Analysis of the Disease Burden and Future Trend Projections of Parkinson' s Disease in China and Globally from 1990 to 2021 (Postprint)

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Date: 2026-04-30T09:28:21+00:00

Abstract

Background: Parkinson' s disease (PD) is a common neurodegenerative disease, and the global disease burden continues to increase. China faces more severe challenges due to its large population base and rapid aging process. Objective: Based on the Global Burden of Disease 2021 (GBD 2021) database, this study aims to analyze the differences and trends in the disease burden of PD between China and the world from 1990 to 2021, and to predict future changes in disease burden, providing a scientific basis for optimizing PD prevention and control strategies. Methods: Using GBD 2021 data, indicators such as incidence, prevalence, mortality, and disability-adjusted life years (DALYs) of PD globally and in China from 1990 to 2021 were extracted. An age-period-cohort model was used to analyze epidemiological trends, combined with a Bayesian age-period-cohort model to predict the disease burden from 2022 to 2035. Results: From 1990 to 2021, the number of incident cases of PD in China increased by 455.7% (compared to a 220.1% increase globally), and the age-standardized incidence rate (ASIR) showed an upward trend, rising from 12.83/100,000 to 24.34/100,000, with an estimated annual percentage change (EAPC) of 2.16% (compared to 1.09% globally). The number of prevalent cases increased by 678.9% (compared to 273.8% globally). The age-standardized mortality rate (ASMR) in China showed a downward trend, decreasing from 6.11/100,000 to 5.03/100,000, with an EAPC of -0.76%, while the global ASMR showed an upward trend (EAPC = 0.18%). The age-period-cohort model indicated that the growth rate of the PD burden in China was higher than the global average, particularly among males and the 75–79 age group. Bayesian age-period-cohort model prediction results showed that by 2035, the ASIR (32.26/100,000) and age-standardized prevalence rate (ASPR) (332.67/100,000) of PD in China will far exceed global levels. Conclusion: The disease burden of PD is growing rapidly, primarily driven by population aging, although the trend in mortality control in China

is better than the global average. PD is more prevalent among the elderly and males. Future efforts should focus on strengthening management, optimizing policies, and addressing comorbidity management to reduce the overall burden. This study provides data support for formulating targeted PD prevention and control strategies.

Full Text

Preamble

Chinese General Practice

Abstract

In the context of the ongoing transformation of the global healthcare landscape, the discipline of general practice (family medicine) has emerged as a cornerstone of sustainable healthcare systems. This paper examines the current state, challenges, and future trajectories of general practice in China. By analyzing the integration of machine learning and deep learning technologies within primary care settings, we explore how digital health interventions can enhance diagnostic accuracy and patient management. Our findings suggest that while significant progress has been made in training general practitioners (GPs) and establishing community-based health centers, systemic barriers regarding resource allocation and inter-institutional coordination remain. We propose a framework for strengthening the gatekeeper role of GPs through enhanced clinical decision support systems and integrated care pathways.

Introduction

The development of general practice is a strategic priority for the modernization of China' s medical education and healthcare delivery systems. As the population ages and the burden of chronic non-communicable diseases increases, the demand for comprehensive, continuous, and coordinated care has never been greater. General practice serves as the "first line of defense" in the healthcare system, aiming to provide accessible and cost-effective medical services to the public.

[Figure 1: see original paper]

Recent policy shifts have emphasized the transition from a hospital-centric model to a community-oriented primary care model. This transition requires not only a robust workforce of qualified GPs but also the adoption of advanced technological tools to manage complex patient data. The application of machine learning algorithms in risk stratification and early screening for chronic diseases represents a significant frontier in general practice research.

Current Status of General Practice in China

1.1 Workforce Development and Education China has implemented a multi-tiered approach to training GPs, including the "5+3" standardized residency training program and the "3+2" assistant GP training program. Despite these efforts, the density of GPs per 10,000 residents still lags behind that of many developed nations. Furthermore, the quality of training varies significantly across regions, leading to disparities in clinical competency.

1.2 The Role of Community Health Centers Community Health Centers (CHCs) serve as the primary platform for general practice. These centers are responsible for providing basic medical services and public health functions, such as immunization, maternal and child health, and chronic disease management. However, the "gatekeeper" mechanism is still in its infancy, as many patients still prefer to seek care at large tertiary hospitals for minor ailments due to a perceived lack of trust in primary care.

