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Age-related morphometric variations of the human brain across socio-economic classes in a cohort of Nigerians: A magnetic resonance imaging-based analysis

Bolaji I. Jayeoba[1], Anas I. Yahaya[2], Ahmad A. Gaya[2], Felix O. Erondu[3], Kingsley U. Obi[4], Adam J. Nma[2]

[1]Directorate of Medical Services, Defence Headquarters, Abuja, Nigeria; [2]Department of Human Anatomy, Faculty of Basic Medical Sciences, Bayero University Kano, Nigeria; [3]Department of Radiography and Radiation Sciences, Gregory University, Uturu, Nigeria; [4]3661 Nigerian Air Force Hospital, Sam Ethnan Air Force Base, Ikeja, Lagos, Nigeria

Abstract

Brain ageing is a complex biological process that can be affected by genetic, environmental, and social factors. Many studies were conducted worldwide in trying to determine the effect of socio-economic status (SES) on brain ageing, but such studies related to the African population, particularly Nigeria, which is facing multiple economic challenges, are scanty. To determine the effect of SES on brain ageing, this prospective cross-sectional study was conducted at National Hospital, Abuja, Nigeria, among various socio-economic classes and recruited 214 subjects (96 males, 118 females). Magnetic resonance imaging (MRI) with DICOM-compatible imaging software was used to take morphometric measurements and perform non-contrast brain MRIs on the participants. A validated socio-economic index was used to classify participants into three groups: low, middle, and high SES. Morphometric differences between four age groups (30–40, 41–50, 51–60, and 61+ years) among the SES groups were evaluated using a one-way ANOVA. When participants were analyzed collectively, no significant age-related differences were observed across the measured brain parameters. However, within the low and middle SES groups, temporal gyrus thickness decreased significantly with advancing age ($p = 0.016$ and $p = 0.004$, respectively). In addition, brain volume showed a significant age-related decline in the middle SES group ($p = 0.002$). No statistically significant age-related morphometric changes were observed among participants in the high SES group. In conclusion, the study demonstrates that SES may moderate the effects of ageing on brain structure in a Nigerian population.

Keywords

Brain ageing, Socio-economic status, Magnetic resonance imaging, Cortical thickness, Brain volume

Correspondence: A. A. Gaya, MSc, Department of Human Anatomy, Faculty of Basic Medical Sciences, Bayero University Kano, Nigeria. Email: aagaya.ana@buk.edu.ng; Phone Number - +2347067092876; ORCID - 0009-0006-2538-0558

Bolaji I. Jayeoba – bijayeoba@yahoo.com, 0009-0005-6315-6314; Anas. I. Yahaya – suhhis@yahoo.com 0009-0003-36864-7548; Felix O. Erondu – f.erondu@gregoryuniversityuturu.edu.ng, 0000-0002-8821-4075; Kingsley U. Obi – uferekingsleyobi@yahoo.com, 0009-0001-0142-3545; Adam J. Nma – adamndako@yahoo.com, 0009-0008-0626-4302

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Introduction

The brain is a complex organ that controls and monitors the functions of the body. The brain structure and functions change in accordance with the multitude of factors. Among these factors are brain ageing and social environments. Natural processes linked to cognitive ageing include changes in gyral and sulci patterns, cortical thinning, and decrease in brain volume as people age (Nyberg *et al.,* 2023; Cox *et al.,* 2021; Pietrasik *et al.,* 2023; Chien *et al.,* 2024). However, some recently conducted studies clearly indicate that socio-economic status (SES), which is influenced by various factors such as education, income, occupation, and living conditions, affects brain age-related changes rather than these changes occurring independently (Chan *et al*., 2018).

For a long time, researchers have understood that differences in socio-economic exposure affect an individual's

overall well-being. An individual with unrestricted access to nutrition, education, and healthcare is likely to experience healthy brain ageing. It is known that those with higher SES have such privileges, while those with low SES will be faced with many environmental stressors, including limited access to healthcare and inadequate nutrition (Farah, 2017), which could hasten neurodegenerative changes or jeopardise brain reserve (Noble *et al*., 2012; Gianaros and Hackman, 2013). In Nigeria, which is one of the developing countries, facing such socioeconomic challenges with unbalanced access to resources such as standardised medical services with cutting-edge equipment like magnetic resonance imaging is still restricted to urban areas. These environmental exposures to pressures are particularly pertinent.

