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## Association of objective and subjective socioeconomic status with cognitive impairment among older adults: A population-based study in a developing country

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3 **Association of objective and subjective socioeconomic status with cognitive impairment**  
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5 **among older adults: A population-based study in a developing country**  
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## Abstract

**Objective:** The present study aims to explore the late-life cognitive impairment as a function of older individuals' objective and subjective socio-economic status.

**Design:** A cross-sectional study was conducted using a large representative survey data.

**Setting and participant:** The present study uses data of the Longitudinal Aging Study in India (LASI's) baseline wave (Wave 1) conducted during 2017-18. The total sample size for the present study was 31,464 older adults aged 60 years and above.

**Primary and secondary outcome measures:** The outcome variable was cognitive impairment among older adults. Descriptive statistics along with cross-tabulation were presented in the present study. Chi square test was used to evaluate the significance level of differences in cognitive impairment for subjective and objective SES. Additionally, binary logistic regression analysis was used to fulfil the objectives.

## Results

It was found that about 41.7 per cent and 43.4 per cent of older adults belonged to low subjective and objective SES respectively. Older adults with lower subjective (17.8 per cent) and objective SES (16.6 per cent) status had higher chances of cognitive impairment. It was also revealed that older adults with lower subjective SES [AOR: 2.04;  $p < 0.05$ ] and objective SES [AOR: 1.32;  $p < 0.05$ ] had significantly higher odds of cognitive impairment in comparison to their counterparts with a stronger subjective SES-cognitive impairment association. Further it was revealed that the older adults who belonged to lower subjective as well as objective SES were 2.45 times more likely to suffer from cognitive impairment compared to older adults from higher subjective as well as objective SES [AOR: 2.45;  $p < 0.05$ ].

## Conclusion

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3 The results also suggest that more attention should be placed on subjective SES indicators  
4  
5 when investigating socioeconomic influences on cognitive functioning among older adults in  
6  
7 India.  
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10 **Keywords:** *Subjective; Objective; Socioeconomic status; Cognitive impairment; Older adult*  
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**Strengths and limitations:**

- The study utilizes a large nationally representative sample of the older population
- The major limitation is the cross-sectional design of the study eliminating the drawing of causal inferences among variables.
- It is important to consider that some individuals may become cognitively impaired because they are illiterate and could not respond to several measures with accuracy

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## Introduction

Cognitive impairment, including dementia as an outcome of decline in cognitive ability, increases considerably with the rapidly growing population of older adults [1]. Worldwide, almost 80% of the general public are concerned about developing dementia at some point in time and 1 in 4 people think that they can do nothing to prevent such a cognitive decline [2].

Various indices of economic hardship, including lack of education, poor household economy, unemployment, and employment frustration, are linked with poor physical health conditions resulting in cognitive deficits [3–5]. Similarly, evidence suggests an aggregate or cumulative effect of socio-economic risk factors on cognitive impairment in later years of life [6–8]. Persons with higher cumulative socioeconomic status (SES) demonstrated an advantage in cognitive functioning [9]. A growing body of literature suggests that people who accumulated more wealth may be able to more easily translate it into better environmental circumstances or less stressful living conditions, further contributing to better cognitive health in later life [7, 10, 11]. Studies reported improvements in mental well-being for older people after the introduction of an income supplemental program [12, 13]. Measured by a test of processing speed, associations of educational attainment and current poverty index were found with late-life cognitive impairment in multiple studies [7, 14, 15]. Furthermore, a major contributing factor may include poor literacy resulting in an inability to benefit from strategies for early prevention of cognitive impairment [16].

### *Two Approaches to SES: Subjective and objective SES measures*

Objective SES, which is commonly indicated by household wealth index and individual educational attainment [17]. Although these indicators are highly correlated [18], they reflect more of one's power or prestige [19]. In comparison, the subjective SES captures individuals'



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3 perceptions of their position in the social hierarchy, thus representing a psychological process  
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5 [20].  
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8 In this regard, people make judgments of where they belong in the social hierarchy relative to  
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10 others based on cognitive averaging of their economic status, education, occupation, and  
11  
12 other objective indicators using different reference groups [17]. There is a growing body of  
13  
14 research documenting that if people perceive themselves to be subordinate to others, they  
15  
16 report lower self-esteem and greater stress, and they are likely to suffer from diseases more  
17  
18 often than people who do not regard themselves to be of lower status [21]. Hence, subjective  
19  
20 SES as a rank-based judgment that is composed of an evaluative judgment of where the  
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22 objective resources would place a person in rank within a specific context, which is derived  
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24 mainly via the social comparison process.  
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30 Evidence for the association between poor socioeconomic indicators with worse mental  
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32 health outcomes is abundant in the geriatric research. Many previous studies in India and  
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34 other countries have reinforced that illiteracy and poor financial status were strongly  
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36 associated with worse cognitive function at the individual level [1, 22, 23]. However, the  
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38 difference in the role that subjective and objective socioeconomic factors play in contributing  
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40 to declining in late life cognition is poorly understood in the context of developing countries.  
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42 Therefore, we in this study aim to explore the late-life cognitive impairment as a function of  
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44 older individuals' objective and subjective SES using a large representative survey  
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46 information of older adults aged 60 and above in India.  
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## 51 **Data, Variables, and Methods**

### 52 **Data Source**

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55 Data for this study was utilized from the recent release of Longitudinal Ageing Study in India  
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57 (LASI) wave 1 [24]. LASI is a full-scale national survey of scientific investigation of the  
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3 health, economic, and social determinants and consequences of population aging in India,  
4  
5 conducted in 2017-18. The LASI is a nationally representative survey of over 72000 older  
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7 adults aged 45 and above across all states and union territories of India [24]. The main  
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9 objective of the survey is to study the health status and the social and economic well-being of  
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11 older adults in India. LASI adopted a multistage stratified area probability cluster sampling  
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13 design to arrive at the eventual units of observation: older adults age 45 and above and their  
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15 spouses irrespective of age. The survey adopted a three-stage sampling design in rural areas  
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17 and a four-stage sampling design in urban areas. In each state/UT, the first stage involved the  
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19 selection of Primary Sampling Units (PSUs), that is, sub-districts (Tehsils/Talukas), and the  
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21 second stage involved the selection of villages in rural areas and wards in urban areas in the  
22  
23 selected PSUs [24]. In rural areas, households were selected from selected villages in the  
24  
25 third stage. However, sampling in urban areas involved an additional stage. Specifically, in  
26  
27 the third stage, one Census Enumeration Block (CEB) was randomly selected in each urban  
28  
29 area [24]. In the fourth stage, households were selected from this CEB. The detailed  
30  
31 methodology, with the complete information on the survey design and data collection, was  
32  
33 published in the survey report [24]. The present study is conducted on eligible respondents  
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35 aged 60 years and above. The total sample size for the present study is 31,464 older adults  
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37 aged 60 years and above.  
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### 45 ***Variable description***

### 46 ***Outcome variable***

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51 Cognitive impairment was measured through five broad domains (memory, orientation,  
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53 arithmetic function, executive function, and object naming). The cognitive impairment in our  
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55 study is based on the different cognitive measures including: immediate (0–10 points) and  
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57 delayed word recall (0–10 points); orientation related to time (0-4 points), and place (0-4  
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3 points); arithmetic ability based on serial 7s (0–5 points), computation (0-2) and backward  
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5 counting from 20 (0–2 points); executive functioning based on paper folding (0-3) and  
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7 pentagon drawing (0-1); and object naming (0-2). The overall score ranges between 0 and  
8  
9 43, and a higher score indicate better cognitive functioning. In our study, the respondents  
10  
11 who received assistance during the cognition module were excluded from the analysis. The  
12  
13 lowest 10th percentile is used as a proxy measure of poor cognitive functioning [24].  
14  
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### 17 ***Control variables***

18  
19 The control variables were divided into four sections namely socio-economic status (SES),  
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21 individual factors, health factors and household factors.  
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### 26 ***Socio-economic status***

27  
28 The main explanatory variables were subjective socio-economic status and objective socio-  
29  
30 economic status among older adults.  
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- 34 1. The subjective socio-economic status was assessed using ladder technique and the  
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36 question used to assess the variable was “Think of the ladder with 10 stairs as  
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38 representing where people stand in our society. At the top of the ladder are the people  
39  
40 who are the best off – those who have the most money, most education, and best jobs. At  
41  
42 the bottom are the people who are the worst off – who have the least money, least  
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44 education, and the worst jobs or no jobs. The higher up you are on this ladder, the closer  
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46 you are to the people at the very top and the lower you are, the closer you are to the  
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48 people at the very bottom of your society”. A score of 0-10 was hence generated using  
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50 this technique and variable subjective socio-economic status was coded as 0-3 as “low”,  
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52 4-7 as “middle” and 8-10 as “high” [25].  
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- 56 2. The monthly per capita expenditure (MPCE) quintile was assessed using household  
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58 consumption data. Sets of 11 and 29 questions on the expenditures on food and non-food  
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3 items, respectively, were used to canvas the sample households. Food expenditure was  
4 collected based on a reference period of seven days, and non-food expenditure was  
5 collected based on reference periods of 30 days and 365 days. Food and non-food  
6 expenditures have been standardized to the 30-day reference period. The monthly per  
7 capita consumption expenditure (MPCE) is computed and used as the summary measure  
8 of consumption [24]. The variable was then divided into five quintiles i.e., from poorest  
9 to richest. The variable objective socio-economic status was coded as low which includes  
10 poorest and poorer, middle which includes middle and high which includes richer and  
11 richest [26].

### 22 *Individual factors*

23  
24 Age was coded as young old (60-69 years), old-old (70-79 years), and oldest-old (80+ years).  
25  
26 Sex was coded as male and female. Educational status was coded as no education/primary not  
27 completed, primary, secondary and higher. Working status was coded as currently working,  
28 retired, and not working [27]. Marital status was coded as currently married, widowed and  
29 others. Others included divorced/separated/never married. Living arrangement was coded as  
30 living alone, living with spouse, living with spouse and children and living with others [28].  
31 Social participation was coded as no and yes. Social participation was measured through the  
32 question “Are you a member of any of the organizations, religious groups, clubs, or societies?”  
33 The response was coded as no and yes. Physical activity status was coded as frequent (every  
34 day), rare (more than once a week, once a week, one to three times in a month), and never.  
35 The question through which physical activity was assessed was “How often do you take part  
36 in sports or vigorous activities, such as running or jogging, swimming, going to a health  
37 centre or gym, cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work,  
38 fast bicycling, cycling with loads?” [24].  
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### *Health factors*

The probable major depression among the older adults with symptoms of dysphoria, calculated using the CIDI-SF (Short Form Composite International Diagnostic Interview) score of 3 or more. This scale estimates a probable psychiatric diagnosis of major depression and has been validated in field settings and widely used in population-based health surveys [24]. The lowest 10th percentile is used as a proxy measure for major depression among older adults. Self-rated health was coded as good which includes excellent, very good, and good whereas poor includes fair and poor [29]. Difficulty in ADL (Activities of Daily Living) was coded as no and yes. Activities of Daily Living (ADL) is a term used to refer to normal daily self-care activities (such as movement in bed, changing position from sitting to standing, feeding, bathing, dressing, grooming, personal hygiene, etc.) The ability or inability to perform ADLs is used to measure a person's functional status, especially in the case of people with disabilities and the ones in their older ages [27]. Difficulty in IADL (Instrumental Activities of Daily Living) was coded as no and yes. Activities of daily living that are not necessarily related to the fundamental functioning of a person, but they let an individual live independently in a community. These tasks are necessary for independent functioning in the community. Respondents were asked if they were having any difficulties that were expected to last more than three months, such as preparing a hot meal, shopping for groceries, making a telephone call, taking medications, doing work around the house or garden, managing money (such as paying bills and keeping track of expenses), and getting around or finding an address in unfamiliar places [30]. Morbidity was coded as no morbidity, 1 and 2+ [30].

### *Household factors*

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3 Religion was coded as Hindu, Muslim, Christian, and Others [31]. Caste was recoded as  
4 Scheduled Tribe, Scheduled Caste, Other Backward Class, and others [31]. The Scheduled  
5 Caste include “untouchables”; a group of the population that is socially segregated and  
6 financially/economically by their low status as per Hindu caste hierarchy. The Scheduled  
7 Tribes (STs) and Scheduled Castes (SCs) are among the most disadvantaged and  
8 discriminated socio-economic groups in India. The OBC is the group of people who were  
9 identified as “educationally, economically and socially backward”. The OBC’s are  
10 considered low in the traditional caste hierarchy but are not considered untouchables. The  
11 “other” caste category is identified as having higher social status [32]. Place of residence was  
12 coded as rural and urban. The regions of India were coded as North, Central, East, Northeast,  
13 West, and South [28].

### 29 ***Statistical analysis***

31  
32 Descriptive statistics along with cross-tabulation were presented in the present study. Chi  
33 square test was used to evaluate the significance level of differences in cognitive impairment  
34 for subjective and objective SES [33, 34]. Additionally, binary logistic regression analysis  
35 [35] was used to establish the association between the outcome variable (cognitive  
36 impairment) and socio-economic status.

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39 The binary logistic regression model is usually put into a more compact form as follows:

$$40 \text{Logit [P(Y = 1)]} = \beta_0 + \beta * X + \epsilon$$

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44 The parameter  $\beta_0$  estimates the log odds of cognitive impairment for the reference group,  
45 while  $\beta$  estimates the maximum likelihood, the differential log odds of cognitive impairment  
46 associated with a set of predictors X, as compared to the reference group, and  $\epsilon$  represents the  
47 residual in the model. Variance inflation factor (VIF) was generated in STATA 14 [36] to  
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3 check the multicollinearity and it was found that there was no evidence of multicollinearity in  
4 the variables used [37, 38].  
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8 Moreover, interaction effects [30, 39–42] were observed for subjective SES and objective  
9 SES with cognitive impairment among older adults in India. Model-1 (figure-1) represents  
10 the unadjusted effects whereas model-2 (figure-2) represents the adjusted effects. Model-3  
11 (figure-3) represents interaction effects which are adjusted for individual characteristics,  
12 health factors and household factors.  
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### 19 20 21 **Patient and Public Involvement**

22  
23 No patient involved  
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### 26 27 **Results**

28  
29 Table-1 represents socio-economic and demographic profile of older adults in India. It was  
30 found that about 41.7 per cent of older adults belong to low subjective SES and nearly seven  
31 per cent belong to higher subjective SES. Additionally, about 43.4 per cent of older adults  
32 belonged to low objective SES and about 35.6 percent belonged to higher objective SES.  
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37 About 26.4 per cent of older adults got retired and 30.8 per cent were currently working.  
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39 Nearly 36.2 per cent of older adults were widowed. Almost 5.7 per cent of older adults were  
40 living alone and 68.3 per cent were living with their children and spouse. Only 4.5 per cent of  
41 older adults reported they socially participate. Nearly, 69.3 per cent of older adults were  
42 never involved in any physical activity. About 8.7 per cent of older adults suffered from  
43 major depression. Nearly, 48.6 per cent of older adults reported poor self-rated health. About  
44 24.4 percent and 48.7 per cent of older adults reported difficulty in ADL and IADL.  
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55 [Insert table-1 here]  
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3 Figure-1 reveals percentage of older adults with cognitive impairment by their subjective and  
4 objective socio-economic status. It was found that lower the subjective (17.8 per cent) and  
5 objective SES (16.6 per cent) status of an older adults higher the percentage of cognitive  
6 impairment among them.  
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13 [Insert figure-1 here]  
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16 Figure-2 represents the plots for logistic regression estimates for cognitive impairment among  
17 older adults in India. In model-1 which is an unadjusted model it was found that the older  
18 adults who belonged to lower subjective SES had significantly higher odds for cognitive  
19 impairment [UOR: 3.83;  $p < 0.05$ ] in reference to older adults who belonged to higher  
20 subjective SES. Moreover, older adults who belonged to lower objective SES had 50%  
21 significantly higher likelihood to suffer from cognitive impairment [UOR: 1.50;  $P < 0.05$ ] in  
22 comparison to older adults who belonged to higher objective SES.  
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33 [Insert figure-2 here]  
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36 Similarly, in model-2 (figure-3) which is an adjusted model, it was revealed that the older  
37 adults who belonged to lower subjective SES had significantly higher odds for cognitive  
38 impairment [AOR: 2.04;  $p < 0.05$ ] in reference to older adults who belonged to higher  
39 subjective SES. Moreover, older adults who belonged to lower objective SES had 32%  
40 significantly higher likelihood to suffer from cognitive impairment [AOR: 1.32;  $p < 0.05$ ] in  
41 comparison to older adults who belonged to higher objective SES. The estimates for other  
42 covariates can be viewed in *supplementary file* (table-S1).  
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53 [Insert figure-3 here]  
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56 In model-3 (figure-4) which reveals the interaction results for cognitive impairment. It was  
57 found that older adults who belong to lower subjective as well as objective SES were 2.45  
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3 times significant more likely to suffer from cognitive impairment in reference to older adults  
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5 from higher subjective as well as objective SES [AOR: 2.45;  $p < 0.05$ ].  
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8 [Insert figure-4 here]  
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## 10 11 **Discussion**

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14 This study using a large representative information on older population in India was in  
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16 parallel to multiple earlier studies in India and other developing countries which found that  
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18 older individuals with higher SES experience cognitive impairment compared with people  
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20 with lower SES [1, 43–45]. This association has been identified in case of both objective and  
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22 subjective measures of SES. Moreover, studies have amassed empirical evidence on the  
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24 positive relationship between SES as measured by objective indices of material resources  
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26 along with subjective measures and psychological well-being [46, 47]. Similarly, the  
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28 interactive effect in our study found that older adults with lower levels of subjective and  
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30 objective SES were at greater risk of cognitive impairment.  
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35 However, subjective SES was identified to have a much stronger association with cognitive  
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37 impairment in the unadjusted and adjusted regression estimates in comparison to objective  
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39 SES. With respect to this strong association, there can be some possible explanations. At first,  
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41 obviously, subjective SES was more meaningful than household wealth index. Higher  
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43 economic status does not necessarily mean more available resources, if compared with higher  
44  
45 individual circumstances, but positive social comparison does. In addition, people with  
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47 greater household economic status may endure more pressures and mental stress, which in  
48  
49 turn may affect their mental health status and cognitive ability [48]. This could be mainly due  
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51 to the subjectivity character of subjective SES. This potential explanation can also be  
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53 attributed to different perceptions towards wealth and social statuses among older population  
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55 in India.  
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3 The finding underscores the need for further longitudinal investigation of subjective SES-  
4 related measurement strategies to obtain a better understanding of the SES-cognitive  
5 functioning link especially in poor resource settings. The effects of country affluence on  
6 population health have been demonstrated. Several cross-country comparisons have  
7 documented considerable variations in the strength of subjective SES-health relationship  
8 between affluent and low-income countries with a stronger association in the later ones [49,  
9 50].

10  
11  
12 There are several limitations of the present study to be considered. The major limitation is the  
13 cross-sectional design of the study eliminating the drawing of causal inferences among  
14 variables. Indeed, it is important to consider that some individuals may become cognitively  
15 impaired because they are illiterate and could not respond to several measures with accuracy.  
16 Finally, there may also be floor or ceiling effects for SES because we have only three  
17 categories for both SES measures. Notwithstanding these limitations, there were several  
18 advantages in this study. At first, this may be the first study to identify the association  
19 between both objective and subjective SES indicators and cognitive impairment based on a  
20 comprehensive measure with a score of 0 to 43 among the older Indian population. The large  
21 sample of the present study that is free from selection bias includes all SES groups of Indian  
22 population that credits to the representativeness and generalizability of the findings. Further,  
23 the findings of the present study provide empirical support to the body of literature that  
24 highlights the vulnerability of older adults who have low subjective and objective  
25 socioeconomic status to the worse mental health outcomes.

## 51 52 **Conclusion**

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55 In conclusion, the findings of the study highlight the importance of subjective SES measure  
56 in assessing mental health outcomes in developing countries. The results also suggest that  
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3 more attention should be placed on subjective SES indicators when investigating  
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5 socioeconomic influences on cognitive functioning among older adults in India.  
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3 **Abbreviations:**  
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5 **OSSES:** Objective socio-economic status  
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7 **SSES:** Subjective socio-economic status  
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9 **SES:** Socio-economic status  
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11 **AOR:** Adjusted odds ratio  
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13 **CI:** Confidence interval  
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15 **LASI:** Longitudinal Ageing Study in India  
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17 **PSUs:** Primary Sampling Units  
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19 **CEB:** Census Enumeration Block  
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21 **MPCE:** Monthly per capita expenditure  
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**Contributor statement**

Conceived and designed the research paper: SS, MT and TVS; analysed the data: SS and MT; Contributed agents/materials/analysis tools: SS; Wrote the manuscript: SS and MT; Refined the manuscript: SS, MT and TVS.

**Competing interest**

The authors declare that there is no competing interest

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**Data sharing statement**

The study uses a secondary data which is available on reasonable request through <https://www.iipsindia.ac.in/content/lasi-wave-i>

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**Table-1.** Socio-economic and demographic profile of older adults in India.