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· Epidemiological Research ·

Analysis of the Disease Burden and Future Trend Predictions of Parkinson' s Disease in China and Globally from 1990 to 2021 Wu Yixuan[1], Xiao Liangman[1], Liu Xin[1], Yan Ziqi[1], Wang Yuting[2], Lin Shumin[1], Zhuang Lixing[3,4*]

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Abstract

Background: Parkinson' s disease (PD) is a common neurodegenerative disorder with a global disease burden that continues to intensify. Due to its large population base and rapid aging process, China faces particularly severe challenges in managing this condition. **Objective:** Based on the Global Burden of Disease 2021 (GBD 2021) database, this study analyzes the differences and trends in the disease burden of PD between China and the rest of the world from 1990 to 2021. Furthermore, it predicts future changes in disease burden to provide a scientific basis for optimizing PD prevention and control strategies. **Methods:** Utilizing GBD 2021 data, we extracted indicators including incidence, prevalence, mortality, and disability-adjusted life years (DALYs) for PD globally and in China from 1990 to 2021. An Age-Period-Cohort (APC)

model was employed to analyze epidemiological trends, and a Bayesian Age-Period-Cohort (BAPC) model was used to predict the disease burden from 2022 to 2035. **Results:** From 1990 to 2021, the number of incident PD cases in China increased by 455.7% (compared to a 220.1% increase globally). The age-standardized incidence rate (ASIR) showed an upward trend, rising from 12.83/100,000 to 24.34/100,000, with an estimated annual percentage change (EAPC) of 2.16% (compared to 1.09% globally). The number of prevalent cases increased by 678.9% (compared to 273.8% globally). Conversely, China' s age-standardized mortality rate (ASMR) showed a downward trend, decreasing from 6.11/100,000 to 5.03/100,000, with an EAPC of -0.76%, while the global ASMR exhibited an upward trend (EAPC = 0.18%). The Age-Period-Cohort model indicated that the growth rate of the PD burden in China is higher than the global average, with the burden being particularly prominent among males and the 75-79 age group. Projections from the Bayesian Age-Period-Cohort model suggest that by 2035, China' s ASIR (32.26/100,000) and age-standardized prevalence rate (ASPR) (332.67/100,000) will far exceed global levels. **Conclusion:** The disease burden of PD is growing rapidly, primarily driven by population aging; however, China' s trend in mortality control is superior to the global average. PD is more prevalent among the elderly and male populations. Future efforts should focus on strengthening management, optimizing policies, and addressing comorbidity management to reduce the overall burden. This study provides data support for formulating targeted PD prevention and control strategies.

Keywords: Parkinson' s disease; Incidence; Cost of illness; Predictive analysis; Age-Period-Cohort model; Bayesian Age-Period-Cohort model

CLC Number: R 742.5 **Document Code:** A **DOI:** 10.12114/j.issn.1007-9572.2025.0319

Cite this article: WU Yixuan, XIAO Liangman, LIU Xin, et al. Analysis of the Disease Burden and Future Trend Prediction of Parkinson' s Disease in China and Globally from 1990 to 2021 [J]. Chinese General Practice, 2025.

Introduction

Parkinson' s disease (PD) is a common neurodegenerative disorder primarily characterized by clinical features such as bradykinesia, resting tremor, muscle rigidity, and postural instability. Its pathological mechanism is closely associated with the degeneration of dopaminergic neurons in the substantia nigra and the abnormal aggregation of α-synuclein (α-syn) [**?**]. Although the exact pathogenesis of PD remains unclear, substantial evidence suggests that the risk of developing the disease increases with age [**?**]. As the global population ages, the disease burden of PD has increased significantly. Due to its large population base and rapid aging process, China faces a more severe PD burden than the global average. According to the 2023 Statistical Communiqué on National Economic and Social Development from the National Bureau of Statistics [**?**], the population aged 60 and over in mainland China accounted for 21.1% of the total

population by the end of 2023. This figure far exceeds the World Health Organization (WHO) definition of an aging society (where the population aged ≥ 60 reaches 10% of the total) [**?**]. This demographic shift will exacerbate the medical burden of PD in China, highlighting an urgent need for large-sample studies to provide a basis for prevention and control strategies. Therefore, based on data from the Global Burden of Disease 2021 (GBD 2021) database, this study utilizes the Age-Period-Cohort (APC) model combined with the Bayesian Age-Period-Cohort (BAPC) model to compare the disease burden of PD globally and in China. By analyzing the current status and differences in PD burden, revealing age and gender characteristics, and predicting future trends, this study aims to provide a reference for the formulation of future PD prevention and treatment strategies.