Nigeria's Federal Capital Territory, Abuja, offers a distinct demographic blend of people from various socioeconomic backgrounds living in a rapidly urbanising environment. Inequalities in wealth, education, and living standards persist despite advancements in healthcare infrastructure. There is still a noticeable lack of locally generated data from African populations, although numerous international studies have examined the effect of SES on brain morphometry across the lifespan (Chan *et al.,* 2018; Dufford *et al.,* 2019). Little is known about how Nigerians' structural brain changes are influenced by the interaction of biological ageing and socioeconomic factors. The creation of evidence-based cognitive health strategies and customised public health interventions that are appropriate for Nigeria's ageing population is hampered by the lack of contextual data.

Brain volume, cortical thickness, gyrus thickness, and sulcal width can all be precisely measured thanks to MRI, which has completely changed the non-invasive visualisation and quantification of the brain's intricate morphology (Lin *et al.,* 2025; Joshi *et al.,* 2025). MRI allows for a more nuanced investigation of the ways in which environment and age co-modulate brain structure when paired with demographic and socio-economic data. Although research from high-income nations has shown that brain volume and cortical thickness generally decrease with age (Chan *et al.,* 2018; Dufford *et al.,* 2019), little is known about how much SES affects these trends in African contexts.

When considering the neuroanatomical correlates of ageing and SES, the concepts of brain reserve and cognitive reserve, though distinct, are two pivotal models of resilience against age- or pathology-related cognitive decline and are critical to clearly understand (Stern *et al.,* 2020). 'Brain reserve' refers to the innate structural capital of the brain, including its size, neuronal count, and synaptic density, which provides a passive threshold for damage that can be sustained before clinical symptoms emerge, allowing the brain to withstand ageing or structural damage without showing cognitive deterioration. While the cognitive reserve indicates the brain's strategies to cope with damage or optimise performance, which are achieved through differential recruitment of neural networks or alternative cognitive strategies, it is largely influenced by lifetime intellectual, social, and physical activities.

The main constituents of brain reserve are individual variations in brain volume, cortical thickness, and subcortical integrity. The development and maintenance of this structural capital is thought to be greatly influenced by socioeconomic factors, which operate throughout the lifespan through mechanisms like nutrition, access to healthcare, chronic stress exposure, and educational quality (Noble *et al.,* 2015).

Therefore, this study uses MRI to determine age-related morphometric differences in brain structure across various socioeconomic classes in the Federal Capital Territory, Nigeria, to close this very important gap. It specifically looks at how age affects metrics like sulcal width, cortical and gyral thickness, and brain volume, as well as whether these changes differ for people in low, middle, and high SES groups. Comprehending these dynamics is crucial for the interpretation of clinical neuroimaging in Nigeria as well as for creating focused plans to promote cognitive ageing in all socioeconomic groups.

Materials and Methods

Study design and setting

The study was a cross-sectional study design which used two-dimensional magnetic resonance imaging scans to evaluate brain morphometric parameters in 214 adult Nigerians, ages between 30 and 70. The study population was made up of those verified to have Nigerian ancestry through all four grandparents. Four age groups were created: age 30 to 40, 41 to 50, 51 to 60, and 61 and above, comprising 96 males and 118 females. The study was conducted at the Radiology Department of National Hospital, Abuja, which is a tertiary referral centre situated in Nigeria's Federal Capital Territory. Because of the demographic diversity of the population it serves, the hospital is well-suited to documenting differences across socio-economic classes.

The study included adults between the ages of 30 and 70 who had undergone a normal, diagnostic-quality brain MRI with full-brain coverage. Participants were excluded if they were older than the specified age range, if their MRI revealed pathology or structural abnormalities, or if the scan quality was poor or did not cover the entire brain.