<b>Background characteristics</b>		<b>Sample</b>	<b>Percentage</b>
<b>Socio-economic status</b>			
<b>Subjective SES</b>			
	Low	13,127	41.7
	Medium	16,142	51.3
	High	2,195	7.0
<b>Objective SES</b>			
	Low	13,660	43.4
	Medium	6,590	21.0
	High	11,213	35.6
<b>Individual characteristics</b>			
<b>Age</b>			
	Young-old	18,410	58.5
	Old-old	9,501	30.2
	Oldest-old	3,553	11.3
<b>Sex</b>			
	Male	14,931	47.5
	Female	16,533	52.6
<b>Education</b>			
	Not educated/primary not completed	21,381	68.0
	Primary	3,520	11.2
	Secondary	4,371	13.9
	Higher	2,191	7.0
<b>Working status</b>			
	Working	9,680	30.8
	Retired	13,470	42.8
	Not working	8,314	26.4
<b>Marital status</b>			
	Currently married	19,391	61.6
	Widowed	11,389	36.2
	Others	684	2.2
<b>Living arrangement</b>			
	Living alone	1,787	5.7
	Living with spouse	6,397	20.3
	Living with children and spouse	21,475	68.3
	Living with others.	1,805	5.7
<b>Social participation</b>			
	No	30,053	95.5
	Yes	1,411	4.5
<b>Physical activity</b>			
	Frequent	5,651	18.0
	Rarely	4,023	12.8
	Never	21,790	69.3
<b>Health factors</b>			
<b>Depression*</b>			
	No	27,995	91.3
	Yes	2,657	8.7
<b>Self-rated health*</b>			
	Good	15,850	51.4

	Poor	14,961	48.6
<b>Difficulty in ADL</b>	No	23,802	75.7
	Yes	7,662	24.4
<b>Difficulty in IADL</b>	No	16,130	51.3
	Yes	15,334	48.7
<b>Morbidity</b>	No morbidity	14,773	47.0
	1	9,171	29.2
	2+	7,520	23.9
<b>Household factors</b>			
<b>Religion</b>	Hindu	25,871	82.2
	Muslim	3,548	11.3
	Christian	900	2.9
	Others	1,145	3.6
<b>Caste</b>	Scheduled Caste	5,949	18.9
	Scheduled Tribe	2,556	8.1
	Other Backward Class	14,231	45.2
	Others	8,729	27.7
<b>Place of residence</b>	Rural	22,196	70.6
	Urban	9,268	29.5
<b>Region</b>	North	3,960	12.6
	Central	6,593	21.0
	East	7,439	23.6
	Northeast	935	3.0
	West	5,401	17.2
	South	7,136	22.7
<b>Total</b>		31,464	100.0
<i>*if Sample may be less due to missing cases.</i>			

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3 **Figure-1.** Percentage of older adults with cognitive impairment by their subjective and  
4 objective socio-economic status.  
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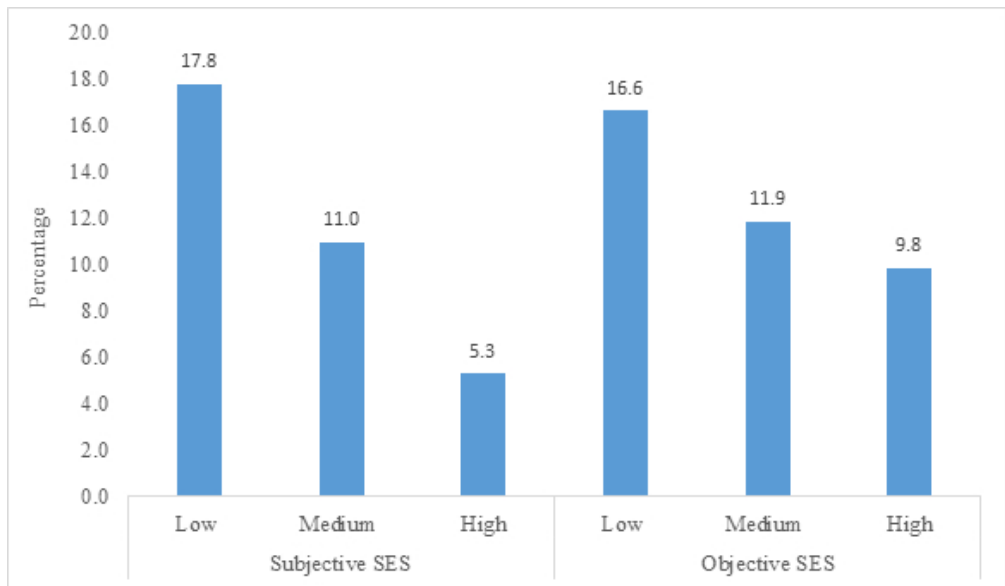
6 **Figure-2.** Plots for logistic regression estimates (unadjusted) for cognitive impairment among  
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9 **Figure-3.** Plots for logistic regression estimates (adjusted) for cognitive impairment among  
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12 **Figure-3.** Plots for logistic regression estimates (interaction effects) for cognitive impairment  
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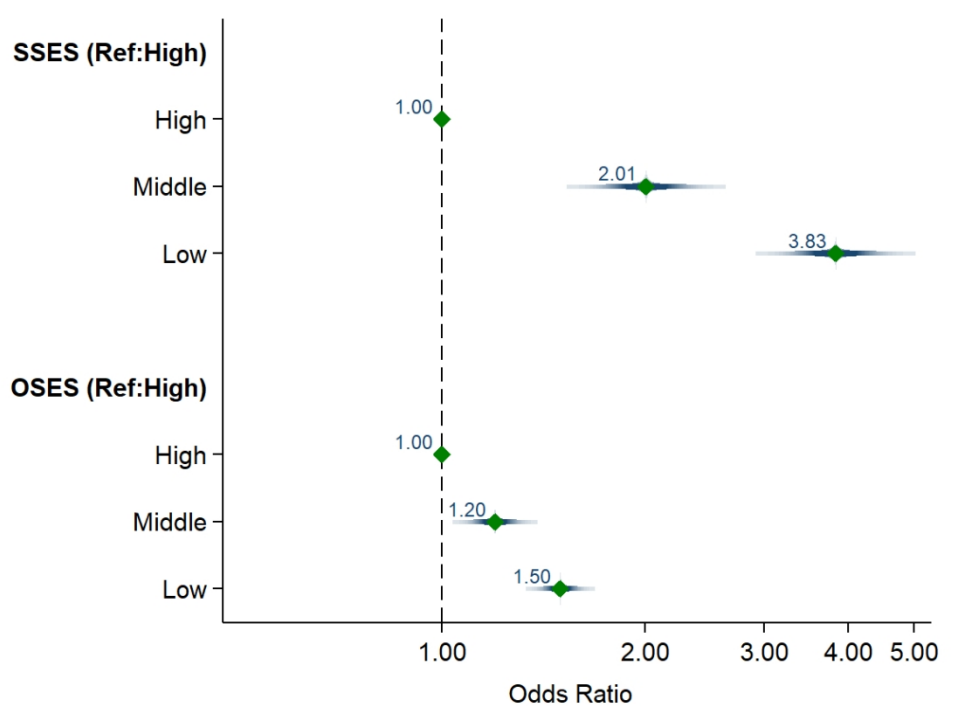
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Percentage of older adults with cognitive impairment by their subjective and objective socio-economic status.

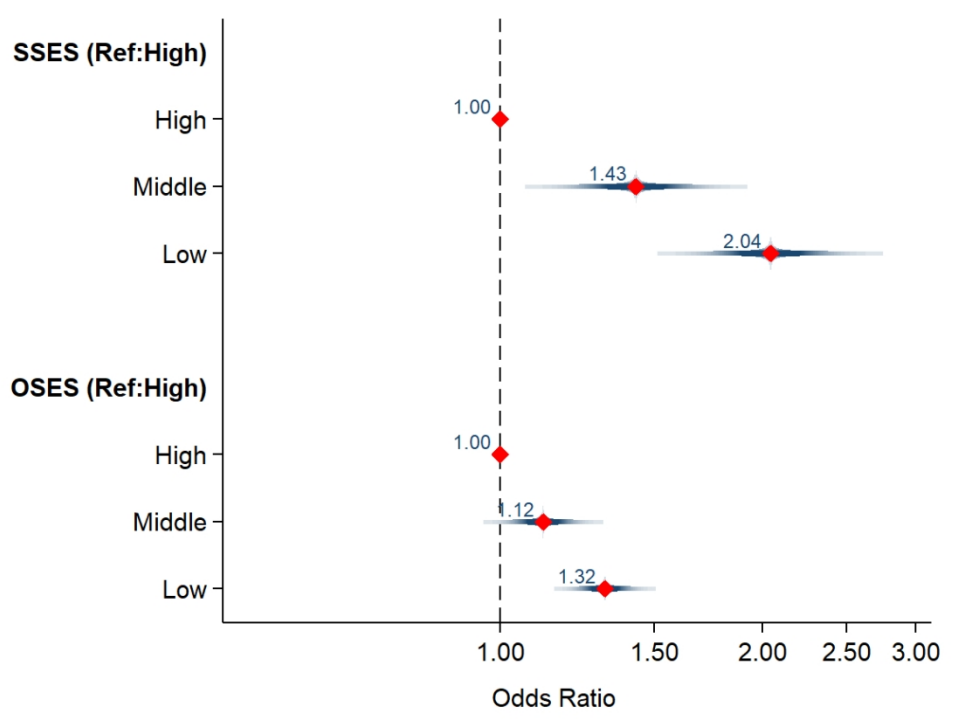
102x80mm (144 x 144 DPI)



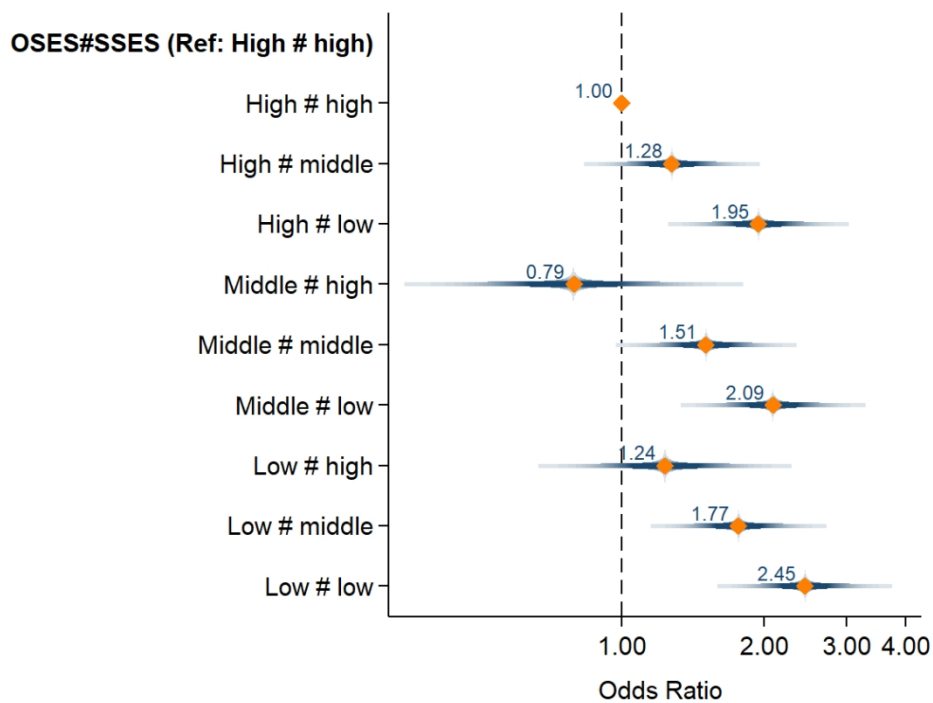
Plots for logistic regression estimates (unadjusted) for cognitive impairment among older adults in India

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Plots for logistic regression estimates (adjusted) for cognitive impairment among older adults in India  
423x308mm (72 x 72 DPI)



Plots for logistic regression estimates (interaction effects) for cognitive impairment among older adults in India

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## Supplementary material

**Table-S1.** Logistic regression estimates for cognitive impairment among older adults in India, 2017-18

Background characteristics	Model-1	Model-2	Model-3
	UOR (95% CI)	AOR (95% CI)	AOR (95% CI)
<b>Socio-economic status</b>			
<b>Subjective SES</b>			
High	Ref.	Ref.	
Medium	2.01*(1.63,2.47)	1.43*(1.14,1.79)	
Low	3.83*(3.11,4.71)	2.04*(1.63,2.56)	
<b>Objective SES</b>			
High	Ref.	Ref.	
Medium	1.20*(1.07,1.34)	1.12(0.99,1.26)	
Low	1.50*(1.37,1.64)	1.32*(1.19,1.46)	
<b>Subjective SES # Objective SES</b>			
High # high			Ref.
High # middle			1.28(0.92,1.77)
High # low			1.95*(1.39,2.72)
Middle # high			0.79(0.42,1.48)
Middle # middle			1.51*(1.08,2.11)
Middle # low			2.09*(1.49,2.95)
Low # high			1.24(0.77,1.98)
Low # middle			1.77*(1.28,2.45)
Low # low			2.45*(1.77,3.39)
<b>Individual characteristics</b>			
<b>Age</b>			
Young-old		Ref.	Ref.
Old-old		1.61*(1.46,1.78)	1.61*(1.46,1.78)
Oldest-old		2.95*(2.58,3.37)	2.95*(2.58,3.37)
<b>Sex</b>			
Male		Ref.	Ref.
Female		2.1*(1.88,2.34)	2.1*(1.88,2.34)
<b>Education</b>			
Not educated/primary not completed		22.4*(10.58,47.41)	22.4*(10.58,47.41)
Primary		3.83*(1.75,8.36)	3.83*(1.75,8.36)
Secondary		1.94(0.86,4.38)	1.94(0.86,4.38)
Higher		Ref.	Ref.
<b>Working status</b>			
Working		Ref.	Ref.
Retired		1.17*(1.03,1.33)	1.17*(1.03,1.33)
Not working		1.34*(1.17,1.54)	1.34*(1.17,1.54)
<b>Marital status</b>			
Currently married		Ref.	Ref.
Widowed		1.37*(1.23,1.53)	1.37*(1.23,1.53)
Others		1.34*(1.01,1.79)	1.34*(1.01,1.79)
<b>Living arrangement</b>			
Living alone		Ref.	Ref.
Living with spouse		1.18(0.95,1.46)	1.18(0.95,1.46)
Living with children and spouse		1.04(0.87,1.24)	1.04(0.87,1.24)
Living with others.		1.29*(1.03,1.61)	1.29*(1.03,1.61)
<b>Social participation</b>			
No		1.65*(1.3,2.09)	1.65*(1.3,2.09)

	Yes	Ref.	Ref.
<b>Physical activity</b>			
	Frequent	Ref.	Ref.
	Rarely	1.06(0.89,1.26)	1.06(0.89,1.26)
	Never	1.35*(1.17,1.55)	1.35*(1.17,1.55)
<b>Health factors</b>			
<b>Depression</b>			
	No	Ref.	Ref.
	Yes	1.09(0.93,1.27)	1.09(0.93,1.27)
<b>Self-rated health</b>			
	Good	Ref.	Ref.
	Poor	1.27*(1.16,1.39)	1.27*(1.16,1.39)
<b>Difficulty in ADL</b>			
	No	Ref.	Ref.
	Yes	1.41*(1.26,1.56)	1.41*(1.26,1.56)
<b>Difficulty in IADL</b>			
	No	Ref.	Ref.
	Yes	1.37*(1.24,1.5)	1.37*(1.24,1.5)
<b>Morbidity</b>			
	No morbidity	Ref.	Ref.
	1	0.81*(0.74,0.9)	0.81*(0.74,0.9)
	2+	0.73*(0.65,0.82)	0.73*(0.65,0.82)
<b>Household factors</b>			
<b>Religion</b>			
	Hindu	Ref.	Ref.
	Muslim	1.02(0.89,1.17)	1.02(0.89,1.17)
	Christian	0.97(0.81,1.17)	0.97(0.81,1.17)
	Others	0.83(0.68,1.02)	0.83(0.68,1.02)
<b>Caste</b>			
	Scheduled Caste	Ref.	Ref.
	Scheduled Tribe	1.48*(1.28,1.73)	1.48*(1.28,1.73)
	Other Backward Class	0.81*(0.72,0.91)	0.81*(0.72,0.91)
	Others	0.82*(0.72,0.94)	0.82*(0.72,0.94)
<b>Place of residence</b>			
	Rural	Ref.	Ref.
	Urban	0.54*(0.48,0.6)	0.54*(0.48,0.6)
<b>Region</b>			
	North	Ref.	Ref.
	Central	0.81*(0.7,0.95)	0.81*(0.7,0.95)
	East	0.86*(0.75,1)	0.86*(0.75,1)
	Northeast	1.07(0.89,1.28)	1.07(0.89,1.28)
	West	1.26*(1.08,1.49)	1.26*(1.08,1.49)
	South	0.87(0.75,1.01)	0.87(0.75,1.01)

#: Interaction; Ref: Reference; UOR: Unadjusted Odds Ratio; AOR: Adjusted Odds Ratio; CI: Confidence Interval; SES: Socio-economic status; Model-2 and Model-3 were adjusted for Individual, Health and Household factors

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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
<b>Title and abstract</b>	1	Yes
<b>Introduction</b>		
Background/rationale	2	Yes
Objectives	3	Yes
<b>Methods</b>		
Study design	4	Yes
Setting	5	Yes
Participants	6	Yes
Variables	7	Yes
Data sources/ measurement	8*	Yes
Bias	9	Yes
Study size	10	Yes
Quantitative variables	11	Yes
Statistical methods	12	Yes
<b>Results</b>		
Participants	13*	Yes
Descriptive data	14*	Yes
Outcome data	15*	Yes
Main results	16	Yes
Other analyses	17	Yes
<b>Discussion</b>		
Key results	18	Yes
Limitations	19	Yes
Interpretation	20	Yes
Generalisability	21	Yes
<b>Other information</b>		
Funding	22	Yes

\*Give information separately for exposed and unexposed groups.

# BMJ Open

## Association of objective and subjective socioeconomic markers with cognitive impairment among older adults: cross-sectional evidence from a developing country

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3 **Association of objective and subjective socioeconomic markers with cognitive**  
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5 **impairment among older adults: cross-sectional evidence from a developing country**  
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## Abstract

**Objective:** The present study explored how various markers of objective and subjective socio-economic status (SES) are associated with cognitive impairment among older Indian adults.

**Design:** A cross-sectional study was conducted using a large representative survey data.

**Setting and participant:** The present study uses data from the Longitudinal Aging Study in India (2017-18). The total sample size was 31,464 older adults aged 60 years and above.

**Primary and secondary outcome measures:** The outcome variable was cognitive impairment measured through five broad domains (memory, orientation, arithmetic function, executive function, and object naming). Descriptive statistics and cross-tabulations were presented. Chi square test was used to evaluate the significance level of differences in cognitive impairment by subjective (ladder) and objective SES measures (monthly per-capita consumption expenditure (MPCE) quintile, education and caste status). Additionally, multivariable linear and logistic regression analyses were conducted to fulfil the objectives.

## Results

About 41.7% and 43.4% of older adults belonged to low subjective (ladder) and objective (MPCE) SES respectively. Older adults with lower subjective SES [aOR: 2.04;  $p < 0.05$ ] and objective SES (measured by MPCE quintile) [aOR: 1.32;  $p < 0.05$ ] had significantly higher odds of having cognitive impairment in comparison to their counterparts, with a stronger subjective SES-cognitive impairment association. Older adults with lower education or belonged to lower caste hierarchy had higher odds of cognitive impairment than their counterparts. Further interaction analyses revealed that older adults who belonged to lower subjective as well as objective (poorest MPCE quintile, Scheduled Castes and lowest education) SES had 2.45 (CI: 1.77, 3.39), 4.56 (CI: 2.97, 6.98) and 54.41 (CI: 7.61, 388.93)

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3 significantly higher odds of cognitive impairment compared to older adults from higher  
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5 subjective as well as objective SES.  
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## 8 **Conclusion**

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11 The findings suggest that more attention should be placed on subjective SES indicators when  
12  
13 investigating the socioeconomic influences on the cognitive functioning among older adults.  
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16 **Keywords:** *Subjective; Objective; Socioeconomic status; Cognitive impairment; Older adults,*  
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18 *India*  
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**Strengths and limitations:**

- The study utilizes a large nationally representative sample of older persons from both rural and urban areas of India
- The major limitation is the cross-sectional design of the study eliminating the opportunity for drawing of causal inferences among variables.
- It is important to consider that some individuals may become cognitively impaired because they are illiterate and could not respond with accuracy to several measures

For peer review only

## Introduction

Cognitive impairment, including dementia as an outcome of decline in cognitive ability, increases considerably with the rapidly growing population of older adults [1]. Worldwide, almost 80% of the general public are concerned about developing dementia at some point in time and 1 in 4 people think that they can do nothing to prevent such a cognitive decline [2].

Various indices of economic hardship, including lack of education, poor household economy, unemployment, and employment frustration, are linked with poor physical health conditions resulting in cognitive deficits [3–5]. Similarly, evidence suggests an aggregate or cumulative effect of socio-economic risk factors on cognitive impairment in later years of life [6–8]. Persons with higher cumulative socioeconomic status (SES) demonstrated an advantage in cognitive functioning [9]. A growing body of literature suggests that people who accumulated more wealth may be able to more easily translate it into better environmental circumstances or less stressful living conditions, further contributing to better cognitive health in later life [7, 10, 11]. Studies reported improvements in mental well-being for older people after the introduction of an income supplemental program [12, 13]. Measured by a test of processing speed, associations of educational attainment and current poverty index were found with late-life cognitive impairment in multiple studies [7, 14, 15]. Furthermore, a major contributing factor may include poor literacy resulting in an inability to benefit from strategies for early prevention of cognitive impairment [16].

### *Two Approaches to SES: Subjective and objective SES measures*

Objective SES is commonly indicated by household wealth index and individual educational attainment, and caste status in particular Indian context [17–19]. Although these indicators are highly correlated [20], they reflect more of one's power or prestige [21]. In

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3 comparison, the subjective SES captures individuals' perceptions of their position in the  
4 social hierarchy, thus representing a psychological process [22].  
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8 In this regard, people make judgments of where they belong in the social hierarchy relative to  
9 others based on cognitive averaging of their economic status, education, occupation, and  
10 other objective indicators using different reference groups [23]. There is a growing body of  
11 research documenting that if people perceive themselves to be subordinate to others, they  
12 report lower self-esteem and greater stress, and they are likely to suffer from diseases more  
13 often than people who do not regard themselves to be of lower status [24]. Hence, subjective  
14 SES as a rank-based judgment that is composed of an evaluative judgment whereas the  
15 objective resources would place a person in rank within a specific context, which is derived  
16 mainly via the social comparison process.  
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30 Evidence for the association between poor socioeconomic indicators with worse mental  
31 health outcomes is abundant in the geriatric research. Many previous studies in India and  
32 other countries have reinforced that illiteracy, lower social status and poor financial status  
33 were strongly associated with worse cognitive function at the individual level [1, 25, 26].  
34 Similarly, the association of subjective SES and physical and mental health of older adults is  
35 explored in a couple of studies in Asian countries [27, 28]. However, the difference in the  
36 role that subjective and objective socioeconomic factors play in contributing to declining in  
37 late life cognition is poorly understood in the context of developing countries. Therefore, in  
38 this study, we aim to explore the late-life cognitive impairment as a function of older  
39 individuals' objective and subjective SES using a large representative survey information of  
40 older adults aged 60 and above in India. A conceptual framework based on the  
41 abovementioned theoretical background is summarised in Figure-1.  
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## 58 **Data, Variables, and Methods**

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## Data Source

Data for this study was utilized from the recent release of Longitudinal Ageing Study in India (LASI) wave 1 [29]. LASI is a full-scale national survey of scientific investigation of the health, economic, and social determinants and consequences of population aging in India, conducted in 2017-18. The LASI is a nationally representative survey of over 72000 older adults aged 45 and above across all states and union territories of India. The survey adopted a three-stage sampling design in rural areas and a four-stage sampling design in urban areas. In each state/UT, the first stage involved the selection of Primary Sampling Units (PSUs), that is, sub-districts (Tehsils/Talukas), and the second stage involved the selection of villages in rural areas and wards in urban areas in the selected PSUs [29]. In rural areas, households were selected from selected villages in the third stage. However, sampling in urban areas involved an additional stage. Specifically, in the third stage, one Census Enumeration Block (CEB) was randomly selected in each urban area [29]. In the fourth stage, households were selected from this CEB. The detailed methodology, with the complete information on the survey design and data collection is published elsewhere and in the survey report [29, 30]. The present study is conducted on eligible respondents aged 60 years and above (31,464 older individuals from both rural and urban areas).

