Prevalence, distribution and future projections of Parkinson disease in Brazil: insights from the ELSI-Brazil cohort study

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Summary

Background There is limited epidemiological data regarding Parkinson's disease (PD) prevalence in Brazil, which hinders adequate public health policies planning and patient care. This study aimed to investigate the distribution, prevalence, and clinical characteristics of PD among older adults in Brazil.

Methods This cross-sectional study used data from the ELSI-Brazil cohort, a Brazilian nationally representative study of individuals aged 50 and older. Data were collected through door-to-door surveys with standardized questionnaires. PD diagnosis was based on self-reported data. We calculated PD prevalence in the general population and specific age groups, studied its association with clinical variables, and projected PD prevalence in Brazil from 2024 to 2060.

Findings A total of 9881 respondents were included in this study, and 93 reported a medical diagnosis of PD. The crude prevalence of PD among Brazilians aged 50 or more was 0.84% (95% CI: 0.64%–1.09%), with an age- and sex-standardized prevalence of 0.86% (95% CI: 0.62%–1.10%). Men were more affected than women (OR: 2.35, 95% CI: 1.35–4.08; $p < 0.01$), and the prevalence was higher in older age groups, from 0.39% in those aged 50–59 years to 2.75% in those 80 years and older. PD individuals had higher rates of stroke, depression, functional dependency, and were more likely to need walking support or be bedridden. Projections indicated that PD cases in Brazil will rise from 535,999 (95% CI: 309,963–922,948) in 2024 to 1,250,638 (95% CI: 734,660–2,117,585) by 2060.

Interpretation This study reveals the prevalence and distribution of PD in Brazil, showing many patients with advanced disease and suggesting underdiagnosis in early stages. There is a need for better diagnostic accuracy,

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For the Portuguese translation of the abstract see the Supplementary Material section

improved access to neurologists, and comprehensive public health strategies to manage the rising prevalence and healthcare demands of PD in Brazil.

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Keywords: Parkinson's disease; Movement disorders; Epidemiology; Prevalence; Neurodegenerative diseases

Research in context

Evidence before this study

A systematic review was conducted to identify studies reporting the prevalence of PD in Brazil using the Medline/PubMed, Embase, LILACS, and Web of Science databases. The search terms included "Brazil" AND "Parkinson Disease" AND ("Epidemiology" OR "Prevalence") from inception until June 26, 2024. Only one relevant study was found. This study was published in 2006 and assessed the prevalence of PD among a population over 65 years old through a door-to-door, population-based survey in a single municipality, identifying a prevalence of 3.3%. This evidence may not adequately represent the entire Brazilian population or its current distribution, as it was conducted in a single center and published eighteen years ago.

Added value of this study

This study provides the first national estimate of PD prevalence in Brazil using a representative sample of individuals aged 50 years or older from all regions of the country. Our findings offer a comprehensive view of PD distribution across diverse demographic and socioeconomic groups. The study reveals a crude prevalence of 0.84% and an age- and sex-adjusted prevalence of 0.85%, identifies associated health conditions, and projects future population trends of PD in Brazil, indicating significant growth in prevalence through the years until 2060.

Implications of all the available evidence

Our findings underscores the urgent need for targeted public health strategies to address the rising prevalence of PD in Brazil. Policies should focus on improving early diagnosis, access to healthcare services, and comprehensive management, particularly in underserved regions. Future research should prioritize longitudinal studies to monitor PD trends, investigate risk factors, and refine preventive measures. Enhanced surveillance and data collection are crucial for developing effective interventions and mitigating the social and economic impact of PD on the Brazilian population.

Introduction

Parkinson's Disease (PD) is a debilitating condition that reduces the quality of life for a growing number of individuals.[1] Currently, about 8.5 million people globally are living with PD, with high estimated costs worldwide[2] and in Brazil,[3] which is the seventh most populated country globally. The primary risk factor for PD is age, but genetic mutations and environmental exposures, such as pesticides, solvents, and metals, also contribute to the risk.[2,4–6]

PD impacts about 0.3%–0.4% of the global population.[7] Epidemiological data reveal a higher prevalence of PD among older adults, with men and rural inhabitants being particularly affected.[8,9] Most existing studies predominantly originate from Europe and North America, providing limited insight into the disease's manifestation in diverse epidemiological contexts.[10,11] Thus, the global prevalence and epidemiological nuances of PD remain incompletely understood. This narrow focus underscores the need for research in regions with different sociodemographic dynamics to inform comprehensive public health strategies.

Brazil offers a unique context for studying PD due to its large, heterogeneous population and significant regional and cultural diversity. Also, the country's public health system, despite its comprehensive coverage, struggles with accessibility and equity issues. To date, only one population-based study has assessed PD prevalence in Brazil, reporting a crude prevalence of 3.3% among Brazilians aged 64 and older. However, this study was limited to a single center and was published in 2006.[12] Consequently, representative and updated data on the prevalence of PD are lacking in Brazil, which is essential both for public policy and for providing equity of care for affected patients and caregivers.[13] This study aims to investigate the distribution, prevalence, and clinical characteristics of PD among older adults in Brazil, leveraging a large, nationwide, representative cohort to inform effective public health policies and improve patient care.

