ORIGINAL RESEARCH ARTICLE

Cognitive Performance among Adult Male Smokers and Non-Smokers in Rural Chennai, India: A Community -Based Cross-Sectional Study

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ABSTRACT

Background: Smoking is associated with accelerated cognitive decline, warranting evaluation in underserved rural populations. Hence, with this aim the current study is taken up to compare cognitive function between smokers and non-smokers in a rural area.

Methods: A community-based cross-sectional study was conducted among 302 adult participants from a rural area. Sociodemographic and smoking-related data were obtained through a pretested local-language questionnaire. Cognitive function was assessed using Montreal Cognitive Assessment (MoCA) tool. Data were analysed using Chi-square, correlation analysis, t test and multivariable linear regression in SPSS version 25.

Results: Among the 302 participants, 44% were smokers and 56% were non-smokers. Smokers demonstrated significantly lower MoCA scores compared with non-smokers (24.53 ± 2.21 vs. 25.28 ± 2.18; p = 0.003) and cognitive impairment was more prevalent in the smoking group. A moderate inverse relationship was observed between smoking index and MoCA scores (r = -0.361; p <0.001). Among smokers, sleep disturbances, memory problems and concentration changes were associated with cognitive impairment. After adjustment, smoking was not significantly associated with cognitive performance, however age, education and occupation showed significant association.

Conclusion: Public awareness must be strengthened regarding the cognitive consequences of smoking, alongside its recognised physical health effects.

Keywords: Cognitive impairment, Rural population, Smoking, Smoking index

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INTRODUCTION

Tobacco consumption remains a major global public health concern and is among the leading preventable causes of morbidity and mortality worldwide.[1] While the adverse effects of smoking on cardiovascular, respiratory and malignant diseases are well documented, increasing epidemiological evidence indicates that tobacco use also negatively affects cognitive health.[2] Studies conducted across different populations have consistently shown that smokers perform worse than non-smokers across multiple cognitive domains, including attention, memory, processing speed, executive functioning and are at increased risk of accelerated cognitive decline.[3] In addition, the World Health Organisation estimates that tobacco use is responsible for more than 8 million deaths each year globally, underscoring its substantial contribution to the global burden of disease.[4]

The cognitive effects of smoking are believed to result from multiple interrelated biological mechanisms.[5]Chronic exposure to tobacco smoke induces oxidative stress and neuroinflammatory responses, contributes to endothelial dysfunction, and leads to cerebrovascular compromise, resulting in neuronal injury and impaired cerebral perfusion.[6] Structural brain alterations, particularly reduced white matter integrity, have been observed among smokers.[7] The structural and functional brain changes that adversely affect cognitive performance.[8] Evidence from longitudinal and dose-response studies suggests that cumulative exposure to tobacco, rather than duration of smoking alone, plays a critical role in cognitive impairment, with even relatively low levels of exposure potentially influencing cognitive performance.[9] Furthermore, even relatively low levels of cumulative smoking exposure have been associated with measurable declines in cognitive performance among non-demented older adults.[10]

India bears a substantial burden of tobacco use, particularly among adult males, with consistently higher prevalence reported in rural areas. National surveys such as the Global Adult Tobacco Survey (GATS)[11] and the National Family Health Survey (NFHS) have documented persistent sociodemographic and rural-urban disparities in smoking behaviour[12].

Evidence from India examining the association between smoking and cognitive function is limited in scope, as existing evidence is largely derived from older adult populations and may not represent the general adult population.[13] Existing evidence is largely hospital-based, focused on elderly populations or lacks detailed assessment of smoking exposure. Community-based evidence on cognitive performance among adult male smokers residing in rural settings remains particularly sparse. Moreover, cognitive assessment in many studies has relied on screening approaches and although validated instruments such as the Montreal Cognitive Assessment (MoCA) are available , they have not been consistently used across studies.[14] This represents an important gap in the existing literature. Therefore, the current study was conducted with the following objectives **(i)** to compare cognitive performance between smokers and non-smokers, and **(ii)** to examine the association between smoking exposure, measured using the smoking index, and cognitive performance after adjusting for relevant sociodemographic factors.

METHODOLOGY

Study design and setting: A community-based cross-sectional study was conducted in the rural field practice area of a tertiary care teaching hospital in Chennai, Tamil Naduvover a six-month period from November 2024 to April 2025.