## *Variable description*

### *Outcome variable*

Cognitive impairment was measured through five broad domains (memory, orientation, arithmetic function, executive function, and object naming). It is followed from the cognitive module of the Health and Retirement Study (HRS), based on different cognitive measures including: immediate (0–10 points) and delayed word recall (0–10 points); orientation related to time (0-4 points), and place (0-4 points); arithmetic ability based on serial 7s (0–5 points),

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3 computation (0-2) and backward counting from 20 (0–2 points); executive functioning based  
4 on paper folding (0-3) pentagon drawing (0-1); and object naming (0-2). The overall score  
5 ranged between 0 and 43, and a higher score indicated better cognitive functioning. The  
6 lowest 10th percentile is used as a proxy measure of poor cognitive functioning [29]. Further,  
7 for the analytical purpose, the score was reversed to assess the cognitive impairment among  
8 older adults and thus after reversing, the higher score indicated higher levels of cognitive  
9 impairment. In our study, the respondents who received assistance during the cognition  
10 module were excluded from the analysis.  
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### 22 ***SES exposures***

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25 The main explanatory variables were subjective SES (ladder SES) and objective SES  
26 (household MPCE quintile, education and caste) among older adults.  
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30 The subjective SES was assessed using the Macarthur scale [31], with a ladder technique and  
31 the question used to assess the variable was “Think of the ladder with 10 stairs as  
32 representing where people stand in our society. At the top of the ladder are the people who  
33 are the best off – those who have the most money, most education, and best jobs. At the  
34 bottom are the people who are the worst off – who have the least money, least education, and  
35 the worst jobs or no jobs. The higher up you are on this ladder, the closer you are to the  
36 people at the very top and the lower you are, the closer you are to the people at the very  
37 bottom of your society”. The scale is used to measure the subjective SES across different  
38 populations in India and other countries [32, 33]. A score of 0-10 was generated as per the  
39 number of rungs marked by the respondents and the variable of subjective SES was coded as  
40 0-3 as “low”, 4-7 as “middle” and 8-10 as “high” [34].  
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56 The monthly per capita consumption expenditure (MPCE) quintile was assessed using  
57 household consumption data. The MPCE was used as one of the measures of objective SES.  
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3 Sets of 11 and 29 questions on the expenditures on food and non-food items, respectively,  
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5 were used to canvas the consumption pattern of the sample households. Food expenditure  
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7 was collected based on a reference period of seven days, and non-food expenditure was  
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9 collected based on reference periods of 30 days and 365 days. Food and non-food  
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11 expenditures have been standardized to the 30-day reference period. The MPCE is computed  
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13 and used as the summary measure of consumption [29]. The variable was then divided into  
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15 five quintiles i.e., from poorest to richest. The variable was coded as low which includes  
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17 poorest and poorer, middle which includes middle and high which includes richer and richest  
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19 [35]. Another objective SES measure was educational status of older adults. As documented  
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21 in multiple studies, brain functioning and cognitive processing are modulated by formal  
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23 education of individuals and the illiterate population who received no formal education due to  
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25 several socio-cultural and economic reasons are at greater risk for cognitive impairment and  
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27 dementias [36]. The educational status in the current study was coded as no  
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29 education/primary not completed, primary, secondary and higher. Finally, caste system in  
30  
31 India is a social hierarchy that is passed down through families and groups of people dictate  
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33 the professions and social prestige merely by their caste status [19]. As an objective SES  
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35 measure, caste in the study was recoded as Scheduled Tribes, Scheduled Castes, Other  
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37 Backward Classes, and others based on specific administrative classification [19]. The  
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39 Scheduled Caste includes “untouchables”; a group of the population that is socially  
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41 segregated and financially/economically marginalized by their low status as per Hindu caste  
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43 hierarchy. The Scheduled Tribes (STs) and Scheduled Castes (SCs) are among the most  
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45 disadvantaged and discriminated socio-economic groups in India [37]. The OBC is the group  
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47 of people who were identified as “educationally, economically and socially backward”. The  
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49 OBCs are considered low in the traditional caste hierarchy but are not considered  
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3 untouchables. The “other” caste category is identified as having higher social status and  
4 refers to many of the forward/upper castes in the country [38].  
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### 8 ***Other covariates***

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11 *Individual factors:* Age was used as continuous variable. Sex was coded as male and female.  
12 Working status was coded as currently working, retired, and not working. Marital status was  
13 coded as currently married, widowed and others. Others included divorced/separated/never  
14 married. Living arrangement was coded as living alone, living with spouse, living with  
15 spouse and children and living with others [39]. Social participation was coded as ‘no’ and  
16 ‘yes’. Social participation was measured through the question “Are you a member of any of  
17 the organizations, religious groups, clubs, or societies?” The response was coded as ‘no’ and  
18 ‘yes’. Physical activity status was coded as frequent (every day), rare (more than once a  
19 week, once a week, one to three times in a month), and never. The question through which  
20 physical activity was assessed was “How often do you take part in sports or vigorous  
21 activities, such as running or jogging, swimming, going to a health centre or gym, cycling, or  
22 digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling  
23 with loads”? [29].  
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42 *Health factors:* The probable major depression among the older adults with symptoms of  
43 dysphoria, calculated using the CIDI-SF (Short Form Composite International Diagnostic  
44 Interview) score of 3 or more. This scale estimates a probable psychiatric diagnosis of major  
45 depression and has been validated in field settings and widely used in population-based  
46 health surveys [29]. The lowest 10th percentile is used as a proxy measure for major  
47 depression among older adults. Self-rated health was coded excellent, very good, good, fair  
48 and poor [40]. Difficulty in ADL (Activities of Daily Living) was coded as ‘no’ and ‘yes’.  
49 Activities of Daily Living (ADL) is a term used to refer to normal daily self-care activities  
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(such as movement in bed, changing position from sitting to standing, feeding, bathing, dressing, grooming, personal hygiene, etc.) The ability or inability to perform ADLs is used to measure a person's functional status, especially in the case of people with disabilities and the ones in their older ages [41]. Difficulty in IADL (Instrumental Activities of Daily Living) was coded as 'no' and 'yes'. Activities of daily living that are not necessarily related to the fundamental functioning of a person, but they let an individual live independently in a community, by undertaking certain tasks. Respondents were asked if they were having any difficulties that were expected to last more than three months, such as preparing a hot meal, shopping for groceries, making a telephone call, taking medications, doing work around the house or garden, managing money (such as paying bills and keeping track of expenses), and getting around or finding an address in unfamiliar places [40]. Morbidity was coded as no morbidity, 1 and 2+ [40]. The variable morbidity was created using the data on chronic diseases which include hypertension, chronic heart diseases, stroke, any chronic lung disease, diabetes, cancer or malignant tumor, any bone/joint disease, neurological/psychiatric disease, or high cholesterol.

*Household factors:* Religion was coded as Hindu, Muslim, Christian, and Others. Place of residence was coded as rural and urban. The geographical regions of India were categorized as North, Central, East, Northeast, West, and South.

### ***Statistical analysis***

Descriptive statistics along with cross-tabulation were presented in the study. Additionally, binary logistic and linear regression analysis [42, 43] were used to establish the association between the outcome variable (cognitive impairment) and socio-economic status. The results were presented in the form of odds ratio (OR) and standardized regression coefficients (beta) with 95% confidence interval (CI). Variance inflation factor (VIF) was generated in STATA



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3 14 [44] to check the multicollinearity and it was found that there was no evidence of  
4 multicollinearity in the variables used [45, 46].  
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8 Moreover, interaction effects [40, 47] were observed for subjective SES and multiple  
9 objective SES measures with cognitive impairment among older adults in India. Model-1  
10 represents the unadjusted effects whereas model-2 represents the adjusted effects. The  
11 analysis was controlled for age, sex, working status, marital status, living arrangement, social  
12 participation, physical activity, depression, self-rated health, difficulty in ADL and IADL,  
13 morbidity, religion, place of residence and regions. Models-3, 4 and 5 represent interaction  
14 effects which are adjusted for individual characteristics, health factors and household factors.  
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## 25 **Patient and Public Involvement**

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28 No patient involved  
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## 30 **Results**

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33 Table-1 represents socio-economic and demographic profile of Indian older adults included  
34 in this study. The mean age of the study population was 69.2 years (standard deviation: 7.5).  
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36 It was found that about 41.7 per cent of older adults belong to low subjective SES and only  
37 seven per cent belong to higher subjective SES. Additionally, about 43.4 per cent of older  
38 adults belonged to low objective SES and about 35.6 percent belonged to higher objective  
39 SES. About 13.1% (n=3250) older adults were cognitively impaired in reference to 86.9%  
40 (n=21580) who were not cognitively impaired.  
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50 About 26.4 per cent of older adults got retired from employment and 30.8 per cent were  
51 currently working. Nearly 36.2 per cent of older adults were widowed. Only 5.7 per cent of  
52 older adults were living alone and 68.3 per cent were living with their children and spouse.  
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54 Only 4.5 per cent of older adults reported that they socially participate. Nearly, 69.3 per cent  
55 of older adults were never involved in any physical activity. About 8.7 per cent of older  
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3 adults suffered from major depression. Nearly, 15.0 per cent of older adults reported poor  
4 self-rated health. About 24.4 percent and 48.7 per cent of older adults reported difficulty in  
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6 ADL and IADL.  
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11 [Insert table-1 here]  
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14 Figure-2 presents the percentage distribution of subjective SES (ladder SES) that ranges from  
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16 1 to 10, representing lowest to highest rank. A proportion of 8.2% of older adults marked  
17 their SES in the bottom of the ladder (lowest), whereas, a proportion of only 1.1% marked  
18 their SES at the top of the ladder (highest).  
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23 [Insert figure-2 here]  
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26 Figure-3 reveals that lower the subjective SES (17.8 per cent;  $p < 0.001$ ) of an older adult,  
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28 higher the prevalence of cognitive impairment.  
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32 [Insert figure-3 here]  
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35 Figure-4 reveals that lower the objective SES (measured by MPCE quintile) (16.6 per cent;  
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37  $p < 0.001$ ) of an older adult, higher the prevalence of cognitive impairment. With regard to  
38 other objective SES measures, older adults with no education/primary not completed had  
39 highest prevalence of cognitive impairment (19.9%;  $p < 0.001$ ). Similarly, older adults from  
40 Scheduled Tribe category had highest prevalence of cognitive impairment (22.1%;  $p < 0.001$ ).  
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47 [Insert figure-4 here]  
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50 Table-2a represents the logistic regression estimates of cognitive impairment among older  
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52 adults. In model-2 which is adjusted model, it was revealed that older adults who belonged to  
53 lower subjective SES had significantly higher odds of cognitive impairment [aOR: 2.04;  
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55  $p < 0.05$ ] in reference to older adults who belonged to higher subjective SES. Moreover, older  
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57 adults who belonged to lower objective SES (MPCE quintile) had 32% significantly higher  
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3 odds of suffering from cognitive impairment [aOR: 1.32; p<0.05] in comparison to older  
4 adults who belonged to higher objective SES (MPCE quintile). Older adults who were not  
5 educated/ with minimum education had significantly higher odds of cognitive  
6 impairment in reference to older adults with higher education [aOR: 22.4; p<0.05]. Older  
7 adults who belonged to the Scheduled Castes and Scheduled Tribes had 22% [aOR: 1.22;  
8 p<0.05] and 80% [aOR: 1.80; p<0.05] significantly higher odds of cognitive impairment in  
9 reference to older adults from other (higher) caste category, respectively.  
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20 [Insert Table-2a]  
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23 In model-3, 4 and 5 (Table-2b) which reveals the interaction results for cognitive impairment.  
24 It was found that older adults who belong to lower subjective as well as objective SES were  
25 2.45 times significant more likely to suffer from cognitive impairment in reference to older  
26 adults from higher subjective as well as objective SES (MPCE quintile) [aOR: 2.45; p<0.05].  
27 In reference to older adults with high ladder SES and higher education, older adults with high  
28 ladder SES and no education/primary not completed [aOR: 24.14; p<0.05], middle ladder  
29 SES and no education/primary not completed [aOR: 37.07; p<0.05] and low ladder SES and  
30 no education/primary not completed [aOR: 54.41; p<0.05] had significantly higher odds for  
31 cognitive impairment. Older adults from low ladder SES and belonged to the Scheduled  
32 Castes [aOR: 2.88; p<0.05], low ladder SES and belonged to the Scheduled Tribes [aOR:  
33 4.56; p<0.05] and low ladder SES and belonged to the Other Backward Classes [aOR: 2.15;  
34 p<0,05] had significantly higher odds of cognitive impairment in reference to older adults  
35 from high ladder SES and other (higher) caste category.  
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52 [Insert Table-2b]  
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## 56 Discussion 57 58 59 60

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3 This study using a large representative data on older population in India was in parallel to  
4 multiple earlier studies in India and other developing countries which found that older  
5 individuals with lower SES experience cognitive impairment compared with people with  
6 higher SES [1, 48–50]. This association has been identified in case of both objective and  
7 subjective measures of SES. Studies have illustrated empirical evidence on the positive  
8 relationship between SES as measured by objective indices of material resources and  
9 subjective measures, and psychological well-being [51, 52]. Similarly, the interactive effect  
10 in our study found that older adults with lower levels of subjective and objective SES were at  
11 a greater risk of having cognitive impairment.  
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24 However, subjective SES was identified to have a much stronger association with cognitive  
25 impairment in the unadjusted and adjusted regression estimates in comparison to objective  
26 SES measured by household MPCE quintile. With respect to this strong association, there can  
27 be some possible explanations. At first, obviously, subjective SES was more meaningful than  
28 household wealth index. Higher economic status does not necessarily mean more resources at  
29 disposal, if compared with higher individual circumstances, but positive social comparison  
30 does. In addition, people with greater household economic status may endure more pressures  
31 and mental stress, which in turn may affect their mental health status and cognitive ability  
32 [53]. This could be mainly due to the subjectivity character of subjective SES. This potential  
33 explanation can also be attributed to different perceptions towards wealth and social status  
34 among older population in India.  
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50 Furthermore, considering the education-cognitive function association, the current findings  
51 suggest that higher education is a protective factor against cognitive impairment in older  
52 individuals. A hypothesized mechanism is that education is transformed to personal  
53 experience and self-perceptions about own social standing, which in turn translate into health  
54 and disease. Similarly, the current findings suggest that older adults with no education and  
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3 low levels of subjective SES had greater odds of cognitive impairment compared to those  
4 with higher education and higher subjective SES. This finding agrees with the previous  
5 evidence on the moderating role of education in the relationship between subjective SES and  
6 cognitive function. Also, as documented in earlier research [22], subjective SES is a means  
7 through which education may influence health outcomes among older people. Nevertheless,  
8 proper path analysis using longitudinal data and conducting moderation as well as mediation  
9 analyses is needed to test these claims.

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12 Finally, older adults belonging to the lower caste groups (with low social status) were found  
13 to be more likely to be cognitively impaired in the study in comparison to those belong to  
14 higher castes. Importantly, in a previous study, it was observed that indicators of subjective  
15 SES differ across socio-demographic groups including race, and interpretations may vary  
16 when perceiving themselves on the existing social hierarchy [24]. Previous studies in India  
17 have demonstrated that the socioeconomic disadvantages such as lower income and lack of  
18 education were associated with belonging to lower castes (scheduled tribes and other  
19 backward classes) [18, 19, 54, 55]. Further, lower caste status being a factor of less  
20 opportunities in economic spectrum also contributes to poorer health, health inequalities and  
21 mortality burden in India [17, 38, 56]. It is however demonstrated that since individuals may  
22 estimate their SES relative to others in a specific community or social group, the social  
23 disadvantage may not necessarily negatively influence their mental wellbeing [51]. This  
24 suggests that the SES could be better captured by assessing the interactions between  
25 subjective and objective measures of SES.

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28 The current study provides crucial clues about what measure of SES highly reflect on the  
29 mental health in old age by underlining the importance of the cumulative dimension of  
30 subjective SES and different traditional measures including wealth status, education and  
31 caste, and showing the underperformance of traditional measure of wealth status compared to

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3 subjective SES. Considering the current findings and the existing evidence [51], separate  
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5 SES-related ladders that evaluate subjective perceptions of individuals' economic status  
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7 (MPCE), education and social status (caste hierarchy in Indian context) may be suggested in  
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9 wellbeing research. This is because subjective SES may reflect individuals' present social  
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11 circumstances and an assessment of their past experiences and future prospects. As suggested  
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13 in previous studies, subjective perception of one's SES might also encompass his/her  
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15 household resources, life chances and opportunities, and thus captures a broad range of  
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17 aspects of social stratification than traditional measures of SES do [23, 31, 57]. The finding  
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19 further underscores the need for future longitudinal investigation of subjective SES-related  
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21 measurement strategies to obtain a better understanding of the SES-cognitive functioning link  
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23 especially in poor resource settings. The effects of country affluence on population health  
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25 have been demonstrated. Several cross-country comparisons have documented considerable  
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27 variations in the strength of subjective SES-health relationship between affluent and low-  
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29 income countries with a stronger association in the later ones [58, 59].  
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36 There are several limitations of the present study to be considered. The major limitation is the  
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38 cross-sectional design of the study eliminating the opportunity for drawing of causal  
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40 inferences among variables. Indeed, it is important to consider that some individuals may  
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42 become cognitively impaired because they are illiterate and could not respond to several  
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44 measures with accuracy. Finally, there may also be floor or ceiling effects for SES because  
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46 we have only three categories for both SES measures. Notwithstanding these limitations,  
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48 there were several advantages in this study. At first, this may be the first study to identify the  
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50 association between both objective and subjective SES indicators and cognitive impairment  
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52 based on a comprehensive measure with a score of 0 to 43 among the older Indian  
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54 population. The large sample of the present study that is free from selection bias includes all  
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56 SES groups of Indian population that credits to the representativeness and generalizability of  
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3 the findings. In addition to including multiple SES groups, this study also includes  
4 participants living both in rural and urban areas which enhance the generalizability of the  
5 results. Further, the findings of the present study provide empirical support to the body of  
6 literature that highlights the vulnerability of older adults who have low subjective and  
7 objective SES to the worse mental health outcomes. Finally, future research may focus on  
8 longitudinal associations of various socioeconomic markers with mental health outcomes  
9 among middle aged and older adults in India.

## 10 11 12 13 14 15 16 17 18 19 20 **Conclusion**

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23 In conclusion, the findings of the study highlight the importance of subjective SES measure  
24 and its interaction with objective (traditional) measures of SES including wealth, education  
25 and caste status in assessing the mental health outcomes in developing countries. The results  
26 also suggest that more attention should be placed on subjective SES indicators when  
27 investigating socioeconomic influences on cognitive functioning among older adults in India.  
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3 **Abbreviations:**  
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5 **OSES:** Objective socio-economic status  
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7 **SSES:** Subjective socio-economic status  
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9 **SES:** Socio-economic status  
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11 **aOR:** Adjusted odds ratio  
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13 **CI:** Confidence interval  
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15 **LASI:** Longitudinal Ageing Study in India  
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17 **PSU** Primary Sampling Unit  
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19 **CEB:** Census Enumeration Block  
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21 **MPCE:** Monthly per capita expenditure  
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23 **ADL:** Activities of daily living  
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25 **IADL:** Instrumental activities of daily living  
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## Declarations

### Ethics approval

The necessary guidelines and ethics for undertaking the LASI survey were approved by the Indian Council of Medical Research (ICMR). ICMR approved the study. There was no number/ID of the approval(s) mentioned in the LASI report ([https://www.iipsindia.ac.in/sites/default/files/LASI\\_India\\_Report\\_2020\\_compressed.pdf](https://www.iipsindia.ac.in/sites/default/files/LASI_India_Report_2020_compressed.pdf)).

All methods were carried out in accordance with relevant guidelines and regulations by the Indian Council of Medical Research (ICMR).

### Contributor statement

Conceived and designed the research paper: TM and TVS; analysed the data: SS and TM; Contributed agents/materials/analysis tools: TVS; Wrote the manuscript: TM and SS; Refined the manuscript: TM, SS and TVS.

### Competing interest

The authors declare that there is no competing interest

### Funding

No funding was received for the study

### Data sharing statement

The study uses a secondary data which is available on request through <https://www.iipsindia.ac.in/content/lasi-wave-i>

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**Table-1.** Socio-economic and demographic profile of older adults in India.

Background characteristics		Sample	Percentage
<b>Socio-economic status</b>			
<b>Subjective SES</b>			
<b>Ladder SES</b>			
	Low	13,127	41.7
	Medium	16,142	51.3
	High	2,195	7.0
<b>Objective SES</b>			
<b>MPCE quintile</b>			
	Low	13,660	43.4
	Medium	6,590	21.0
	High	11,213	35.6
<b>Education</b>			
	Not educated/primary not completed	21,381	68.0
	Primary	3,520	11.2
	Secondary	4,371	13.9
	Higher	2,191	7.0
<b>Caste</b>			
	Scheduled Castes	5,949	18.9
	Scheduled Tribes	2,556	8.1
	Other Backward Classes	14,231	45.2
	Others	8,729	27.7
<b>Individual characteristics</b>			
<b>Age in years (mean (sd))</b>			69.2 (7.5)
<b>Sex</b>			
	Male	14,931	47.5
	Female	16,533	52.6
<b>Working status</b>			
	Working	9,680	30.8
	Retired	13,470	42.8
	Not working	8,314	26.4
<b>Marital status</b>			
	Currently married	19,391	61.6
	Widowed	11,389	36.2
	Others	684	2.2
<b>Living arrangement</b>			
	Living alone	1,787	5.7
	Living with spouse only	6,397	20.3
	Living with children and spouse	21,475	68.3
	Living with others.	1,805	5.7
<b>Social participation</b>			
	No	30,053	95.5
	Yes	1,411	4.5
<b>Physical activity</b>			
	Frequent	5,651	18.0
	Rarely	4,023	12.8
	Never	21,790	69.3
<b>Health factors</b>			
<b>Depression*</b>			

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	No	27,995	91.3
	Yes	2,657	8.7
<b>Self-rated health*</b>	Excellent	964	3.1
	Very good	4,192	13.6
	Good	10,693	34.7
	Fair	10,331	33.5
	Poor	4,630	15.0
<b>Difficulty in ADL</b>	No	23,802	75.7
	Yes	7,662	24.4
<b>Difficulty in IADL</b>	No	16,130	51.3
	Yes	15,334	48.7
<b>Morbidity</b>	No morbidity	14,773	47.0
	1	9,171	29.2
	2+	7,520	23.9
<b>Household factors</b>			
<b>Religion</b>	Hindu	25,871	82.2
	Muslim	3,548	11.3
	Christian	900	2.9
	Others	1,145	3.6
<b>Place of residence</b>	Rural	22,196	70.6
	Urban	9,268	29.5
<b>Region</b>	North	3,960	12.6
	Central	6,593	21.0
	East	7,439	23.6
	Northeast	935	3.0
	West	5,401	17.2
	South	7,136	22.7
<b>Total</b>		31,464	100.0
<i>*if Sample may be less due to missing cases; sd: standard deviation</i>			

**Table-2a.** Regression estimates for cognitive impairment among older adults in India, 2017-18

Background characteristics	Model-1		Model-2	
	OR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta
<b>Socio-economic status</b>				
<b>Subjective SES</b>				
<b>Ladder SES</b>				
High	Ref.		Ref.	
Medium	2.01*(1.63,2.47)	0.107	1.43*(1.14,1.79)	0.102
Low	3.83*(3.11,4.71)	0.172	2.04*(1.63,2.56)	0.157
<b>Objective SES</b>				
<b>MPCE quintile</b>				
High	Ref.		Ref.	
Medium	1.20*(1.07,1.34)	0.011	1.12(0.99,1.26)	0.020
Low	1.50*(1.37,1.64)	0.032	1.32*(1.19,1.46)	0.051
<b>Education</b>				
Not educated/primary not completed	58.91*(27.97,124.07)	0.694	22.40*(10.58,47.41)	0.514
Primary	6.45*(2.96,14.03)	0.204	3.83*(1.75,8.36)	0.142
Secondary	2.55*(1.13,5.73)	0.108	1.94(0.86,4.38)	0.072
Higher	Ref.		Ref.	
<b>Caste</b>				
Scheduled Castes	1.03(0.91,1.16)	0.005	1.22*(1.06,1.39)	0.027
Scheduled Tribes	1.38*(1.22,1.55)	0.029	1.80*(1.55,2.09)	0.067
Other Backward Classes	0.86*(0.78,0.96)	-0.038	0.98(0.87,1.1)	-0.005
Others	Ref.		Ref.	

