RESEARCH ARTICLE

Prevalence and Incidence of Parkinson's Disease in Latin America: A Meta-Analysis

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ABSTRACT: Background: Parkinson's disease (PD) is a rapidly growing neurodegenerative disorder, but up-to-date epidemiological data are lacking in Latin America. We sought to estimate the prevalence and incidence of PD and parkinsonism in Latin America.

Methods: We searched Medline, Embase, Scopus, Web of Science, Scientific Electronic Library Online, and Literatura Latino-Americana e do Caribe em Ciências da Saúde or the Latin American and Caribbean Health Science Literature databases for epidemiological studies reporting the prevalence or incidence of PD or parkinsonism in Latin America from their inception to 2022. Quality of studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist. Data were pooled via random-effects meta-analysis and analyzed by data source (cohort studies or administrative databases), sex, and age group. Significant differences between groups were determined by meta-regression.

Results: Eighteen studies from 13 Latin American countries were included in the review. Meta-analyses of 17 studies (nearly 4 million participants) found a prevalence of 472 (95% CI, 271–820) per 100,000 and three studies an incidence of 31 (95% CI, 23–40) per 100,000 person-years for PD; and seven studies found a prevalence of 4300 (95% CI, 1863–9613) per 100,000 for parkinsonism. The prevalence of PD differed by data source (cohort studies, 733 [95% CI, 427–1255] vs. administrative databases. 114 [95% CI, 63–209] per 100,000, $P < 0.01$), age group ($P < 0.01$), but not sex ($P = 0.73$). PD prevalence in ≥60 years also differed significantly by data source (cohort studies. 1229 [95% CI, 741–2032] vs. administrative databases, 593 [95% CI, 480–733] per 100,000, $P < 0.01$). Similar patterns were observed for parkinsonism.

Conclusions: The overall prevalence and incidence of PD in Latin America were estimated. PD prevalence differed significantly by the data source and age, but not sex. © 2023 The Authors. *Movement Disorders* published by Wiley Periodicals LLC on behalf of International Parkinson and Movement Disorder Society.

Key Words: Parkinson's disease; Hispanics; Latin America; prevalence; incidence

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Introduction

Parkinson's disease (PD) is one of the fastest growing neurological conditions worldwide.[1] PD predominantly affects older adults, causing motor and non-motor symptoms like bradykinesia, rigidity, tremor, and cognitive decline,[2] and affected individuals are at greater risk of disability,[3] adverse hospital outcomes,[4] and mortality.[5] Parkinsonism is an umbrella term that covers several conditions, including PD, which share similar motor symptoms, but may not have the cardinal symptoms that lead to a specific diagnosis (eg, PD, cortical basal syndrome, and progressive supranuclear palsy). There are major gaps in the understanding of the epidemiology of PD and parkinsonism and wide variation in their management and treatment geographically.[6,7] It is, therefore, of public health interest to monitor the prevalence and incidence of PD and parkinsonism, as well as their variability between population subgroups, to guide future health policy.

Previous studies reported that PD affects ~8.5 million people worldwide[8] with a global prevalence of 315 per 100,000 individuals.[9] The epidemiology of PD in specific regions, such as Latin America, however, is limited. PD is believed to be influenced by environmental and genetic factors, which may result in geographic differences. Pringshiem et al[9] identified significant geographical variation in the prevalence of PD where the highest prevalence was found in South America, but included only four studies from Latin America. Similarly, Hirsh et al[10] only found one study in Latin America reporting the incidence of PD. Latin America is also a highly heterogeneous region with varying exposure to environmental, genetic, and socioeconomic factors related to PD. This systematic review aims to estimate the prevalence and incidence of PD and parkinsonism in Latin America.

Methods

This review was conducted following Meta-analyses Of Observational Studies in Epidemiology (MOOSE)[11] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[12] guidelines (Supplementary Material). The protocol for the present review was registered on PROSPERO (CRD42023377908).

Selection of Studies

The search strategy was developed with a medical librarian (M.D.). The search used a combination of standardized terms and keywords including but not limited to: (Parkinson disease OR parkinsonism) AND (prevalence OR epidemiology OR risk OR incidence OR disease rate) AND (Latin America OR South America or Central America or Caribbean or Region or Latin American country names) (Supplementary Table S1). Ovid Medline, Embase, Scopus, Web of Science, Scientific Electronic Library Online (SciELO), and The Literatura Latino-Americana e do Caribe em Ciências da Saúde or the Latin American and Caribbean Health Science Literature (LILACS) databases were searched for relevant studies published from their inception to December 27, 2022 and was not restricted to the English language. The inclusion criteria were studies (1) conducted in Latin America and (2) reported the prevalence or incidence of PD or parkinsonism in adults. Review articles, conference abstracts, or those containing non-original data were excluded as information on PD diagnosis and quality of studies may be missing. Systematic reviews were not included, but were checked to ensure that the included studies were identified by our search. Two independent reviewers (D.J.K. and A.L.I.P.) carried out the title, abstract, and full-text screening to determine whether studies should be included in the review. Conflicts arising from each stage of the screening were resolved by discussion (D.J.K., A.L.I.P., J.L.G., and M.P.). The literature screening was conducted on the Covidence platform.

Data Extraction

Data extraction was performed by two reviewers using a standardized form including the following: name of first author, study characteristics (year study conducted, data source, mean age, sex [%], country, and sample size), diagnostic criteria for PD or parkinsonism, number of cases, the prevalence or incidence results, and details of standardization if relevant. Prevalence was reported as cases per 100,000 persons and incidence rates as cases per 100,000 person-years. Stratified prevalence or incidence by age group and sex was extracted separately when reported for the subgroup analysis. The two reviewers equally shared the data extraction, but A.L.I.P. extracted data from Spanish or Portuguese papers. For 10% of the studies, data was extracted in duplicate and compared for any inconsistencies (J.L.G. and M.P.), which were discussed among the reviewers until a consensus was reached.

