Original Article

Cognitive reserve and other determinants of cognitive function in older adults: Insights from a community-based cross-sectional study

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Abstract

Background: India will be the home of 323 million elderly persons by 2050. This means a surge in the dependent population primarily due to age-related cognitive decline. Evidence suggests that life course factors may have a modulatory role on cognitive function. The present study explores such potential influence by investigating the effect of cognitive reserve (a latent construct using education and occupation) and physical, psychological, and social determinants on cognitive function in community dwelling elderly. **Methods:** A community-based cross-sectional study was conducted in urban areas of West Bengal (India) among elderly aged ≥60 years. Data was collected by personal interviews for socio-demographic and medical profile. Cognitive function was assessed using Bangla Adaptation of Mini-Mental State Examination (BAMSE). Educational level and occupational complexity were used as proxy indicators for calculating cognitive reserve. **Results:** Of the 370 elderlies interviewed (mean age = 68.9 years), cognitive function was abnormal in 13.5%. The cognitive function had a significant inverse relationship with depression symptoms, loneliness, hypertension, anemia, and basic activities of daily living. There was a significant difference in the cognitive reserve of the elderly with normal and abnormal cognitive function (mean 33.7 and 26.8, respectively). In the presence of covariates like sleep quality, depression, hypertension, and hemoglobin levels, the effect of age on cognitive function had a significant mediation influence of cognitive reserve – total effect = −0.2349; 95% CI = (−0.2972 to −0.1725) and direct effect = −0.2583; 95% CI = (−0.3172 to −0.1994). **Conclusion:** The quantum of effect of the age on cognitive function decreases with good cognitive reserve as a cognitive reserve has a significant mediation effect on the relationship between age and cognitive function.

Keywords: Cognitive function, cognitive reserve, elderly adults, health determinants, social determinants

Introduction

The rapid growth of the population aged 60 years and above is a global phenomenon. There were nearly 138 million elderly persons in India in 2021, and the population is likely to increase by around 56 million by 2031.[1] The transition will conduce to a surge of the dependent population primarily due to cognitive impairment – alleged as among the costliest medical conditions, even more expensive in both direct and indirect costs than cardiovascular disease or cancer.

Besides genetic factors, age-related cognitive changes depend on lifestyles and environments – which are modifiable throughout the life course. The Lancet Commission on dementia prevention 2020 has listed 12 such modifiable factors which can

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counterweigh the genetic influence and, thus, define/redefine the trajectories of cognitive health. This also explicates different cognitive abilities in people with similar age, disease, or damage to brain and has consequentially inducted the concept of brain reserve and cognitive reserve.[2,3] While brain reserve is a passive form of capacity, cognitive reserve describes an active mechanism for coping with brain pathology independent of brain reserve and encompassing life experience and the innate intelligence of the individual.[4] Existing evidence suggests that although the brain reserve declines with age, cognitive reserve compensates and helps sustain cognitive function during the aging process by maintaining physiological robustness within functional brain networks.[4]

Cognitive reserve is a latent construct, and its assessment, therefore, relies on proxy indicators.[5,6] Though the highest education attained by an individual is commonly chosen as a single proxy measure of cognitive reserve, there is a difference in opinion about its sole impact on cognitive function.[7] Therefore, recent emphasis is on the need to combine other indicators, like occupational attainment and involvement in leisure activities as well.[8,9] Furthermore, literature portrays variation in the influence of cognitive reserve on cognitive aging based on the individual, environmental, and cultural influences.[7]

The studies exploring the mediating role of cognitive reserve on cognitive aging, especially reflecting the cultural context of India, are far and few. In the present cross-sectional survey, conducted among elderly residing in urban areas of West Bengal (India), we proposed that cognitive reserve, taken as a cross-product of educational level and occupational complexity, would mediate the association between physical, psychological, and social determinants on cognitive function.

Methods

Study setting

The present community-based cross-sectional study was conducted in the Kalyani Municipality area, district Nadia, West Bengal. The Kalyani municipality area caters to a population of around one lakh (a hundred thousand). There are two Urban Primary Health Centers and ten Subcenters in the area. The data collection was done in August–September 2021.