Methods

Study design and sampling

This was a cross-sectional study using data from the ELSI-Brazil, a population-based cohort to study factors

associated with aging in Brazil that recruited non-institutionalized individuals aged 50 years or older.[14] The sample of this study was designed to be representative of the non-institutionalized Brazilian population within the eligible age range. Patients were interviewed in a door-to-door study with a sampling design that ensured the representation of urban and rural areas of small, medium, and large municipalities of all five geopolitical regions of Brazil (North, Northwest, Center-west, Southeast, and South). Sampling was performed with selection stages, combining stratification of primary sampling units (municipalities), census tracts, and households. We used data from its second wave, which was collected between 2019 and 2021. Data from the second wave comprised a sample of 9949 participants from 70 municipalities across the 5 geopolitical regions in Brazil. All participants signed separate informed consent forms for each research procedure. Patients who did not respond to the question present in their survey pertaining to their PD diagnosis were excluded from our analysis. The study was conducted by the Oswaldo Cruz Foundation (FIOCRUZ), Minas Gerais, Brazil, and approved by the Ethics Committee of FIOCRUZ. A complex sample design was adopted to ensure the representation of the urban and rural areas of small, medium, and large municipalities. Further details regarding the survey methodology are described elsewhere.[15]

Variables and data sources

All data were obtained through a standardized individual questionnaire following the ELSI-Brazil study design. A researcher involved in the study conducted these evaluations in each participant's household. The assessments included a wide range of topics and incorporated simple cognitive tests and physical and vital signs measurements. The complete content of the questionnaires is available at https://elsi.cpqrr.fiocruz.br/.

From the available data, several variables related to sociodemographic factors (age, sex, household income, and years of education), comorbidities (self-reported diagnoses of hypertension, diabetes mellitus, dyslipidemia, myocardial infarction or angina pectoris, stroke, osteoporosis, depression, and cognitive decline), health profile (degree of functional dependency for basic and instrumental activities of daily living, and mobility-related questions), and health service access (number of any medical appointments or visits with specialists within the past 12 months) were analyzed. PD status was determined based on self-reported diagnoses provided by the patient and/or caretakers. Race was self-reported and included the categories White, Black, Brown, Indigenous, and Asian. Due to small sample size in some of these groups, race was dichotomized into white and non-white categories.

The degree of independence for basic activities of daily living (ADLs) was measured using the Katz scale, which evaluates tasks such as bathing, changing clothes, hygiene, transference, continence, and eating, and presented values ranging from 0 to 6, with lower values indicating more dependency for these tasks.[16] Independence in functional activities of daily living (IADLs) was calculated according to the capacity to perform tasks such as using a telephone, shopping, preparing meals, performing domestic chores, managing transportation, and taking care of medications and finances, which are based on the Lawton scale.[17] IADL scores ranged from 0 to 8, with lower values indicating greater functional dependency for instrumental activities. The items used to calculate both scales were based on the self-reported ability of the individual or the caregiver's assessment of the individual's capacity to perform these tasks (yes/no).

Cognitive status was assessed using tests for memory, semantic verbal fluency, and temporal orientation. Memory was evaluated by recalling 10 words immediately and after a delay. Semantic verbal fluency was measured by naming as many animals as possible in one minute. Temporal orientation involves stating the current day, month, and year. Z-scores were calculated for each test and combined into a global z-score. Cognitive decline was defined as a z-score below 1.5 standard deviations from the mean, based on previously published studies evaluating cognitive impairment in PD.[18]

A projection analysis of the future prevalence of PD among adults aged 50 and older was performed. We applied our identified prevalence of PD in the age groups of 50–59, 60–69, 70–79, and more than 80 years to the estimated distribution of the Brazilian population for each year from 2024 to 2060, assuming these prevalence estimates for age groups remained constant. Data on the estimated age distributions of the aforementioned age groups in Brazil used for this analysis were obtained from the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*, IBGE, for the acronym in Portuguese).[19] Details on the methodology used for these population distribution estimates calculations are available on the IBGE website (https://www.ibge.gov.br/estatisticas/sociais/populacao/9109-projecao-da-populacao.html?=&t=conceitos-e-metodos). These data were used to estimate the prevalence of PD based on the projected demographic composition of the population. A cleaned version of the data provided by IBGE and utilized for these analyses is available in Supplementary Table S1.