Quality Assessment

A quality assessment was performed for each study using the Joanna Briggs Institute (JBI) Critical Appraisal checklist for prevalence studies.[13] This checklist includes nine statements regarding the methodological quality of studies, specifically, the appropriateness of the study design, the validity and reliability of the clinical assessment, the quality of the statistical analysis, and the possibility of bias.

Data Synthesis

To be included in the meta-analysis, studies needed to report: (1) the number of cases; (2) the sample size (or person-years); and (3) the prevalence or incidence estimate (ie, prevalence per 100,000 persons and incidence per 100,000 person-years). Studies were included if the information required to calculate the missing values were present. Authors were contacted for additional data if they were not presented in the manuscript. The amount of between-study heterogeneity was quantified using the Cochran's Q statistic and Higgins I^2.[14,15] A random-effects model was used to pool results and data were visualized in a forest plot. Data were analyzed by data source (cohort studies vs. administrative databases), sex (males vs. females), and age group (40–49, 50–59, 60–69, 70–79, ≥80 years old or ≥60 years old). Administrative databases were local or national electronic medical records that recorded diagnosis and/or prescription codes. Meta-regression was used to determine whether any significant differences were present between groups.[16]

All analyses were carried out in R version 4.2.1 using the meta package (version 6.0.0). The data used for the analyses, analytic code, and template data collection forms can be accessed by contacting the corresponding authors.

Results

Study Characteristics

The combined database searches yielded 3015 references (Fig. 1). A total of 1199 duplicates were removed resulting in 1816 unique citations. After screening, 257 full-text articles were assessed for eligibility. We identified 18 studies that met the inclusion criteria and contained the information needed for extraction on the prevalence or incidence of PD or parkinsonism in Latin

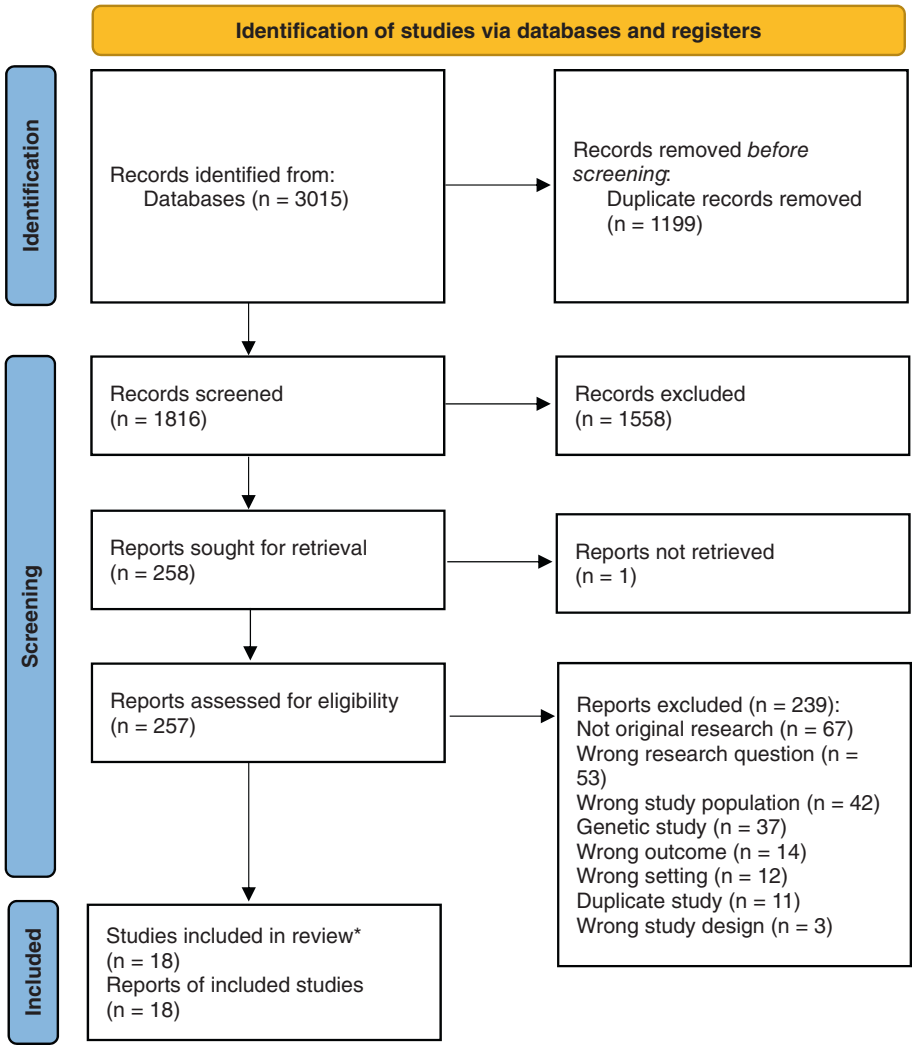

FIG. 1. PRISMA flow diagram. *Of the 18 studies, 15 studies reported prevalence only, one study reported incidence only, and the remaining two studies reported prevalence and incidence. Thirteen studies reported data on PD only, whereas five studies reported data on PD and parkinsonism. [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 1 *Characteristics of included papers and results ordered by author name*