Study participants

Elderly **(**aged ≥60 years**)** males and females residing in the study area for at least the past one year were included in the study. Any elderly with problems in speech, hearing, vision, or any other neurological/medical condition which could impede the interview were excluded.

Sample size

As no study on cognitive function was available in this urban region of the country, we calculated the required sample size assuming the prevalence of cognitive impairment among the elderly as 50% with absolute precision of 5% and an alpha value of 0.05.[10] The required sample size was 400. Considering a nonresponse rate of 10% minimum calculated sample size was 440.

Data collection

Face-to-face interview was done for all study participants using a predesigned, semistructured questionnaire. The questionnaire included information regarding –

- Sociodemographic.
- Heath profile.
- Cognitive function assessment using Bangla Adaptation of Mini-Mental State Examination (BAMSE).[11]
- Depression using Patient Health Questionnaire (PHQ)-2.
- Sleep quality – single question sleep quality scale.

The list of households was obtained from the Kalyani Municipality which acted as the sampling frame. Study households were selected through simple random sampling. In case of the nonavailability of an elderly person in the selected household/family, the house next door was approached. If more than one elderly member were present in the same household, the Draw method was applied to select the study participant.

Operational definitions

- *Classification of elderly*:
  - Young old: age 60–69 years.
  - Middle old: age 70–79 years.
  - Old–old: age ≥ 80 years.
- *Cognitive function*: Cognitive function was assessed using the BAMSE questionnaire.[11] Permission for the use of the instrument was taken from the authors. The cut-offs were chosen based on the education of the study participants – <21: Abnormal for eight-grade education, <23: Abnormal for high school education, and <24: Abnormal for college education.[12]
- *For assessing severity*, 24–30 was taken as no cognitive impairment, 18–23 as mild cognitive impairment, and 0–17 as severe cognitive impairment.[12]
- *Depressive symptoms*: The screening was done by Patient Health Questionnaire – 2 (PHQ-2). The score of 3 or greater was taken as cut-off for presence of depressive disorder.[13]
- *Sleep Quality*: It was assessed using the Single-item Sleep Quality Scale that incorporated a discretizing visual analogue scale. The respondent was asked to mark an integer score from 0 to 10 to rate the overall quality of sleep over a 7-day recall period. The integer score from 0 to 10 was classified into five categories – 0 = terrible, 1–3 = poor, 4–6 = fair, 7–9 = good, and 10 = excellent.[14]
- *Cognitive reserve*: Cognitive reserve was measured by combining two proxy indicators: educational level (years of full-time education) and occupational complexity using the formula derived/quoted by Clare *et al*.[6] Occupational complexity was

calculated using the occupational titles of the main lifetime occupation of the individual. The occupational titles were matched to occupations listed in an online resource, the DOT (Dictionary of Occupational Titles) – a catalog of occupations used in the United States.[15] The DOT classifies occupations based on a nine-digit code where the fourth, fifth, and sixth digits represent occupational complexity with data, people, and things, respectively. For ease of comprehension, scores have been reversed, so a higher score reflects greater complexity.

The housewife/homemakers, which is not a paid occupation, and therefore not classified in DOT. But the work profile of a housewife in Indian culture/society involves household chores like cleaning, cooking and kitchen store management, laundry, shopping grocery and clothes, managing household finances, supervision of housemaids/servants, childcare, and much more. Although the occupation of women, taking care of their households, is categorized as informal work, it requires more or equivalent cognitive ability as a paid job of a housekeeper/homemaker. These activities should be considered work because, theoretically, one would pay a third person to perform them. Therefore, with a consensus of all the authors, housewife was classified under the category of the DOT which best described the role of these women, and the job complexity coding was given accordingly.

The DOT classification was completed by one researcher, and a subsample of 50 occupations was recoded by another researcher to check reliability.