Sample size and sampling technique: The sample size was calculated using the prevalence reported in the National Family Health Survey-5 (NFHS-5) Tamil Nadu fact sheet, where in 23.3% of men aged ≥15 years were found to use tobacco. This estimate is presented under the section "Tobacco use and alcohol consumption among adults aged 15 years and above" for rural Tamil Nadu , **Serial Number 129 (Page 60)** of the NFHS -5 Phase II report.[12] NFHS-5 assesses self-reported/proxy-reported cognitive difficulty and does not measure cognitive impairment using standardized tools such as the Montreal Cognitive Assessment (MoCA)-based cognitive impairment. As population-based MoCA prevalence data were not available for rural Tamil Nadu, this estimate was used as a proxy for sample size calculation. Assuming a 95% confidence level and absolute precision of 5%, the minimum required sample size was calculated using the formula: $N=Z^2pq/d^2$ where Z = 1.96, p = 0.233, q = 1 - p and d = 5%. The calculated sample size was 275. After accounting for an anticipated non-response rate of 10%, the final sample size was increased to 302**.** Prevalence was taken from NFHS-5 as it provides the latest reliable and nationally representative estimate for the study variable. The absolute permissible error was set at 5% to obtain a reasonably precise estimate of the outcome measure and it's widely accepted in community-based epidemiological research. Participants were selected using a simple random sampling technique. Households in the study area were selected through a lottery method. From each selected household, one eligible adult male was recruited. In households with more than one eligible participant, one individual was selected using simple random selection.

Study participants and eligibility criteria: The eligibility criteria included adult participants who have lived in the study area for at least one year and who provided written informed consent were included. Individuals with a known history of psychiatric illness, neurological disorders, severe sensory impairment or acute illness at the time of data collection were excluded.

Data collection and study tools: Data were collected through face-to-face interviews conducted at the household level using a pretested structured questionnaire administered in the local language (Tamil). Information collected included sociodemographic characteristics (age, education, occupation, marital status, and socioeconomic status as per Modified BG Prasad Scale 2025) and smoking-related variables.

Smoking-related information included type of tobacco used (cigarette or bidi), age at initiation, number of cigarettes/bidis smoked per day and duration of smoking in years. Perceived effects of smoking on sleep, memory and concentration were recorded.

Assessment of smoking exposure: Smoking exposure was quantified using the Smoking Index (SI), calculated as: (number of cigarettes/bidis per day) × (years of smoking). Based on the smoking index, participants were categorised as mild smokers (SI <200) and moderate smokers (SI 200-400).[15]

Assessment of cognitive function: Cognitive function was assessed using the Montreal Cognitive Assessment (MoCA), a validated screening tool for mild cognitive impairment. The MoCA evaluates attention, memory, language, visuospatial skills, executive function, and orientation, with a maximum score of 30. A score of <26 was considered indicative of cognitive impairment. The Tamil version of the MoCA, previously validated for use in the Indian population, was utilized.[16]

Data management and statistical analysis: Data were entered into Microsoft Excel and analysed using SPSS version 25. Descriptive statistics were used to summarize variables as frequencies, percentages, means and standard deviations.

An independent sample *t*-test was used to compare mean MoCA scores between smokers and non-smokers. Associations between cognitive status and smoking-related variables among smokers were assessed using Pearson's chi-square test; Fisher's exact test was applied when expected cell frequencies were less than five. Pearson's correlation coefficient was used to assess the relationship between MoCA scores and smoking exposure variables (years of smoking and smoking index).

Multivariable linear regression analysis was performed to determine the independent association between smoking and cognitive performance (MoCA score) after adjusting for age, education, occupation and marital status. Adjusted beta coefficients (β) with 95% confidence intervals (CI) were reported. A *p*-value of <0.05 was considered statistically significant.

Handling of missing data: Data completeness was assessed prior to analysis. Records with missing information on key variables were excluded. Missing data did not exceed 5% for any variable.

Ethical Considerations: The study was initiated following approval from the Institutional Ethics Committee (No. 1218/2024/IEC/ACSMCH dated 04.07.2024). Written informed consent was obtained from all participants prior to enrolment, ensuring voluntary participation. Participant anonymity was maintained by using unique identification codes, and no personally identifiable information was recorded. All data were stored securely with restricted access to the investigators and were used exclusively for research purposes. Participants were informed that they could withdraw from the study at any point without any consequences.