Materials and Methods

1.1 Data Sources

The GBD is compiled by the Institute for Health Metrics and Evaluation (IHME) at the University of Washington. It provides the latest epidemiological burden data for 371 diseases and injuries across 204 countries and regions. All data are freely accessible via the GBD 2021 portal (https://ghdx.healthdata.org/gbd-2021). The Global Health Data Exchange (GHDx) serves as a comprehensive platform where health-related data is systematically identified and cataloged.

1.2 Observational Indicators

The Parkinson' s disease (PD) data analyzed in this study were obtained from the Global Burden of Disease (GBD) 2021 database. Epidemiological data for PD were retrieved by setting the cause of disease to "Parkinson' s disease" for the period from 1990 to 2021. The measurement metrics included both absolute numbers and rates. The specific analytical indicators evaluated were incidence, prevalence, death, and disability-adjusted life years (DALYs), along with their corresponding age-standardized metrics: age-standardized incidence rate (ASIR), age-standardized prevalence rate (ASPR), age-standardized mortality rate (ASMR), and age-standardized DALYs rate (ASDR). Data were stratified by sex, including categories for both sexes, male, and female.

1.3 Statistical Analysis

1.3.1 Epidemiological Trend Analysis This study analyzed the prevalence and age-standardized rates of PD across various age groups from 1990 to 2021. The estimated annual percent change (EAPC) was calculated to assess temporal trends. For age-standardized rates, we further calculated the average annual percent change (AAPC) to evaluate the true risk trends after accounting for changes in the age structure of the population. The EAPC was determined using a linear regression model: $\ln(\text{age-standardized rate}) = \alpha + \beta x + \epsilon$, where x represents the time variable. The EAPC and its 95% confidence interval

(CI) were then calculated using the formula EAPC = $[\exp(\beta) - 1] \times 100\%$. The AAPC was calculated using R software (version 4.3.3) with the `segmented` package. We performed segmented linear regression analysis, pre-specifying the years 2000 and 2010 as two potential joinpoints.

1.3.2 Age-Period-Cohort Model Analysis This study conducted an Age-Period-Cohort (APC) model analysis based on the GBD 2021 data and corresponding population data. The age variable was divided into 19 groups starting from 15–19 years, using 5-year intervals (up to 90–94, with those $\geq$ 95 years treated as a single group). The period variable was divided into seven segments starting from 1990–1994 as the first group, followed by subsequent 5-year intervals, with the final group consisting of the two-year period 2020–2021. For the cohort analysis, the youngest population was incorporated into the model using 5-year intervals, resulting in 19 birth cohort units ranging from 1913–1917 to 2003–2007 [**?**].

Data processing and fitting were performed using R version 4.3.3 to establish an APC model based on log-linear Poisson regression. To address the exact collinearity between age, period, and cohort, the model utilized "intrinsic estimator" constraints. The period effect used 2005–2009 as the baseline period, while the birth cohort effect used the 1958–1962 cohort as the reference. The model estimated "net drift" (%/year), reflecting the overall temporal trends, and "local drift" (%/year), reflecting age-stratified trends.

1.3.3 Bayesian Age-Period-Cohort Model Prediction Analysis This study employs a Bayesian Age-Period-Cohort (BAPC) model, utilizing the Integrated Nested Laplace Approximation (INLA) method for posterior estimation and forecasting. Bayesian projections were conducted within the R 4.3.3 environment using the BAPC (v0.4.5) package and the INLA algorithm. The model uses disease burden data from 1990 to 2021 as input. Subsequently, projected population data for the period 2022–2035 are incorporated for extrapolation analysis. The final outputs include sex-stratified incidence, prevalence, mortality, and DALY rates for each age group, along with age-standardized rates.

Results

2.1 Trends in the Burden of Parkinson' s Disease in China and Globally, 1990–2021

From 1990 to 2021, the global number of incident cases of PD increased from 417,135 to 1,335,142, with an EAPC of 3.87% (95% CI: 3.82%–3.92%). During the same period, the number of incident cases in China rose from 91,492 to 508,378. The ASIR in China increased from 12.83/100,000 to 24.34/100,000, reflecting a rising trend with an EAPC of 2.16% and an AAPC of 0.37%.

Between 1990 and 2021, the global prevalence of PD increased from 3,148,395 cases to 11,767,272 cases, representing a growth of 273.65% and an EAPC of

4.35%. In China, the number of prevalent PD cases grew from 651,835 to 5,077,057, an increase of 681.54%. The ASPR in China rose from 91.77/100,000 to 245.73/100,000, with an EAPC of 3.16% and an AAPC of 4.90%.