- *Years of schooling*: This was calculated by recording the highest educational degree of the study participant.
- *Skill Level*: This was based on the National Classification of Occupations – 2004, India.[16] The classification of skill levels was based on the years of formal education and skills acquired through informal training and experience.
- *Basic activities of daily living*: Activities of daily living (ADL) included difficulty in walking across a small room, bathing, eating, dressing, moving in and out of bed, and using toilet. If the participant had difficulty in performing one or more out of these six activities without assistance was considered to have difficulty in ADL.
- *Hypertension*: A person on regular prescribed antihypertensive drugs was recorded as hypertensive.
- *Severity of Anemia*: This was based on the World Health Organization classification of anemia among adults.[17]

Data management and statistical analysis

Data were collected through the Epicollect5 application and analyzed using Microsoft Excel 2016 and Statistical Package for the Social Sciences (SPSS for Windows, version 16.0, SPSS Inc., Chicago, USA) software. Pearson's Chi-square test was used to evaluate differences between groups for categorized variables; a *P* value of less than 0.05 was considered statistically significant. The correlation between quantitative independent and dependent variables was calculated using the Pearson Correlation Coefficient. Mediation analysis was done to assess the indirect effect of cognitive reserve on cognitive function.

Ethical clearance

Ethical approval was obtained from Institute Ethics Committee (Reference number: T/IM-NF/Kalyani/20/09). Informed consent was taken before the questionnaire was administered to the study participants. The elderly screened for different medical morbidities were referred to AIIMS Kalyani and facilitated service utilization in the institute.

Results

Of 440 individuals the data collectors approached, 27 refused to participate due to pre-existing engagements. There were no elderly people who had a diagnosed neurological/medical condition or problems in speech, hearing, or vision which could impede the interview.

Out of 413 individuals who participated in the study, coding for occupational complexity was possible for 370 study participants. Therefore, the final analysis was done for 370 subjects.

All the study participants understood the Bangla language well. The mean age (SD) of study participants was 68.9 (7.2) years. The proportions of male and female participants in the study were similar. The mean (SD) years of schooling was 14.1 (3.8) years.

Taking the cut-off value of 24 for BAMSE, abnormal cognitive function was present in 50 (13.5%) of the study participants – with 8% of participants having mild and 5% having severe cognitive impairment. [Figure 1] Whence taking the cut-off according to the educational status, cognitive impairment was found in 31 (8.4%) of the elderly – this was designated as normal and abnormal cognitive function and has been used in bivariate analysis – Tables 1 and 2.

In bivariate analysis, the cognitive function was found to be significantly associated with age, skill level, marital status, and house ownership. The individuals with higher age, unmarried or divorced/separated/widowed, and not owning a house had significantly higher chance of having abnormal cognitive function then others [Table 1].

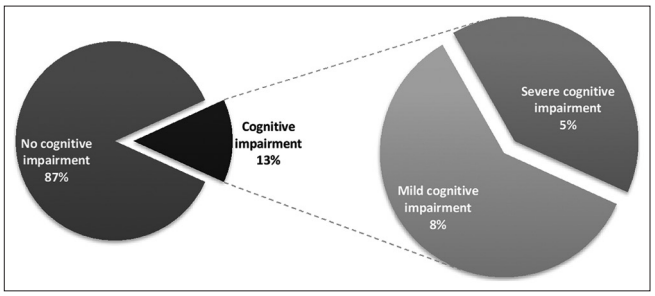

Figure 1: Pie of Piechart showing the severity of cognitive impairment

Table 1: Distribution of study participants according to the sociodemographic profile and cognitive function (*n*=370)