Assessment of SES

A structured questionnaire that was modified from Oyedeji (1985) and Yahaya (2020) was used to measure SES. The questionnaire assessed various variables, including education, income, occupation, housing, transportation, and ownership of electronic devices. Each item received a numerical score with a maximum possible score of 38. Low SES participants were defined as those who scored less than 23, middle SES participants were defined as those who scored between 23 and 27, and high SES participants were defined as those who scored more than 27.

MRI acquisition and imaging parameters

A Philips Ingenia 1.5 Tesla (1.5T) system, made in Japan, was used to perform MRI scans. Proton-attenuated sequences, axial T1 and sagittal T2-weighted multi-section images, were acquired at a slice thickness of 5 mm over a 230 mm field of view. All subjects underwent the same imaging procedure, and high-resolution images were chosen for morphometric study.

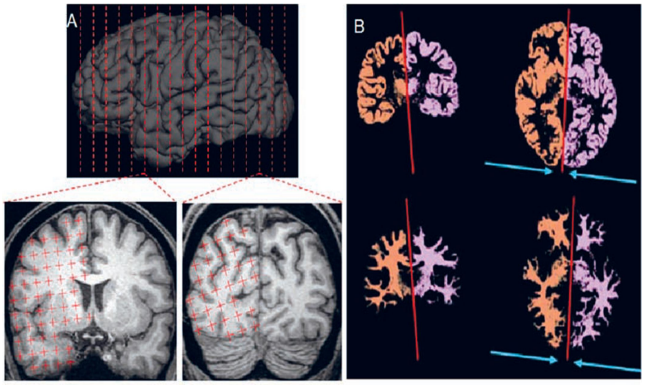

Fig. 1: Automatic cerebral hemisphere extraction and volume estimation. T1-weighted axial (left) and T2-weighted sagittal (right) (Manjón and Coupe, 2016; Barrick *et al.,* 2005).

Morphometric measurements and data extraction

Volumetric and morphometric analyses were conducted using digital imaging and communication in medicine (DICOM)-compatible software integrated with the MRI workstation. Parameters measured included:

Brain volume (BVOL): Total volume of the intracranial contents, measured in mm^3.

Cortical thickness: Thickness of the frontal lobe (frontal lobe thickness, FLT), parietal lobe (parietal lobe thickness, PLT), temporal (temporal lobe thickness, TLT), and occipital lobe (occipital lobe thickness, OLT), in millimetres (mm).

Gyrus thickness: Measured across the same lobes (frontal gyrus thickness, FGT; parietal gyrus thickness, PGT; temporal gyrus thickness, TGT; and occipital gyrus thickness, OGT).

Sulcal width: Including frontal, parietal, temporal, and occipital sulci (frontal sulcus width, FSW; parietal sulcus width, PSW; temporal sulcus width, TSW; and occipital sulcus width, OSW), in mm.

Every measurement was either taken straight out of the program or manually verified by a neuroradiologist/neuroradiographer looking it over. To guarantee consistency and direct segmentation, an automated brain atlas was employed (Barrick *et al.,* 2005).

Data integration and statistical analysis

The demographic and socio-economic data of the participants were combined with morphometric data. SPSS Version 25 was used to analyse the data. Standard deviations and means were used to report descriptive statistics. Within each SES class, brain parameters were compared across age groups using a one-way ANOVA. Statistical significance was defined as a p-value of less than 0.05.

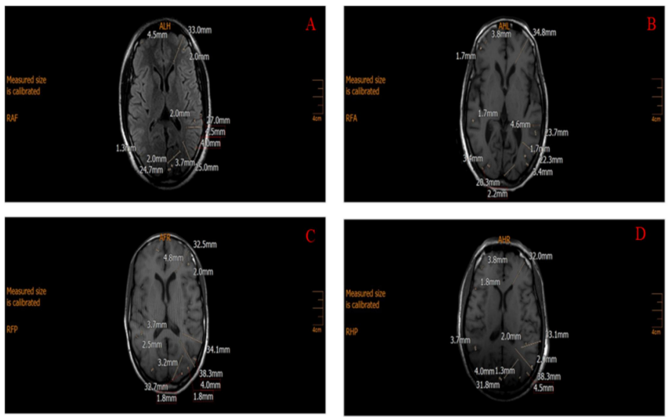

Fig. 2: Prototype of measured MRI brain images – Coronal sections (National Hospital Abuja, 2023).