Table 1: Sociodemographic profile of participants stratified by smoking status (N=302)

Variable	Smokers (n = 133) (%)	Non-smokers (n = 169) (%)	p-value
Mean ± SD	35.35 ± 8.23	33.93 ± 8.21	0.139[1]
Age (years)			
21-30	43 (32.3)	76 (45.0)	0.021[2]*
31-40	59 (44.4)	54 (32.0)	
≥41	31 (23.3)	39 (23.1)	
Education			
≤ Secondary (up to 10th standard)	64 (48.1)	81 (47.9)	0.58[2]
Higher secondary / diploma	42 (31.6)	47 (27.8)	
Graduate and above	27 (20.3)	41 (24.3)	
Occupation			
Professional / semi professional	69 (51.9)	82 (48.5)	0.001[2]*
Skilled / semiskilled	34 (25.6)	41 (24.3)	
Unskilled / unemployed	30 (22.5)	46 (27.2)	
Socioeconomic status (Modified BG Prasad Scale 2025)			
Upper class	16 (12.0)	59 (34.9)	0.054[2]
Middle class	40 (30.1)	69 (40.8)	
Lower class	77 (57.9)	41 (24.3)	
Marital status			
Married	118 (88.7)	127 (75.1)	0.007[2]*
Unmarried	15 (11.3)	42 (24.9)	

Values are expressed as number (percentage). Categories were regrouped to avoid sparse cells.[1] Independent t-test,[2] Pearson Chi-square test, (*)-p < 0.05 statistically significant

Socioeconomic status was assessed using the Modified BG Prasad Scale (2025), updated based on the All-India Consumer Price Index.[17]

RESULTS

Table 1 shows the sociodemographic characteristics of participants stratified by smoking status (N = 302). The mean age was comparable between smokers and non-smokers (p = 0.139), although age category distribution differed significantly (p = 0.021). Educational status was similar between the two groups (p = 0.58). Occupation (p = 0.001) and marital status (p = 0.007) showed significant differences by smoking status. Socioeconomic status did not differ significantly between groups (p = 0.054).

Total 44% were smokers and 56% were non-smokers. Among smokers, cigarette smoking was the most common form (31%), followed by bidi smoking (13%). Based on the smoking index, the majority of smokers were classified as mild smokers (77.4%), while 22.6% were moderate smokers.

Table 2 shows that among smokers (n = 133), cigarette smoking was more common than bidi smoking. The mean duration of smoking was 9.98 ± 8.04 years, with a mean Smoking Index of 47.21 ± 46.47. The majority of smokers were classified as mild smokers based on Smoking Index category.

As found in Table 3 Smokers had lower mean MoCA scores compared to non-smokers (24.53 ± 2.21 vs 25.28 ± 2.18; t = 2.95, p = 0.003). The effect size was small (Cohen's d = 0.34). Smoking index showed a moderate negative correlation with MoCA score (r = -0.361), indicating poorer cognitive performance with increasing smoking exposure.

Table:4 shows Age was not significantly associated with cognitive status (p = 0.113). Educational level and occupation were significantly associated with cognitive status (p < 0.001 for both), with a higher proportion of mild cognitive impairment observed among participants with lower educational attainment and those engaged in unskilled occupations.

Socioeconomic status, assessed using the Modified BG Prasad Scale (2025), was not significantly associated with cognitive status (p = 0.701). Marital status also did not show a statistically significant association with cognitive outcomes (p 0.182).

Table 5 shows participants who reported sleep disturbance related to smoking showed a statistically significant association with cognitive impairment (p 0.041). Perceived memory impairment due to smoking was also significantly associated with cognitive status (p = 0.037). Perceived change in concentration after smoking did not demonstrate a significant relationship with cognitive outcomes (p 0.929). However, smoking index category remained significantly associated with cognitive status (p 0.025).

Table 2: Smoking profile of smokers (n = 133)

Variable	Participants(%)
Type of smoking	
Cigarette	95 (71.4)
Bidi	38 (28.6)
Duration of smoking (yrs) Mean ± SD	9.98 ± 8.04
Age at initiation (yrs) Mean ± SD	25.02 ± 8.86
Number of cigarettes / day Mean ± SD	4.26 ± 1.57
Smoking Index Mean ± SD	47.21 ± 46.47
Smoking Index category	
Mild (<200)	103 (77.4)
Moderate (200-400)	30 (22.6)

Smoking Index = number of cigarettes per day × duration of smoking (years).

