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**Prevalence, incidence and years lived with disability of polycystic ovary syndrome using the Global Burden of Disease Study 2021: an increasing concern among adolescents**

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## **ABSTRACT**

Research Question: Polycystic ovary syndrome (PCOS) is a common endocrine disorder with major reproductive and metabolic effects, though its global burden remains difficult to estimate. This study examines the global, regional, and national burden of PCOS, emphasizing adolescents, using data from the Global Burden of Disease (GBD) Study 2021.

Design: Prevalence, incidence, and years lived with disability (YLDs) for PCOS were extracted from the GBD 2021 database, standardized via Bayesian meta-regression, and stratified by age, region, and socio-demographic index (SDI). Temporal trends (1990–2021) were presented and future projections (to 2045) were modeled using autoregressive integrated moving average models.

Results: Between 1990 and 2021, global PCOS prevalent cases rose from 36.7 million (95% UI: 26.2–50.6) to 69.5 million (95% UI: 49.5–95.7), with incident cases increasing from 1.5 million (95% UI: 1.1–2.0) to 2.3 million (95% UI: 1.7–3.2). YLDs nearly doubled during this period. Adolescents (15–19 years) showed the largest incidence increase, influenced by diagnostic improvements and environmental changes. Projections analyses suggested continued growth, particularly in middle-SDI regions, by 2045.

Conclusions: The rising global burden of PCOS, particularly among adolescents, underscores the need for early screening, targeted interventions, and socioeconomic support, especially in resource-limited regions.

Keywords: PCOS; Global burden; Prevalence; Incidence; Years lived with disability

## Introduction

Polycystic ovary syndrome (PCOS), a prevalent reproductive endocrine disorder affecting approximately 11–13% of females globally, is characterized by irregular period, elevated androgen levels, and polycystic ovaries (Stener-Victorin et al., 2024). The lifelong prevalence of comorbidities associated with PCOS—such as insulin resistance, obesity, type 2 diabetes, and cardiovascular disease—exacerbates its clinical manifestations and contributes to a substantial health burden worldwide (Riestenberg et al., 2022). Furthermore, PCOS imposes a substantial economic burden. Yadav et al. estimated that annual healthcare costs related to PCOS in the United States exceeded \$15 billion, including over \$4 billion for

mental health disorders (Yadav et al., 2023). These findings underscore the urgent need to prioritize PCOS research and management within the healthcare and scientific communities.

Accurately determining the global burden of PCOS remains challenging, as it is frequently misdiagnosed in clinical practice (Hatoum et al., 2025). Socioeconomic disparities further complicate the accurate diagnosis of PCOS, leading to delayed diagnoses, patient dissatisfaction, and uncertainties in current burden estimates (Merkin et al., 2011; Kaur et al., 2024). Several studies estimating the global burden of PCOS from 1990 to 2019 have identified notable socioeconomic disparities. Regions with a high Socio-Demographic Index (SDI) showed higher prevalence, incidence, and years lived with disability (YLDs) (Motlagh Asghari et al., 2022; Safiri et al., 2022). Liu et al. observed the greatest increase in PCOS incidence in middle-SDI regions, potentially due to improved women's health policies, more developed healthcare systems, and greater awareness of PCOS among both healthcare providers and patients (Liu et al., 2021). These regional discrepancies underscore the need for a deeper understanding of how socioeconomic factors influence temporal and geographic variations in the PCOS burden.

Despite adolescence being a critical window for PCOS development, the disease burden during this period remains poorly understood (Tay et al., 2020; Ibáñez and de Zegher, 2023; Neven et al., 2024). Although adolescence is a critical period for PCOS development, its disease burden in this age group remains poorly understood. To date, three major diagnostic criteria have been proposed. The NIH first defined PCOS in 1990, requiring clinical or biochemical hyperandrogenism and oligo- or anovulation, excluding other causes. In 2003, the Rotterdam criteria expanded this definition by adding ultrasound-based polycystic