Results

Brain morphometric parameters across age categories (all participants combined)

Regardless of socio-economic background, Table 1 shows the average values of brain parameters for each of the four age groups. From the table it can be observed that none of the measured parameters showed statistically significant variation across all age groups ($p > 0.05$). Although this difference was not statistically significant ($F = 1.105$, $p = 0.956$), brain volume (BVOL) displayed a fluctuating pattern, with the highest mean value in the 51–60 age group (1161.89 mm^3) and the lowest in the 61-and-above group (1061.31 mm^3). In a similar vein, lobe and gyri thickness measurements did not consistently show age-related trends throughout the sample.

Morphometric variations within the low socio-economic class

Variations in brain parameters among participants with low SES are displayed in Table 2. As shown, the majority of the parameters in this group did not differ statistically significantly by age group. On the other hand, temporal gyrus thickness decreased significantly with age ($F = 3.957$, $p = 0.016$), going from 4.10 mm in the 30- to 40-year-old group to 3.41 mm in the group aged 61 and up. Other measured parameters, such as brain volume, parietal lobe thickness, and frontal lobe thickness, varied among age groups but did not reach statistical significance.

Morphometric variations within the middle socio-economic class

When the parameters were assessed among the middle SES group, two brain parameters showed significant differences (Table 3). The temporal gyrus thickness decreased from 4.10 mm in the youngest group to 3.48 mm in the 51–60 group, with a minor increase in the 61-above group. This variation was statistically significant across age groups ($F = 5.273$, $p = 0.004$). Brain volume also declined significantly with age ($F = 6.250$, $p = 0.002$), with the group aged 61 and older having the low-

est volume (995.14 mm³) and the group aged 51 to 60 having the highest volume (1231.72 mm³). These results point to a structural decline in this socio-economic class that is related to age.

Table 1: Variations in the brain parameters across age categories regardless of the socio-economic class

Parameters	30-40 yrs	41-50 yrs	51-60 yrs	>60 yrs	F	P
			Mean±SD			
FLT (mm)	33.42±2.14	33.82±2.31	33.29±2.55	33.20±2.61	0.320	0.811
PLT (mm)	26.67±3.66	27.59±4.27	27.29±1.31	27.36±3.41	0.590	0.627
TLT (mm)	30.25±2.77	30.73±2.84	31.22±3.29	31.31±3.46	1.401	0.266
OLT (mm)	25.06±3.69	26.41±3.51	26.69±5.37	24.71±3.99	2.185	0.115
FGT (mm)	3.77±0.52	3.97±0.69	3.68±0.65	4.03±0.52	1.430	0.258
PGT (mm)	3.80±0.57	3.87±0.52	3.81±0.59	3.83±0.43	0.131	0.941
TGT(mm)	4.05±0.405	3.84±0.51	3.66±0.59	3.96±0.49	0.365	0.779
OGT(mm)	3.77±0.581	3.61±0.56	3.76±0.61	3.88±0.47	1.231	0.319
FSW(mm)	1.88±0.33	1.88±0.27	1.77±0.35	1.95±0.35	0.151	0.928
PSW(mm)	1.90±0.34	1.71±0.34	1.78±0.35	1.87±0.37	0.758	0.528
TSW(mm)	1.87±0.23	1.84±0.29	1.79±0.27	1.82±0.35	0.170	0.916
OSW(mm)	1.77±.29	1.88±0.36	1.77±0.28	1.85±0.32	1.072	0.379
BVOL(mm^3)	1088.19±132.05	1134.30±120.80	1161.89±147.19	1061.31±122.52	1.105	0.956

n = 214; FLT = Frontal lobe thickness, PLT = Parietal lobe thickness, TLT = Temporal lobe thickness, OLT = Occipital lobe thickness, FGT = Frontal gyrus thickness, PGT = Parietal gyrus thickness, TGT = Temporal gyrus thickness, OGT = Occipital gyrus thickness, FSW = Frontal sulcus width, PSW = Parietal sulcus width, TSW = Temporal sulcus width, OSW = Occipital sulcus width, BVOL = Brain volume.