Variable		*n* (%) (column %)	Cognitive Function		*P*
			Normal *n* (%) (row%)	Abnormal *n* (%) (row%)	
Age group	Young old	220 (59.5)	216 (98.2)	04 (1.8)	0.000
	Middle old	107 (28.9)	97 (90.7)	10 (9.3)	
	Old–old	43 (11.6)	26 (60.5)	17 (39.5)	
Sex	Female	211 (57.0)	192 (91.0)	19 (9.0)	0.706
	Male	159 (43.0)	147 (92.5)	12 (7.5)	
Living with	Spouse only	79 (21.4)	59 (86.8)	09 (13.2)	0.107
	Son/Daughter	18 (4.9)	18 (100.0)	00 (0.0)	
	Family	205 (55.4)	186 (90.7)	19 (9.3)	
	Alone/caretaker	68 (18.4)	59 (86.8)	09 (13.2)	
Skill level	I	50 (13.5)	49 (98.0)	01 (2.0)	0.030
	II	78 (21.1)	66 (84.6)	12 (15.4)	
	III	146 (39.5)	133 (91.1)	13 (8.9)	
	IV	96 (25.9)	91 (94.8)	05 (5.2)	
Marital status	Unmarried	31 (8.4)	25 (80.6)	06 (19.4)	0.002
	Married	235 (63.5)	224 (95.3)	11 (4.7)	
	Divorced/Separated/Widowed	104 (28.1)	90 (86.5)	14 (13.5)	
Caste	SC/ST	64 (17.3)	54 (84.4)	10 (15.6)	0.060
	OBC	26 (7.0)	25 (96.2)	01 (3.8)	
	General	280 (75.7)	260 (92.9)	20 (7.1)	
House ownership	Self	294 (79.5)	278 (94.6)	16 (5.4)	0.000
	Children	36 (9.7)	30 (83.3)	06 (16.7)	
	Rent/others	40 (10.8)	31 (77.5)	09 (22.5)	

The cognitive function was also found to be significantly associated with the presence of depressive symptoms, feeling of loneliness, one or more morbidity, hypertension, anemia, and impaired ADL [Table 2].

When the cut-off was taken as 24 to assess cognitive function, the mean (SD) values of the cognitive reserve were 33.7 (6.8) in the case of elderly with normal cognitive function and 26.8 (9.9) in case of elderly suffering from cognitive impairment; the difference in cognitive reserve of elderly with normal cognition and those with cognitive impairment was found to be significant ($P < 0.001$).

The cognitive function was observed to have a significant positive correlation with cognitive reserve, ADL, hemoglobin levels, and sleep quality, while it was negatively correlated with the presence of depressive symptoms and age [Table 3].

The results of mediation analysis are shown in Figure 2. Here the effect of age on cognitive function is depicted, taking cognitive reserve as the mediator and sleep quality, depressive symptoms, hypertension, and blood hemoglobin levels as covariates. The direct effect (DE = −0.2583) of age on cognitive function was found to be significant and inverse (95% CI = −0.3172 to −0.1994). The indirect effect (IE = 0.0235) of age on cognitive function, considering cognitive reserve as a mediator and sleep quality, depressive symptoms, hypertension, and hemoglobin levels as covariates, was also significant and in the positive direction; 95% CI = (0.0032–0.0504). This reflects an overriding effect of cognitive reserve on cognitive function as a mediator. We may also infer that if the cognitive reserve is high it neutralizes the deteriorating effect of age.

Discussion

Population aging poses a different set of challenges, one of which is a complex, critical, and confining phenomenon of cognitive impairment. In the present study, abnormal cognitive function was present in 13.5% of the elderly, having a direct relationship with age. A similar prevalence of 14.9% mild cognitive impairment among individuals of age greater than 50 years has been reported by Das *et al.* (2007)[18] in a study conducted in urban Kolkata. The observed inverse relation of age with cognitive impairment is a known fact quoted by many in other studies[18,19] and can be attributed to the organic changes in the brain tissue – neuroanatomical and neurophysiological – as a part of the normal aging process.[20,21]

Table 2: Distribution of study participants according to the morbidity profile and cognitive function (*n*=370)