Ref: Reference; OR: Unadjusted Odds Ratio; aOR: Adjusted Odds Ratio; aCoef: adjusted coefficients; CI: Confidence Interval; SES: Socio-economic status; Model-2 was adjusted for Individual, Health and Household factors



**Table-2b.** Interaction estimates for cognitive impairment among older adults in India, 2017-18

Background characteristics	Model-3	Model-4	Model-5	Model-3	Model-4	Model-5
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	Standardiz ed beta	Standardized beta	Standardized beta
<b>Ladder SES # MPCE quintile</b>						
High # high	Ref.					
High # middle	1.28(0.92,1.77)			0.085		
High # low	1.95*(1.39,2.72)			0.102		
Middle # high	0.79(0.42,1.48)			0.008		
Middle # middle	1.51*(1.08,2.11)			0.084		
Middle # low	2.09*(1.49,2.95)			0.092		
Low # high	1.24(0.77,1.98)			0.011		
Low # middle	1.77*(1.28,2.45)			0.125		
Low # low	2.45*(1.77,3.39)			0.160		
<b>Ladder SES # Education</b>						
High # higher		Ref.				
High # secondary		2.12(0.22,20.49)			0.021	
High # primary		8.91*(1.1,72.16)			0.037	
High # Not educated/primary not completed		24.14*(3.34,174. 63)			0.168	
Middle # higher		1.57(0.18,13.48)			0.032	
Middle # secondary		3.06(0.41,22.74)			0.116	
Middle # primary		5.82(0.8,42.55)			0.167	
Middle # Not educated/primary not completed		37.07*(5.19,264. 9)			0.568	
Low # higher		2.11(0.13,34.01)			0.020	
Low# secondary		4.68(0.6,36.81)			0.079	
Low # primary		8.65*(1.17,64.2)			0.129	

Low # Not educated/primary not completed	54.41*(7.61,388.93)	0.602
<b>Ladder SES # Caste</b>		
High # Others	Ref.	
High # Other Backward Class	1.39(0.83,2.32)	0.003
High # Scheduled Caste	1.69(0.82,3.48)	0.016
High # Scheduled Tribe	1.04(0.52,2.07)	-0.005
Middle # Others	1.53*(1.01,2.32)	0.081
Middle # Other Backward Class	1.60*(1.06,2.41)	0.081
Middle # Scheduled Caste	1.89*(1.23,2.89)	0.078
Middle # Scheduled Tribe	2.72*(1.77,4.2)	0.105
Low # Others	2.27*(1.49,3.46)	0.083
Low # Other Backward Class	2.15*(1.42,3.26)	0.111
Low # Scheduled Caste	2.88*(1.89,4.39)	0.108
Low # Scheduled Tribe	4.56*(2.97,6.98)	0.132
#: Interaction; Ref: Reference; OR: Unadjusted Odds Ratio; aOR: Adjusted Odds Ratio; aCoef: adjusted coefficients; CI: Confidence Interval; SES: Socio-economic status; Model-3, 4 and 5 were adjusted for Individual, Health and Household factors		

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3 **Figure legend: -**  
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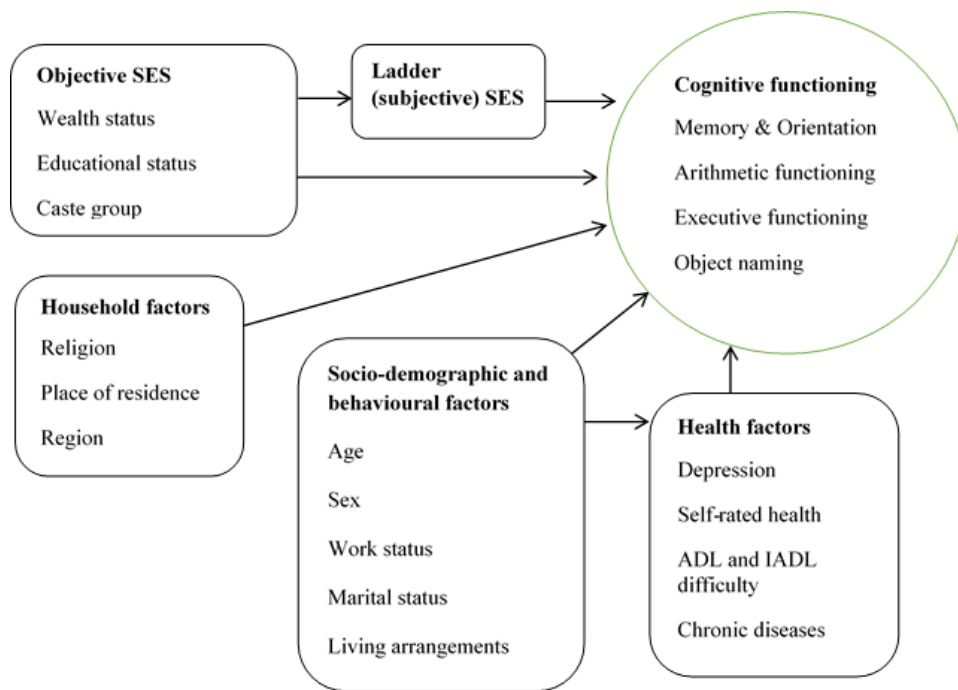
5 **Figure 1.** Conceptual framework  
6

7 **Figure-2.** The distribution of the subjective socio-economic status (1-10: lowest to highest  
8 rank)  
9

10 **Figure-3.** Percentage of older adults with cognitive impairment by their subjective socio-  
11 economic status.  
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13 **Figure-4.** Percentage of older adults with cognitive impairment by their objective socio-  
14 economic status.  
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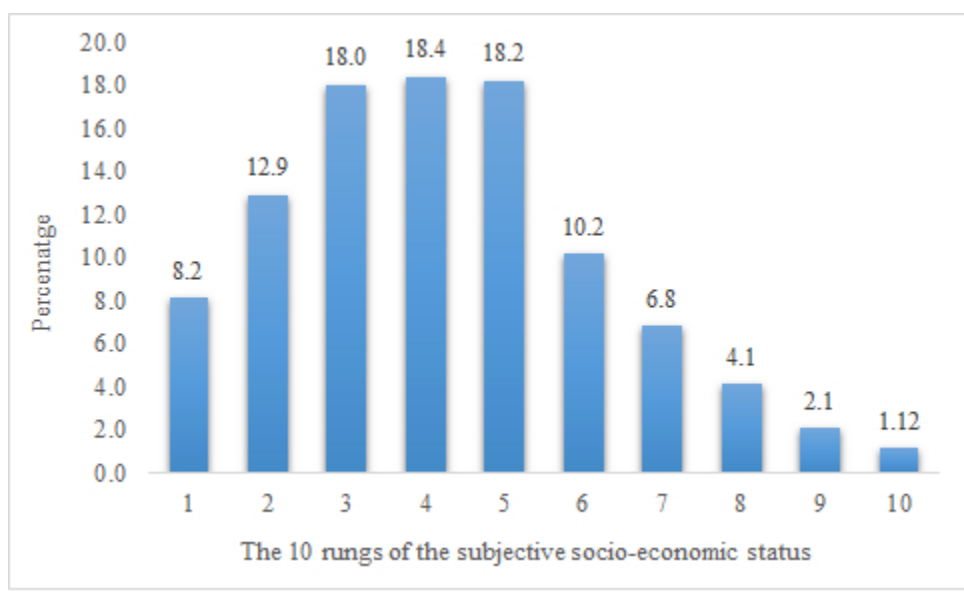
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Conceptual framework

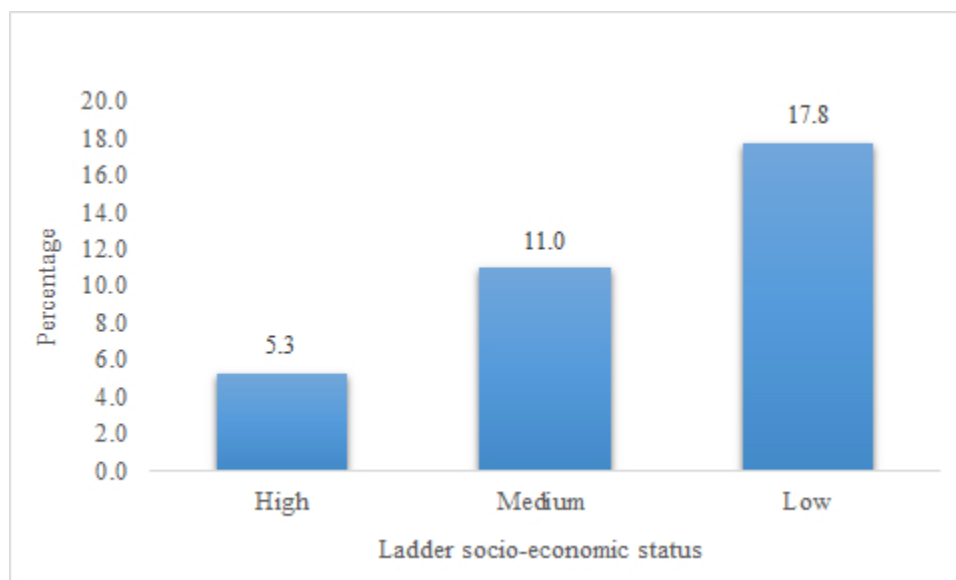
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The distribution of the subjective socio-economic status (1-10: lowest to highest rank)

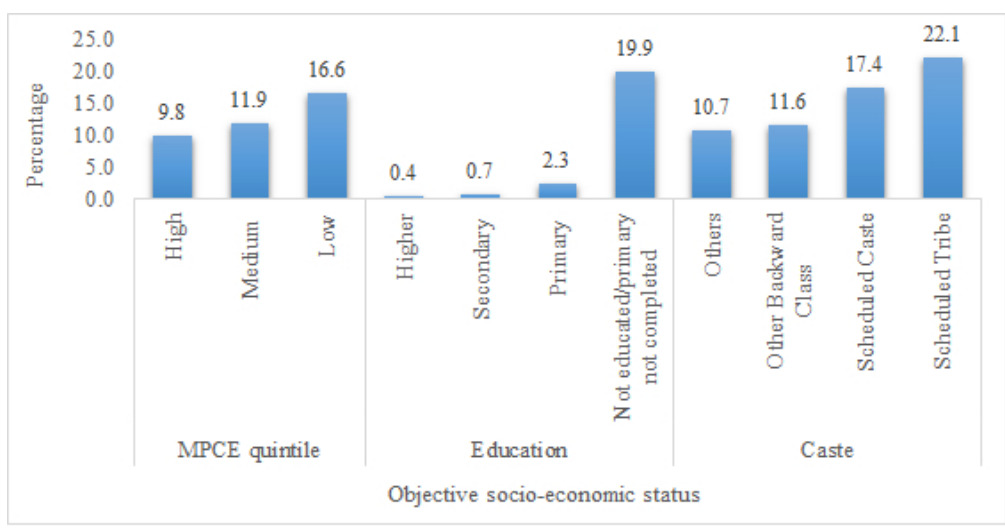
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Percentage of older adults with cognitive impairment by their subjective socio-economic status.

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Percentage of older adults with cognitive impairment by their objective socio-economic status.

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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
<b>Title and abstract</b>	1	1-2
<b>Introduction</b>		
Background/rationale	2	5
Objectives	3	6
<b>Methods</b>		
Study design	4	7
Setting	5	7
Participants	6	7
Variables	7	7-8
Data sources/ measurement	8*	7
Bias	9	-
Study size	10	7
Quantitative variables	11	7-8
Statistical methods	12	11-12
<b>Results</b>		
Participants	13*	12-13
Descriptive data	14*	12-13 12-13
Outcome data	15*	
Main results	16	12-14
Other analyses	17	12-14
<b>Discussion</b>		
Key results	18	15-18
Limitations	19	17
Interpretation	20	15-18
Generalisability	21	15-18
<b>Other information</b>		
Funding	22	20

\*Give information separately for exposed and unexposed groups.



# BMJ Open

## Association of objective and subjective socioeconomic markers with cognitive impairment among older adults: cross-sectional evidence from a developing country

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<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Epidemiology, Health policy, Public health
Keywords:	Old age psychiatry < PSYCHIATRY, Delirium & cognitive disorders < PSYCHIATRY, MENTAL HEALTH, Economics < TROPICAL MEDICINE

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3 **Association of objective and subjective socioeconomic markers with cognitive**  
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5 **impairment among older adults: cross-sectional evidence from a developing country**  
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## Abstract

**Objective:** This study explored how various markers of objective and subjective socio-economic status (SES) are associated with cognitive impairment among older Indian adults.

**Design:** A cross-sectional study was conducted using a large nationally representative survey data.

**Setting and participant:** This study used data from the Longitudinal Aging Study in India (2017-18). The total sample size was 31,464 older adults aged 60 years and above.

**Primary and secondary outcome measures:** The outcome variable was cognitive impairment measured through broad domains of memory, orientation, arithmetic function, and visuo-spatial and constructive skills. We estimated descriptive statistics and presented cross-tabulations of the outcome. Chi square test was used to evaluate the significance level of differences in cognitive impairment by subjective (ladder) and objective SES measures (monthly per-capita consumption expenditure (MPCE) quintile, education and caste status). Multivariable linear and logistic regression analyses were conducted to fulfil the objectives.

## Results

A proportion of 41.7% and 43.4% of older adults belonged to low subjective (ladder) and objective (MPCE) SES, respectively. Older adults with low subjective SES [aOR: 2.04;  $p < 0.05$ ] and objective SES (measured by MPCE quintile) [aOR: 1.32;  $p < 0.05$ ] had significantly higher odds of having cognitive impairment in comparison to their counterparts, with a stronger subjective SES-cognitive impairment association. Older adults with lower education or belonged to lower caste hierarchy had higher odds of cognitive impairment than their counterparts. Interaction analyses revealed that older adults who belonged to lower subjective and objective (poorest MPCE quintile, Scheduled Castes and lowest education) SES had 2.45 (CI: 1.77, 3.39), 4.56 (CI: 2.97, 6.98) and 54.41 (CI: 7.61, 388.93) significantly

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3 higher odds of cognitive impairment compared to older adults from higher subjective and  
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5 objective SES.  
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## 8 **Conclusion**

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11 Our findings suggest that more attention should be placed on subjective SES indicators when  
12  
13 investigating the socioeconomic influences on the cognitive functioning among older adults.  
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16 **Keywords:** *Subjective; Objective; Socioeconomic status; Cognitive impairment; Older adults,*  
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18 *India*  
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**Strengths and limitations:**

- The study utilizes a large nationally representative sample of older persons from both rural and urban areas of India
- The cross-sectional design of the study eliminates the opportunity for drawing of causal inferences among variables.
- Some individuals may become cognitively impaired because they are illiterate and could not respond with accuracy to several measures

## Introduction

Cognitive impairment, including dementia as an outcome of decline in cognitive ability, increases considerably with the rapidly growing population of older adults [1]. Worldwide, almost 80% of the general public are concerned about developing dementia at some point in time and 1 in 4 people think that they can do nothing to prevent such a cognitive decline [2].

Various indices of economic hardship, including lack of education, poor household economy, unemployment, and employment frustration, are linked with poor physical health conditions resulting in cognitive deficits [3–5]. Similarly, evidence suggests an aggregate or cumulative effect of socio-economic risk factors on cognitive impairment in later years of life [6–8]. Persons with higher cumulative socioeconomic status (SES) demonstrated an advantage in cognitive functioning [9]. A growing body of literature suggests that people who accumulated more wealth may be able to more easily translate it into better environmental circumstances or less stressful living conditions, further contributing to better cognitive health in later life [7, 10, 11]. Studies reported improvements in mental well-being for older people after the introduction of an income supplemental program [12, 13]. Measured by a test of processing speed, associations of educational attainment and current poverty index were found with late-life cognitive impairment in multiple studies [7, 14, 15]. Furthermore, a major contributing factor may include poor literacy resulting in an inability to benefit from strategies for early prevention of cognitive impairment [16].

### *Two approaches to SES: Subjective and objective SES measures*

Objective SES is commonly indicated by household wealth index and individual educational attainment, and caste status in particular Indian context [17–19]. Although these indicators are highly correlated [20], they reflect more of one's power or prestige [21]. In

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3 comparison, the subjective SES captures individuals' perceptions of their position in the  
4 social hierarchy, thus representing a psychological process [22].  
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8 In this regard, people make judgments of where they belong in the social hierarchy relative to  
9 others based on cognitive averaging of their economic status, education, occupation, and  
10 other objective indicators using different reference groups [23]. There is a growing body of  
11 research documenting that if people perceive themselves to be subordinate to others, they  
12 report lower self-esteem and greater stress, and they are likely to suffer from diseases more  
13 often than people who do not regard themselves to be of lower status [24]. Hence, subjective  
14 SES as a rank-based judgment that is composed of an evaluative judgment whereas the  
15 objective resources would place a person in rank within a specific context, which is derived  
16 mainly via the social comparison process.  
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30 Evidence for the association between poor socioeconomic indicators with worse mental  
31 health outcomes is abundant in the geriatric research. Many previous studies in India and  
32 other countries have reinforced that illiteracy, lower social status and poor financial status  
33 were strongly associated with worse cognitive function at the individual level [1, 25, 26].  
34 Similarly, the association of subjective SES and physical and mental health of older adults is  
35 explored in a couple of studies in Asian countries [27, 28]. However, the difference in the  
36 role that subjective and objective socioeconomic factors play in contributing to declining in  
37 late life cognition is poorly understood in the context of developing countries. Therefore, in  
38 this study, we aimed to explore the late-life cognitive impairment as a function of older  
39 individuals' objective and subjective SES using a large representative survey information of  
40 older adults aged 60 and above in India. A conceptual framework based on the  
41 abovementioned theoretical background is summarised in Figure-1.  
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## 58 **Data, variables, and methods**

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## Data Source

We utilized data from the recent release of Longitudinal Ageing Study in India (LASI) wave 1 [29]. LASI is a full-scale national survey of scientific investigation of the health, economic, and social determinants and consequences of population aging in India, conducted in 2017-18. The LASI is a nationally representative survey of over 72000 older adults aged 45 and above across all states and union territories (UTs) of India. The survey adopted a three-stage sampling design in rural areas and a four-stage sampling design in urban areas. In each state/UT, the first stage involved the selection of Primary Sampling Units (PSUs), that is, sub-districts (Tehsils/Talukas), and the second stage involved the selection of villages in rural areas and wards in urban areas in the selected PSUs [29]. In rural areas, households were selected from selected villages in the third stage. However, sampling in urban areas involved an additional stage. Specifically, in the third stage, one Census Enumeration Block (CEB) was randomly selected in each urban area [29]. In the fourth stage, households were selected from this CEB. The detailed methodology, with the complete information on the survey design and data collection is published elsewhere and in the survey report [29, 30]. The present study is conducted on eligible respondents aged 60 years and above (31,464 older individuals from both rural and urban areas).

The necessary guidelines and ethics for undertaking the LASI survey were approved by the Indian Council of Medical Research (ICMR). The agencies that conducted the field survey for the data collection had collected prior informed consent (signed and oral) for both the interviews and biomarker tests from the eligible respondents in accordance with the Human Subjects Protection. All methods in this study were carried out in accordance with relevant guidelines and regulations by the ICMR.

## *Variable description*

### ***Outcome variable***

Cognitive impairment was measured through broad domains of memory, orientation, arithmetic function, and visuo-spatial and constructive skills. It is followed from the cognitive module of the Health and Retirement Study (HRS), the China Health and Retirement Longitudinal Study (CHARLS), and the Mexican Health and Aging Study (MHAS), based on different cognitive measures including: immediate (0–10 points) and delayed word recall (0–10 points); orientation related to time (0-4 points), and place (0-4 points); arithmetic ability based on serial 7s (0–5 points), computation (0-2) and backward counting from 20 (0–2 points); visuo-spatial and constructive skills based on paper folding (0-3) pentagon drawing (0-1); and object naming (0-2). The overall score ranged between 0 and 43, and a higher score indicated better cognitive functioning. The lowest 10th percentile was used as a proxy measure of poor cognitive functioning [29]. Further, for the analytical purpose, the score was reversed to assess the cognitive impairment among older adults and thus after reversing, the higher score indicated higher levels of cognitive impairment. In our study, the respondents who received assistance during the cognition module were excluded from the analysis.

### ***SES exposures***

The main explanatory variables were subjective SES (ladder SES) and objective SES (household MPCE quintile, education and caste) among older adults.

The subjective SES was assessed using the Macarthur scale [31], with a ladder technique and the question used to assess the variable was “Think of the ladder with 10 stairs as representing where people stand in our society. At the top of the ladder are the people who are the best off – those who have the most money, most education, and best jobs. At the bottom are the people who are the worst off – who have the least money, least education, and the worst jobs or no jobs. The higher up you are on this ladder, the closer you are to the

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3 people at the very top and the lower you are, the closer you are to the people at the very  
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5 bottom of your society". The scale is used to measure the subjective SES across different  
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7 populations in India and other countries [32, 33]. A score of 0-10 was generated as per the  
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9 number of rungs marked by the respondents and the variable of subjective SES was coded as  
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11 0-3 as "low", 4-7 as "middle" and 8-10 as "high" [34].  
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15 The monthly per capita consumption expenditure (MPCE) quintile was assessed using  
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17 household consumption data. The MPCE was used as one of the measures of objective SES.  
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19 Sets of 11 and 29 questions on the expenditures on food and non-food items, respectively,  
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21 were used to canvas the consumption pattern of the sample households. Food expenditure  
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23 was collected based on a reference period of seven days, and non-food expenditure was  
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25 collected based on reference periods of 30 days and 365 days. Food and non-food  
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27 expenditures have been standardized to the 30-day reference period. The MPCE is computed  
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29 and used as the summary measure of consumption [29]. The variable was then divided into  
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31 five quintiles i.e., from poorest to richest. However, for the purpose of this study, the MPCE  
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33 quintile variable was recoded as 'low' (poorest and poorer), 'middle' and 'high' (richer and  
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35 richest) [35].  
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41 Another objective SES measure was educational status of older adults. As documented in  
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43 multiple studies, brain functioning and cognitive processing are modulated by formal  
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45 education of individuals and the illiterate population who received no formal education due to  
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47 several socio-cultural and economic reasons are at greater risk for cognitive impairment and  
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49 dementias [36]. The educational status in the current study was coded as no  
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51 education/primary not completed, primary, secondary and higher. Finally, caste system in  
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53 India is a social hierarchy that is passed down through families and groups of people dictate  
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55 the professions and social prestige merely by their caste status [19]. As an objective SES  
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57 measure, caste in the study was recoded as Scheduled Tribes, Scheduled Castes, Other  
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3 Backward Classes, and Others based on specific administrative classification [19]. The  
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5 Scheduled Caste includes a group of the population that is socially segregated and  
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7 financially/economically marginalized by their low status as per Hindu caste hierarchy. The  
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9 Scheduled Tribes and Scheduled Castes are among the most disadvantaged socio-economic  
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11 groups and have substantially lower wealth than the “forward” caste groups in India [37]. The  
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13 Other Backward Classes refer to the group of people who were identified as “educationally,  
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15 economically and socially backward” and occupy positions in the middle [38]. The ‘Others’  
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17 caste category denotes the groups having higher social status and refers to a large number of  
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19 the forward castes and comparatively advantaged populations in the country [38].  
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### 24 ***Other covariates***

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27 *Individual factors:* The following socio-demographic variables were included in the analysis  
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29 according to the previous literature [39–42]. Age was used as continuous variable. Sex was  
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31 coded as male and female. Working status was coded as currently working, retired, and not  
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33 working. Marital status was coded as currently married, widowed and others. Others included  
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35 divorced/separated/never married. Living arrangement was coded as living alone, living with  
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37 spouse, living with spouse and children and living with others. Social participation was coded  
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39 as ‘no’ and ‘yes’. Social participation was measured through the question “Are you a member  
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41 of any of the organizations, religious groups, clubs, or societies?” The response was coded as  
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43 ‘no’ and ‘yes’ [43]. Physical activity status was coded as frequent (every day), rare (more  
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45 than once a week, once a week, one to three times in a month), and never. The question  
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47 through which physical activity was assessed was “How often do you take part in sports or  
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49 vigorous activities, such as running or jogging, swimming, going to a health centre or gym,  
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51 cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling,  
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53 cycling with loads”? [44].  
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3 *Health factors:* Health status covariates that were shown to associate with cognitive  
4 impairment include depression [42], functional difficulty [45] and morbidity [46]. The  
5 probable major depression among older adults with symptoms of dysphoria was calculated  
6 using the Short Form Composite International Diagnostic Interview (CIDI-SF). This scale  
7 estimates a probable psychiatric diagnosis of major depression and has been validated in field  
8 settings and widely used in population-based health surveys [29]. On a scale of 0-10, the  
9 respondents who had three or more symptoms were considered as depressed [47]. Self-rated  
10 health was coded excellent, very good, good, fair and poor [43]. Difficulty in activities of  
11 daily living (ADL) was coded as 'no' and 'yes'. ADL refers to normal daily self-care  
12 activities (such as movement in bed, changing position from sitting to standing, feeding,  
13 bathing, dressing, grooming, personal hygiene, etc.) The ability or inability to perform ADLs  
14 is used to measure a person's functional status, especially in case of people with disabilities  
15 and the ones in their older ages [48]. Difficulty in instrumental ADL (IADL) was coded as  
16 'no' and 'yes'. Respondents were asked if they were having any difficulties that were  
17 expected to last more than three months, such as preparing a hot meal, shopping for groceries,  
18 making a telephone call, taking medications, doing work around the house or garden,  
19 managing money (such as paying bills and keeping track of expenses), and getting around or  
20 finding an address in unfamiliar places [43]. Morbidity was coded as no morbidity, 1 and 2+  
21 [43]. This variable was created using the data on chronic diseases which include  
22 hypertension, chronic heart diseases, stroke, any chronic lung disease, diabetes, cancer or  
23 malignant tumor, any bone/joint disease, neurological/psychiatric disease, or high cholesterol.