Table 2: Variations in the brain parameters across age categories of low SES

Parameters	30-40 yrs	41-50 yrs	51-60 yrs	>60 yrs	F	P
			Mean±SD			
FLT (mm)	33.80±2.07	33.39±2.41	32.00±2.76	33.12±3.19	0.892	0.455
PLT (mm)	27.43±3.18	27.84±4.15	28.95±4.89	28.58±3.46	0.314	0.815
TLT (mm)	30.30±2.34	31.11±1.95	31.23±3.00	31.94±3.82	0.620	0.607
OLT (mm)	26.08±3.80	25.95±3.21	28.47±4.60	27.15±3.25	0.887	0.457
FGT (mm)	3.57±0.38	4.06±0.72	3.53±0.63	4.00±0.61	2.172	0.109
PGT (mm)	3.57±0.67	4.00±0.49	3.50±0.67	3.92±0.38	1.696	0.186
TGT(mm)	4.10±0.43	4.04±0.42	3.98±0.65	3.41±0.40	3.957	0.016
OGT(mm)	3.84±0.51	3.77±0.73	4.11±0.41	3.78±0.56	0.64	0.594
FSW(mm)	1.97±0.23	1.97±0.14	1.86±0.15	2.07±0.44	0.824	0.489
PSW(mm)	1.83±0.43	1.64±0.36	1.83±0.30	1.91±0.49	0.770	0.518
TSW(mm)	1.87±0.25	1.92±0.22	1.95±0.20	1.91±0.41	0.121	0.947
OSW(mm)	1.69±0.39	1.87±0.24	1.86±0.28	1.82±0.29	0.793	0.506
BVOL(mm^3)	1103.17±147.38	1116.79±9.95	1157.36±3.44	1064.87±1.43	0.536	0.61

n = 78; FLT = Frontal lobe thickness, PLT = Parietal lobe thickness, TLT = Temporal lobe thickness, OLT = Occipital lobe thickness, FGT = Frontal gyrus thickness, PGT = Parietal gyrus thickness, TGT = Temporal gyrus thickness, OGT = Occipital gyrus thickness, FSW = Frontal sulcus width, PSW = Parietal sulcus width, TSW = Temporal sulcus width, OSW = Occipital sulcus width, BVOL = Brain volume.

Morphometric variations within the high SES

Results for participants in the high SES category are shown in Table 4. No statistically significant age-related changes were found for any of the measured parameters, including cortical thickness, gyrus thickness, sulcal width, and brain volume ($p > 0.05$). Even though there were some small differences in the means, such as a slight decrease in brain volume and occipital lobe thickness with age, these differences were not statistically significant. This could suggest that people from higher socio-economic backgrounds appear to have more stable brain structures as they get older.

Discussion

The current study utilised high-resolution MRI to examine the interplay between SES and age-related changes in brain morphology in adults in the Federal Capital Territory of Nigeria. Three SES classes (low, middle, and high) and four age groups (30–40, 41–50, 51–60, and 61+ years) were the focus of the morphometric parameters that were analyzed, which included brain volume, cortical thickness, gyrus thickness, and sulcal width. The results highlight the important but complex role that SES plays in

influencing the architecture of the ageing brain. As highlighted in the respective tables, while the lower and middle SES groups showed some age-related morphometric changes, particularly in temporal gyrus thickness and brain volume, the high SES group showed no such changes or only negligible ones.

the combined influence of lifestyle, environmental, and genetic factors. More recent large-scale studies have further emphasised the multifactorial nature of structural brain ageing (Grødem *et al.,* 2025; Jawinski *et al.,* 2025. In the present study, age-related patterns became clearer only after stratifying participants by SES, suggesting that pooling all SES groups may have masked subgroup-