Variable		*n* (%)	Cognitive Function		*P*
			Normal	Abnormal	
ADL	Max performance	320 (86.5)	309 (96.6)	11 (3.4)	0.000
	Mild impairment	22 (5.9)	20 (90.9)	02 (9.1)	
	Moderate–Severe impairment	28 (7.6)	10 (35.7)	18 (64.3)	
Depressive symptoms	Present	31 (8.4)	24 (77.4)	07 (22.6)	0.009
	Absent	339 (91.6)	315 (92.9)	24 (7.1)	
Feeling of loneliness	Not lonely	263 (71.1)	244 (92.8)	19 (7.2)	0.035
	Most days	64 (17.3)	60 (93.8)	04 (6.3)	
	Everyday	43 (11.6)	35 (81.4)	08 (18.6)	
Number of diagnosed morbidities	Nil	60 (16.2)	60 (100.0)	00 (0.0)	0.040
	One	142 (38.4)	130 (91.5)	12 (8.5)	
	Two	112 (30.3)	101 (90.2)	11 (9.8)	
	≥ Three	56 (15.1)	48 (85.7)	08 (14.3)	
Diabetes	Not diabetic	276 (74.6)	251 (90.9)	25 (9.1)	0.521
	Diabetic	94 (25.4)	88 (93.6)	06 (6.4)	
Thyroid status	Euthyroid	323 (87.3)	294 (91.0)	29 (9.0)	0.400
	Thyroid dysfunction	47 (12.7)	45 (95.7)	02 (4.3)	
Hypertension	No	162 (43.8)	156 (96.3)	06 (3.7)	0.004
	Yes	208 (56.2)	183 (88.0)	25 (12.0)	
Sleep quality	Fair	37 (10.0)	32 (86.5)	05 (13.5)	0.399
	Good	279 (75.4)	256 (91.8)	23 (8.2)	
	Excellent	54 (14.6)	51 (94.4)	03 (5.6)	
Anemia	No anemia	123 (33.2)	117 (95.1)	06 (4.9)	0.021
	Mild	209 (56.5)	191 (91.4)	18 (8.6)	
	Moderate	36 (9.7)	30 (83.3)	06 (16.7)	
	Severe	02 (0.5)	01 (50.0)	01 (50.0)	

Table 3: Correlation of cognitive function with cognitive reserve and other selected parameters

	Age	Cognitive reserve	Cognitive function	ADL	Depressive symptoms	Haemoglobin	Sleep quality
Age	1						
Cognitive reserve	0.048	1					
	0.357						
Cognitive function	−0.420**	0.359**	1				
	0.000	0.000					
ADL	−0.409**	0.129*	0.739**	1			
	0.000	0.013	0.000				
Depressive symptoms	0.214**	−0.196**	−0.419**	−0.399**	1		
	0.000	0.000	0.000	0.000			
Haemoglobin	−0.135**	0.108*	0.173**	0.129*	−0.067	1	
	0.010	0.037	0.001	0.013	0.200		
Sleep quality	−0.093	0.289**	0.216**	0.107*	−0.199**	0.193**	1
	0.073	0.000	0.000	0.041	0.000	0.000	

**.Correlation is significant at the 0.01 level (2-tailed). *.Correlation is significant at the 0.05 level (2-tailed)

The abnormal cognitive function was significantly lower among elderly who were married and living with their spouses. The protective effect of marriage on cognition is braced by other authors too.[19] Loneliness and social isolation have been put forward as a risk factor for impaired cognitive function by Lara *et al*.[22] In our study, more than half of unmarried and divorced/separated/widowed people felt loneliness and depressive symptoms. The elderly individuals living alone or with caretakers mostly belonged to a higher age group, and they too, felt more loneliness and depressive symptoms than others. This explains the higher cognitive impairment in the elderly who were unmarried, separated/divorced, or living alone.