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52 *Household/community-related factors:* Taking cue from earlier research, we also added the  
53 following characteristics [39, 49, 50]. Religion was coded as Hindu, Muslim, Christian, and  
54 Others. Place of residence was coded as rural and urban. The geographical regions of India  
55 were categorized as North, Central, East, Northeast, West, and South.  
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### ***Statistical analysis***

We estimated descriptive statistics and presented cross-tabulations of the outcome in the study. Additionally, multivariable logistic and linear regression analysis [51, 52] were conducted to establish the association between the outcome variable (cognitive impairment) and socio-economic status. The results were presented in the form of odds ratio (OR), adjusted OR (aOR) and standardized regression coefficients (beta) with 95% confidence interval (CI). Variance inflation factor (VIF) was generated in STATA 14 [53] to check the multicollinearity and it was found that there was no evidence of multicollinearity in the variables used [54, 55].

Moreover, interaction effects [43, 56] were observed for subjective SES and multiple objective SES measures with cognitive impairment among older adults in India. Model-1 represents the unadjusted effects whereas model-2 represents the adjusted effects. The analysis was controlled for age, sex, working status, marital status, living arrangement, social participation, physical activity, depression, self-rated health, difficulty in ADL and IADL, morbidity, religion, place of residence and regions. Models-3, 4 and 5 represent interaction effects which are adjusted for individual, health and household/community related factors.

### **Patient and Public Involvement**

No patient involved

### **Results**

Table-1 represents socio-economic and demographic profile of Indian older adults included in this study. The mean age of the study population was 69.2 years (standard deviation: 7.5). It was found that about 41.7 per cent of older adults belong to low subjective SES and only seven per cent belong to higher subjective SES. Additionally, about 43.4 per cent of older adults belonged to low objective SES and about 35.6 percent belonged to higher objective

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3 SES. About 13.1% (n=3250) older adults were cognitively impaired in reference to 86.9%  
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5 (n=21580) who were not cognitively impaired.  
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8 About 26.4 per cent of older adults got retired from employment and 30.8 per cent were  
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10 currently working. Nearly 36.2 per cent of older adults were widowed. Only 5.7 per cent of  
11  
12 older adults were living alone and 68.3 per cent were living with their children and spouse.  
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14 Only 4.5 per cent of older adults reported that they socially participate. Nearly, 69.3 per cent  
15  
16 of older adults were never involved in any physical activity. About 8.7 per cent of older  
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18 adults suffered from major depression. Nearly, 15.0 per cent of older adults reported poor  
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20 self-rated health. About 24.4 percent and 48.7 per cent of older adults reported difficulty in  
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22 ADL and IADL.  
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27 [Insert table-1 here]  
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31 Figure-2 presents the percentage distribution of subjective SES (ladder SES) that ranges from  
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33 1 to 10, representing lowest to highest rank. A proportion of 8.2% of older adults marked  
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35 their SES in the bottom of the ladder (lowest), whereas a proportion of only 1.1% marked  
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37 their SES at the top of the ladder (highest).  
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40 [Insert figure-2 here]  
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43 Figure-3 reveals that lower the subjective SES (17.8 per cent;  $p < 0.001$ ) of an older adult,  
44  
45 higher the prevalence of cognitive impairment.  
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48 [Insert figure-3 here]  
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51 Figure-4 reveals that lower the objective SES (measured by MPCE quintile) (16.6 per cent;  
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53  $p < 0.001$ ) of an older adult, higher the prevalence of cognitive impairment. With regard to  
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55 other objective SES measures, older adults with no education/primary not completed had  
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3 highest prevalence of cognitive impairment (19.9%;  $p<0.001$ ). Similarly, older adults from  
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5 Scheduled Tribe category had highest prevalence of cognitive impairment (22.1%;  $p<0.001$ ).  
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8 [Insert figure-4 here]  
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11 Table-2a represents the logistic regression estimates of cognitive impairment among older  
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13 adults. In model-2 which is adjusted model, it was revealed that older adults who belonged to  
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15 lower subjective SES had significantly higher odds of cognitive impairment [aOR: 2.04;  
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17  $p<0.05$ ] in reference to older adults who belonged to higher subjective SES. Moreover, older  
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19 adults who belonged to lower objective SES (MPCE quintile) had 32% significantly higher  
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21 odds of suffering from cognitive impairment [aOR: 1.32;  $p<0.05$ ] in comparison to older  
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23 adults who belonged to higher objective SES (MPCE quintile). Older adults who were not  
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25 educated/ with minimum education had significantly higher odds of cognitive  
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27 impairment in reference to older adults with higher education [aOR: 22.4;  $p<0.05$ ]. Older  
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29 adults who belonged to the Scheduled Castes and Scheduled Tribes had 22% [aOR: 1.22;  
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31  $p<0.05$ ] and 80% [aOR: 1.80;  $p<0.05$ ] significantly higher odds of cognitive impairment in  
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33 reference to older adults from other (higher) caste category, respectively. Table-S1 represents  
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35 the regression estimates for cognitive impairment among older adults in India. In table S2,  
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37 model-1 was controlled for subjective SES and individual, health and household factors;  
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39 model-2 was controlled for MPCE quintile and individual, health and household factors;  
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41 model-3 was controlled for education and individual, health and household factors and  
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43 model-4 were controlled for caste and individual, health and household factors. Table S2  
44  
45 represents sensitivity analysis estimates (aORs) of cognitive impairment among older adults  
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47 and the outcome variable i.e., cognitive impairment was adjusted for education (lowest 10<sup>th</sup>  
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49 percentile of each educational category was considered cognitively impaired, i.e, with a cut-  
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51 off score of 14 for no educated/primary not completed, 21 for primary, 24 for secondary and  
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53 27 for higher education groups).  
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[Insert Table-2a]

In model-3, 4 and 5 (Table-2b) which reveals the interaction results for cognitive impairment. It was found that older adults who belong to lower subjective as well as objective SES were 2.45 times significant more likely to suffer from cognitive impairment in reference to older adults from higher subjective as well as objective SES (MPCE quintile) [aOR: 2.45; p<0.05]. In reference to older adults with high ladder SES and higher education, older adults with high ladder SES and no education/primary not completed [aOR: 24.14; p<0.05], middle ladder SES and no education/primary not completed [aOR: 37.07; p<0.05] and low ladder SES and no education/primary not completed [aOR: 54.41; p<0.05] had significantly higher odds for cognitive impairment. Older adults from low ladder SES and belonged to the Scheduled Castes [aOR: 2.88; p<0.05], low ladder SES and belonged to the Scheduled Tribes [aOR: 4.56; p<0.05] and low ladder SES and belonged to the Other Backward Classes [aOR: 2.15; p<0.05] had significantly higher odds of cognitive impairment in reference to older adults from high ladder SES and other (higher) caste category. Table S3 represents sensitivity analysis estimates (interaction models) for cognitive impairment among older adults and the outcome variable i.e., cognitive impairment was adjusted for education.

[Insert Table-2b]

## Discussion

This study using a large representative data on older population in India was in parallel to multiple earlier studies in India and other developing countries which found that older individuals with lower SES experience cognitive impairment compared with people with higher SES [1, 57–59]. This association has been identified in case of both objective and subjective measures of SES. Studies have illustrated empirical evidence on the positive relationship between SES as measured by objective indices of material resources and

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3 subjective measures, and psychological well-being [60, 61]. Similarly, the interactive effect  
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5 in our study found that older adults with lower levels of subjective and objective SES were at  
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7 a greater risk of having cognitive impairment.  
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11 However, subjective SES was identified to have a much stronger association with cognitive  
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13 impairment in the unadjusted and adjusted regression estimates in comparison to objective  
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15 SES measured by household MPCE quintile. With respect to this strong association, there can  
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17 be some possible explanations. At first, obviously, subjective SES was more meaningful than  
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19 household wealth index. Higher economic status does not necessarily mean more resources at  
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21 disposal, if compared with higher individual circumstances, but positive social comparison  
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23 does. In addition, people with greater household economic status may endure more pressures  
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25 and mental stress, which in turn may affect their mental health status and cognitive ability  
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27 [62]. This could be mainly due to the subjectivity character of subjective SES. This potential  
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29 explanation can also be attributed to different perceptions towards wealth and social status  
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31 among older population in India.  
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37 Furthermore, considering the education-cognitive function association, the current findings  
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39 suggest that higher education is a protective factor against cognitive impairment in older  
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41 individuals. A hypothesized mechanism is that education is transformed to personal  
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43 experience and self-perceptions about own social standing, which in turn translate into health  
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45 and disease. Similarly, the current findings suggest that older adults with no education and  
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47 low levels of subjective SES had greater odds of cognitive impairment compared to those  
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49 with higher education and higher subjective SES. This finding agrees with the previous  
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51 evidence on the moderating role of education in the relationship between subjective SES and  
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53 cognitive function. Also, as documented in earlier research [22], subjective SES is a means  
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55 through which education may influence health outcomes among older people. Nevertheless,  
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3 proper path analysis using longitudinal data and conducting moderation as well as mediation  
4 analyses is needed to test these claims.  
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8 Finally, older adults belonging to the lower caste groups (with low social status) were found  
9 to be more likely to be cognitively impaired in the study in comparison to those belong to  
10 higher castes. Importantly, in a previous study, it was observed that indicators of subjective  
11 SES differ across socio-demographic groups including race, and interpretations may vary  
12 when perceiving themselves on the existing social hierarchy [24]. Previous studies in India  
13 have demonstrated that the socioeconomic disadvantages such as lower income and lack of  
14 education were associated with belonging to lower castes (scheduled tribes and other  
15 backward classes) [18, 19, 63, 64]. Further, lower caste status being a factor of less  
16 opportunities in economic spectrum also contributes to poorer health, health inequalities and  
17 mortality burden in India [17, 38, 65]. It is however demonstrated that since individuals may  
18 estimate their SES relative to others in a specific community or social group, the social  
19 disadvantage may not necessarily negatively influence their mental wellbeing [60]. This  
20 suggests that the SES could be better captured by assessing the interactions between  
21 subjective and objective measures of SES.  
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41 The current study provides crucial clues about what measure of SES highly reflect on the  
42 mental health in old age by underlining the importance of the cumulative dimension of  
43 subjective SES and different traditional measures including wealth status, education and  
44 caste, and showing the underperformance of traditional measure of wealth status compared to  
45 subjective SES. Considering the current findings and the existing evidence [60], separate  
46 SES-related ladders that evaluate subjective perceptions of individuals' economic status  
47 (MPCE), education and social status (caste hierarchy in Indian context) may be suggested in  
48 wellbeing research. This is because subjective SES may reflect individuals' present social  
49 circumstances and an assessment of their past experiences and future prospects. As suggested  
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3 in previous studies, subjective perception of one's SES might also encompass his/her  
4 household resources, life chances and opportunities, and thus captures a broad range of  
5 aspects of social stratification than traditional measures of SES do [23, 31, 66]. The finding  
6 further underscores the need for future longitudinal investigation of subjective SES-related  
7 measurement strategies to obtain a better understanding of the SES-cognitive functioning link  
8 especially in poor resource settings. The effects of country affluence on population health  
9 have been demonstrated. Several cross-country comparisons have documented considerable  
10 variations in the strength of subjective SES-health relationship between affluent and low-  
11 income countries with a stronger association in the later ones [67, 68].

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There are several limitations of the present study to be considered. The major limitation is the cross-sectional design of the study eliminating the opportunity for drawing of causal inferences among variables. Indeed, it is important to consider that some individuals may become cognitively impaired because they are illiterate and could not respond to several measures with accuracy. Importantly, due to lack of evidence of algorithm for combining various cognitive tests in the Indian context, we weight all tests equally and use an additive measure for overall cognitive functioning in the current study. Some of the tests may be far better than others in screening for or assessing the degree of cognitive dysfunction or dementia, and thus, the current approach may be misleading and should be addressed in future studies. In addition, there is a possibility of some of the covariates included in the analysis potentially being on the pathway from, say, objective SES to cognition. For example, in case of objective SES measured by caste, this is generally determined at birth, which could then influence individuals' life course in multiple ways, including how often they partake in physical activity or social activity, eventually resulting in collider stratification bias in the multivariable models in the current study. Finally, there may also be floor or ceiling effects for SES because we have only three categories for both SES measures.

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3 Notwithstanding these limitations, there were several advantages in this study. At first, this  
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5 may be the first study to identify the association between both objective and subjective SES  
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7 indicators and cognitive impairment based on a comprehensive measure with a score of 0 to  
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9 43 among the older Indian population. The large sample of the present study that is free from  
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11 selection bias includes all SES groups of Indian population that credits to the  
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13 representativeness and generalizability of the findings. In addition to including multiple SES  
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15 groups, this study also includes participants living both in rural and urban areas which  
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17 enhance the generalizability of the results. Further, the findings of the present study provide  
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19 empirical support to the body of literature that highlights the vulnerability of older adults who  
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21 have low subjective and objective SES to the worse mental health outcomes. Finally, future  
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23 research may focus on longitudinal associations of various socioeconomic markers with  
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25 mental health outcomes among middle aged and older adults in India.  
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### 30 31 **Conclusion**

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34 The current findings highlight the importance of subjective SES measure and its interaction  
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36 with objective (traditional) measures of SES including wealth, education and caste status in  
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38 assessing the mental health outcomes in developing countries. The results also suggest that  
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40 more attention should be placed on subjective SES indicators when investigating  
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42 socioeconomic influences on cognitive functioning among older adults in India.  
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**Abbreviations:****SES:** Socio-economic status**aOR:** Adjusted odds ratio**CI:** Confidence interval**LASI:** Longitudinal Ageing Study in India**PSU** Primary Sampling Unit**CEB:** Census Enumeration Block**MPCE:** Monthly per capita consumption expenditure**ADL:** Activities of daily living**IADL:** Instrumental activities of daily living

## Declarations

### Ethics approval

The necessary guidelines and ethics for undertaking the LASI survey were approved by the Indian Council of Medical Research (ICMR). ICMR approved the study. There was no number/ID of the approval(s) mentioned in the LASI report ([https://www.iipsindia.ac.in/sites/default/files/LASI\\_India\\_Report\\_2020\\_compressed.pdf](https://www.iipsindia.ac.in/sites/default/files/LASI_India_Report_2020_compressed.pdf)).

All methods were carried out in accordance with relevant guidelines and regulations by the Indian Council of Medical Research (ICMR).

### Contributor statement

Conceived and designed the research paper: TM and TVS; analysed the data: SS and TM; Contributed agents/materials/analysis tools: TVS; Wrote the manuscript: TM and SS; Refined the manuscript: TM, SS and TVS.

### Competing interest

The authors declare that there is no competing interest

### Funding

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### Data sharing statement

The study uses a secondary data which is available on request through

<https://www.iipsindia.ac.in/content/lasi-wave-i>

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**Table-1.** Socio-economic and demographic profile of older adults in India.

Background characteristics		Sample	Percentage
<b>Socio-economic status</b>			
<b>Subjective SES</b>			
<b>Ladder SES</b>			
	Low	13,127	41.7
	Medium	16,142	51.3
	High	2,195	7.0
<b>Objective SES</b>			
<b>MPCE quintile</b>			
	Low	13,660	43.4
	Medium	6,590	21.0
	High	11,213	35.6
<b>Education</b>			
	Not educated/primary not completed	21,381	68.0
	Primary	3,520	11.2
	Secondary	4,371	13.9
	Higher	2,191	7.0
<b>Caste</b>			
	Scheduled Castes	5,949	18.9
	Scheduled Tribes	2,556	8.1
	Other Backward Classes	14,231	45.2
	Others	8,729	27.7
<b>Individual characteristics</b>			
<b>Age in years (mean (sd))</b>			69.2 (7.5)
<b>Sex</b>			
	Male	14,931	47.5
	Female	16,533	52.6
<b>Working status</b>			
	Working	9,680	30.8
	Retired	13,470	42.8
	Not working	8,314	26.4
<b>Marital status</b>			
	Currently married	19,391	61.6
	Widowed	11,389	36.2
	Others	684	2.2
<b>Living arrangement</b>			
	Living alone	1,787	5.7
	Living with spouse only	6,397	20.3
	Living with children and spouse	21,475	68.3
	Living with others.	1,805	5.7
<b>Social participation</b>			
	No	30,053	95.5
	Yes	1,411	4.5
<b>Physical activity</b>			
	Frequent	5,651	18.0
	Rarely	4,023	12.8
	Never	21,790	69.3
<b>Health factors</b>			
<b>Depression*</b>			

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	No	27,995	91.3
	Yes	2,657	8.7
<b>Self-rated health*</b>			
	Excellent	964	3.1
	Very good	4,192	13.6
	Good	10,693	34.7
	Fair	10,331	33.5
	Poor	4,630	15.0
<b>Difficulty in ADL</b>			
	No	23,802	75.7
	Yes	7,662	24.4
<b>Difficulty in IADL</b>			
	No	16,130	51.3
	Yes	15,334	48.7
<b>Morbidity</b>			
	No morbidity	14,773	47.0
	1	9,171	29.2
	2+	7,520	23.9
<b>Household/community-related factors</b>			
<b>Religion</b>			
	Hindu	25,871	82.2
	Muslim	3,548	11.3
	Christian	900	2.9
	Others	1,145	3.6
<b>Place of residence</b>			
	Rural	22,196	70.6
	Urban	9,268	29.5
<b>Region</b>			
	North	3,960	12.6
	Central	6,593	21.0
	East	7,439	23.6
	Northeast	935	3.0
	West	5,401	17.2
	South	7,136	22.7
<b>Total</b>		<b>31,464</b>	<b>100.0</b>
<i>*if Sample may be less due to missing cases; sd: standard deviation</i>			

**Table-2a.** Regression estimates for cognitive impairment among older adults in India, 2017-18

Background characteristics	Model-1		Model-2	
	OR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta
<b>Socio-economic status</b>				
<b>Subjective SES</b>				
<b>Ladder SES</b>				
High	Ref.		Ref.	
Medium	2.01*(1.63,2.47)	0.107	1.43*(1.14,1.79)	0.102
Low	3.83*(3.11,4.71)	0.172	2.04*(1.63,2.56)	0.157
<b>Objective SES</b>				
<b>MPCE quintile</b>				
High	Ref.		Ref.	
Medium	1.20*(1.07,1.34)	0.011	1.12(0.99,1.26)	0.020
Low	1.50*(1.37,1.64)	0.032	1.32*(1.19,1.46)	0.051
<b>Education</b>				
Not educated/primary not completed	58.91*(27.97,124.07)	0.694	22.40*(10.58,47.41)	0.514
Primary	6.45*(2.96,14.03)	0.204	3.83*(1.75,8.36)	0.142
Secondary	2.55*(1.13,5.73)	0.108	1.94(0.86,4.38)	0.072
Higher	Ref.		Ref.	
<b>Caste</b>				
Scheduled Castes	1.03(0.91,1.16)	0.005	1.22*(1.06,1.39)	0.027
Scheduled Tribes	1.38*(1.22,1.55)	0.029	1.80*(1.55,2.09)	0.067
Other Backward Classes	0.86*(0.78,0.96)	-0.038	0.98(0.87,1.1)	-0.005
Others	Ref.		Ref.	