Statistical analysis

All statistical analyses accounted for the complex sample; therefore, primary sampling units, strata, and weights were applied to the data. A more detailed explanation of the analysis process is provided in the Supplementary Methods. The prevalence of PD with 95% confidence intervals was estimated for the entire sample and according to specific variables such as country region, age and age groups, sex, living area

(rural or urban), and ethnicity (white versus non-white). The differences across these variables were calculated using chi-square. We also calculated the age- and sex-standardized prevalence of PD among Brazilians aged 50 years or older based on Brazilian census data from the year 2020, which provides data for the distribution of the Brazilian population for each specific age and sex groups (e.g., number of females aged 50–59 years).[19] Our identified prevalences for each age and sex group were then normalized based on the distribution of these groups in the Brazilian population. This analysis provides an estimate that standardizes for these demographic factors and may facilitate comparisons between studies and countries, irrespective of the population's age and sex demographic structure.[20]

The association of selected sociodemographic and clinical variables with PD was evaluated using linear regression for continuous variables, quasi-Poisson regression for count variables (frequency of medical consultations and consultations with specialists, ADL and IADL), and binomial logistic regression for categorical variables. Effect sizes were expressed as Odds Ratio (OR) for binomial regression, beta coefficients for linear regression, and Rate Ratio (RR) for quasi-Poisson regression. To avoid selection bias, only variables with at least 70% non-missing values for the entire population were included in this analysis and differences in missing rates were evaluated and found to be absent across geographical regions. To explore the influence of age and sex on the observed associations and to account for potential bias due to confounding, an additional regression analysis adjusting each individual variable for age and sex was performed.

All analyses were conducted using the built-in functions and the 'survey' package in R software (V4.2.2).[21,22] Normality was assumed for the distributions of the variables using visual inspection. Categorical variables are displayed as percentages with 95% confidence interval, and quantitative variables as mean (standard deviation).

Role of funding sources
This study did not receive any direct funding.

Results

Population characteristics and prevalence analysis
From the total 9949 patients evaluated in ELSI's second wave, 68 were excluded for not providing information related to their PD diagnosis. Therefore, the total sample consisted of 9881 individuals of whom 93 self-reported PD. Table 1 and Fig. 1 present prevalence estimates of PD according to different settings. The overall crude prevalence of PD among individuals aged 50 or more years in Brazil was 0.84% (95% CI: 0.64%–1.09%). Regarding sex, the PD group had a higher proportion of men compared to the control group (OR: 2.35; 95% CI: 1.35–4.08; p = 0.003). The prevalence of PD was higher in older age groups. It ranged from 0.39% (95% CI: 0.17%–0.6%) in individuals aged 50–59 years, to 0.48% (95% CI: 0.17%–0.8%) in those aged 60–69 years, 1.91% (95% CI: 0.93%–2.89%) in those aged 70–79 years, and 2.75% (95% CI: 1.39%–4.11%) in individuals aged 80 years and older. Patients aged 70–79 and over 80 years demonstrated a higher prevalence compared to those aged 50–59 years (OR: 5.02; 95% CI: 2.22–11.39; p < 0.001 and OR: 7.31; 95% CI: 3.36–15.91; p < 0.0001, respectively). Overall prevalence standardized by age and sex distribution of the Brazilian population in 2020 was 0.85% (0.62%–1.10%).

The prevalence across different regions of the country was 0.51% (95% CI: 0.25%–1.03%) in the North, 0.77% (95% CI: 0.48%–1.21%) in the Southeast, 0.91% (95% CI: 0.34%–2.44%) in the South, 0.94% 95% CI: (0.56%–1.58%) in the Northeast, and 0.98% (95% CI: 0.54%–1.75%) in the Midwest. No significant difference in PD prevalence was found between these regions (p = 0.791) or in direct comparisons between them (Table 1). There was no evidence of a difference in the proportions between PD and respondents without PD diagnose (non-PD) regarding white race (p = 0.178), living in a rural region until the age of 15 (p = 0.59) and income quartiles (p = 0.603). Among the 93 self-reported PD patients, 50 were white, 34 were brown, 8 were black, and no patient identified as Asian or Indigenous. One patient did not respond to this question. Among individuals aged 65 or more years, PD's prevalence was 1.58% (1.07%–2.08%).

Sociodemographic profile, self-reported comorbidities and health profile analysis
Table 2 presents data regarding sociodemographic profiles and self-reported comorbidities. The PD group had an average of 5.2 ± 0.5 years of education, while the non-PD group had an average of 6.8 ± 0.2 years (beta: –1.6; p < 0.001), however, this difference was not significant after adjusting for age and sex (beta: –0.7; p = 0.101). No differences between groups were observed with regards to household income (unadjusted and adjusted p = 0.179 and 0.307, respectively). Compared to the non-PD group, patients with PD had a higher proportion of self-reported stroke, even after adjusting for sex and age (adjusted OR: 2.66; 95% CI: 1.17–6.05; p = 0.02), and depression, also remaining significant after adjustments (adjusted OR: 3.04; 95% CI: 1.62–5.68; p = 0.0005). There were no significant differences in cognitive or other comorbidities between groups.

Table 3 presents data regarding self-reported health profiles of PD and non-PD groups. Both in unadjusted and adjusted analyses, PD patients had lower scores in ADL (adjusted RR: 0.83; 95% CI: 0.76–0.91; p < 0.0001) and IADLs (adjusted RR: 0.74; 95% CI: 0.63–0.87; p < 0.0001) and had more frequent medical

consultations overall and with specialists over 12 months (adjusted RR: 1.31; 95% CI: 1.05–1.64; p = 0.016 and adjusted RR: 1.54; 95% CI: 1.06–2.23; p = 0.025, respectively). PD patients also reported a higher impairment in mobility, such as needing support to walk (adjusted OR: 5.74, 95% CI: 2.31–14.3; p < 0.001) and being bedridden (adjusted OR: 5.63 95% CI: 2.61–12.13; p < 0.001) compared to the non-PD group. There was no difference between the groups regarding falls in the last year (p = 0.103).