Author (year study conducted)	Country, source population	Mean age (SD) [min]	Sample size (male, %)	Prevalent cases [incident cases]	Prevalence per 100,000 cases (95% CI) [incidence per 100,000 person-years (95% CI)]	PD or Pnism diagnosis	Were statistical weights used?
Cohort studies							
Barbosa[22]	Brazil, residents ages ≥60 y in rural town Bambuí	73.5 (6.9) [min, 64]	1186 (38.0%)	PD: 39 Pnism: 86	PD: 3288.36 Pnism: 7251.26	Stage 1: Pnism patients identified using a screening questionnaire (Tanner et al., 1990). Stage 2: Potential cases underwent full neurological evaluation independently by two neurologist/geriatrician. PD diagnosed using the UKPDSBB criteria. Each case was confirmed by a senior neurologist expert.	Crude results
Chouza[33]	Uruguay, residents in rural town Migues	n/s	4468 (n/s)	PD: 9	PD: 201.43	PD diagnosed by neurologists as the presence of two or more of the symptoms of akinesia, rigidity, and tremor in the absence of neuroleptic medication, previous encephalitis, or other known etiology.	Crude results
Del Brutto[30]	Ecuador, residents ages ≥40 y in rural village Atahualpa	59.1 (12.6) [min, 40]	642 (41.0%)	PD: 2	PD: 311.53	Stage 1: Suspected PD identified using a published screening questionnaire adapted for Spanish-speaking communities. Stage 2: Cases confirmed by neurologist, but precise definition was not given.	Crude results
Giroud Benitez[28]	Cuba, residents ages ≥15 y in urban area of Havana City province	[min, 15]	17,784 (47.4%)	PD: 24	PD: 134.9	Stage 1: Potential cases identified using the UKPDSBB criteria (bradykinesia, tremor, rigidity, and gait disorder) by family physicians. Stage 2: Cases confirmed by two neurologists.	Crude results
Instituto de Neurología, Sección de Neuroepidemiología[34]	Uruguay residents in rural village Migues	n/s	1975 (46.8%)	PD: 13 Pnism: 31	PD: 660 Pnism: 1570	Stage 1: Potential cases identified using the WHO criteria by healthcare professionals. Stage 2: Cases confirmed by 18 neurologists, but precise definition was not given.	Crude results
Llibre-Guerra[29]	Cuba, residents ages ≥65 y in urban Havana and Matanzas	75.1 (7.0) [min, 65]	2903 (35.0%)	**PD: 75** **Pnism: 183**	PD: 2600 (2100–3300) Pnism: 6300 (5500–7300)	Cases identified using UKPDSBB criteria by field examiners (graduate physicians, primary care providers, geriatricians, specialists in internal medicine, and registered nurses). The sensitivity and specificity of diagnostic criteria were 86% and 99%, respectively, compared with diagnosis by neurologist.	Direct standardization (for age, sex, and education) was used with the whole sample serving as the standard population.
Llibre-Guerra[29]	Dominican Republic, residents ages ≥65 y in urban Santo Domingo	75.3 (7.5) [min, 65]	1835 (35.0%)	**PD: 39** **Pnism: 200**	PD: 2100 (1500–2900) Pnism: 10900 (9600–12,400)		

(Continues)

TABLE 1 *Continued*

Author (year study conducted)	Country, source population	Mean age (SD) [min]	Sample size (male, %)	Prevalent cases [incident cases]	Prevalence per 100,000 cases (95% CI) [incidence per 100,000 person-years (95% CI)]	PD or Pnism diagnosis	Were statistical weights used?
Llibre-Guerra[29]	Puerto Rico, residents ages ≥65 y in urban Bayamon	76.3 (7.4) [min, 65]	1605 (32.8%)	**PD: 26 Pnism: 138**	PD: 1600 (1100–2300) Pnism: 8600 (7300–10,100)		
Llibre-Guerra[29]	Peru, residents ages ≥65 y in urban Lima and rural Canete Province	74.8 (7.4) [min, 65]	1904	**PD: 24 Pnism: 143**	PD: 2600 Pnism: 14500		
Llibre-Guerra[29]	Venezuela, residents ages ≥65 y in urban Caracas	72.5 (6.9) [min, 65]	1398 (36.2%)	**PD: 25 Pnism: 88**	PD: 1800 (1200–2600) Pnism: 6300 (5200–7700)		
Llibre-Guerra[29]	Mexico, residents ages ≥65 y in urban Mexico City and rural Morelos State	74.3 (6.7) [min, 65]	1965	**PD: 38 Pnism: 177**	PD: 3900 Pnism: 18000		
Melcon[19]	Argentina, residents ≥40 y in urban city Junín	[min, 40]	7765 (n/s)	PD: 51 Pnism: 213	PD: 656.8 Pnism: 2743.08	Stage 1: Potential cases identified using screening questionnaire by non-medical interviewers. Stage 2: Cases confirmed by neurologists, but precise definition was not given.	Crude results
Montalvo-Herdoiza[31]	Ecuador residents ages >40 y from Manabí province	[min, 40]	116,698 (n/s)	PD: 285	PD: 244.22	Stage 1: Potential cases identified using the UKPDSBB criteria. Stage 2: Cases confirmed by neurologist.	Crude results
Nicoletti[21]	Bolivia, residents >40 y from Cordillera Province, Santa Cruz Department	[min, 40]	1780 (49.8%)	PD: 5 Pnism: 156	PD: 286 (28–543) Pnism: 8764.04	Stage 1: Potential cases identified using SNES screening instrument, a modified WHO protocol by non-physician health worker. Stage 2: Cases confirmed by neurologist using UKPDSBB criteria. Parkinsonism was defined as at least two of four cardinal signs present (resting tremor, bradykinesia, rigidity, and postural-reflect impairment). PD was diagnosed by ruling out the subtypes of parkinsonism and the presence of resting tremor or bradykinesia.	Adjusted for area stratification and clustering

(Continues)