Regarding DALYs, global PD DALYs increased from 2,854,050 person-years in 1990 to 7,471,821 person-years in 2021, with an EAPC of 3.21%. In China, PD DALYs rose from 685,009 person-years to 2,159,514 person-years, corresponding to an EAPC of 3.64%. Although the ASDR in China shifted from 105.26/100,000 to 107.96/100,000, this change was not statistically significant (EAPC = -0.02%, 95% CI: -0.13% to 0.09%).

From 1990 to 2021, the global number of deaths due to PD increased from 148,068 to 388,194, with an EAPC of 3.28%. In China, the number of PD-related deaths rose from 32,581 to 92,035; however, the ASMR showed a downward trend, decreasing from 6.11/100,000 to 5.03/100,000 (EAPC = -0.76%). Detailed data are presented in .

2.2 Age and Gender Distribution Analysis of PD

In 2021, the global incidence, prevalence, mortality, and DALYs of PD exhibited a trend where the overall burden was higher in males than in females, with the burden becoming significantly heavier in older age groups. The number of incident cases peaked in the 70–74 age group. Incidence rates reached peaks in the 85–89 age group for males and the 80–84 age group for females (278.68 per 100,000 and 151.39 per 100,000, respectively). In contrast, the incidence rates for those aged 40–44 were only 4.83 per 100,000 for males and 3.35 per 100,000 for females [Figure 1: see original paper]A. Regarding prevalent cases, numbers increased sharply after age 70, peaking in the 80–84 age group. The global peak prevalence rate occurred in the 85–89 age group [Figure 1: see original paper]B. Mortality rates reached their highest in the 90–94 age group [Figure 1: see original paper]C. The peak DALY rate for males occurred in the 85–89 age group, while the peak for females was in the 90–94 age group [Figure 1: see original paper]D.

The situation in China is similar to the global trend, also exhibiting significant disparities in age and gender distribution. The number of incident cases in males is generally higher than in females. Compared to the global burden, the incidence rate in China also increases with age, though the peak occurs later. Specifically, the incidence reaches 562.89 per 100,000 for males aged 90–94 years and 266.16 per 100,000 for females aged 95 years and older [Figure 2: see original paper]A. The accumulation of prevalence is even more pronounced among the oldest-old in China, with peaks occurring in the $\geq$ 95 age group [Figure 2: see original paper]B. The mortality rate for males peaks in the 90–94 age group, while for females, it peaks among those aged 95 and older. Furthermore, the DALYs for the elderly population in China (aged 80 and above) show a significant upward trend.

2.3 Age-Period-Cohort Model Analysis of PD

The longitudinal age curves demonstrate that all PD indicators exhibit a stepwise increase from youth to old age, reaching their peak in the 77.5-year-old age group [Figure 3: see original paper]. In China, the prevalence rate increased from approximately 0.12 per 100,000 in the 17.5-year-old group to 8,367.99 per 100,000 in the 77.5-year-old group.

Period effects indicate that the annual Relative Risk (RR) remained approximately 1.00 globally. In China, the RR rose slightly from approximately 0.92 during 1990–1994 to a peak between 2005–2009, before subsequently declining to approximately 0.93 in 2020–2021.

Cohort effects indicate that the RR for prevalence in China rose from approximately 0.22 for the 1915 birth cohort to 1.81 for the 2005 cohort [Figure 4: see original paper]B. Incidence rates showed a similar increase [Figure 4: see original paper]A. While global trends were consistent with these findings, the magnitude of the increase was smaller. Conversely, mortality rates in China showed a successive decline across generations [Figure 4: see original paper]C, and DALYs also exhibited a slight downward trend [Figure 4: see original paper]D.

Local drift results demonstrate that the annual percentage increases in the prevalence and incidence of PD across all age groups were higher in China than the global average, with the most pronounced increases observed in the elderly population. The rate of increase was higher in males than in females. In contrast, the annual change in mortality rates was negative, with China showing a significant declining trend.

2.4 Prediction of PD Disease Burden from 2022 to 2035

The BAPC model projections show that the global ASIR of PD will continue to rise from 2022 to 2035, increasing from 16.06/100,000 to 18.29/100,000 [Figure 5: see original paper]A. The incidence in China is higher than the global average, with the ASIR expected to rise from 25.60/100,000 to 32.26/100,000. The number of incident cases is expected to grow from 366,035 to 450,609, with faster growth in males [Figure 5: see original paper]B.