Projection analysis

Based on the demographic distribution and projections of the Brazilian population, and assuming that PD prevalence among age groups remained constant throughout the years, the number of PD cases in Brazil is estimated to be approximately 535,000 in 2024 (95% CI: 309,963–922,948) and will rise to 750,000 cases by 2034 (95% CI: 436,643–1,286,433); 1,000,000 cases by 2046 (95% CI: 589,899–1,721,746); and 1,250,000 cases by 2060 (95% CI: 734,660–2,117,585). This growth translates to an average increase in PD burden in Brazil by 19,851 cases each year. Among individuals aged 50 years and older, the prevalence of PD is expected to increase from 0.89% (95% CI: 0.52%–1.54%) in 2024 to 1.23% in 2060 (95% CI: 0.72–2.08). A graphical depiction of these projections is presented in Fig. 2, while the comprehensive annual projections values are detailed in Supplementary Table S2.

	Prevalence (95% CI)	OR	p
Age and sex groups			
Overall (50 or older)			
Females	0.52% (0.31%–0.73%)	REF	REF
Males	1.21% (0.79%–1.63%)	2.35 (1.35–4.08)	**0.003**
Total	0.84% (0.64%–1.09%)		
50–59			
Females	0.23% (0.01%–0.45%)	REF	REF
Males	0.57% (0.13%–1.01%)	2.55 (0.67–9.69)	0.17
Total	0.39% (0.17%–0.6%)		
60–69			
Females	0.17% (0.01%–0.32%)	REF	REF
Males	0.86% (0.28%–1.43%)	5.18 (2.32–11.58)	**<0.0001**
Total	0.48% (0.17%–0.8%)		
70–79			
Females	1.35% (0.52%–2.17%)	REF	REF
Males	2.57% (0.48%–4.66%)	1.94 (0.63–5.93)	0.25
Total	1.91% (0.93%–2.89%)		
80 or older			
Females	1.96% (0.67%–3.25%)	REF	REF
Males	3.69% (1.44%–5.95%)	1.92 (0.83–4.46)	0.13
Total	2.75% (1.39%–4.11%)		
Age and sex standardized	0.86% (0.62%–1.10%)		
Geographical region			
North	0.51% (0.25%–1.03%)	REF	REF
Northeast	0.94% (0.56%–1.58%)	1.87 (0.8–4.39)	0.15
Midwest	0.98% (0.54%–1.75%)	1.93 (0.79–4.72)	0.15
Southeast	0.77% (0.48%–1.21%)	1.52 (0.65–3.53)	0.34
South	0.91% (0.34%–2.44%)	1.8 (0.6–5.36)	0.29
Race			
Non-white	0.70% (0.47%–0.93%)	REF	REF
White	0.95% (0.60%–1.31%)	1.37 (0.87–2.16)	0.18
Living area			
Urban	0.89% (0.66%–1.13%)	REF	REF
Rural	0.53% (0.08%–0.97%)	0.59 (0.24–1.42)	0.24
Income quartiles			
First	0.66% (0.34%–0.99%)	REF	REF
Second	0.80% (0.38%–1.22%)	1.21 (0.57–2.55)	0.62
Third	1.10% (0.20%–2.00%)	1.66 (0.58–4.76)	0.34
Fourth	0.99% (0.52%–1.47%)	1.5 (0.72–3.11)	0.27

REF = Reference category. Rural living defined as living in a rural area up to 15 years. Age and sex standardized prevalence are based on census data regarding the Brazilian's population structure of 2020.

Table 1: **Prevalence estimates of PD according to different settings.**

Discussion

To our knowledge, this is the first study to estimate the prevalence of PD using a representative sample of the Brazilian population. The estimated crude prevalence of PD among individuals aged 50 years or older is 0.84%, with a age- and sex-standardized prevalence of 0.85%. Comparison between age groups indicates prevalence rises with increasing age and was higher among males. However, there were no significant differences in prevalence across regions, ethnicity, income levels, or other demographic characteristics. Even when adjusting for age and sex confounders, PD patients exhibited a higher prevalence of stroke, depression, greater dependency in both ADL and IADL, difficulties in walking, being bedridden, and a higher frequency of medical appointments compared to non-PD patients. Based on population estimates, it is predicted that at least 535,000 individuals in Brazil were living with PD in 2024, with this number expected to gradually increase to 1,250,000 individuals by 2060, and potentially reaching 2,100,000 in the upper 95% confidence interval estimate.