Table 3: Variations in the brain parameters across age categories of middle SES

Parameters	30-40 years	41-50 years	51-60 years	>60yrs	F	P
			Mean±SD			
FLT (mm)	33.28±2.36	33.86±1.79	34.17±1.03	32.40±1.94	0.693	0.563
PLT (mm)	26.18±4.05	28.07±5.87	24.57±3.92	28.60±1.22	1.074	0.373
TLT (mm)	30.73±3.04	31.32±3.50	30.80±2.71	30.83±2.28	0.075	0.973
OLT (mm)	24.97±3.56	27.40±3.72	22.92±3.63	22.23±4.74	2.420	0.082
FGT (mm)	4.00±0.49	3.82±0.82	3.50±0.63	4.23±0.46	1.603	0.206
PGT (mm)	3.94±0.47	3.82±0.62	4.04±0.53	3.66±0.41	0.482	0.697
TGT(mm)	4.10±0.38	3.57±0.60	3.48±0.37	4.10±0.36	5.273	0.004
OGT(mm)	3.65±0.58	3.47±0.42	3.40±0.53	4.00±0.43	1.069	0.375
FSW(mm)	1.86±0.39	1.85±0.30	0.70±0.48	1.93±0.11	0.391	0.760
PSW(mm)	1.90±0.29	1.68±0.28	1.65±0.46	1.93±0.11	1.669	0.191
TSW(mm)	1.89±0.23	1.83±0.35	1.67±0.31	2.033±0.40	1.455	0.244
OSW(mm)	1.81±0.22	1.76±0.36	1.67±0.33	1.86±0.60	0.460	0.712
BVOL(mm^3)	1071.27±4.19	1184.35±4.96	1231.72±8.90	995.14±64.18	6.250	0.002

n = 78; FLT = Frontal lobe thickness, PLT = Parietal lobe thickness, TLT = Temporal lobe thickness, OLT = Occipital lobe thickness, FGT = Frontal gyrus thickness, PGT = Parietal gyrus thickness, TGT = Temporal gyrus thickness, OGT = Occipital gyrus thickness, FSW = Frontal sulcus width, PSW = Parietal sulcus width, TSW = Temporal sulcus width, OSW = Occipital sulcus width, BVOL = Brain volume.

Table 4: Variations in the brain parameters across age categories of high socio-economic class

Parameters	30-40 years	41-50 yrs	51-60 yrs	>60	F- value	P- value
			Mean±SD			
FLT (mm)	32.82±0.79	34.40±2.87112	33.72±2.90	33.57±2.52	0.320	0.811
PLT (mm)	26.75±3.45	26.68±2.34480	27.87±3.50	25.82±3.57	0.590	0.627
TLT (mm)	27.55±0.45	29.51±3.14983	31.51±4.10	31.95±3.79	1.401	0.266
OLT (mm)	21.97±2.75	25.94±3.96100	27.90±6.02	23.51±3.59	2.185	0.115
FGT (mm)	3.32±0.57	4.01±0.56400	3.94±0.66	4.00±0.51	1.430	0.258
PGT (mm)	3.82±0.46	3.75±0.49281	3.91±0.51	3.82±0.52	0.131	0.941
TGT(mm)	3.67±0.25	3.87±0.43095	4.00±0.56	3.90±0.63	0.365	0.779
OGT(mm)	4.20±0.66	3.55±0.43150	3.75±.69	3.93±0.45	1.231	0.319
FSW(mm)	1.75±0.33	1.81±0.38914	1.76±0.37	1.86±0.32	0.151	0.928
PSW(mm)	2.10±0.29	1.84±0.37796	1.82±0.31	1.82±0.34	0.758	0.528
TSW(mm)	1.72±0.15	1.74±0.30472	1.76±0.25	1.67±0.25	0.170	0.916
OSW(mm)	1.90±0.11	2.05±0.49618	1.77±0.25	1.87±0.27	1.072	0.379
BVOL(mm^3)	1124.59±187.14	1102.11±3.00569	1116.64±156.170	1083.00±4.34	1.105	0.456

n = 58; nFLT = Frontal lobe thickness, PLT = Parietal lobe thickness, TLT = Temporal lobe thickness, OLT = Occipital lobe thickness, FGT = Frontal gyrus thickness, PGT = Parietal gyrus thickness, TGT = Temporal gyrus thickness, OGT = Occipital gyrus thickness, FSW = Frontal sulcus width, PSW = Parietal sulcus width, TSW = Temporal sulcus width, OSW = Occipital sulcus width, BVOL = Brain volume