Ref: Reference; OR: Unadjusted Odds Ratio; aOR: Adjusted Odds Ratio; CI: Confidence Interval; SES: Socio-economic status; Model-2 was adjusted for Individual, Health and Household factors

**Table-2b.** Interaction estimates for cognitive impairment among older adults in India, 2017-18

Background characteristics	Model-3		Model-4		Model-5	
	aOR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta
<b>Ladder SES # MPCE quintile</b>						
High # high	Ref.					
High # middle	1.28(0.92,1.77)	0.085				
High # low	1.95*(1.39,2.72)	0.102				
Middle # high	0.79(0.42,1.48)	0.008				
Middle # middle	1.51*(1.08,2.11)	0.084				
Middle # low	2.09*(1.49,2.95)	0.092				
Low # high	1.24(0.77,1.98)	0.011				
Low # middle	1.77*(1.28,2.45)	0.125				
Low # low	2.45*(1.77,3.39)	0.160				
<b>Ladder SES # Education</b>						
High # higher			Ref.			
High # secondary			2.12(0.22,20.49)	0.021		
High # primary			8.91*(1.1,72.16)	0.037		
High # Not educated/primary not completed			24.14*(3.34,174.63)	0.168		
Middle # higher			1.57(0.18,13.48)	0.032		
Middle # secondary			3.06(0.41,22.74)	0.116		
Middle # primary			5.82(0.8,42.55)	0.167		
Middle # Not educated/primary not			37.07*(5.19,264.9)	0.568		



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completed			
Low # higher	2.11(0.13,34.01)	0.020	
Low# secondary	4.68(0.6,36.81)	0.079	
Low # primary	8.65*(1.17,64.2)	0.129	
Low # Not educated/primary not completed	54.41*(7.61,388.93)		0.602
<b>Ladder SES # Caste</b>			
High # Others		Ref.	
High # Other Backward Class		1.39(0.83,2.32)	0.003
High # Scheduled Caste		1.69(0.82,3.48)	0.016
High # Scheduled Tribe		1.04(0.52,2.07)	-0.005
Middle # Others		1.53*(1.01,2.32)	0.081
Middle # Other Backward Class		1.60*(1.06,2.41)	0.081
Middle # Scheduled Caste		1.89*(1.23,2.89)	0.078
Middle # Scheduled Tribe		2.72*(1.77,4.2)	0.105
Low # Others		2.27*(1.49,3.46)	0.083
Low # Other Backward Class		2.15*(1.42,3.26)	0.111
Low # Scheduled Caste		2.88*(1.89,4.39)	0.108
Low # Scheduled Tribe		4.56*(2.97,6.98)	0.132

#: Interaction; Ref: Reference; OR: Unadjusted Odds Ratio; aOR: Adjusted Odds Ratio; CI: Confidence Interval; SES: Socio-economic status; Model-3, 4 and 5 were adjusted for Individual, Health and Household factors

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5 **Figure-1:** Conceptual Framework  
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7 **Figure-2** The distribution of the subjective socio-economic status (1-10: lowest to highest  
8 rank)  
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10 **Figure-3** Percentage of older adults with cognitive impairment by their subjective socio-  
11 economic status.  
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13 **Figure-4** Percentage of older adults with cognitive impairment by their objective socio-  
14 economic status.  
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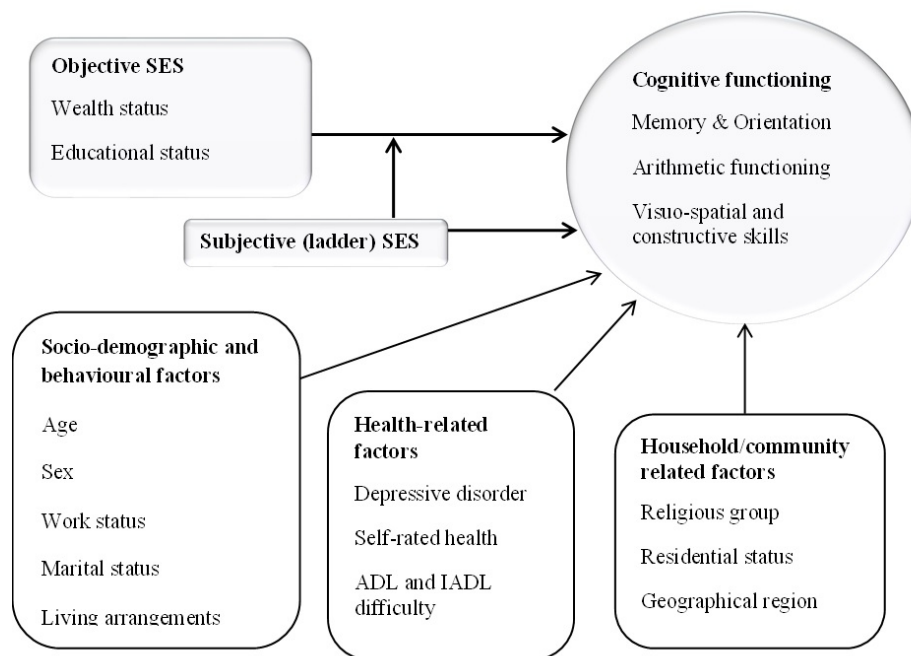


Figure-1: Conceptual Framework

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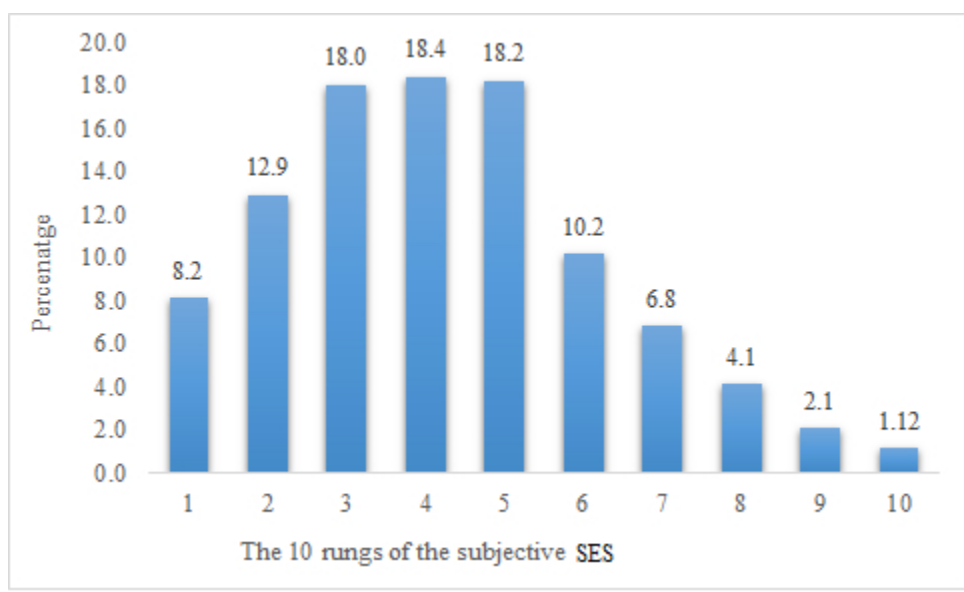


Figure-2 The distribution of the subjective socio-economic status (1-10: lowest to highest rank)

85x51mm (144 x 144 DPI)

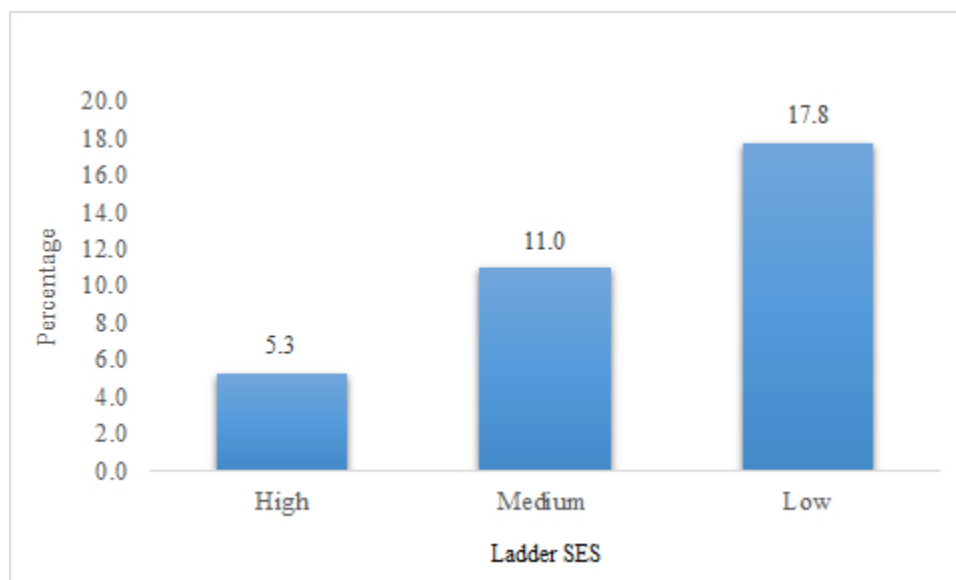


Figure-3 Percentage of older adults with cognitive impairment by their subjective socio-economic status.

85x51mm (144 x 144 DPI)

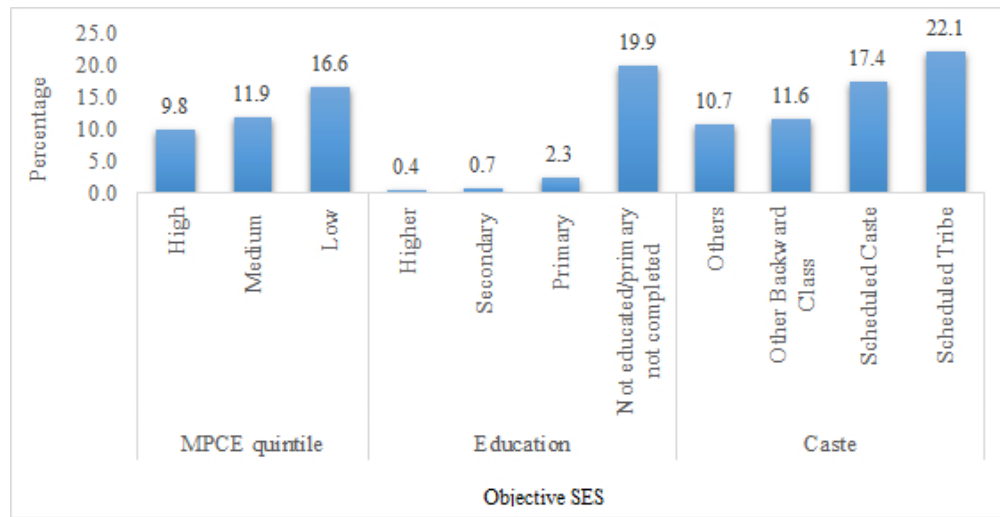


Figure-4 Percentage of older adults with cognitive impairment by their objective socio-economic status.

148x77mm (96 x 96 DPI)

**Table-S1.** Regression estimates for cognitive impairment among older adults in India, 2017-18

Background characteristics	Model-1		Model-2		Model-3		Model-4	
	aOR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta
<b>Subjective SES</b>								
<b>Ladder SES</b>								
Low	Ref.							
Medium	1.76*(1.42, 2.18)	0.17						
High	3.16*(2.54, 3.93)	0.30						
<b>Objective SES</b>								
<b>MPCE quintile</b>								
Low			Ref.					
Medium			1.3*(1.16, 1.46)	0.06				
High			1.76*(1.6, 1.94)	0.15				
<b>Education</b>								
Not educated/primary not completed					31.13*(14.74, 65.73)	0.58		
Primary					4.75*(2.18, 10.35)	0.17		
Secondary					2.19(0.97, 4.94)	0.09		
Higher					Ref.			
<b>Caste</b>								
Scheduled Castes							1.88*(1.66, 2.15)	0.13
Scheduled Tribes							2.75*(2.38, 3.18)	0.17
Other Backward Classes							1.26*(1.13, 1.42)	0.08
Others							Ref.	

*Ref: Reference; aOR: Adjusted Odds Ratio;; CI: Confidence Interval; SES: Socio-economic status; MPCE: Monthly per capita consumption expenditure;*

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*Model-1 was control for Subjective SES and Individual, Health and Household factors; Model-2 was controlled for MPCE quintile and Individual, Health and Household factors; Model-3 was controlled for education and Individual, Health and Household factors and Model-4 was controlled for caste and Individual, Health and Household factors.*

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**Table-S2.** Sensitivity analysis estimates for cognitive impairment among older adults in India, 2017-18

Background characteristics		Model-1 OR (95% CI)	Model-2 aOR (95% CI)
<b>Socio-economic status</b>			
<b>Subjective SES</b>			
<b>Ladder SES</b>			
	High	Ref.	Ref.
	Medium	1.44*(1.21,1.7)	1.53*(1.28,1.82)
	Low	1.81*(1.52,2.16)	2.04*(1.69,2.46)
<b>Objective SES</b>			
<b>MPCE quintile</b>			
	High	Ref.	Ref.
	Medium	1.06(0.95,1.18)	1.14*(1.01,1.27)
	Low	1.17*(1.08,1.28)	1.28*(1.16,1.42)
<b>Education</b>			
	Not educated/primary not completed	0.72*(0.63,0.82)	0.21*(0.18,0.25)
	Primary	0.81*(0.69,0.95)	0.43*(0.36,0.51)
	Secondary	0.87(0.75,1.01)	0.61*(0.52,0.71)
	Higher	Ref.	Ref.
<b>Caste</b>			
	Scheduled Castes	1.03(0.91,1.16)	1.26*(1.11,1.44)
	Scheduled Tribes	1.21*(1.08,1.37)	1.71*(1.47,1.98)
	Other Backward Classes	0.84*(0.76,0.92)	0.98(0.88,1.09)
	Others	Ref.	Ref.

*Ref: Reference; OR: Unadjusted Odds Ratio; aOR: Adjusted Odds Ratio; CI: Confidence Interval; SES: Socio-economic status; Cognitive impairment was adjusted for education (lowest 10<sup>th</sup> percentile of each educational category was considered cognitively impaired, i.e, with a cut-off score of 14 for no educated/primary not completed, 21 for primary, 24 for secondary and 27 for higher education groups); Model-2 was adjusted for Individual, Health and Household related factors*

**Table-S3.** Sensitivity analysis estimates (Interaction models) for cognitive impairment among older adults in India, 2017-18

Background characteristics	Model-3	Model-4	Model-5
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
<b>Ladder SES # MPCE quintile</b>			
High # high	Ref.		
High # middle	1.44*(1.14,1.83)		
High # low	1.97*(1.52,2.57)		
Middle # high	1.14(0.73,1.76)		
Middle # middle	1.68*(1.3,2.17)		
Middle # low	2.16*(1.64,2.85)		
Low # high	1.08(0.72,1.62)		
Low # middle	1.89*(1.48,2.42)		
Low # low	2.51*(1.95,3.23)		
<b>Ladder SES # Education</b>			
High # higher		Ref.	
High # secondary		0.6*(0.39,0.94)	
High # primary		0.54*(0.32,0.92)	
High # Not educated/primary not completed		0.19*(0.12,0.3)	
Middle # higher		1.52*(1.09,2.13)	
Middle # secondary		0.93(0.67,1.28)	
Middle # primary		0.67*(0.48,0.94)	
Middle # Not educated/primary not completed		0.34*(0.25,0.47)	
Low # higher		1.84*(1.15,2.95)	
Low # secondary		1.34(0.94,1.93)	
Low # primary		0.87(0.61,1.25)	
Low # Not educated/primary not completed		0.47*(0.34,0.65)	
<b>Ladder SES # Caste</b>			
High # Others			Ref.
High # Other Backward Class			1.33(0.92,1.94)
High # Scheduled Caste			2.04*(1.14,3.62)
High # Scheduled Tribe			0.97(0.52,1.8)
Middle # Others			1.72*(1.3,2.26)
Middle # Other Backward Class			1.73*(1.3,2.29)
Middle # Scheduled Caste			2.23*(1.65,3.03)
Middle # Scheduled Tribe			2.49*(1.82,3.42)

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3	Low # Others	2.19*(1.63,2.96)
4	Low # Other Backward Class	2.16*(1.61,2.89)
5	Low # Scheduled Caste	2.89*(2.13,3.92)
6	Low # Scheduled Tribe	4.99*(3.65,6.83)
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8 #: Interaction; Ref: Reference; aOR: Adjusted Odds Ratio; CI: Confidence Interval; SES: Socio-economic status;

9 Cognitive impairment was adjusted for education (lowest 10<sup>th</sup> percentile of each educational category was considered cognitively impaired, i.e, with a cut-off  
10 score of 14 for no educated/primary not completed, 21 for primary, 24 for secondary and 27 for higher education groups); Model-3, 4 and 5 were adjusted  
11 for Individual, Health and Household related factors

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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
<b>Title and abstract</b>	1	1-2
<b>Introduction</b>		
Background/rationale	2	5
Objectives	3	6
<b>Methods</b>		
Study design	4	7
Setting	5	7
Participants	6	7
Variables	7	7-8
Data sources/ measurement	8*	7
Bias	9	-
Study size	10	7
Quantitative variables	11	7-8
Statistical methods	12	11-12
<b>Results</b>		
Participants	13*	12-13
Descriptive data	14*	12-13 12-13
Outcome data	15*	
Main results	16	12-14
Other analyses	17	12-14
<b>Discussion</b>		
Key results	18	15-18
Limitations	19	17
Interpretation	20	15-18
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\*Give information separately for exposed and unexposed groups.

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## Association of objective and subjective socioeconomic markers with cognitive impairment among older adults: cross-sectional evidence from a developing country

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3 **Association of objective and subjective socioeconomic markers with cognitive**  
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5 **impairment among older adults: cross-sectional evidence from a developing country**  
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## Abstract

**Objective:** This study explored how various markers of objective and subjective socio-economic status (SES) are associated with cognitive impairment among older Indian adults.

**Design:** A cross-sectional study was conducted using large nationally-representative survey data.

**Setting and participant:** This study used data from the Longitudinal Aging Study in India (2017-18). The sample included 31,464 older adults aged 60 years and above.

**Primary and secondary outcome measures:** Outcome variable was cognitive impairment, measured through broad domains of memory, orientation, arithmetic function, and visuo-spatial and constructive skills. We estimated descriptive statistics and presented cross-tabulations of the outcome. Chi-square test was used to evaluate the significance level of differences in cognitive impairment by subjective (ladder) and objective SES measures (monthly per-capita consumption expenditure (MPCE) quintile, education and caste status). Multivariable linear and logistic regression analyses were conducted to fulfil the objectives.

## Results

A proportion of 41.7% and 43.4% of older adults belonged to low subjective (ladder) and objective (MPCE) SES, respectively. Older adults with low subjective [aOR: 2.04;  $p < 0.05$ ] and objective SES [aOR: 1.32;  $p < 0.05$ ] had higher odds of having cognitive impairment in comparison to their counterparts, with a stronger subjective SES-cognitive impairment association. Older adults with lower education or belonged to lower caste had higher odds of cognitive impairment than their counterparts. Interaction analyses revealed that older adults who belonged to lower subjective and objective (poorest MPCE quintile, Scheduled Castes and lowest education) SES had 2.45 (CI: 1.77, 3.39), 4.56 (CI: 2.97, 6.98) and 54.41 (CI:



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3 7.61,388.93) higher odds of cognitive impairment than those from higher subjective and  
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5 objective SES.  
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## 8 **Conclusion**

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11 Subjective measures of SES were linked to cognitive outcomes, even more strongly than  
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13 objective measures of SES; considering the relative ease of obtaining such measures,  
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15 subjective SES measures are a promising target for future study on socioeconomic indicators  
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17 of cognitive impairment.  
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20  
21 **Keywords:** *Subjective; Objective; Socioeconomic status; Cognitive impairment; Older adults,*  
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**Strengths and limitations:**

- The study utilizes a large nationally representative sample of older persons from both rural and urban areas of India
- The cross-sectional design of the study eliminates the opportunity for drawing of causal inferences among variables.
- Some individuals may become cognitively impaired because they are illiterate and could not respond with accuracy to several measures

For peer review only

## Introduction

Cognitive impairment, including dementia as an outcome of decline in cognitive ability, increases considerably with the rapidly growing population of older adults [1]. Worldwide, almost 80% of the general public are concerned about developing dementia at some point in time and 1 in 4 people think that they can do nothing to prevent such a cognitive decline [2].

Various indices of economic hardship, including lack of education, poor household economy, unemployment, and employment frustration, are linked with poor physical health conditions resulting in cognitive deficits [3–5]. Similarly, evidence suggests an aggregate or cumulative effect of socio-economic risk factors on cognitive impairment in later years of life [6–8]. Persons with higher cumulative socioeconomic status (SES) demonstrated an advantage in cognitive functioning [9]. A growing body of literature suggests that people who accumulated more wealth may be able to more easily translate it into better environmental circumstances or less stressful living conditions, further contributing to better cognitive health in later life [7, 10, 11]. Studies reported improvements in mental well-being for older people after the introduction of an income supplemental program [12, 13]. Measured by a test of processing speed, associations of educational attainment and current poverty index were found with late-life cognitive impairment in multiple studies [7, 14, 15]. Furthermore, a major contributing factor may include poor literacy resulting in an inability to benefit from strategies for early prevention of cognitive impairment [16].

### *Two approaches to SES: Subjective and objective SES measures*

Objective SES is commonly indicated by household wealth index and individual educational attainment, and caste status in particular Indian context [17–19]. Although these indicators are highly correlated [20], they reflect more of one's power or prestige [21]. In

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3 comparison, the subjective SES captures individuals' perceptions of their position in the  
4 social hierarchy, thus representing a psychological process [22].  
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8 In this regard, people make judgments of where they belong in the social hierarchy relative to  
9 others based on cognitive averaging of their economic status, education, occupation, and  
10 other objective indicators using different reference groups [23]. There is a growing body of  
11 research documenting that if people perceive themselves to be subordinate to others, they  
12 report lower self-esteem and greater stress, and they are likely to suffer from diseases more  
13 often than people who do not regard themselves to be of lower status [24]. Hence, subjective  
14 SES as a rank-based judgment that is composed of an evaluative judgment whereas the  
15 objective resources would place a person in rank within a specific context, which is derived  
16 mainly via the social comparison process.  
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30 Evidence for the association between poor socioeconomic indicators with worse mental  
31 health outcomes is abundant in the geriatric research. Many previous studies in India and  
32 other countries have reinforced that illiteracy, lower social status and poor financial status  
33 were strongly associated with worse cognitive function at the individual level [1, 25, 26].  
34 Similarly, the association of subjective SES and physical and mental health of older adults is  
35 explored in a couple of studies in Asian countries [27, 28]. However, the difference in the  
36 role that subjective and objective socioeconomic factors play in contributing to declining in  
37 late life cognition is poorly understood in the context of developing countries. Therefore, in  
38 this study, we aimed to explore the late-life cognitive impairment as a function of older  
39 individuals' objective and subjective SES using a large representative survey information of  
40 older adults aged 60 and above in India. A conceptual framework based on the  
41 abovementioned theoretical background is summarised in Figure-1.  
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## 58 **Data, variables, and methods**

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## Data Source

We utilized data from the recent release of Longitudinal Ageing Study in India (LASI) wave 1 [29]. LASI is a full-scale national survey of scientific investigation of the health, economic, and social determinants and consequences of population aging in India, conducted in 2017-18. The LASI is a nationally representative survey of over 72000 older adults aged 45 and above across all states and union territories (UTs) of India. The survey adopted a three-stage sampling design in rural areas and a four-stage sampling design in urban areas. In each state/UT, the first stage involved the selection of Primary Sampling Units (PSUs), that is, sub-districts (Tehsils/Talukas), and the second stage involved the selection of villages in rural areas and wards in urban areas in the selected PSUs [29]. In rural areas, households were selected from selected villages in the third stage. However, sampling in urban areas involved an additional stage. Specifically, in the third stage, one Census Enumeration Block (CEB) was randomly selected in each urban area [29]. In the fourth stage, households were selected from this CEB. The detailed methodology, with the complete information on the survey design and data collection is published elsewhere and in the survey report [29, 30]. The present study is conducted on eligible respondents aged 60 years and above (31,464 older individuals from both rural and urban areas).

The necessary guidelines and ethics for undertaking the LASI survey were approved by the Indian Council of Medical Research (ICMR). The agencies that conducted the field survey for the data collection had collected prior informed consent (signed and oral) for both the interviews and biomarker tests from the eligible respondents in accordance with the Human Subjects Protection. All methods in this study were carried out in accordance with relevant guidelines and regulations by the ICMR.

## *Variable description*

### ***Outcome variable***

Cognitive impairment was measured through broad domains of memory, orientation, arithmetic function, and visuo-spatial and constructive skills. It is followed from the cognitive module of the Health and Retirement Study (HRS), the China Health and Retirement Longitudinal Study (CHARLS), and the Mexican Health and Aging Study (MHAS), based on different cognitive measures including: immediate (0–10 points) and delayed word recall (0–10 points); orientation related to time (0-4 points), and place (0-4 points); arithmetic ability based on serial 7s (0–5 points), computation (0-2) and backward counting from 20 (0–2 points); visuo-spatial and constructive skills based on paper folding (0-3) pentagon drawing (0-1); and object naming (0-2). The overall score ranged between 0 and 43, and a higher score indicated better cognitive functioning. The lowest 10th percentile was used as a proxy measure of poor cognitive functioning [29]. Further, for the analytical purpose, the score was reversed to assess the cognitive impairment among older adults and thus after reversing, the higher score indicated higher levels of cognitive impairment. In our study, the respondents who received assistance during the cognition module were excluded from the analysis.