Comparative assessments of PD prevalence between studies are complicated by variations in the minimum age of inclusion and methodological differences. Nonetheless, in comparison to studies that included patients 45 years or older, our findings of crude prevalence among individuals 50 years or older reveal a prevalence slightly above the 0.57% reported in a North American study conducted in 2010,[11] but align closely with the 0.94% prevalence found in a recent Chinese study.[23] PD crude prevalence of 1.58% among individuals aged 65 years or older is comparable, albeit slightly lower than the 2% reported by a Latin American consortium.[24] However, it is lower than the 3.3% prevalence observed in a Brazilian populational study, which evaluated the same age group.[12] The discrepancies between the prevalence reported here and those of the

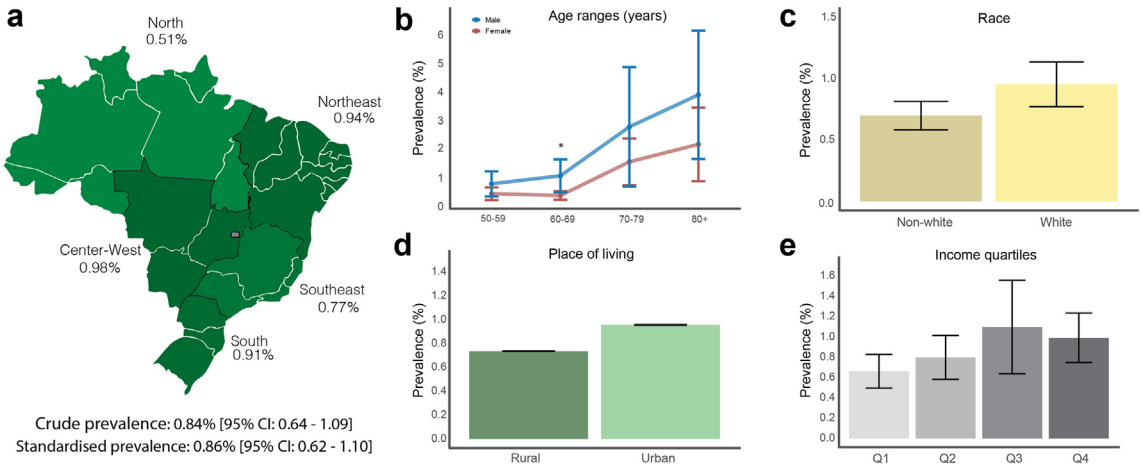

Fig. 1: **Prevalence and distribution of PD in Brazil.** **(a)** Prevalence estimates across the five Brazilian geographical regions and for the entire country, with both crude and age- and sex-standardized prevalences based on the 2020 national census data. **(b)** PD prevalence by age range and sex. A significant difference in prevalence is observed among patients aged 60–69 years ($p < 0.0001$). **(c)** Prevalence by race. **(d)** PD prevalence based on whether individuals lived in a rural setting until 15 years of age. **(e)** PD prevalence according to income quartiles. * indicates a statistically significant difference at the 0.05 p-value threshold.

aforementioned Brazilian study can be attributed to several factors. The previous study, confined to a single center, may reflect specific local influences on PD prevalence, such being a small city with only 15,000 inhabitants and sharing demographic features with only 60% of all Brazilian municipalities; while our study includes representation from all Brazilian regions and might portray a more representative prevalence. Additionally, the earlier study utilized a population-based door-to-door method with diagnostic confirmation, whereas our results are based on self-reported data, even though populational door-to-door design was also utilized. Nonetheless, the differences observed between our findings and the study discussed above highlight a critical gap in our understanding of PD's current prevalence in Brazil and indicate that further studies on this topic are needed, some of which are currently ongoing.[25]

Concerning age-standardized prevalence comparisons, our identified prevalence aligns with those reported in recent studies from other middle- and upper-middle-income countries, as shown in Supplementary Table S3.[26–35] Our standardized PD prevalence of 0.85% (or 850 per 100,000 individuals) among those aged 50 years or older is similar to those reported in more recently published studies, such as those from China (1070 and 1370 per 100,000),[25,33] Ecuador (760 per

	PD (n = 93)	Non PD (n = 9788)	p	OR/beta	Adjusted p	Adjusted OR/beta	Complete data (%)
Sociodemographic profile							
Age (years)	71.4 ± 1.7	63.3 ± 0.3	**<0.0001**	**8.15**	–	–	100%
Sex (male)	52 (55.91%)	3978 (40.64%)	**0.003**	2.35 (1.35–4.08)	–	–	100%
Education (years)	5.2 ± 0.5	6.8 ± 0.2	**0.0007**	−1.6	0.10	−0.7	98.7%
Household income (R$)	3620 ± 380	3250 ± 110	0.18	327.3	0.31	365.4	94.7%
Comorbidities							
Hypertension (yes)	51 (55.43%)	5053 (51.76%)	0.06	1.7 (0.98–2.95)	0.19	1.47 (0.82–2.64)	99.6%
Diabetes mellitus (yes)	19 (20.43%)	1757 (18.06%)	0.15	1.73 (0.81–3.7)	0.21	1.67 (0.75–3.69)	99.4%
Dyslipidemia (yes)	26 (28.26%)	2184 (22.58%)	0.72	1.1 (0.65–1.87)	0.51	1.2 (0.69–2.1)	98.8%
Myocardial infarction or angina pectoris (yes)	9 (9.8%)	528 (5.4%)	0.71	1.23 (0.41–3.75)	0.92	0.94 (0.3–2.98)	99.7%
Stroke (yes)	7 (7.69%)	430 (4.4%)	**0.001**	4.18 (1.78–9.82)	**0.020**	2.66 (1.17–6.05)	99.8%
Osteoporosis (yes)	21 (23.3%)	1362 (14%)	0.10	1.96 (0.89–4.32)	0.12	1.92 (0.84–4.39)	99.4%
Depression (yes)	22 (24.2%)	1236 (12.7%)	**0.029**	2.12 (1.08–4.18)	**0.0005**	3.04 (1.62–5.68)	99.8%
Cognitive decline (z-score)	0.17 ± 0.19	0.1 ± 0.07	0.72	0.07	0.29	0.18	70.3%
Cognitive decline (yes)	5 (11.9%)	511 (7.4%)	0.74	1.21 (0.39–3.7)	0.97	1.02 (0.34–3.11)	70.3%