TABLE 1 *Continued*

Author (year study conducted)	Country, source population	Mean age (SD) [min]	Sample size (male, %)	Prevalent cases [incident cases]	Prevalence per 100,000 cases (95% CI) [incidence per 100,000 person-years (95% CI)]	PD or Pnism diagnosis	Were statistical weights used?
Pradilla[25]	Colombia, residents from Bogota, Cali, Barranquilla, Medellin, and Bucaramanga	n/s	8910 (40.0%)	PD: 9	PD: 470 (220–890)	Stage 1: Potential cases identified using the modified WHO neuroepidemiology protocol by healthcare professionals. Stage 2: Cases confirmed by neurologist or neuropediatrician, but precise definition was not given.	Adjusted by sex and age
Takeuchi[26]	Colombia, residents from Cali, Medellin, Barranquilla, Bogota, and Bucaramanga	[min, 50]	8910 (n/s)	**PD: 42**	PD: 470 (220–890)	Stage 1: Potential cases identified using the modified WHO neuroepidemiology protocol. Stage 2: Cases confirmed by neurologist when tremor, rigidity, and hypokinesia present.	Crude results
Vale[23]	Brazil residents aged >75 y in Caeté	83.3 (6.1) [min, 75]	610 (38.5%)	PD: 19 Pnism: 65	PD: 3100 (1900–4800) Pnism: 106656 (8321–13,380)	10 physicians (five neurologist, four geriatricians, and four psychiatrist) identified parkinsonism according to the UKPDSBB and UPDRSm >9 and confirmed possible/probable PD when bradykinesia, rest tremor, rigidity, postural instability was present (UKBB criteria).	Crude results
Administrative							
Bauso[20]	Argentina, members of two HMOs in Buenos Aires	71.5 (10.8) at PD diagnosis [min, 0]	140,000 (n/s) [754,082 person years]	**PD: 307 [PD: 239]**	PD: 219 [PD: 31.2 (27.4–35.4)]	PD was identified using the UKPDSBB criteria. ICD9 codes for PD and related symptoms and computerized prescription data were used to identify potential cases, which were confirmed by movement disorder specialists.	Crude results
Orozco[17]	Colombia, members of two HMOs	73 (64–80) for PD cases [min, 30]	2,066,780 (n/s)	PD: 3264	PD: 157.92 (152.25–163.43)	PD diagnosed using previously published algorithm. First, probable PD cases were detected using diagnosis and prescription codes identified by a neurologist trained in movement disorders. Next, patients were excluded based on specific prescription patterns that argue against PD.	Adjusted by sex and age
Pinilla-Monsalve[18]	Colombia, a national electronic database	[min, 15]	21,300,910 (n/s)	PD: 24403	PD: 115 (113–116)	PD diagnosis defined using the ICD10 codes G20X and F023. Diagnosis was mandatorily registered in the national administrative database of the Ministry of Health by licensed physicians on each healthcare event (consultations, emergency visits, procedures, etc.)	Adjusted by sex and age

(Continues)

TABLE 1 *Continued*

Author (year study conducted)	Country, source population	Mean age (SD) [min]	Sample size (male, %)	Prevalent cases [incident cases]	Prevalence per 100,000 cases (95% CI) [incidence per 100,000 person-years (95% CI)]	PD or Pnism diagnosis	Were statistical weights used?
Rodriguez-Violante[32]	Mexico, a national electronic database	[min, 20]	75,044,831 person years	[PD: 28457]	[PD: 9.48]	PD (ICD10 code G20) cases were identified through an electronic system reported on a weekly basis and regularly evaluated for compliance and consistency.	Crude results
Sanchez[27]	Colombia, two medical institutions in urban city Medellín	n/s	**PD: 1442997/ Pnsim: 256,532** (50.2%)	PD: 443 Pnism: 108	PD: 30.7 (29.2–32.2) Pnism: 42.1 (40.3–43.8)	Neurologist	Crude results
Vial[24]	Chile, a national electronic database	76.4 (10.08) at PD diagnosis [min, 0]	**14,032,981** (50.0% in PD cases) [**14,037,975** person years]	PD: 22551 [PD: 3327]	PD: 160.7 [PD: 23.7]	PD was identified using UKPDSBB criteria. Probable PD cases identified when a primary care physician suspects PD and activates the GES (the Universal System with Explicit Guarantees in Health). The patient is seen by a neurologist within 60 days who will confirm or exclude the diagnosis using the UKPDSBB criteria.	Crude results

Note: Bold numbers indicate that numbers were calculated from the available data using the following equation: result per 100,000 persons = cases/denominator × 100,000 persons (or person-years).
Abbreviations: SD, standard deviation; min, minimum; CI, confidence interval; PD, Parkinson's disease; Pnism, parkinsonism; UKPDSBB, United Kingdom Parkinson's Disease Society Brain Bank diagnostic criteria; n/s, not shown; WHO, World Health Organization; UPDRSm, Unified Parkinson's Disease Rating Scale motor section; HMO, Health Maintenance Organization; UKBB, United Kingdom Brain Bank; ICD9, International Classification of Diseases ninth edition; ICD10, International Classification of Diseases tenth edition; SNES, Sicilian Neuro-Epidemiology Study; GES, Garantias Explicitas de Salud.