### ***SES exposures***

The main explanatory variables were subjective SES (ladder SES) and objective SES (household wealth quintile, education and caste status) among older adults.

The subjective SES was assessed using the Macarthur scale [31], with a ladder technique and the question used to assess the variable was “Think of the ladder with 10 stairs as representing where people stand in our society. At the top of the ladder are the people who are the best off – those who have the most money, most education, and best jobs. At the bottom are the people who are the worst off – who have the least money, least education, and the worst jobs or no jobs. The higher up you are on this ladder, the closer you are to the

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3 people at the very top and the lower you are, the closer you are to the people at the very  
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5 bottom of your society". The scale is used to measure the subjective SES across different  
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7 populations in India and other countries [32, 33]. A score of 0-10 was generated as per the  
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9 number of rungs marked by the respondents and the variable of subjective SES was coded as  
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11 0-3 as "low", 4-7 as "middle" and 8-10 as "high" [34].  
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15 The monthly per capita consumption expenditure (MPCE) quintile was assessed using  
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17 household consumption data. The MPCE was used as one of the measures of objective SES.  
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19 Sets of 11 and 29 questions on the expenditures on food and non-food items, respectively,  
20  
21 were used to canvas the consumption pattern of the sample households. Food expenditure  
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23 was collected based on a reference period of seven days, and non-food expenditure was  
24  
25 collected based on reference periods of 30 days and 365 days. Food and non-food  
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27 expenditures have been standardized to the 30-day reference period. The MPCE is computed  
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29 and used as the summary measure of consumption [29]. The available categories of the  
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31 variable comprised of five quintiles i.e., poorest, poorer, middle, richer and richest. Since  
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33 keeping the actual categories would produce large number of categories during the interaction  
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35 analysis, MPCE was further recoded into three categories for easy interpretability and better  
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37 understanding while applying the interaction terms. Thus, the MPCE quintile was further  
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39 recoded as 'low' (poorest and poorer), 'middle' and 'high' (richer and richest) [35].  
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46 Another objective SES measure was educational status of older adults. As documented in  
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48 multiple studies, brain functioning and cognitive processing are modulated by formal  
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50 education of individuals and the illiterate population who received no formal education due to  
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52 several socio-cultural and economic reasons are at greater risk for cognitive impairment and  
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54 dementias [36]. The educational status in the current study was coded as no  
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56 education/primary not completed, primary, secondary and higher. Finally, caste system in  
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58 India is a social hierarchy that is passed down through families and groups of people dictate  
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3 the professions and social prestige merely by their caste status [19]. As an objective SES  
4 measure, caste in the study was recoded as Scheduled Tribes, Scheduled Castes, Other  
5 Backward Classes, and Others based on specific administrative classification [19]. The  
6 Scheduled Caste includes a group of the population that is socially segregated and  
7 financially/economically marginalized by their low status as per Hindu caste hierarchy. The  
8 Scheduled Tribes and Scheduled Castes are among the most disadvantaged socio-economic  
9 groups and have substantially lower wealth than the “forward” caste groups in India [37]. The  
10 Other Backward Classes refer to the group of people who were identified as “educationally,  
11 economically and socially backward” and occupy positions in the middle [38]. The ‘Others’  
12 caste category denotes the groups having higher social status and refers to a large number of  
13 the forward castes and comparatively advantaged populations in the country [38].  
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### 29 ***Other covariates***

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32 *Individual factors:* The following socio-demographic variables were included in the analysis  
33 according to the previous literature that have shown their associations with the cognitive  
34 outcomes [39–42]. Age was used as continuous variable. Sex was coded as male and female.  
35 Working status was coded as currently working, retired, and not working. Marital status was  
36 coded as currently married, widowed and others. Others included divorced/separated/never  
37 married. Living arrangement was coded as living alone, living with spouse, living with  
38 spouse and children and living with others. Social participation was coded as ‘no’ and ‘yes’.  
39 Social participation was measured through the question “Are you a member of any of the  
40 organizations, religious groups, clubs, or societies?” The response was coded as ‘no’ and  
41 ‘yes’ [43]. Physical activity status was coded as frequent (every day), rare (more than once a  
42 week, once a week, one to three times in a month), and never. The question through which  
43 physical activity was assessed was “How often do you take part in sports or vigorous  
44 activities, such as running or jogging, swimming, going to a health centre or gym, cycling, or  
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3 digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling  
4 with loads”? [44].  
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8 *Health-related factors:* Health-related covariates that were shown to associate with cognitive  
9 impairment and are considered as possible confounders of the SES-cognition relationship in  
10 the current analyses include depression [42], self-rated health [45], functional difficulty [46]  
11 and morbidity [47]. The probable major depression among older adults with symptoms of  
12 dysphoria was calculated using the Short Form Composite International Diagnostic Interview  
13 (CIDI-SF). This scale estimates a probable psychiatric diagnosis of major depression and has  
14 been validated in field settings and widely used in population-based health surveys [29]. On a  
15 scale of 0-10, the respondents who had three or more symptoms were considered as  
16 depressed [48]. Self-rated health was available in five-point scale, representing excellent,  
17 very good, good, fair and poor [49]. Difficulty in activities of daily living (ADL) was coded  
18 as ‘no’ and ‘yes’. ADL refers to normal daily self-care activities (such as movement in bed,  
19 changing position from sitting to standing, feeding, bathing, dressing, grooming, personal  
20 hygiene, etc.) The ability or inability to perform ADLs is used to measure a person’s  
21 functional status, especially in case of people with disabilities and the ones in their older ages  
22 [50]. Difficulty in instrumental ADL (IADL) was coded as ‘no’ and ‘yes’. Respondents were  
23 asked if they were having any difficulties that were expected to last more than three months,  
24 such as preparing a hot meal, shopping for groceries, making a telephone call, taking  
25 medications, doing work around the house or garden, managing money (such as paying bills  
26 and keeping track of expenses), and getting around or finding an address in unfamiliar places  
27 [43]. Morbidity was coded as no morbidity, 1 and 2+ [43]. This variable was created using  
28 the data on chronic diseases which include hypertension, chronic heart diseases, stroke, any  
29 chronic lung disease, diabetes, cancer or malignant tumor, any bone/joint disease,  
30 neurological/psychiatric disease, or high cholesterol.  
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3 *Household/community-related factors:* Taking cue from earlier research, we also added the  
4 following characteristics as control variables in order to improve the precision of the results  
5 [39, 51, 52]. Religion was coded as Hindu, Muslim, Christian, and Others. Place of residence  
6 was coded as rural and urban. The geographical regions of India were categorized as North,  
7 Central, East, Northeast, West, and South.  
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### 15 ***Statistical analysis***

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18 We estimated descriptive statistics and presented cross-tabulations of the outcome in the  
19 study. Additionally, multivariable logistic and linear regression analysis [53, 54] were  
20 conducted to establish the association between the outcome variable (cognitive impairment)  
21 and socio-economic status. The results were presented in the form of odds ratio (OR),  
22 adjusted OR (aOR) and standardized regression coefficients (beta) with 95% confidence  
23 interval (CI). Variance inflation factor (VIF) was generated in STATA 14 [55] to check the  
24 multicollinearity and it was found that there was no evidence of multicollinearity in the  
25 variables used [56, 57].  
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37 Moreover, interaction effects [43, 58] were observed for subjective SES and multiple  
38 objective SES measures with cognitive impairment among older adults in India. Model-1  
39 represents the unadjusted effects whereas model-2 represents the adjusted effects. The  
40 analysis was controlled for age, sex, working status, marital status, living arrangement, social  
41 participation, physical activity, depression, self-rated health, difficulty in ADL and IADL,  
42 morbidity, religion, place of residence and regions. Models-3, 4 and 5 represent interaction  
43 effects which are adjusted for individual, health and household/community related factors.  
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### 54 **Patient and Public Involvement**

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57 No patient involved  
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### 59 **Results**

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3 Table-1 represents socio-economic and demographic profile of Indian older adults included  
4 in this study. The mean age of the study population was 69.2 years (standard deviation: 7.5).  
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6 It was found that about 41.7% of older adults belong to low subjective SES and only 7%  
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8 belong to higher subjective SES. Additionally, about 43.4% of older adults belonged to low  
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10 objective SES and about 35.6% belonged to higher objective SES. About 13.1% (n=3250)  
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12 older adults were cognitively impaired in reference to 86.9% (n=21580) who were not  
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14 cognitively impaired.  
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20 About 26.4% of older adults got retired from employment and 30.8% were currently working.  
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22 Nearly 36.2% of older adults were widowed. Only 5.7% of older adults were living alone and  
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24 68.3% were living with their children and spouse. Only 4.5% of older adults reported that  
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26 they socially participate. Nearly, 69.3% of older adults were never involved in any physical  
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28 activity. About 8.7% of older adults suffered from major depression. Nearly, 15.0% of older  
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30 adults reported poor self-rated health. About 24.4% and 48.7% of older adults reported  
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32 difficulty in ADL and IADL.  
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37 [Insert table-1 here]  
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40 Figure-2 presents the percentage distribution of subjective SES (ladder SES) that ranges from  
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42 1 to 10, representing lowest to highest rank. A proportion of 8.2% of older adults marked  
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44 their SES in the bottom of the ladder (lowest), whereas a proportion of only 1.1% marked  
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46 their SES at the top of the ladder (highest).  
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49 [Insert figure-2 here]  
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52 Figure-3 reveals that lower the subjective SES (17.8%;  $p < 0.001$ ) of an older adult, higher the  
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54 prevalence of cognitive impairment.  
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57 [Insert figure-3 here]  
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3 Figure-4 reveals that lower the objective SES (measured by MPCE quintile) (16.6%;  
4 p<0.001) of an older adult, higher the prevalence of cognitive impairment. With regard to  
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6 other objective SES measures, older adults with no education/primary not completed had  
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8 highest prevalence of cognitive impairment (19.9%; p<0.001). Similarly, older adults from  
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10 Scheduled Tribe category had highest prevalence of cognitive impairment (22.1%; p<0.001).  
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15 [Insert figure-4 here]  
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18 Table-2a represents the logistic regression estimates of cognitive impairment among older  
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20 adults. In model-2 which is adjusted model, it was revealed that older adults who belonged to  
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22 lower subjective SES had significantly higher odds of cognitive impairment [aOR: 2.04;  
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24 p<0.05] in reference to older adults who belonged to higher subjective SES. Moreover, older  
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26 adults who belonged to lower objective SES (MPCE quintile) had 32% significantly higher  
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28 odds of suffering from cognitive impairment [aOR: 1.32; p<0.05] in comparison to older  
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30 adults who belonged to higher objective SES (MPCE quintile). Older adults who were not  
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32 educated/ with minimum education had significantly higher odds of cognitive  
33  
34 impairment in reference to older adults with higher education [aOR: 22.4; p<0.05]. Older  
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36 adults who belonged to the Scheduled Castes and Scheduled Tribes had 22% [aOR: 1.22;  
37  
38 p<0.05] and 80% [aOR: 1.80; p<0.05] significantly higher odds of cognitive impairment in  
39  
40 reference to older adults from other (higher) caste category, respectively. Table-S1 represents  
41  
42 the regression estimates for cognitive impairment among older adults in India. In table S2,  
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44 model-1 included subjective SES and individual, health and household factors; model-2  
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46 included MPCE quintile and individual, health and household factors; model-3 included  
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48 education and individual, health and household factors and model-4 included caste and  
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50 individual, health and household factors. These separate models for each aspect of SES also  
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52 showed the similar pattern and odds of cognitive impairment were even greater in case of  
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54 older adults who were not educated/with minimum education. Table S2 represents sensitivity  
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3 analysis estimates (aORs) of cognitive impairment among older adults when the outcome  
4 variable i.e., cognitive impairment, was adjusted for education (lowest 10<sup>th</sup> percentile of each  
5 educational category was considered cognitively impaired, i.e, with a cut-off score of 14 for  
6 no educated/primary not completed, 21 for primary, 24 for secondary and 27 for higher  
7 education groups). The results showed no changes in the observed associations and the  
8 pattern remained same for all the subjective and objective SES measures, except education.  
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17 [Insert Table-2a]  
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20 In model-3, 4 and 5 (Table-2b) which reveals the interaction results for cognitive impairment.  
21 It was found that older adults who belong to lower subjective as well as objective SES were  
22 2.45 times significant more likely to suffer from cognitive impairment in reference to older  
23 adults from higher subjective as well as objective SES (MPCE quintile) [aOR: 2.45; p<0.05].  
24 In reference to older adults with high ladder SES and higher education, older adults with high  
25 ladder SES and no education/primary not completed [aOR: 24.14; p<0.05], middle ladder  
26 SES and no education/primary not completed [aOR: 37.07; p<0.05] and low ladder SES and  
27 no education/primary not completed [aOR: 54.41; p<0.05] had significantly higher odds for  
28 cognitive impairment. Older adults from low ladder SES and belonged to the Scheduled  
29 Castes [aOR: 2.88; p<0.05], low ladder SES and belonged to the Scheduled Tribes [aOR:  
30 4.56; p<0.05] and low ladder SES and belonged to the Other Backward Classes [aOR: 2.15;  
31 p<0,05] had significantly higher odds of cognitive impairment in reference to older adults  
32 from high ladder SES and other (higher) caste category. Table S3 represents sensitivity  
33 analysis estimates (interaction models) for cognitive impairment among older adults after  
34 adjusting for education, and the results indicated towards similar findings.  
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55 [Insert Table-2b]  
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## 58 Discussion 59 60

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3 This study using a large representative data on older population in India was in parallel to  
4 multiple earlier studies in India and other developing countries which found that older  
5 individuals with lower SES experience cognitive impairment compared with people with  
6 higher SES [1, 59–61]. This association has been identified in case of both objective and  
7 subjective measures of SES. Studies have illustrated empirical evidence on the positive  
8 relationship between SES as measured by objective indices of material resources and  
9 subjective measures, and psychological well-being [62, 63]. Similarly, the interactive effect  
10 in our study found that older adults with lower levels of subjective and objective SES were at  
11 a greater risk of having cognitive impairment.  
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24 However, subjective SES was identified to have a much stronger association with cognitive  
25 impairment in the unadjusted and adjusted regression estimates in comparison to objective  
26 SES measured by household MPCE quintile. With respect to this strong association, there can  
27 be some possible explanations. At first, obviously, subjective SES was more meaningful than  
28 household wealth index. Higher economic status does not necessarily mean more resources at  
29 disposal, if compared with higher individual circumstances, but positive social comparison  
30 does. In addition, people with greater household economic status may endure more pressures  
31 and mental stress, which in turn may affect their mental health status and cognitive ability  
32 [64]. This could be mainly due to the subjectivity character of subjective SES. This potential  
33 explanation can also be attributed to different perceptions towards wealth and social status  
34 among older population in India.  
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50 Furthermore, considering the education-cognitive function association, the current findings  
51 suggest that higher education is a protective factor against cognitive impairment in older  
52 individuals. A hypothesized mechanism is that education is transformed to personal  
53 experience and self-perceptions about own social standing, which in turn translate into health  
54 and disease. Similarly, the current findings suggest that older adults with no education and  
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3 low levels of subjective SES had much greater odds of cognitive impairment compared to  
4 those with higher education and higher subjective SES. This finding agrees with the previous  
5 evidence on the moderating role of education in the relationship between subjective SES and  
6 cognitive function. Also, as documented in earlier research [22], subjective SES is a means  
7 through which education may influence health outcomes among older people. Nevertheless,  
8 proper path analysis using longitudinal data and conducting moderation as well as mediation  
9 analyses is needed to test these claims.

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12 Finally, older adults belonging to the lower caste groups (with low social status) were found  
13 to be more likely to be cognitively impaired in the study in comparison to those belong to  
14 higher castes. Importantly, in a previous study, it was observed that indicators of subjective  
15 SES differ across socio-demographic groups including race, and interpretations may vary  
16 when perceiving themselves on the existing social hierarchy [24]. Previous studies in India  
17 have demonstrated that the socioeconomic disadvantages such as lower income and lack of  
18 education were associated with belonging to lower castes (scheduled tribes and other  
19 backward classes) [18, 19, 65, 66]. Further, lower caste status being a factor of less  
20 opportunities in economic spectrum also contributes to poorer health, health inequalities and  
21 mortality burden in India [17, 38, 67]. It is however demonstrated that since individuals may  
22 estimate their SES relative to others in a specific community or social group, the social  
23 disadvantage may not necessarily negatively influence their mental wellbeing [62]. This  
24 suggests that the SES could be better captured by assessing the interactions between  
25 subjective and objective measures of SES.

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28 The current study provides crucial clues about what measure of SES highly reflect on  
29 cognitive health in old age by underlining the importance of the cumulative dimension of  
30 subjective SES and different traditional measures including wealth status, education and  
31 caste. Similarly, although no statistical test was performed which assesses whether the

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3 difference in magnitude of the association detected by separate models is non-zero and  
4 statistically significant, the current findings revealed a greater strength of correlation between  
5 subjective SES and cognitive impairment, compared to objective SES measure. The findings  
6 also showed the underperformance of traditional measure of wealth status compared to  
7 subjective SES. Considering the current findings and the existing evidence [62], separate  
8 SES-related ladders that evaluate subjective perceptions of individuals' economic status  
9 (MPCE), education and social status (caste hierarchy in Indian context) may be suggested in  
10 wellbeing research. This is because subjective SES may reflect individuals' present social  
11 circumstances and an assessment of their past experiences and future prospects. As suggested  
12 in previous studies, subjective perception of one's SES might also encompass his/her  
13 household resources, life chances and opportunities, and thus captures a broad range of  
14 aspects of social stratification than traditional measures of SES do [23, 31, 68]. The finding  
15 further underscores the need for future longitudinal investigation of subjective SES-related  
16 measurement strategies to obtain a better understanding of the SES-cognitive functioning link  
17 especially in poor resource settings. The effects of country affluence on population health  
18 have been demonstrated. Several cross-country comparisons have documented considerable  
19 variations in the strength of subjective SES-health relationship between affluent and low-  
20 income countries with a stronger association in the later ones [69, 70].  
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45 There are several limitations of the present study to be considered. The major limitation is the  
46 cross-sectional design of the study eliminating the opportunity for drawing of causal  
47 inferences among variables. Indeed, it is important to consider that the cognitive measure  
48 used in this study included elements that are acquired through years of education and several  
49 elements are compounded by literacy levels. Hence, a large number of individuals who are  
50 illiterate may be mis-categorized as cognitively impaired because they cannot respond with  
51 accuracy to several measures, and therefore, reliable cognitive assessment tools should be  
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3 developed and validated among poorly educated older people in Indian context. In this  
4 regard, much greater odds of cognitive impairment among illiterate population with large  
5 confidence interval even after controlling for several covariates in the main and sensitivity  
6 analyses, with separate models for each aspect of SES, may also be a result of a very different  
7 sample of older adults with higher education (7%) from those without education (68%).  
8 Importantly, due to lack of evidence of algorithm for combining various cognitive tests in the  
9 Indian context, we weight all tests equally and use an additive measure for overall cognitive  
10 functioning in the current study. Some of the tests may be far better than others in screening  
11 for or assessing the degree of cognitive dysfunction or dementia, and thus, the current  
12 approach may be misleading and should be addressed in future studies.  
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27 In addition, there is a possibility of some of the covariates included in the current analysis  
28 potentially being on the pathway between the key explanatory variables and outcome  
29 variable. For example, the objective SES, measured by caste, which is generally determined  
30 at birth could influence individuals' life course in multiple ways, such as their participation in  
31 physical or social activities. This may eventually result in collider stratification that leads to  
32 biased estimates in the multivariable models in the current study. Finally, there may also be  
33 floor or ceiling effects for SES because we have only three categories for both SES measures  
34 of ladder and MPCE quintiles.  
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46 Notwithstanding these limitations, there were several advantages in this study. At first, this  
47 may be the first study to identify the association between both objective and subjective SES  
48 indicators and cognitive impairment based on a comprehensive measure with a score of 0 to  
49 43 among the older Indian population. The large sample of the present study that is free from  
50 selection bias includes all SES groups of Indian population that credits to the  
51 representativeness and generalizability of the findings. In addition to including multiple SES  
52 groups, this study also includes participants living both in rural and urban areas which  
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3 enhance the generalizability of the results. Further, the findings of the present study provide  
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5 empirical support to the body of literature that highlights the vulnerability of older adults who  
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7 have low subjective and objective SES to the worse cognitive health outcomes. Finally,  
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9 future research may focus on longitudinal associations of various socioeconomic markers  
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11 with mental health outcomes among middle aged and older adults in India.  
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## 15 **Conclusion**

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18 Subjective measures of SES were linked to cognitive outcomes, potentially even more  
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20 strongly than were the objective measures of SES. Thus, considering the relative ease of  
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22 obtaining such measures, subjective SES measures are a promising target for future study on  
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24 socioeconomic indicators of cognitive impairment. The current findings also highlight the  
25  
26 importance of subjective SES measure and its interaction with objective (traditional)  
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28 measures of SES including wealth, education and caste status in assessing the mental health  
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30 outcomes in developing countries. The results also suggest that more attention should be  
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32 placed on subjective SES indicators when investigating socioeconomic influences on  
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34 cognitive functioning among older adults in India.  
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3 **Abbreviations:**  
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5 **SES:** Socio-economic status  
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7 **aOR:** Adjusted odds ratio  
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9 **CI:** Confidence interval  
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11 **LASI:** Longitudinal Ageing Study in India  
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13 **PSU** Primary Sampling Unit  
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15 **CEB:** Census Enumeration Block  
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17 **MPCE:** Monthly per capita consumption expenditure  
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19 **ADL:** Activities of daily living  
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21 **IADL:** Instrumental activities of daily living  
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## Declarations

### Ethics approval

The necessary guidelines and ethics for undertaking the LASI survey were approved by the Indian Council of Medical Research (ICMR). ICMR approved the study. There was no number/ID of the approval(s) mentioned in the LASI report ([https://www.iipsindia.ac.in/sites/default/files/LASI\\_India\\_Report\\_2020\\_compressed.pdf](https://www.iipsindia.ac.in/sites/default/files/LASI_India_Report_2020_compressed.pdf)).

All methods were carried out in accordance with relevant guidelines and regulations by the Indian Council of Medical Research (ICMR).

### Contributor statement

Conceived and designed the research paper: TM and TVS; analysed the data: SS and TM; Contributed agents/materials/analysis tools: TVS; Wrote the manuscript: TM and SS; Refined the manuscript: TM, SS and TVS.

### Competing interest

The authors declare that there is no competing interest

### Funding

No funding was received for the study

### Data sharing statement

The study uses a secondary data which is available on request through

<https://www.iipsindia.ac.in/content/lasi-wave-i>

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**Table-1.** Socio-economic and demographic profile of older adults in India.