OR = odds ratio for categorical variables obtained through binomial regression. beta = beta values obtained for numerical variables through linear regression. Categorical variables are displayed as OR (95% confidence interval) and numerical variables are displayed as mean ± standard deviation. BRL = Brazilian reais. Adjusted p and OR = adjusted p value for age and sex.

Table 2: **Demographic characteristics and self-reported comorbidities of PD and Non-PD groups.**

	PD (n = 93)	Non PD (n = 9788)	p	OR/RR	Adjusted p	Adjusted OR/RR	Complete data (%)
Number of basic daily activities able to perform	4.7 ± 0.2	5.8 ± 0.1	**<0.0001**	0.81 (0.74–0.89)	**<0.0001**	0.83 (0.76–0.91)	99.7%
Number of instrumental activities able to perform	5.0 ± 0.4	7.2 ± 0.1	**<0.0001**	0.7 (0.6–0.82)	**<0.0001**	0.74 (0.63–0.87)	98.4%
Number of medical consultations in 12 months	4.1 ± 0.4	2.9 ± 0.1	**0.001**	1.41 (1.15–1.72)	**0.016**	1.31 (1.05–1.64)	96.6%
Number of medical consultations with specialists in 12 months	2.6 ± 0.5	1.6 ± 0.1	**0.007**	1.64 (1.15–2.34)	**0.025**	1.54 (1.06–2.23)	95.9%
Needs support to walk (yes)	27 (29.03%)	467 (4.89%)	**<0.0001**	9.37 (4.45–19.73)	**<0.0001**	5.74 (2.31–14.3)	97.6%
Falls in the last year (yes)	24 (26.09%)	1812 (18.57%)	0.07	1.62 (0.96–2.72)	0.10	1.59 (0.91–2.79)	99.4%
Bedridden (yes)	13 (14%)	166 (1.7%)	**<0.0001**	10.3 (5.02–21.11)	**<0.0001**	5.63 (2.61–12.13)	100%

OR = odds ratio for categorical variables obtained through binomial regression (applied to needing support to walk, falls in the last year and being bedridden). RR = Rate Ratio for count variables obtained through quasi-poisson regression (applied to the remaining variables). Categorical variables are displayed as OR (95% confidence interval) and count variables are displayed as mean ± standard deviation. Adjusted p and OR = adjusted p value for age and sex.

Table 3: **Self-reported health profiles of PD and non-PD groups.**

100,000),[31] and Pakistan (660 per 100,000).[32] However, it is notably higher than the prevalence reported in older studies from China (198 per 100,000),[26] Nigeria (67 per 100,000),[27] Argentina (206 per 100,000),[29] and Bolivia (97 per 100,000).[30] However, comparing these studies is challenging due to variations in standardization techniques, as most studies standardized for either age or sex, while we standardized for both. Additionally, the minimum age for inclusion in these studies varied between 40 and 60 years, further complicating direct comparisons. Nonetheless, the similarity between our identified prevalence and those reported in more recent studies suggests a degree of consistency in our findings.

The prevalence of PD increases with age and is higher among males, an observation supported by previous reports.[11,12,23,24,36] Regional and socioeconomic factors influence PD prevalence in two distinct ways. First, poorer regions might inherently have less access to healthcare, which could affect diagnostic capabilities and thus decrease reported prevalence rates.[37,38] Second, even when adjusted for confounders, previous studies have shown that a lower socioeconomic status may independently increase the prevalence of PD.[37] As for ethnicity influences, while the literature suggests a higher prevalence among Whites and Hispanics,[36] Brazil's ethnically diverse population, characterized by high