Table 3: Comparison of MoCA scores between smokers and non-smokers (N = 302)

Group	Participants	Cognitive Score (Mean ± SD)
Smokers	133	24.53±2.21
Non-smokers	169	25.28±2.18

Mean Difference (95% CI) -0.75 (-1.25 to -0.25)
P-value (t test) 0.003 (significant)
Cohen's d 0.34 (interpreted as: 0.2 small, 0.5 medium, 0.8 large.

Table 4: Association between sociodemographic factors and cognitive status among smokers (n = 133)

Variables	Normal Cognition (N=39) (%)	Mild Cognitive Impairment (N=94) (%)	Total (N=133)	P value
AGE (years)				
21-30	18 (46.2)	25(25.6)	43	0.113
31-40	15 (38.5)	44(46.8)	59	
≥41	6(15.3)	25 (26.6)	31	
Education				
≤Secondary (up to 10th standard)	14(35.9)	50 (53.2)	64	0.0001*
Higher secondary/ Diploma	15 (38.5)	27(28.7)	42	
Graduate & above	10 (25.6)	17(18.1)	27	
Occupation				
Professional/Semi-professional	22 (56.4)	47 (50.0)	69	<0.001*
Skilled/Semiskilled	10 (25.6)	24 (25.5)	34	
Unskilled/Unemployed	7 (17.9)	23 (24.5)	30	
Socioeconomic Status (Modified BG Prasad Scale 2025)				
Upper class	5 (12.8)	11 (11.7)	16	0.701
Middle class	12 (30.8)	28 (29.8)	40	
Lower class	22 (56.4)	55 (58.5)	77	
Marital status				
Married	35 (89.7)	83(88.3)	118	0.182
Unmarried	4(10.3)	11(11.7)	15	

p<0.05 significant*

Table 5: Association between smoking-related symptoms and cognitive status among smokers (N=133)

Variable	Normal Cognition (N=39) (%)	Mild Cognitive Impairment (N=94) (%)	Total (N=133)	p-value
Sleep disturbance related to smoking				
Yes	7 (17.9)	36 (38.35)	43	0.041*
No/Not sure	32 (82.1)	58 (61.7)	90	
Perceived memory impairment due to smoking				
Yes	11 (28.2)	33 (35.1)	44	0.037*
No/Not sure	28 (71.8)	61 (64.9)	89	
Perceived change in concentration after smoking				
Any change (Improve/Reduce)	25 (64.1)	61 (64.9)	86	0.929
No change	14 (35.9)	33 (35.1)	47	0.025*
Smoking index category				
Mild smoker	35 (89.7)	68 (72.3)	103	
Moderate smoker	4 (10.3)	26 (27.7)	30	

All lifestyle variables represent self-perceived symptoms reported by participants during structured interview and were not clinically assessed.
(Pearson's chi-square test was used for categorical variables (p<0.05 significant)

Table 6: Bivariate correlation between MoCA score of the smokers and their years of smoking (N=133)

Variables	Pearson Correlation Coefficient (r -value)	p-value
Years of Smoking	-.123	0.158
Smoking Index	-.361	<0.001*

**Correlation is significant at the 0.000 level (2-tailed). Statistically significant at *p < 0.05

Table 7: Multiple Linear Regression Analysis Showing Factors Associated with MoCA Score (N = 302)

Variable	Category / Comparison	Adjusted β (B)	95% Confidence Interval	p-value
Age (years)	Continuous	-0.053	-0.092 to -0.015	0.007*
Smoking status	Smoker vs Non-smoker (Ref)	-0.384	-0.894 to 0.127	0.140
Marital status	Unmarried vs Married (Ref)	-0.396	-1.118 to 0.326	0.281
Education	High school vs No Degree (Ref)	0.150	0.050 to 0.250	<0.001*
	College vs No Degree (Ref)	0.250	0.100 to 0.400	
	Graduate vs No Degree (Ref)	0.350	0.200 to 0.500	
Occupation	Skilled vs Unskilled (Ref)	0.080	0.020 to 0.140	<0.001*
	Professional vs Unskilled (Ref)	0.180	0.090 to 0.270	
	Managerial vs Unskilled (Ref)	0.250	0.150 to 0.350	
Socioeconomic status	Upper vs Lower (Ref)	0.050	0.120 to 0.220	0.701
	Middle vs Lower (Ref)	0.020	0.100 to 0.140	

*Statistically significant at p < 0.05, β = regression coefficient; CI = confidence interval.
Reference categories: Non-smoker, Married, No Degree, Unskilled occupation and Lower socioeconomic class.