ovarian morphology (PCOM), later endorsed by the 2012 NIH workshop. The 2006 AES criteria, established by the Androgen Excess and PCOS Society (AE-PCOS), excluded non-hyperandrogenic phenotypes permitted by the Rotterdam criteria (Dumesic et al., 2015; Lizneva et al., 2016). These adult criteria are not suitable for adolescents due to overlap with normal pubertal changes, and the lack of consensus led to frequent misdiagnosis. In 2018, adolescent-specific guidelines were introduced, requiring both oligo- or anovulation and hyperandrogenism, while excluding ultrasound due to its low diagnostic specificity in this age group (Teede et al., 2018; Peña et al., 2020). We identified six studies (Liu et al., 2021; Miazgowski et al., 2021; Motlagh Asghari et al., 2022; Safiri et al., 2022; Gao et al., 2023; Zhang et al., 2024) on the burden of PCOS in females aged 15-19. For example, Miazgowski analyzed European data (1990-2016) and found PCOS prevalence increased by 0.73% in Eastern Europe and 1.87% in Central Europe among women aged 15-19. Safiri et al. updated the data to 2019, reporting an incidence rate of 351.77 per 100,000 women in ages 15-19. Zhang et al. analyzed the global burden of PCOS in women aged 15-19 years in 2019, reporting 7,204,381 prevalent cases, along with 1,038,396 incidence cases, respectively. However, none of these studies have assessed the impact of changes in PCOS diagnostic criteria on variations in adolescent burden.

To address these gaps, we retrieved updated data from the GBD 2021 study to analyze the global, regional, and national burden of PCOS. In addition to assessing temporal trends in prevalence, incidence, and YLDs, we evaluated the role of national socioeconomic status and placed a specific focus on the adolescent burden to provide a more comprehensive perspective.

## **Materials and methods**

### **Data sources**

The data on PCOS analyzed in this study were obtained from the Global Burden of Disease (GBD) 2021 study, which provides the most recent epidemiological estimates of the burden of 371 diseases and injuries across 21 GBD regions and 204 countries and territories from 1990 to 2021. All of the aforementioned data are accessible via the Global Health Data Exchange (GHDx) and its associated tools (<https://vizhub.healthdata.org/gbd-results/>) (GBD 2021 Diseases and Injuries Collaborators, 2024). Further detailed information regarding the data, methodology, and statistical modeling can be found in a previous report (GBD 2021 Causes of Death Collaborators, 2024).

### **Case definitions**

The GBD database is a comprehensive repository of epidemiological data that quantifies health loss from diseases, injuries, and risk factors globally. The data in the GBD originate from a wide range of sources, including published studies, government reports, hospital records, surveys, and other publicly available datasets (GBD 2021 Causes of Death Collaborators, 2024). Polycystic ovarian syndrome (PCOS) is a multifaceted endocrinopathy defined by hyperandrogenism, ovulatory dysfunction, and polycystic ovarian morphology. The diagnostic criteria for PCOS lack universal standardization and are primarily categorized into three widely recognized approaches: the National Institutes of Health (NIH) criteria, the Rotterdam criteria, and the Androgen Excess Society (AES) criteria. Among these, the NIH

criteria—used as the reference case definition in GBD studies—require the presence of hyperandrogenism and/or hyperandrogenemia, oligo-anovulation, and the exclusion of secondary conditions (e.g., congenital adrenal hyperplasia, hyperprolactinemia, or androgen-secreting neoplasms). The Rotterdam criteria and subsequent guidelines (including the 2018 and 2023 consensuses), which are widely accepted in the academic community, broaden the diagnostic scope by incorporating milder phenotypes. While this inclusivity can explain higher prevalence estimates in certain studies, it also reflects evolving clinical and research perspectives on PCOS (American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Gynecology, 2018; Teede et al., 2018).

In GBD analyses, PCOS is classified under ICD-10 code E28.2 to facilitate consistent identification across diverse data sources. To reconcile discrepancies between diagnostic frameworks, GBD studies utilize meta-regression-based crosswalk adjustments, which align alternative definitions with the NIH criteria. This standardized methodology promotes uniformity in epidemiological assessments, minimizes variability introduced by differing diagnostic practices, and supports reliable burden estimation for PCOS.

### **Estimation of prevalence, incidence and YLDs**

The GBD 2021 study estimated the prevalence, incidence, and YLDs for PCOS using DisMod-MR 2.1, a Bayesian meta-regression tool. Data from systematic reviews, clinical records, and hospital discharge datasets were standardized through meta-regression Bayesian regularized trimmed (MR-BRT) models to align alternative diagnostic criteria, such as the Rotterdam and AES definitions, with the NIH reference standard. Age-standardized estimates

were restricted to females aged 15-54 and adjusted for age using GBD's standard age groups to ensure consistency and comparability (GBD 2021 Diseases and Injuries Collaborators, 2024).