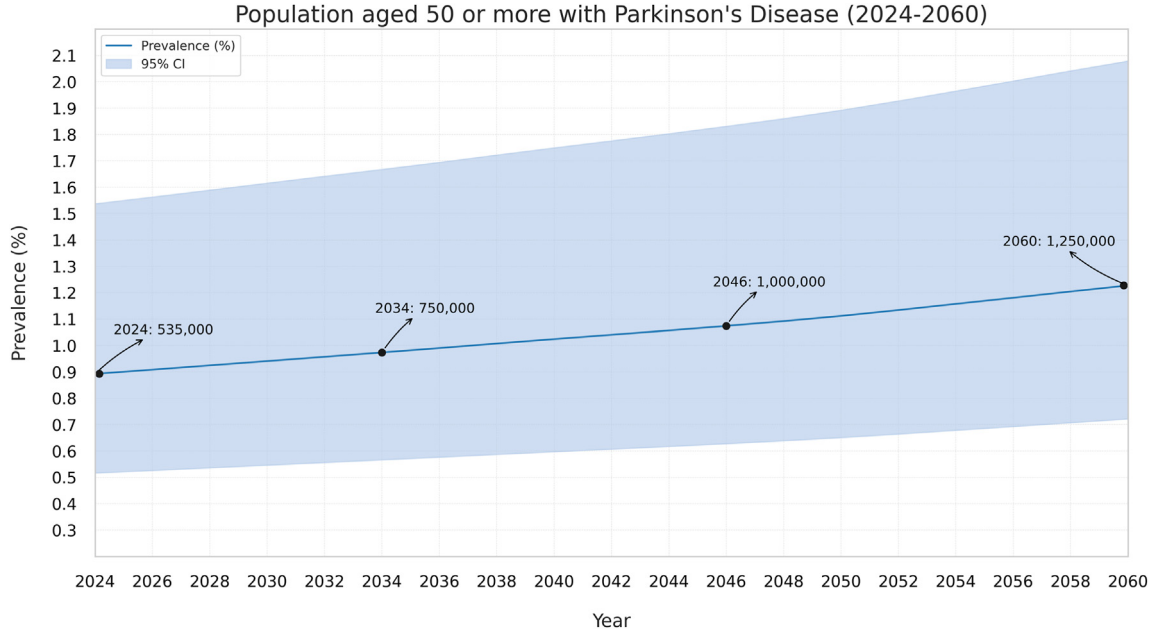

Fig. 2: **Estimated progression of PD prevalence in Brazil**. Projected increase in PD Prevalence in Brazil from 2024 to 2060: Prevalence estimates were calculated by applying our identified PD prevalence rates for the age groups 50–59, 60–69, 70–79, and 80+ years to the projected distribution of the Brazilian population for each year from 2024 to 2060, assuming these prevalence rates remain constant within each age group.

levels of admixture, may dilute these racial correlations. Finally, the urban versus rural divide presents conflicting data across studies, with no clear trend regarding PD prevalence,[24,39–41] reflecting the complexity of the environmental factors involved.

In our study, stroke was notably more prevalent in the PD group. This finding is also present in the literature, with several populational studies conducted in Norway,[42] South Korea,[43] and a Mendelian randomization study identifying a solid relationship between PD and stroke.[44] However, the interpretation of this finding should be carefully addressed as stroke was a rare event in both groups. The literature lacks agreement regarding the association between cardiovascular risk factors such as hypertension and dyslipidemia with PD,[45,46] and our analyses did not reveal a significant difference in these variables between the groups. Despite the associations between diabetes mellitus and PD in several studies,[43,47,48] our study did not observe this correlation. Osteoporosis has also been implicated as a potential risk factor for PD in population-based studies conducted in Taiwan[49] and South Korea.[50] However, we did not find this association in our study. Depression, on the other hand, is a common non-motor symptom in PD with prevalence ranging from 15% to 50%.[51,52] Our study indicated a significantly higher prevalence of depression in the PD group, which is in line with previously published evidence.[24] Differences between our observations and those found in the literature can be attributed to variations in ethnic structure, comorbidity profiles of participants, and the overall strength of the association of the studied conditions to PD. For instance, regarding hypertension, dyslipidemia, osteoporosis, and diabetes, it is possible that the strength of association between these factors and PD is lower compared to their association with depression. Additionally, the conflicting evidence regarding the association between PD and certain comorbidities may be partly due to variations in the diagnostic methods used across studies. In this context, our findings should be interpreted with caution, as they rely on self-reported data to identify comorbidities like depression, diabetes, and dyslipidemia. Consequently, our study may have lacked the power and design necessary to detect these relationships, unlike studies specifically designed to identify these associations.

Among PD patients, the median rate of progression on the Hoehn and Yahr scale, which assesses the severity of PD from stage 1 (minimal disability) to stage 5 (wheelchair-bound or bedridden), is approximately 13 years.[53] A significant portion of PD patients in our study reported a high prevalence of needing support to walk and being bedridden, which are common in the advanced stages of the disease. Clinical diagnosis of PD is notably more challenging in its initial stages compared to later stages, due to diminished diagnostic precision early on.[54] The characteristics observed in our study, even after adjusting for age and sex, suggest that our sample is enriched with individuals in advanced stages, where diagnostic certainty is higher. This observation indicates potential gaps in the early-stage diagnosis of PD in Brazil, also raising concerns that our calculated prevalence rates may be underestimations of the true prevalence of the disease.