In the present study, a significantly higher proportion of elderly who owned their house (94.6%) had normal cognitive function than the ones who either stayed in their children's (16.7%) house or on rent (22.5%). It was also observed that the elderlies living on the rent were either staying alone (75%) or had fewer years of schooling. Besides, elderly individuals with better cognitive function are more likely to retain the ownership of

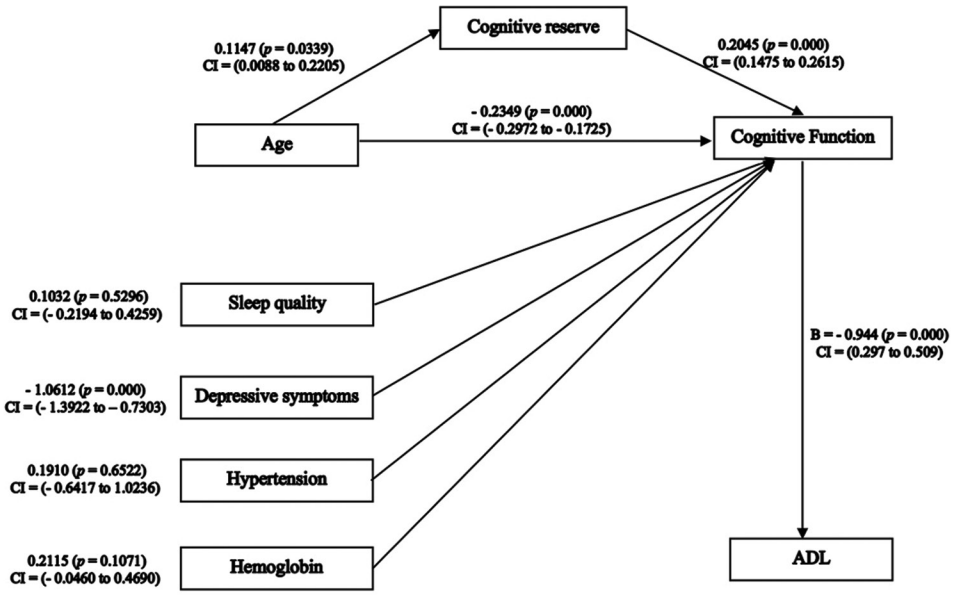

Figure 2: Mediation analysis showing the effect of age on cognitive function taking cognitive reserve as the mediator and sleep quality, depression, hypertension, and blood hemoglobin levels as covariates

their house as intact cognition helps to take effective decision for oneself.

The abnormal cognitive function was significantly higher in the elderly belonging to Schedule Caste/Tribes (SC/ST). These individuals had lesser years of schooling, belonged to a lower skill level, and had depressive symptoms. Education provides the skills, knowledge, and interest to seek intellectual challenges throughout life, which influences the cognitive level of an individual. Studies done in different parts of the globe provide evidence regarding the protective effect of early life education on cognition.[23-25]

In our study, cognitive function was significantly associated with depression symptoms, feeling of loneliness, the number of morbidities, hypertension, anemia, and impaired ADL. [Table 2] The association between these variables is depicted in Table 3. Cognitive function was observed to have a significant positive correlation with cognitive reserve, ADL, hemoglobin levels, and sleep quality and was negatively correlated with depression and age. A higher risk of cognitive impairment in subjects with three or more comorbidities has been stated by Chen *et al*.[26] Similar deleterious effects of depression and loneliness on the cognition of the elderly population have been established by Tzang *et al*.,[27] Kong *et al*.,[28] Donovan *et al*.,[29] and O'Luanaigh *et al*.[30] Although the causal effect of depression on cognitive function is still unclear, few hypotheses suggest the role of brain-derived neurotrophic factor and reduction hippocampal size as probable causes[31], while there is also evidence of genetic susceptibility.[32,33] Some authors suggest cognitive impairment as to be pseudodementia associated with depression. New scientific evidence states that cognition disorders are a core feature of the clinical picture of depression and should not be deemed secondary to it.[34]

In the present study, cognitive function declined with a rise in blood pressure (BP). In a review, Birns and Kalra state that although lowering BP may improve cognition in patients with vascular risk factors, the effects of BP reduction on cognition are unclear.[35] A scientific statement from American Heart Association also reiterates insufficient data to make evidence-based recommendations regarding hypertension and cognitive function.[36] This avenue needs further exploration.

