discrepancy could be due to differences in the study population's characteristics and the correlation between education level and cognitive function. A key component of successful aging is psychological well-being. There is evidence that internet use is associated with less depression (Valenzuela & Sachdev, 2006)[35]. In our study, we found a strong association between frequency of social media use and depression, suggesting that depressive symptoms may be a significant predictor of cognitive function. This suggests that future research should emphasize the role of mental health in elderly internet users, particularly in relation to depressive symptoms.

5. Limitations

This study, being the first of its kind to examine cognitive function among elderly internet users using a nationally representative Indian database, has its unique value. However, some limitations should be acknowledged. Firstly, our research is built on cross-sectional analysis using the fourth wave LASI database. Due to the previous wave not incorporating questions concerning internet usage type and frequency, we cannot definitively establish causal relationships or make precise determinations about cognitive function improvements among elderly internet users. Secondly, while the LASI is widely employed in cognitive impairment diagnosis, there could be variations in the screening and diagnosis of mild cognitive impairment. The current study may not represent the final diagnoses of dementia or Alzheimer's disease among the population. Lastly, considering the relatively small number of elderly internet users in India, a potential direction for future research could be to extend this study into different cultural and social settings.

6. Conclusion

The study's strength lies in its utilization of a nationally representative dataset, inclusive of a broad age range, and its capability to simultaneously examine multiple variables. Attention needs to be directed towards the beneficial effects of internet use in the context of cognitive decline improvement and early cognitive dysfunction screening among the elderly. Frequency of internet use might play a role in cognitive function. Therefore, nurses and other mental health professionals need to consider the frequency and content of internet usage when contemplating strategies to slow or mitigate the adverse effects of cognitive decline in the elderly.

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