The prevalence of PD appears to be rising worldwide, highlighting the need for a public health response,[55] especially in low- to middle-income countries where access to proper diagnosis and treatments is limited.[56,57] The role of exposure to environmental factors, such as industrial by-products like specific pesticides, solvents, and heavy metals, is postulated and debated in contributing to this rise in PD prevalence.[58,59] However, it is unequivocal that population aging and increased life expectancy are major drivers of this trend.[58] Our projections for the number of PD cases up to 2060, based on the age distribution of the Brazilian population aged 50 years and older, align with the rising prevalence indicated in the literature.[56,57] However, factoring in the recently reported 21.7% age-standardized increase in PD prevalence from 1990 to 2016 reported in the Global Burden of Disease study,[57] it is also possible that our current projection for 2060 underestimates the number of PD cases, as our analysis assumes stable prevalence rates across age groups over time, despite recent trends indicating an increase in these rates. Furthermore, a previous epidemiological study conducted in other Latin American countries suggests that PD underdiagnosis is high[24] and our patient profile indicates a high frequency of moderate to late-stage disease. This underscores the necessity for strategic planning and resource allocation to manage the anticipated burden in Brazil. As PD imposes a significant social and economic burden on both families and society,[60,61] it is critical to enhance PD prevention efforts, diagnostic capabilities, access to neurologists, and comprehensive care models in Brazil to address the needs of the growing PD population.

This study has several strengths, including the utilization of a large, complex sampling approach that provides a representative cross-section of the Brazilian population, making the first to outline a general profile of PD in a low- and middle-income country (LMIC) with previously limited data. Additionally, most association analyses performed were adjusted for age and sex, allowing for the identification of factors uniquely associated with the disease rather than confounding variables. However, our study has limitations and should be interpreted in light of them: 1) the reliance on self-reported diagnoses, which, despite matching typical PD profiles, may provide inaccuracies; 2) no inclusion of individuals younger than 50 years, in which the PD prevalence is not negligible[62]; 3) the lack of detailed environmental questionnaires precluded the assessment of possible environmental factors linked to PD, such as pesticide exposure, traumatic

brain injury or specific medication exposures; 4) the limitation in the PD prevalence projection analysis, which considered only demographic distribution trends and did not account for possible long-term modifications of environmental variables that could influence disease incidence and prevalence; and 5) our identified PD prevalence calculations not including institutionalized individuals due to ELSI's design, where PD prevalence could be higher.[63] Addressing these gaps in future research could provide a more comprehensive understanding of PD prevalence and risk factors in Brazil.

In conclusion, our study mapped the prevalence of PD in Brazil and delineated the influences of sex, age, socioeconomic status, ethnicity, and various risk factors, as well as a health profile for Brazilian PD patients. Considering that many PD patients in our study displayed health issues typically associated with the late stages of the disease and that the prevalence we identified is lower than that previously reported in other Latin American and Brazilian studies, it is likely that PD is still significantly underdiagnosed, especially in its early stages. In Brazil, where access to quality healthcare varies greatly, particularly in less affluent regions, PD imposes significant economic and social burdens. The disease incurs considerable costs for families and the government, contributes to loss of productivity, and reduces quality of life. Given the expected increase in PD prevalence due to demographic trends alone, it is imperative for public policies to focus on disease prevention, enhance diagnostic precision, and improve access to appropriate treatments to adequately support the expanding needs of this patient population.

Contributors

AN wrote the manuscript and revised its final version.

AFSS Concepted, designed, wrote the manuscript, coordinated the study and revised its final version.

CRMR wrote the manuscript and revised its final version.

DTS designed, wrote the manuscript, coordinated the study and revised its final version.

ERZ wrote the manuscript and revised its final version.

GAM concepted and performed statistical analyses.

GMP performed statistical interpretation, wrote the manuscript and revised its final version.

IFM wrote the manuscript and revised its final version.

MST concepted, designed, performed statistical interpretation, wrote the manuscript and revised its final version.

THS designed, performed statistical analyses, performed statistical interpretation and wrote the manuscript.

WVB performed statistical interpretation, wrote the manuscript, drafted figures and revised its final version.

Data sharing statement

For this study, we accessed a public database (ELSI-Brazil), which is available on the project website. The R script used to perform the analysis will be available upon request to the corresponding author.

Editor note

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Declaration of interests

AN reports consultancy and personal fees from AstraZeneca, AbbVie, Profile, Roche, Biogen, UCB, Bial, Charco Neurotech, Alchemab, Sosei Heptares and Britannia. CRMR served as a speaker of Biogen, FQM Farmoquimica S.A., and Teva. ERZ served on the scientific advisory boards of Novo Nordisk, Biogen, Masima, and Nintx. ERZ is a co-founder and minority shareholder of Masima. WVB served as speaker of Novo Nordisk. IFM reports grants from the National Institute of Health (NIH), Parkinson's Disease Association, Parkinson's Foundation, and the Aligning Science Across Parkinson's Global Parkinson's Genetics Program (ASAP-GP2). IFM received honorari for his participation as a speaker in the Movement Disorders Society and International Association of Parkinsonism and Related Disorders. IFM participates on the data safety advisory board for the Lewy Body Disease Association. WVB is a co-founder and minority shareholder of Masima. The remaining authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2025.101046.

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