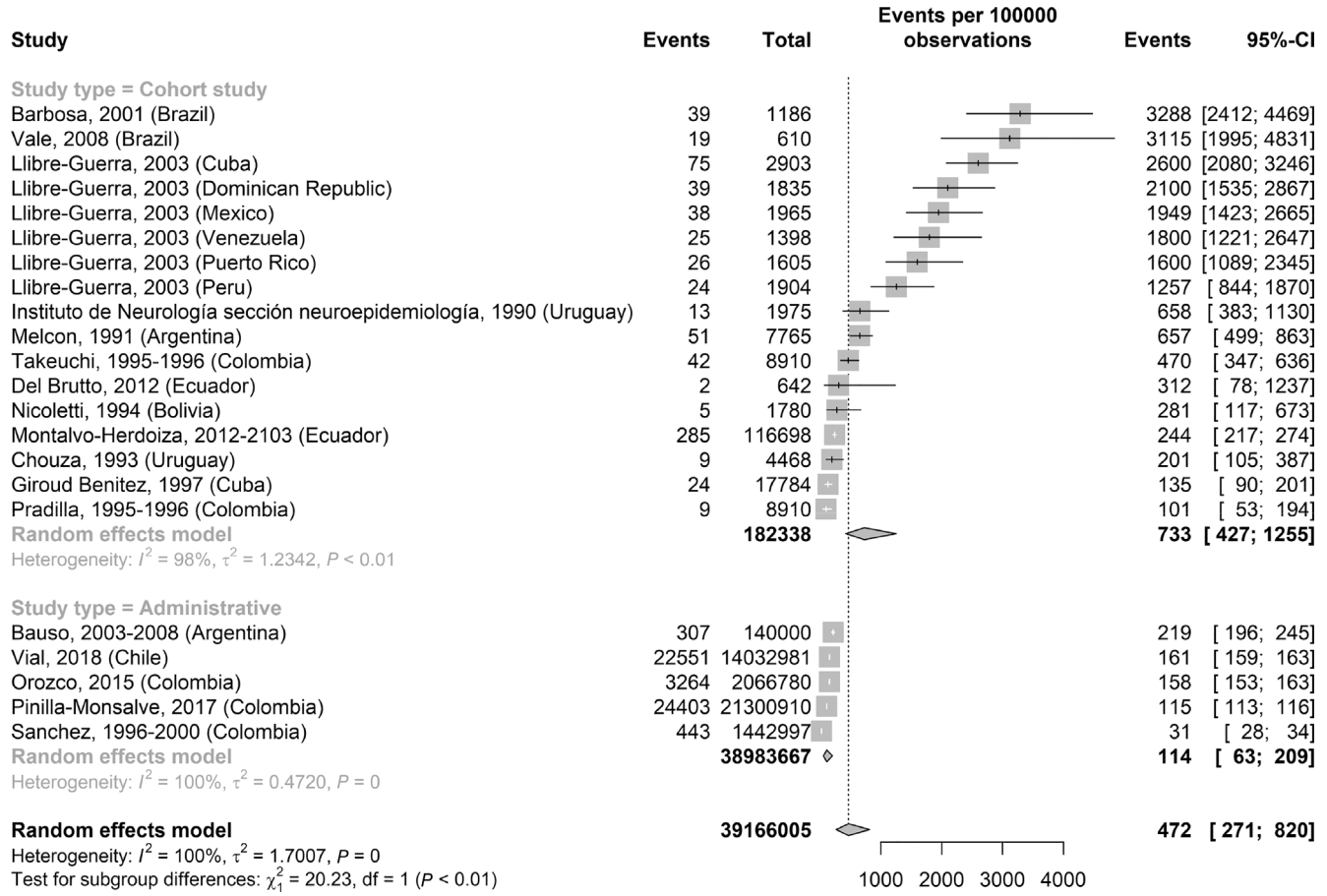

FIG. 2. Prevalence of Parkinson's disease per 100,000 persons.

America. Additional data to conduct group-specific analyses were obtained from contacting authors from two studies.[17,18] The characteristics of the included studies are shown in Table 1.

Of the 18 included studies, 17 reported prevalence and three reported incidence, and 13 reported data on PD, whereas five reported data on both PD and parkinsonism. Data was collected from the following

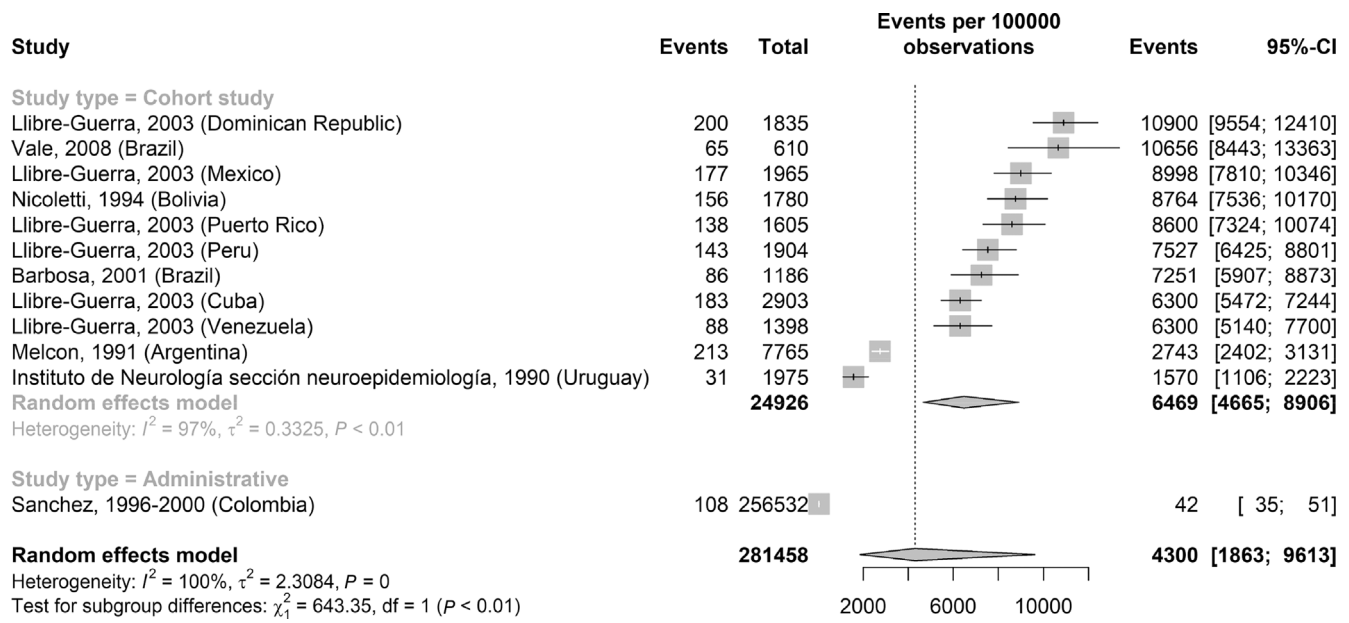

FIG. 3. Prevalence of parkinsonism per 100,000 persons.