Background characteristics		Sample	Percentage
<b>Socio-economic status</b>			
<b>Subjective SES</b>			
<b>Ladder SES</b>			
	Low	13,127	41.7
	Medium	16,142	51.3
	High	2,195	7.0
<b>Objective SES</b>			
<b>MPCE quintile</b>			
	Low	13,660	43.4
	Medium	6,590	21.0
	High	11,213	35.6
<b>Education</b>			
	Not educated/primary not completed	21,381	68.0
	Primary	3,520	11.2
	Secondary	4,371	13.9
	Higher	2,191	7.0
<b>Caste</b>			
	Scheduled Castes	5,949	18.9
	Scheduled Tribes	2,556	8.1
	Other Backward Classes	14,231	45.2
	Others	8,729	27.7
<b>Individual characteristics</b>			
<b>Age in years (mean (sd))</b>			69.2 (7.5)
<b>Sex</b>			
	Male	14,931	47.5
	Female	16,533	52.6
<b>Working status</b>			
	Working	9,680	30.8
	Retired	13,470	42.8
	Not working	8,314	26.4
<b>Marital status</b>			
	Currently married	19,391	61.6
	Widowed	11,389	36.2
	Others	684	2.2
<b>Living arrangement</b>			
	Living alone	1,787	5.7
	Living with spouse only	6,397	20.3
	Living with children and spouse	21,475	68.3
	Living with others.	1,805	5.7
<b>Social participation</b>			
	No	30,053	95.5
	Yes	1,411	4.5
<b>Physical activity</b>			
	Frequent	5,651	18.0
	Rarely	4,023	12.8
	Never	21,790	69.3
<b>Health factors</b>			
<b>Depression*</b>			

	No	27,995	91.3
	Yes	2,657	8.7
<b>Self-rated health*</b>			
	Excellent	964	3.1
	Very good	4,192	13.6
	Good	10,693	34.7
	Fair	10,331	33.5
	Poor	4,630	15.0
<b>Difficulty in ADL</b>			
	No	23,802	75.7
	Yes	7,662	24.4
<b>Difficulty in IADL</b>			
	No	16,130	51.3
	Yes	15,334	48.7
<b>Morbidity</b>			
	No morbidity	14,773	47.0
	1	9,171	29.2
	2+	7,520	23.9
<b>Household/community-related factors</b>			
<b>Religion</b>			
	Hindu	25,871	82.2
	Muslim	3,548	11.3
	Christian	900	2.9
	Others	1,145	3.6
<b>Place of residence</b>			
	Rural	22,196	70.6
	Urban	9,268	29.5
<b>Region</b>			
	North	3,960	12.6
	Central	6,593	21.0
	East	7,439	23.6
	Northeast	935	3.0
	West	5,401	17.2
	South	7,136	22.7
<b>Total</b>		<b>31,464</b>	<b>100.0</b>
<i>*if Sample may be less due to missing cases; sd: standard deviation</i>			

Table-2a. Regression estimates for cognitive impairment among older adults in India, 2017-18

Background characteristics	Model-1		Model-2	
	OR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta
<b>Socio-economic status</b>				
<b>Subjective SES</b>				
<b>Ladder SES</b>				
High	Ref.		Ref.	
Medium	2.01*(1.63,2.47)	0.107	1.43*(1.14,1.79)	0.102
Low	3.83*(3.11,4.71)	0.172	2.04*(1.63,2.56)	0.157
<b>Objective SES</b>				
<b>MPCE quintile</b>				
High	Ref.		Ref.	
Medium	1.20*(1.07,1.34)	0.011	1.12(0.99,1.26)	0.020
Low	1.50*(1.37,1.64)	0.032	1.32*(1.19,1.46)	0.051
<b>Education</b>				
Not educated/primary not completed	58.91*(27.97,124.07)	0.694	22.40*(10.58,47.41)	0.514
Primary	6.45*(2.96,14.03)	0.204	3.83*(1.75,8.36)	0.142
Secondary	2.55*(1.13,5.73)	0.108	1.94(0.86,4.38)	0.072
Higher	Ref.		Ref.	
<b>Caste</b>				
Scheduled Castes	1.03(0.91,1.16)	0.005	1.22*(1.06,1.39)	0.027
Scheduled Tribes	1.38*(1.22,1.55)	0.029	1.80*(1.55,2.09)	0.067
Other Backward Classes	0.86*(0.78,0.96)	-0.038	0.98(0.87,1.1)	-0.005
Others	Ref.		Ref.	

Ref: Reference; OR: Unadjusted Odds Ratio; aOR: Adjusted Odds Ratio; CI: Confidence Interval; SES: Socio-economic status; Model-2 was adjusted for Individual, Health and Household factors

**Table-2b.** Interaction estimates for cognitive impairment among older adults in India, 2017-18

Background characteristics	Model-3		Model-4		Model-5	
	aOR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta
<b>Ladder SES # MPCE quintile</b>						
High # high	Ref.					
High # middle	1.28(0.92,1.77)	0.085				
High # low	1.95*(1.39,2.72)	0.102				
Middle # high	0.79(0.42,1.48)	0.008				
Middle # middle	1.51*(1.08,2.11)	0.084				
Middle # low	2.09*(1.49,2.95)	0.092				
Low # high	1.24(0.77,1.98)	0.011				
Low # middle	1.77*(1.28,2.45)	0.125				
Low # low	2.45*(1.77,3.39)	0.160				
<b>Ladder SES # Education</b>						
High # higher			Ref.			
High # secondary			2.12(0.22,20.49)	0.021		
High # primary			8.91*(1.1,72.16)	0.037		
High # Not educated/primary not completed			24.14*(3.34,174.63)	0.168		
Middle # higher			1.57(0.18,13.48)	0.032		
Middle # secondary			3.06(0.41,22.74)	0.116		
Middle # primary			5.82(0.8,42.55)	0.167		
Middle # Not educated/primary not			37.07*(5.19,264.9)	0.568		

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completed			
Low # higher	2.11(0.13,34.01)	0.020	
Low# secondary	4.68(0.6,36.81)	0.079	
Low # primary	8.65*(1.17,64.2)	0.129	
Low # Not educated/primary not completed	54.41*(7.61,388.93)		0.602
<b>Ladder SES # Caste</b>			
High # Others			Ref.
High # Other Backward Class		1.39(0.83,2.32)	0.003
High # Scheduled Caste		1.69(0.82,3.48)	0.016
High # Scheduled Tribe		1.04(0.52,2.07)	-0.005
Middle # Others		1.53*(1.01,2.32)	0.081
Middle # Other Backward Class		1.60*(1.06,2.41)	0.081
Middle # Scheduled Caste		1.89*(1.23,2.89)	0.078
Middle # Scheduled Tribe		2.72*(1.77,4.2)	0.105
Low # Others		2.27*(1.49,3.46)	0.083
Low # Other Backward Class		2.15*(1.42,3.26)	0.111
Low # Scheduled Caste		2.88*(1.89,4.39)	0.108
Low # Scheduled Tribe		4.56*(2.97,6.98)	0.132
<i>#: Interaction; Ref: Reference; OR: Unadjusted Odds Ratio; aOR: Adjusted Odds Ratio; CI: Confidence Interval; SES: Socio-economic status; Model-3, 4 and 5 were adjusted for Individual, Health and Household factors</i>			

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3 **Figure legend: -**  
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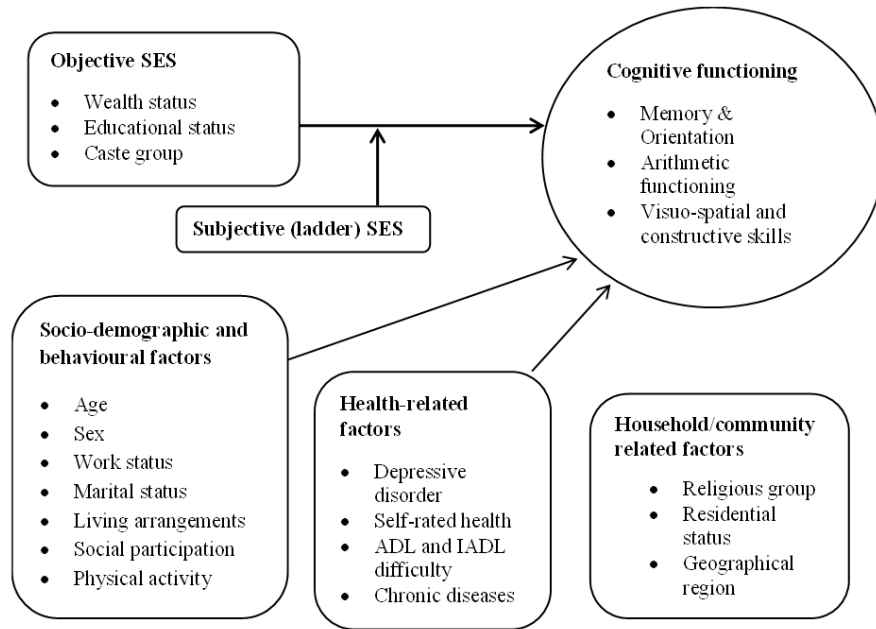
5 **Figure-1:** Conceptual Framework  
6

7 **Figure-2** The distribution of the subjective socio-economic status (1-10: lowest to highest  
8 rank)  
9

10 **Figure-3** Percentage of older adults with cognitive impairment by their subjective socio-  
11 economic status.  
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13 **Figure-4** Percentage of older adults with cognitive impairment by their objective socio-  
14 economic status.  
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Conceptual Framework

186x150mm (144 x 144 DPI)



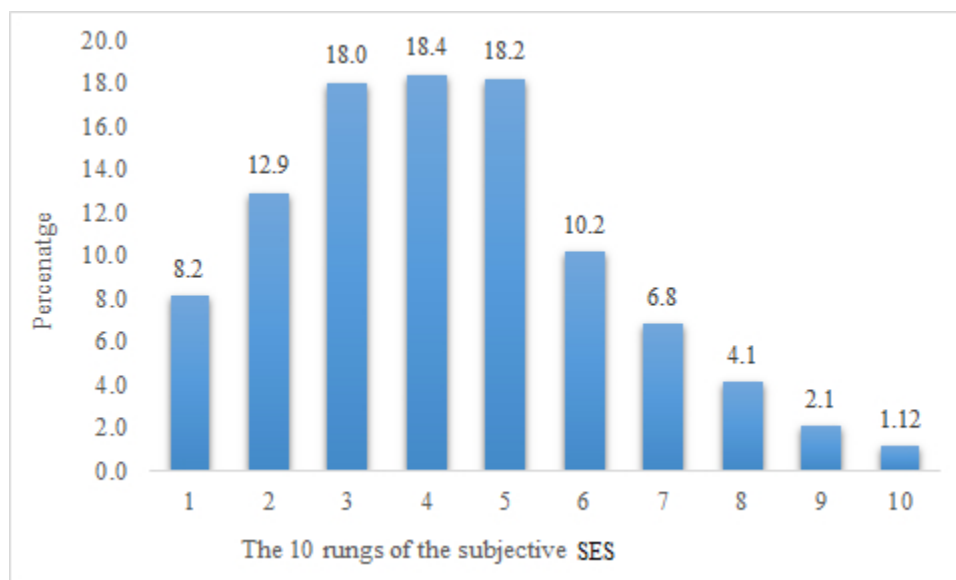


Figure-2 The distribution of the subjective socio-economic status (1-10: lowest to highest rank)

85x51mm (144 x 144 DPI)

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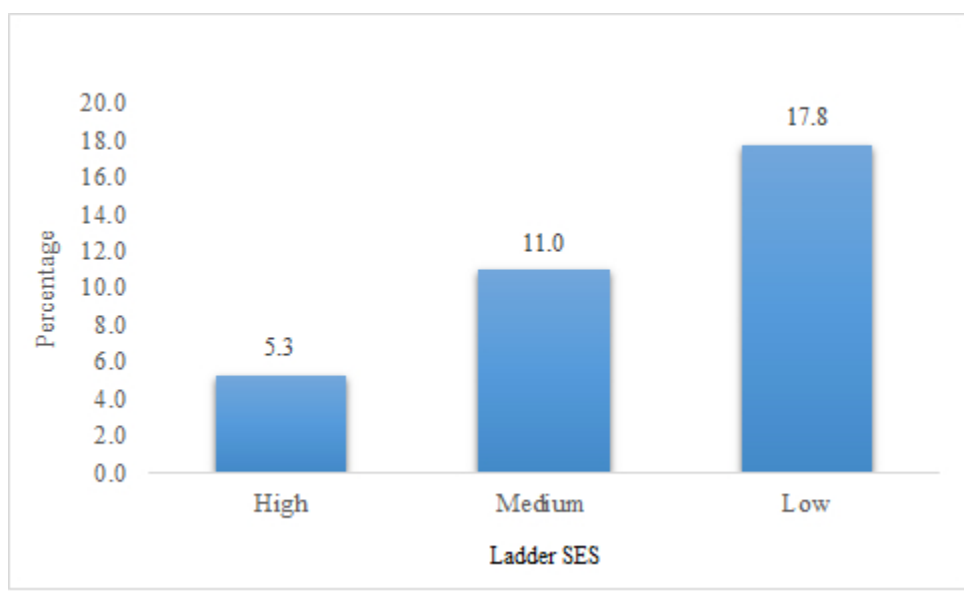


Figure-3 Percentage of older adults with cognitive impairment by their subjective socio-economic status.

85x51mm (144 x 144 DPI)

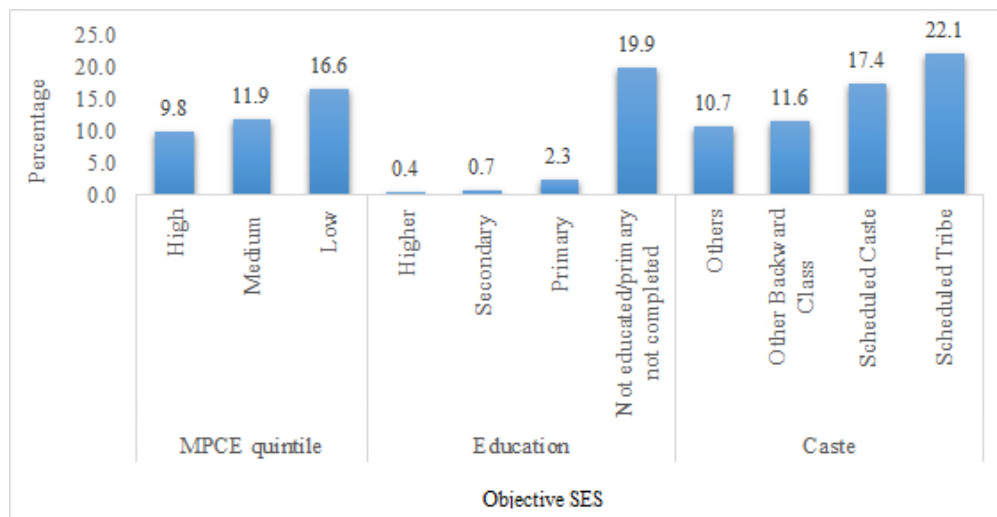


Figure-4 Percentage of older adults with cognitive impairment by their objective socio-economic status.

148x77mm (96 x 96 DPI)

**Table-S1.** Regression estimates for cognitive impairment by each aspect of SES among older adults in India, 2017-18

Background characteristics	Model-1		Mode-2		Model-3		Model-4	
	aOR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta	aOR (95% CI)	Standardized beta
<b>Subjective SES</b>								
<b>Ladder SES</b>								
Low	Ref.							
Medium	1.76*(1.42, 2.18)	0.17						
High	3.16*(2.54, 3.93)	0.30						
<b>Objective SES</b>								
<b>MPCE quintile</b>								
Low			Ref.					
Medium			1.3*(1.16, 1.46)	0.06				
High			1.76*(1.6, 1.94)	0.15				
<b>Education</b>								
Not educated/primary not completed					31.13*(14.74, 65.73)	0.58		
Primary					4.75*(2.18, 10.35)	0.17		
Secondary					2.19(0.97, 4.94)	0.09		
Higher					Ref.			
<b>Caste</b>								
Scheduled Castes							1.88*(1.66, 2.15)	0.13
Scheduled Tribes							2.75*(2.38, 3.18)	0.17
Other Backward Classes							1.26*(1.13, 1.42)	0.08
Others							Ref.	

Ref: Reference; aOR: Adjusted Odds Ratio;; CI: Confidence Interval; SES: Socio-economic status; MPCE: Monthly per capita consumption expenditure;

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*Model-1 included SES and Individual, Health and Household factors; Model-2 included MPCE quintile and Individual, Health and Household factors; Model-3 included education and Individual, Health and Household factors and Model-4 included caste and Individual, Health and Household factors.*

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**Table-S2.** Sensitivity analysis estimates for cognitive impairment after adjusting for education among older adults in India, 2017-18

<b>Background characteristics</b>		<b>Model-1</b>	<b>Model-2</b>
		<b>OR (95% CI)</b>	<b>aOR (95% CI)</b>
<b>Socio-economic status</b>			
<b>Subjective SES</b>			
<b>Ladder SES</b>			
	High	Ref.	Ref.
	Medium	1.44*(1.21,1.7)	1.53*(1.28,1.82)
	Low	1.81*(1.52,2.16)	2.04*(1.69,2.46)
<b>Objective SES</b>			
<b>MPCE quintile</b>			
	High	Ref.	Ref.
	Medium	1.06(0.95,1.18)	1.14*(1.01,1.27)
	Low	1.17*(1.08,1.28)	1.28*(1.16,1.42)
<b>Education</b>			
	Not educated/primary not completed	0.72*(0.63,0.82)	0.21*(0.18,0.25)
	Primary	0.81*(0.69,0.95)	0.43*(0.36,0.51)
	Secondary	0.87(0.75,1.01)	0.61*(0.52,0.71)
	Higher	Ref.	Ref.
<b>Caste</b>			
	Scheduled Castes	1.03(0.91,1.16)	1.26*(1.11,1.44)
	Scheduled Tribes	1.21*(1.08,1.37)	1.71*(1.47,1.98)
	Other Backward Classes	0.84*(0.76,0.92)	0.98(0.88,1.09)
	Others	Ref.	Ref.
<p><i>Ref: Reference; OR: Unadjusted Odds Ratio; aOR: Adjusted Odds Ratio; CI: Confidence Interval; SES: Socio-economic status; Cognitive impairment was adjusted for education (lowest 10<sup>th</sup> percentile of each educational category was considered cognitively impaired, i.e, with a cut-off score of 14 for no educated/primary not completed, 21 for primary, 24 for secondary and 27 for higher education groups); Model-2 was adjusted for Individual, Health and Household related factors</i></p>			

**Table-S3.** Sensitivity analysis estimates (Interaction models) for cognitive impairment after adjusting for education among older adults in India, 2017-18

Background characteristics	Model-3	Model-4	Model-5
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
<b>Ladder SES # MPCE quintile</b>			
High # high	Ref.		
High # middle	1.44*(1.14,1.83)		
High # low	1.97*(1.52,2.57)		
Middle # high	1.14(0.73,1.76)		
Middle # middle	1.68*(1.3,2.17)		
Middle # low	2.16*(1.64,2.85)		
Low # high	1.08(0.72,1.62)		
Low # middle	1.89*(1.48,2.42)		
Low # low	2.51*(1.95,3.23)		
<b>Ladder SES # Education</b>			
High # higher		Ref.	
High # secondary		0.6*(0.39,0.94)	
High # primary		0.54*(0.32,0.92)	
High # Not educated/primary not completed		0.19*(0.12,0.3)	
Middle # higher		1.52*(1.09,2.13)	
Middle # secondary		0.93(0.67,1.28)	
Middle # primary		0.67*(0.48,0.94)	
Middle # Not educated/primary not completed		0.34*(0.25,0.47)	
Low # higher		1.84*(1.15,2.95)	
Low # secondary		1.34(0.94,1.93)	
Low # primary		0.87(0.61,1.25)	
Low # Not educated/primary not completed		0.47*(0.34,0.65)	
<b>Ladder SES # Caste</b>			
High # Others			Ref.
High # Other Backward Class			1.33(0.92,1.94)
High # Scheduled Caste			2.04*(1.14,3.62)
High # Scheduled Tribe			0.97(0.52,1.8)
Middle # Others			1.72*(1.3,2.26)
Middle # Other Backward Class			1.73*(1.3,2.29)
Middle # Scheduled Caste			2.23*(1.65,3.03)
Middle # Scheduled Tribe			2.49*(1.82,3.42)

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Low # Others	2.19*(1.63,2.96)
Low # Other Backward Class	2.16*(1.61,2.89)
Low # Scheduled Caste	2.89*(2.13,3.92)
Low # Scheduled Tribe	4.99*(3.65,6.83)

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*#: Interaction; Ref: Reference; aOR: Adjusted Odds Ratio; CI: Confidence Interval; SES: Socio-economic status; Cognitive impairment was adjusted for education (lowest 10<sup>th</sup> percentile of each educational category was considered cognitively impaired, i.e, with a cut-off score of 14 for no educated/primary not completed, 21 for primary, 24 for secondary and 27 for higher education groups); Model-3, 4 and 5 were adjusted for Individual, Health and Household related factors*

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**S1 Checklist.** STROBE checklist of items that should be included in reports of cross-sectional studies

	<b>Item No</b>	<b>Recommendation</b>	<b>Section, paragraph Response</b>
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Title (Page 1-2; Line 1-2)
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract: Objectives, study design, participants, outcome measures, results, conclusion. Author summary: What did the researchers do and find? (Page 2-3; Line 31-62)
<b>Introduction</b>			
Background/ rationale	2	Explain the scientific background and rationale for the investigation being reported	Author summary: Why was this study done? In the Introduction section (Page 5-6)
Objectives	3	State specific objectives, including any prespecified hypotheses	Introduction: final paragraph. (Page 6; Line 42-46)
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	Abstract: Design, setting, and participants. Introduction: final paragraph. Methods: Data Source (Page 2-3; Line 31-62)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Abstract: Design, setting, and participants (Page 2; Line 34-37). Methods: Data Source, study selection, and inclusion criteria (Page-2 Line 38-44)
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	Abstract: Design, setting, and participants (Page 2; 36-37). Methods: Study selection and inclusion criteria (Page 7; Line 38-44)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Methods: Study Variables (Page 7-12)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Methods: Data Source, study selection, and inclusion criteria (Page 7-12)
Bias	9	Describe any efforts to address potential sources of bias	Discussion: Final paragraph (Page 15-20)
Study size	10	Explain how the study size was arrived at	Methods: Data Source, study selection, and inclusion criteria (Page 7)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Methods: Statistical analysis (Page 12).
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	Methods: Statistical analysis (Page 12)
		(b) Describe any methods used to examine subgroups and interactions	Methods: Statistical analysis (Page 12)
		(c) Explain how missing data were addressed	Methods: Study selection and inclusion criteria, Study Variables, Statistical analysis (Page 7-12)
		(d) If applicable, describe analytical methods taking account of sampling strategy	Methods: Data Source (Page 7-12), Statistical analysis (Page 12)
		(e) Describe any sensitivity analyses	Supplementary file

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<b>Results</b>			
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Table 1 (Page 28-29)
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	Figure-1 Page-33
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1 (Page 28-29)
		(b) Indicate number of participants with missing data for each variable of interest	Method, Table 1 (Page 28-29)
Outcome data	15*	Report numbers of outcome events or summary measures	Table 1 (Page 28-29)
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table-2a and Table-2b (Page 30-32)
		(b) Report category boundaries when continuous variables were categorized	None
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not Applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not Applicable
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	Discussion (Page 16-20)
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Discussion (Page 19-20)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Discussion (Page 16-20)
Generaliseability	21	Discuss the generalisability (external validity) of the study results	Discussion (Page 16-20)
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Provided during the submission process and in Declaration (Page 22)

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Paul R, *et al. BMJ Open* 2022; 12:e053782. doi: 10.1136/bmjopen-2021-053782

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