Ageing is widely known to cause a progressive reduction in brain volume and cortical thickness, especially in the prefrontal and temporal regions (Henry *et al.,* 2025; Singh *et al.,* 2025). However, no discernible variations in brain volume or cortical measurements were observed across age groups in the current study when the data were aggregated across all SES classes.

The absence of significant age-related differences when all participants were analyzed together may reflect individual variability in the neuroaging process. Raz and Rodrigue (2006) noted that brain ageing does not occur in a strictly linear or uniform manner but rather results from specific effects. This observation is in keeping with the concept of brain maintenance described by Nyberg *et al*. (2012), which proposes that some individuals show minimal age-associated structural changes because of accumulated protective influences such as higher education, sustained cognitive engagement, physical activity, and better cardiovascular health.

The temporal gyrus showed the most consistent age-associated reduction among the regions measured in this study, particularly within the low and middle SES groups. This finding agrees with previous research identifying the temporal lobe as one of the brain regions most vulnera-

ble to age-related cortical thinning. Dickerson *et al*. (2009) reported that temporal regions are especially susceptible to structural changes with advancing age. More recent studies have reported similar patterns. For example, Singh *et al*. (2025) found significantly reduced cortical thickness in the temporal regions, including the middle and superior temporal gyri, in older adults compared to younger individuals, with cortical thickness showing a negative relationship with age. In the same vein, Grødem *et al*. (2025) noted that although some structural differences reflect lifelong individual characteristics, temporal lobe regions tend to show greater divergence in ageing patterns after the age of 60. The present findings, particularly the significant reduction in temporal gyrus thickness among participants aged 61 years and above, are therefore in line with these earlier observations and further highlight the sensitivity of the temporal region to age-associated structural variation, especially within certain socio-economic groups.

Cumulative exposure to life-course adversity, which is typical of people from lower socio-economic backgrounds, may make the temporal lobe even more susceptible. According to research, accelerated brain ageing in people from lower socio-economic backgrounds is caused by a number of factors, including exposure to environmental pollutants, poor diet, chronic stress, and limited access to cognitive stimulation (Hackman *et al.,* 2010; Farah, 2017). The high SES group did not exhibit this pattern, indicating that socio-economic advantage may act as a protective factor against these harmful exposures.

SES may play a context-specific role in neuroaging, with stronger effects in low-resource settings like Nigeria, where the protective factors associated with high SES, such as access to healthcare and education, are less widely distributed. This result is in contrast to our findings, which show no SES differences in TGT among older adults in high-income countries (Jefferson *et al.,* 2011).

As the middle SES group grew older, lower brain volume was observed in older age categories, especially in the age group of 61 and older. This result is consistent with longitudinal studies by Raz *et al*. (2010) and Fjell *et al*. (2009), which found that older adults' brain volume decreases more quickly, especially after the age of 60.

In this study, age-associated differences were more noticeable within the middle SES group. Individuals in this category often face considerable financial and social responsibilities, yet they may not consistently have access to the level of healthcare and social support available to those in the high SES group. Over time, such pressures could contribute to differences in health outcomes, including brain structure. Although early-life deprivation may not be as prominent in this group, cumulative midlife stress and environmental exposures might still play a role. This interpretation is in line with the view that midlife represents an important period during which lifestyle and environmental factors can influence later brain health (Nyberg *et al.,* 2012; *Raz et al.*, 2010).

In the low SES group, no statistically significant age-associated difference in brain volume was observed. Although the result may appear unexpected, one possible explanation relates to what Noble *et al*. (2015) described as a floor effect. This concept suggests that individuals from socio-economically disadvantaged backgrounds may already have comparatively lower structural measures earlier in adulthood, which could make further age-associated differences less apparent in cross-sectional analysis. In a related context, Hair *et al*. (2015) reported that exposure to early socio-economic disadvantage was associated with differences in brain structure, which may persist into later life. While this interpretation remains speculative in the present study, it offers a possible framework for understanding the observed pattern.