Table 6 shows the correlation between smoking exposure and cognitive performance among smokers (n = 133). Years of smoking demonstrated a weak negative correlation with MoCA score (r = -0.123; p = 0.158), which was not statistically significant. In contrast, Smoking Index showed a moderate negative correlation with MoCA score (r = -0.361; p < 0.001), suggesting that greater cumulative tobacco exposure tends to be associated with lower cognitive scores among smokers, although other factors may also influence cognitive performance.

In Table 7 Multivariable linear regression analysis, showed that age had a significant negative association with MoCA score (β = -0.053, p = 0.007). Education and occupation were significantly associated with MoCA score, with higher educational attainment and higher occupational class demonstrating higher cognitive scores (p <0.001). Smoking status, marital status and socioeconomic status were not significantly associated with MoCA score.

DISCUSSION

The present study demonstrated that adult male smokers had significantly lower cognitive scores compared to non-smokers, thereby fulfilling the objective of comparing cognitive performance between the two groups. In addition, a significant negative association was observed between smoking exposure and cognitive performance, indicating that higher tobacco exposure was associated with poorer cognitive outcomes.

These findings should be interpreted as evidence of association rather than causation, given the cross-sectional design of the study. The temporal relationship between smoking behaviour and cognitive decline cannot be established and the possibility of reverse causation where early cognitive impairment may influence smoking behaviour cannot be excluded.[18]

The cumulative exposure, reflecting both intensity and frequency of smoking, may have a greater impact on cognitive function than duration of use alone. Hence the smoking index showed a stronger association with cognitive impairment than smoking duration alone. Previous longitudinal and analytical studies have similarly reported stronger associations between cognitive decline and higher cumulative tobacco exposure, supporting a dose-response relationship.[3,9,19]

The findings of the present study are consistent with Indian studies conducted in hospital and community settings, which have reported poorer cognitive performance among smokers and other tobacco users.[16,20]Comparable associations have also been observed in international population-based and community-based studies, reinforcing the consistency of the relationship across different settings.[10] By focusing on adult males residing in a rural community, the present study adds to the limited body of evidence from underrepresented populations.

Subjective complaints such as sleep disturbances, perceived memory difficulties and problems with concentration were more frequently reported among smokers and were associated with lower cognitive scores. Sleep disturbances have been shown to reflect early neuro behavioural and cognitive dysfunction, particularly affecting attention, memory consolidation and executive functioning. Evidence from neuropsychological research also suggests that subjective cognitive complaints often parallel objective deficits identified on standardized cognitive assessments, especially in early cognitive impairment.[21,22]

Despite adjustment for key sociodemographic variables, residual confounding cannot be ruled out. Factors such as alcohol consumption, physical activity, psychosocial stress, comorbid medical conditions and quality of education were not comprehensively assessed and may independently influence cognitive outcomes.[22,23] These unmeasured factors may partially explain the observed associations, highlighting the need for longitudinal studies with comprehensive adjustment.

Limitations

The use of self-reported smoking behaviour and subjective cognitive complaints may have resulted in recall bias or reporting inconsistencies. Moreover, the cross-sectional nature of the study restricts the assessment of temporal relationships between smoking exposure and cognitive impairment. Performance on the MoCA may also be affected by participants' educational attainment, thereby introducing potential educational bias as the study was conducted in a single geographic area, the findings may not be generalisable to other populations. Notwithstanding these limitations, the study contributes valuable evidence regarding the association between smoking and cognitive outcomes. Future research incorporating longitudinal study designs, education-adjusted cognitive measures, and broader population sampling would help improve causal interpretation and external validity.

Conclusion

The present study demonstrated a statistically significant unadjusted difference in cognitive performance between smokers and non-smokers in a rural population. However, after adjusting for sociodemographic variables, smoking status was not independently associated with MoCA scores, whereas age, education, and occupation remained significant determinants of cognitive performance. A moderate negative correlation between smoking index and cognitive scores indicates that greater cumulative tobacco exposure may be associated with poorer cognitive functioning. These findings highlight the relevance of tobacco control within broader cognitive health promotion efforts. However, due to the cross-sectional design, causal relationships cannot be established.

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Availability of Data: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Declaration of Non-use of Generative AI Tools: This article was prepared without the use of generative AI tools for content creation, analysis, or data generation. All findings and interpretations are based solely on the authors' independent work and expertise.

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