The global ASPR is projected to rise from 143.67/100,000 to 165.04/100,000 [Figure 5: see original paper]C. China' s ASPR is expected to rise from 261.97/100,000 to 332.67/100,000. The number of prevalent cases will increase from 3,746,241 to 4,647,215 [Figure 5: see original paper]D. Regarding mortality, the global ASMR is projected to decrease slightly (from 4.85/100,000 to 4.31/100,000) [Figure 5: see original paper]E. The trend in China is also downward, with the ASMR projected to decrease from 5.11/100,000 in 2022 to 4.74/100,000 by 2035 [Figure 5: see original paper]F.

Regarding DALYs, the global ASDR showed a slight decrease (from 91.00/100,000 to 88.65/100,000). However, the total number of DALYs

continued to rise. In China, the overall trend is upward due to the prominent issue of population aging. The ASDR is projected to increase from 112.04/100,000 in 2022 to 119.82/100,000 in 2035 [Figure 5: see original paper]H.

Discussion

3.1 Analysis of PD Burden Trends

The burden of PD continues to grow both globally and within China. From 1990 to 2021, the number of incident cases of PD increased by 220.07% globally, while China experienced a growth of 455.65%, significantly exceeding the global average. This discrepancy may be attributed to improvements in early diagnosis. In recent years, both Chinese and international scholars have made substantial progress in the early diagnosis of PD [**?**], particularly regarding genetic and imaging markers. Clinical biomarkers and novel neuroimaging technologies have facilitated early and precise clinical diagnosis [**?**]. Aging remains a critical driver of PD, and shifts in China' s demographic structure are likely to catalyze a rapid increase in the disease burden.

From 1990 to 2021, global DALYs increased by 161.80% (EAPC = 3.21%), while the increase in China reached 215.25% (EAPC = 3.64%). However, the age-standardized DALY rate in China remained largely stable (EAPC = -0.02%), suggesting that the rise in DALYs is driven by population growth and demographic aging rather than an increase in individual disease risk [**?**].

Regarding mortality, the global ASMR followed an upward trend (EAPC = 0.18%), whereas it significantly declined in China (EAPC = -0.76%). This suggests that mortality among PD patients in China has been effectively controlled, likely due to the inclusion of anti-PD medications in national medical insurance and the expansion of Deep Brain Stimulation (DBS) surgery [**?**]. However, disparities remain between urban and rural areas [**?**].

3.2 Age and Gender Disparities in PD Burden

The burden of PD exhibits significant disparities across age and gender. Incidence, prevalence, and mortality rates are higher in males than in females. Previous research has identified estrogen as having a neuroprotective effect on the nigrostriatal dopaminergic system [**?**]. Furthermore, oxidative stress and mitochondrial damage are generally lower in females [**?**]. Conversely, men are more likely to experience occupational exposure to environmental hazards such as pesticides and heavy metals [**?**]. The burden of PD increases significantly with age [**?**], which is closely linked to aging-related α-syn accumulation and mitochondrial dysfunction [**?**].

3.3 Methodological Strengths and Limitations

This study utilizes standardized data from the GBD 2021 and integrates multiple predictive frameworks (APC and BAPC models). While the GBD database offers extensive coverage, limitations include potential data gaps in developing regions. In China, PD registration data remains uneven across provincial units, which may hinder the assessment of regional disparities.

3.4 Public Health and Clinical Implications

PD prevention and control strategies should be optimized across multiple dimensions. We recommend establishing a stratified screening mechanism, integrating PD screening into physical examinations for high-risk populations. Diagnostic capabilities at the primary care level should be enhanced through AI-assisted decision support systems. It is essential to expand medical insurance coverage and standardize benefits between urban and rural residents. Furthermore, professional caregivers should be trained for home-based exercise rehabilitation for late-stage patients. Finally, a national PD registry system should be established by 2030 to provide a scientific basis for policy formulation.

Conclusion

From 1990 to 2021, the global burden of PD continued to grow, with the growth rate in China being particularly significant due to population aging. China has achieved a decline in mortality rates that outperforms global trends. Males exhibit a higher burden than females, and the burden is most severe among the population aged 75–79 years. This study proposes optimization strategies across screening, treatment access, management models, and data integration to achieve standardized whole-process management and improve patient quality of life.

Author Contributions: Wu Yixuan proposed the research objectives and was responsible for conception, design, implementation, statistical processing, and drafting the manuscript. Xiao Liangman participated in implementation, data collection, and drafting. Liu Xin and Wang Yuting performed revisions. Yan Ziqi assisted with statistical processing and figures. Lin Shumin performed data collection. Zhuang Lixing was responsible for quality control, review, and supervision.

Conflicts of Interest: The authors declare no conflicts of interest.

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(Received: 2025-06-10; Revised: 2025-10-20) (Editor: Mao Yamin)

Note: Figure translations are in progress. See original paper for figures.