However, after controlling for educational attainment and health-related behaviours, Taylor *et al*. (2017), using data from the UK Biobank, found no significant associations between SES and total brain volume. The discrepancy with the current study might result from the UK's more extensive social services and healthcare system than Nigeria's, demonstrating the importance of context.

The relative stability of brain structure across age groups in the high SES population is arguably the study's most compelling finding. This lends credence to the idea of cognitive reserve, which holds that people who have more education, a higher SES, and an intellectually stimulating lifestyle are better able to preserve the structure and function of their brains as they age (Stern, 2009).

This matches what Arenaza-Urquijo *et al*. (2015) found in their study. They showed that older people with higher SES and cognitive reserve still delayed signs of brain decline, even when Alzheimer's disease was already present in the brain. In the same way, Evans *et al*. (2013) worked with a group of people from different backgrounds and found that higher SES helped protect the hippocampus from the harmful effects of ageing.

Numerous pathways, such as decreased allostatic load, improved vascular health, and increased participation in cognitively demanding activities, may mediate this preservation from a neurobiological standpoint (Gianaros and Hackman, 2013; McEwen and Gianaros, 2010). Furthermore, people with a higher SES are more likely to practice health-promoting habits like exercise and eating a balanced diet, which have been linked to neuroprotection on their own (Erickson *et al.,* 2011).

It is important to note that not all studies have found a strong link between SES and brain ageing. For example, Walhovd *et al*. (2012), in a study carried out across several European sites, reported that although SES was related to cognitive performance, its association with structural brain differences was weak. Similarly, Vinke *et al*. (2018) found that after adjusting for genetic factors and existing medical conditions, SES had little influence on patterns of structural brain ageing. These findings suggest that the relationship between SES and brain structure may vary depending on the population studied and the methods used.

These differences across studies may be explained by variations in how SES was defined, the characteristics of the populations studied, and the methods used to measure brain structure. In the present study, a multidimen-

sional SES index adapted to the Nigerian setting was used. This index considered factors such as housing type, ownership of electronic devices, land assets, occupation, and income. Such an approach may better reflect real-life socio-economic conditions in low-resource environments compared to studies conducted in high-income countries, where SES is often measured using only income or educational level.

Conclusion

This study provides evidence that SES may be associated with age-related differences in brain structure within this urban Nigerian sample. In the low and middle SES groups, measures such as brain volume and temporal gyrus thickness showed significant age-associated differences, whereas similar patterns were not observed in the high SES group. These findings suggest that individuals from higher socio-economic backgrounds may experience relatively less structural variation with advancing age. This pattern could be related to long-term advantages such as better access to healthcare, education, improved nutrition, and reduced exposure to chronic stress, although these factors were not directly measured in the present study.

The results support the expanding understanding that environmental and social factors play a significant role in brain ageing and that it is not only a biological process. These findings highlight the importance of incorporating socio-economic factors into clinical neuroimaging interpretation as well as more general public health policies in settings like Nigeria, where differences in wealth, health, and education are noticeable.

Declaration

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Conflict of interest

None declared.

Ethical approval

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki for research involving human subjects. Before the study started, ethical approval with reference number NHA/EC/013/2022 was acquired from the National Hospital's Health Research Ethics Committee in Abuja.

Authors' contribution

BIJ - Conceptualised and designed the study and led the manuscript writing; YAI - Supervised the data collection; AAG - Performed the statistical analysis as well as drafting the manuscript; OKU and NMJ - Performed the morphometric measurements. FOE - MRI image capturing.

Availability of data and material

The dataset for this study is available from corresponding author upon reasonable request.

Consent to participate and publish data

Following a thorough explanation of the study's goals, methods, possible risks, and advantages, each participant gave written informed consent. All personal and medical information was kept strictly confidential, and participation was completely voluntary.

The use of generative artificial intelligence

Generative artificial intelligence was only used for grammar check.

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