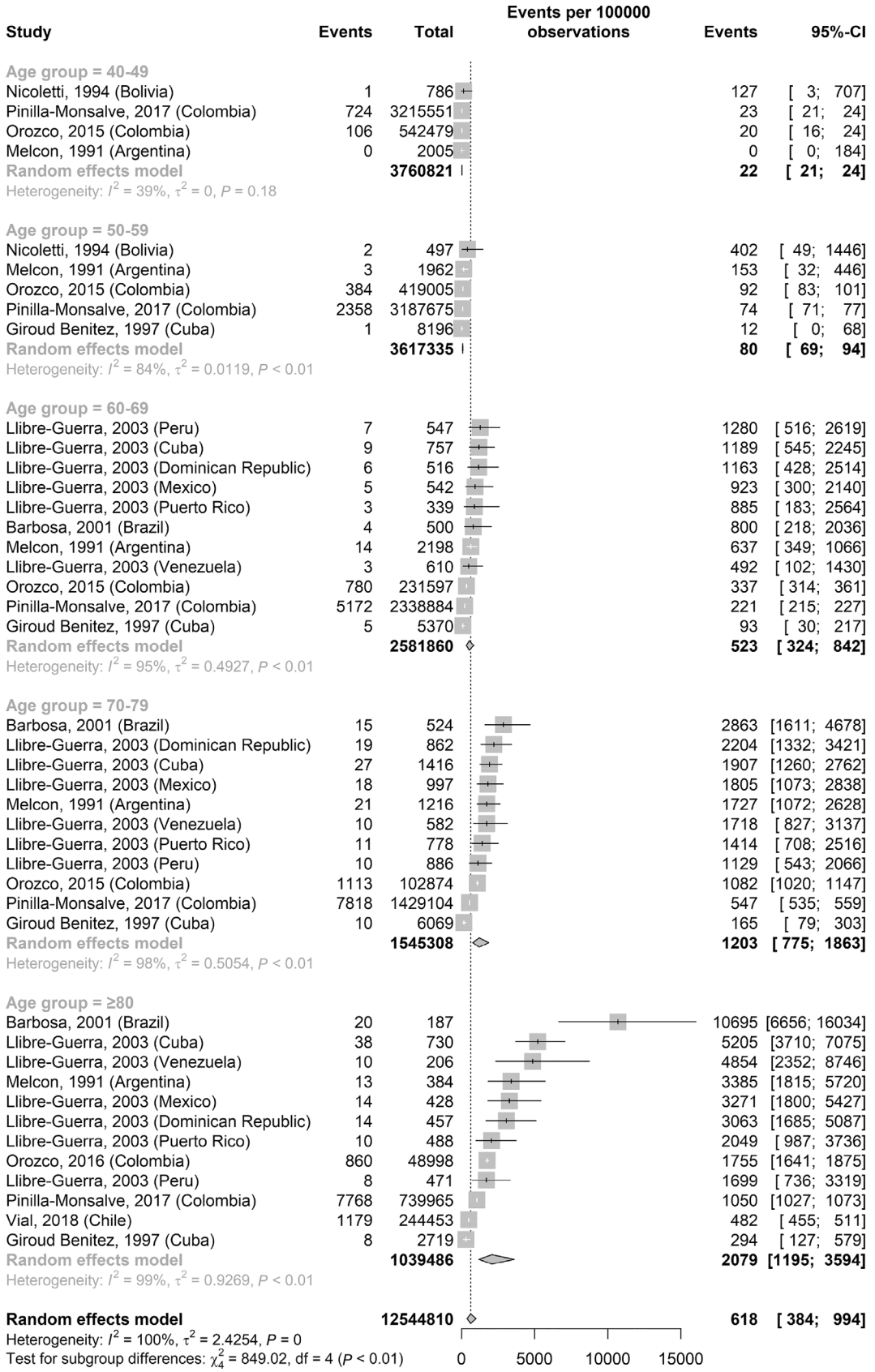

FIG. 4. Prevalence of Parkinson's disease per 100,000 persons by age group.

13 countries: Argentina,[19,20] Bolivia,[21] Brazil,[22,23] Chile,[24] Colombia,[17,18,25-27] Cuba,[28,29] Dominican Republic,[29] Ecuador,[30,31] Mexico,[29,32] Peru,[29] Puerto Rico,[29] Uruguay,[33,34] and Venezuela.[29] One study was a large multi-country cohort that included six Latin American countries.[29] Additionally, 12 studies were population-based cohort studies and six were based on administrative data. Among studies using administrative data, three were nation-wide electronic databases,[18,24,32] two were based on health maintenance organizations (HMOs),[17,20] and one was based on individual institutions.[27]

Populations included also varied in age, geography, and time. Although most cohort studies were restricted to older people (at least 40–75 years old), those based on administrative data had a lower minimum age (0–30). Geographical location also varied, ranging from a rural coastal village in Ecuador[30] to urban capital cities—Buenos Aires in Argentina.[20] The year in which prevalence estimations were made ranged from 1991[34] to 2018.[24]

Studies used varying methods to determine patients with PD or parkinsonism. Studies using administrative databases generally used diagnostic codes for PD, such as International Classification of Diseases ninth edition (ICD9) (332, 332.1, 333, 333.x, 781.0)[20] or ICD10 (G20 and F023) codes,[18,32] or their own algorithms using diagnosis and prescription codes that were additionally confirmed by neurologist.[17] Nine cohort studies[19,21,22,25,26,28,30,31,34] involved a two-stage procedure to identify PD cases. In stage 1, suspected PD cases were usually identified via a screening tool, which then underwent further neurological examination in stage 2 to confirm or refute a diagnosis of PD. The diagnostic criteria used to establish PD also varied considerably between studies. The most common diagnostic criteria used were the United Kingdom (UK) Parkinson's Disease Society Brain Bank (UKPDSBB) diagnostic criteria[35] and a modified version of the World Health Organization neuroepidemiology protocol.[36,37] PD was diagnosed by neurologists or physicians only in two studies.[23,33]

The quality assessment using the JBI Critical Appraisal checklist is reported in Supplementary Table S2. Most studies were considered to have an appropriate sample frame and size for the study and used valid and reliable approaches to identify PD and parkinsonism, but some level of methodological flaw was present in most studies. This included unclear sampling strategies[33] and uncertain reliability of PD diagnoses.[19]

Prevalence of PD and Parkinsonism

The overall prevalence of PD based on 22 estimates (17 studies) was 472 (95% CI, 271–820) per 100,000 persons, which differed significantly by the data source: 733 (95% CI, 427–1255) from cohort studies and 114 (95% CI, 63–209) from administrative databases (Fig. 2). The overall prevalence of parkinsonism based on 12 estimates (seven studies) was 4300 (95% CI, 1863–9613) per 100,000 persons, which also differed significantly by data source: 6469 (95% CI, 4665–8906) from cohort studies and 4300 (95% CI, 1863–9613) from one administrative database (Fig. 3).