The inverse relationship of anemia with cognitive function [Table 2] is verified in the systematic review done by Andro *et al*.[37] Low hemoglobin levels lead to less oxygen delivery to tissues which causes tissue hypoxia; in the case of the brain, this affects cognitive function. Furthermore, experimental studies have suggested iron deficiency as a cause of brain mitochondrial damage, which leads to loss of mitochondrial cytochrome c oxidase (complex IV), the integrity of mtDNA, and function, thereby causing cognitive impairment.[38,39]

We observed that elderly with normal cognitive function had a significantly higher mean value of cognitive reserve than those with abnormal cognitive function. Xu *et al*.[40] (2020) have also observed that high cognitive reserve reduces the risk of mild cognitive impairment. A metanalysis conducted by Opdebeeck *et al*.[9] advocates that indicators of the cognitive reserve are related to cognitive function in different domains. The continuous intellectual stimulation throughout life, provided by acquiring knowledge in schooling and engagement in complex occupations, increases the cognitive reserve, which helps to overcome limitations of cognitive impairment induced by aging.[41] Higher levels of education provide a chance for intellectually engaging situations across adulthood in the form of complex job profiles, which may prevent late-life cognitive impairment.

The mediation analysis indicates that higher age was associated with lower cognitive function; this effect was partly mediated by cognitive reserve – cross product of education and occupation. Therefore, it can be said that either higher education and/or higher occupational complexity significantly reduces the age-standardized risk of cognitive impairment, even in the presence of other medical factors. So, the quantum of a significant inverse effect of age on cognitive function decreases with better cognitive reserve. Involvement in educational activities and skilled and complex jobs in early and middle life are likely to slow the loss of cognitive function with age. Evidence also suggests that individuals with equivalent brain reserve may express variable clinical sequelae as a function of the cognitive reserve.[4] Keeping the brain active by involving it in intellectual, social, physical, and athleisure activities helps improve cognition, irrespective of the changes in brain structure, i.e., brain reserve, resulting from the natural or pathological aging process.[42]

The present study, like any other, is not without limitations. Being cross-sectional in design, causal inferences from the associations are not possible. The authors have used the "United States Employment Services' Dictionary of Occupational Titles" for assessing occupational complexity as no such method of defining occupational complexity exists in India. So, the match may not be absolute which might have resulted in bias. Also, even if a person may have been involved in more than one occupation, only one occupation followed for maximum number of years was considered for occupational complexity. Moreover, cognitive reserve is a complex concept, and factors other than education and occupational complexity may play a part in describing it; this could not be captured in the present study and needs to be explored.

Despite the limitations, the findings of the present study theorize that keeping the brain involved in challenging intellectual and job-related activities from the early life may change the trajectory of the natural/pathological aging effect on cognition for good. It indicates that government policies of investing in education and employment of young will not only boost the economy but also help decrease the old-age dependency related to cognitive impairment. Additionally, self and societal initiatives of active involvement of the elderlies in productive informal jobs and continued self-education will help carry forward the effect. This will increase self-dependency, redefine care dependency, and momentously decrease the burden on the economy and healthcare.

Conclusion

The quantum of the effect of age on cognitive function decreases with good cognitive reserve, as a cognitive reserve has a significant mediation effect on the relationship between age and cognitive function. The study confirms the protective role of cognitive reserve – an indicator of years of schooling and occupational complexity – against cognitive impairment, even in the presence of other sociodemographic and medical independent factors, in the elderly urban Indian population.

Relevance to primary care physicians

The study affirms that cognitive reserve has a protective role against cognitive decline, and therefore, primary care plays a critical role. Promoting an active, stimulating, and healthy lifestyle from an early age and through the middle age is expected to slow the process of age-related cognitive decline. Primary care physicians are strategic position to identify and manage risk factors and create awareness about the same. This will not only improve mental health of the individual but also decrease the burden of noncommunicable diseases in long-term. As stated by Lazar *et al.*,[43] "Delaying cognitive decline through primary care provider–instigated risk factor modification for even a small percentage of individuals would enable many more people to reach end of life without dementia and would have substantial benefits for patients, caregivers, and society."

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Conflicts of interest

There are no conflicts of interest.

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