Sex-specific prevalence of PD (Supplementary Fig. S1) and parkinsonism (Supplementary Fig. S2) showed no significant differences by sex. However, males had small, non-significantly higher prevalence rates than females for PD (646 vs. 544 per 100,000; $P = 0.73$) and parkinsonism (8902 vs. 7676 per 100,000; $P = 0.18$).

The prevalence of PD increased progressively by age group. In 40 to 49, 50 to 59, 60 to 69, 70 to 79, and ≥80 years, the prevalence of PD was 22 (95% CI, 21–24), 80 (95% CI, 69–94), 523 (95% CI, 324–842), 1203 (95% CI, 775–1863), and 2079 (95% CI, 1195–3594) per 100,000 persons, respectively ($P < 0.01$) (Fig. 4). Similarly, the prevalence of parkinsonism increased with age group: the prevalence per 100,000 persons was 2825 in 60 to 69 years; 6457 in 70 to 79 years; and 16,228 in ≥80 years ($P < 0.01$) (Supplementary Fig. S3).

A post hoc sensitivity analysis was conducted given the large differences in prevalence rates by data source. The prevalence of PD in older people (≥60 years old) was estimated by data source (Supplementary Fig. S4). PD prevalence in older people 60 years old or over was 1229 (95% CI, 741–2032) per 100,000 persons in cohort studies and 593 (95% CI, 480–733) per 100,000 persons in administrative databases ($P < 0.01$). This analysis could not be replicated for parkinsonism because of the inclusion of few studies.

Incidence of PD

The incidence of PD was reported by three studies using administrative data.[20,24,32] The overall incidence was 31 (95% CI, 23–40) per 100,000 person-years (Supplementary Fig. S5). The number of studies reporting an incidence rate was too small to assess subgroup differences.

Discussion

Summary of Findings and Comparison with Previous Literature

Our meta-analysis reports the most recent prevalence and incidence estimates of PD for Latin America and, to the best of our knowledge, is the first to collate evidence on the prevalence of parkinsonism in this region. Compared to the global PD prevalence reported by

Pringsheim et al,[9] 315 per 100,000 individuals, our study found a higher prevalence rate of 472 per 100,000 individuals in Latin America. The review also found striking differences in prevalence rates by data source. There was over sixfold difference between the prevalence rate obtained from cohort studies and administrative databases, which was also observed by Muangpaisan et al.[38] Fewer cases of PD are likely to be identified through administrative databases as individuals with subclinical or early-stage PD are not likely to seek medical care, which may lead to a subregistry of PD when using administrative databases relative to population based studies. A crude comparison (ie, a sixfold difference) was made to illustrate the magnitude of difference in prevalence rates observed by data source. However, it should be interpreted with caution as such simplistic comparisons in prevalence rates between studies of different designs are problematic because of large differences in the baseline population characteristics. For instance, study populations using administrative databases were generally younger than those from cohort studies, so age likely explains some of the difference in the prevalence by data source. Another potential reason for the difference may have been because of the relatively small samples used by some of the cohort studies, which resulted in wide confidence intervals. For example, the study from rural Ecuador calculated a prevalence of more than 300 per 100,000 inhabitants based on only two patients.[30] However, a twofold difference in PD prevalence remained between these two data sources when the meta-analysis was restricted to 60 years or older, suggesting that some degree of underestimation is probable when administrative databases are solely used to estimate PD prevalence. Similarly, although our PD prevalence estimate is slightly higher than the previously reported global estimate,[9] a direct comparison is challenging because of differences in survival and distribution of risk factors across countries.

Our meta-analysis found non-significant sex differences in PD and parkinsonism prevalence with slightly higher rates in males than females. Previous systematic reviews have demonstrated a similar non-significant, slight preponderance of PD in males. For instance, Pringsheim et al[9] reported 1267 cases (95% CI, 583–2752) per 100,000 in men and 808 cases (95% CI, 356–1832) in women in a meta-analysis of four Latin America countries. This sex-difference is supported by the current literature, which report a twofold higher risk of developing PD in men than women and attribute this to differences in pathogenic mechanisms and access to specialist treatment by sex[39] and later age at onset for women.[2] True differences in prevalence by sex may have been confounded by age, as shown by Pringsheim et al[9] where significant sex-differences in prevalence was observed in certain age groups only (a higher rate in men in the 50- to 59-year-old age group). This may because of differences in the rate of disease progression and mortality rate by age and sex.[39] In addition, prevalence is affected by the number of affected individuals and their survival,[40] which means that it may differ depending on the survival rate of the population included in the estimation. Therefore, the lower survival rate among men may have led to an underestimation of their prevalence and explain the lack of sex-difference in prevalence rates in our study. Incidence rates, which represent the number of new cases among susceptible populations in a given location over a specified timeframe, may be a more useful measure in this aspect, but not enough incidence studies were included to assess sex differences. Similar to previous reviews and common knowledge that PD is an age-related disease, we found a higher rate of PD prevalence in older age groups. However, subtle changes in the prevalence over time, such as an increase in PD prevalence because of increasing incidence, life expectancy, and improvements in PD care, may have affected the association.

Implications for Clinical Practice and Research

Current knowledge of PD is primarily based on clinical and epidemiological data involving high-income, Western cohorts. However, PD is now known to be a highly heterogeneous disease in terms of epidemiology, clinical manifestations, and outcomes.[41] Our findings provide new data on PD epidemiology with respect to low and middle income countries in Latin America to guide policy, such as determining how many resources to allocate to PD prevention and management at the national level. In addition, our work has revealed large variation in PD prevalence within Latin America, a highly heterogeneous region. Although further investigation is needed to understand the exact reasons, higher PD prevalence may have been found in regions with higher genetic or environmental susceptibility to PD or resulting from differences in socioeconomic or lifestyle factors. For instance, evidence is emerging that ethnicity is a key determinant of PD heterogeneity[42] and the frequency of mutations in leucine repeat rich kinase 2, which is a common genetic cause of PD in Europeans, was shown to vary greatly between Latin American countries and was directly correlated with the European ancestry.[43] Countries with higher PD prevalence may also have higher pesticide exposure, which is a major risk factor of PD,[44] and more rapidly aging populations with higher life expectancy. Additionally, countries with improved awareness of parkinsonism among clinicians or greater access to neurological services may have led to higher diagnoses of PD. Therefore, higher prevalence rates may be seen in countries with higher universal health coverage, such as Argentina, Brazil, Colombia, and Mexico,[45] but this was not clear in the present review and may reflect the

inclusion of older prevalence estimates. Understanding these differences should be useful to target at the population-level to mitigate the rising prevalence of PD and help reduce inequalities in health outcomes. Therefore, future studies investigating other demographic and clinical risk factors of PD are needed.

The large heterogeneity in study design and methodology also limits comparability across studies. Our findings suggest that prevalence estimates vary significantly by the data source, which inherently use different operational definitions of PD. Future studies may consider several aspects in the planning of new epidemiological studies to enhance the comparability of prevalence studies and facilitate future meta-analyses. For example, prevalence estimates could be stratified by gender and age group as standard—the 5- and 10-year age groups routinely used by the World Health Organization, with definite upper and lower limits, could be considered. The diagnosis of PD should be clearly defined and use common, validated diagnostic criteria like the UKPDSBB or Movement Disorder Society criteria. Streamlining PD diagnoses across data sources may lead to linkage of data from multiple sources. Such multisource databases may provide more reliable prevalence estimates than a single source and accurately capture the prevalence of a selected region. However, more research is needed to investigate the feasibility of this approach.

Strengths and Limitations

The major strength of our systematic review is the use of multiple literature databases including those focused on Latin America and having no language restrictions. Previous systematic reviews of PD prevalence or incidence only searched the two main databases, Medline and Embase,[9,10,38] and were restricted to articles written in English,[10,38] which likely excluded studies from Latin America. As a result, our review identified more studies from Latin America than previous reviews (17 vs. 1–4 studies). However, more studies could have been included by using Spanish and Portuguese terms in the literature search strategy. Additionally, our study included studies based on cohort studies and administrative databases and has highlighted contrasting advantages of prevalence estimation using either data source. A major advantage of cohorts is that participants are usually representative of the population of interest via random sampling. Additionally, data collection is generally purposive, reliable, and relevant, allowing accurate estimation of prevalence. However, cohort studies are resource-intensive and susceptible to loss to follow-up. Administrative databases are generally larger than cohort studies, more easily accessible and cost efficient to study, making them suitable for estimating the prevalence of diseases. Although a larger population size does not necessarily mean better representativeness, administrative databases with high coverage, whether national or regional, suggest that any estimated prevalence is representative of that area. However, a major limitation is that administrative data may not include individuals who do not seek or have limited access to healthcare services, potentially introducing selection bias. Additionally, the data included is a snapshot of the real world and not specifically collected for research, which may be reflected in the quality and availability of data.

The main limitation of our study is the large statistical and methodological heterogeneity between the included studies. Although true differences in the prevalence and incidence of PD across populations are plausible, large methodological heterogeneity between studies is inherent in prevalence and incidence studies and is likely to bias comparisons. Meta-analyses should ideally combine data from studies using the same study design and case ascertainment methods, but this would have resulted in the exclusion of many studies. We have tried to mitigate this to an extent by reporting results by data source, but some differences between studies may persist. For instance, the different diagnostic criteria used across studies likely had varying levels of sensitivity and specificity, which makes comparing rates across studies problematic. The more recent criteria, like the UKPDSBB,[35] are stricter criteria, which increases their specificity but decreases sensitivity than older ones. A previous systematic review showed that diagnostic algorithms used in electronic databases generate reasonable, but a wide ranging accuracy for identifying PD (sensitivity range, 15%–73%) and parkinsonism (sensitivity range, 43%–63%) cases.[46] Each diagnostic tool will also be associated with their own degree of reliability, making a single assessment of the diagnosis prone to misclassification. Last, it is important to emphasize that the included studies had differing levels of quality. For instance, the sampling strategy used in the two-stage study design was unclear for certain studies,[33] which may have introduced some bias. In one study the stage 1 screening interview was answered by one responsible adult in the family for each family member living in the same household,[19] but whether this produces valid and reliable diagnoses of PD is uncertain. Additionally, differences in important sociodemographic factors, such as age and sex, between samples may have influenced participation in the study, subsequent PD case ascertainment, and the resulting prevalence or incidence estimate.

Conclusion

We provide an up-to-date estimation of the prevalence and incidence of PD and parkinsonism in

Latin America. Prevalence of PD and parkinsonism was 472 and 4300, respectively, per 100,000 persons, but significantly by the data source. Our findings are limited by problems inherent to meta-analyses of prevalence studies that have been highlighted previously.[9,10,38] Prevalence studies are conducted across distinct populations and settings and often use varying methodological approaches. Therefore, simple comparisons of prevalence rates across studies must be interpreted with caution. Although we have attempted to mitigate this by stratifying results by data source, our efforts were made difficult by the large variability in methodology that persisted. Our findings warrant further epidemiological studies estimating prevalence and incidence using consistent approaches, which will allow more detailed assessment of risk factors and reliable estimation of prevalence and incidence rates.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Data

Additional Supporting Information may be found in the online version of this article at the publisher's web-site.

Author Roles

(1) Research project: A. Conception, B. Organization, C. Execution; (2) Statistical Analysis: A. Design, B. Execution, C. Review and Critique; (3) Manuscript: A. Writing of the First Draft, B. Review and Critique.

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