YLDs were estimated by combining prevalence data with disability weights (DWs) derived from the GBD disability weight survey (Salomon et al., 2015). The primary sequelae of PCOS—hyperandrogenism and infertility—were mapped to corresponding lay descriptions and DWs. Hyperandrogenism was modeled using the health state “disfigurement, level 1” (DW: 0.011, 95%CI: 0.005–0.021), while primary and secondary infertility were assigned DWs of 0.008 (95%CI: 0.003–0.015) and 0.005 (95%CI: 0.002–0.011), respectively. Proportional allocation of cases to these sequelae was informed by the NIH diagnostic criteria and evidence from the literature (Salomon et al., 2015).

Estimates included 95% uncertainty intervals (UIs), derived from multiple sources. These sources encompassed the input data, corrections for measurement error, estimation of residual non-sampling error, and the sampling of 1,000 iterations at each computational step. The UIs were defined as the 2.5<sup>th</sup> and 97.5<sup>th</sup> percentiles of the ordered samples.

### **Socio-demographic index**

The Socio-Demographic Index (SDI) is a comprehensive measure introduced in 2015 by the U.S. Institute for Health Metrics and Evaluation (IHME) to evaluate the development of countries and regions, with a particular focus on the interplay between social progress and population health outcomes. The SDI is calculated as the geometric mean of three key indicators: per capita income, the average years of schooling for individuals aged 15 and

older, and the total fertility rate (GBD 2015 DALYs and HALE Collaborators, 2016). In the GBD 2021 study, countries and regions are classified into five SDI categories based on their SDI values: low SDI ( $<0.46$ ), low-middle SDI ( $0.46\text{--}0.60$ ), middle SDI ( $0.61\text{--}0.69$ ), high-middle SDI ( $0.70\text{--}0.81$ ), and high SDI ( $>0.81$ ). It is important to note that a lower SDI value corresponds to a lower level of social development (Fu et al., 2022).

### Statistical analysis

Counts and age-standardized rates per 100,000 of prevalence (ASPR), incidence (ASIR), and YLDs (ASYR) from 1990 to 2021 were used to assess the burden of PCOS, along with 95% UIs. The data were stratified by SDI quintiles (low, low-middle, middle, high-middle, and high) and 5-year age intervals to provide detailed demographic and geographic insights. The data covered 204 countries and territories, grouped into seven super-regions based on epidemiological patterns, which were further subdivided into 21 regions based on geographical and epidemiological similarities. Temporal trends were assessed across these stratifications, with a particular focus on age-specific patterns to better understand the global burden of PCOS across different age groups.

For future projections of PCOS burden from 2022 to 2045, we applied an autoregressive integrated moving average (ARIMA) (p, d, q) model. This model transforms non-stationary time series into stationary ones, with parameters p (autoregressive order), d (order of differencing), and q (moving average order). More details of this model were described elsewhere (Wei et al., 2022). Data were logarithmically transformed to stabilize variance, and differencing was applied when necessary. The Augmented Dickey–Fuller (ADF) test

confirmed stationarity, while autocorrelation function (ACF) and partial autocorrelation function (PACF) plots guided the selection of the optimal model parameters. The best-fitting models were chosen using the Akaike information criterion (AIC) and Bayesian information criterion (BIC), and residuals were checked for independence and normality with the Ljung–Box Q test. Our optimal ARIMA model parameters and their AIC/BIC values were summarized in **Supplementary Table S10**. Residual analysis indicated an adequate model fit, as no significant patterns were detected. All analyses and visualizations were performed using R statistical software (version 4.3.3).

## RESULTS

### Global Trend in Prevalence, Incidence and YLDs of PCOS

Globally, the number of prevalent cases of PCOS increased from 36.7 million (95%UI: 26.2–50.6) in 1990 to 69.5 million (95%UI: 49.5–95.7) in 2021. Incident cases rose from 1.5 million (95%UI: 1.1–2.0) to 2.3 million (95%UI: 1.7–3.2) during the same period. Additionally, YLDs due to PCOS grew from 323,799 (95%UI: 144,342–675,927) in 1990 to 607,757 (95%UI: 272,745–1,268,607) in 2021 (**Table 1**).

The ASPR of PCOS increased by 28% (95%UI: 25%–31%) from 1372.77 (95%UI: 984.64–1891.60) per 100,000 women in 1990 to 1757.83 (95%UI: 1253.36–2421.26) per 100,000 women in 2021. Similarly, the ASIR rose by 28% (95%UI: 25%–31%), from 49.45 (95%UI: 35.57–68.45) to 63.26 (95%UI: 45.41–87.28) per 100,000 women. The ASYR also rose by 27% (95%UI: 24%–31%) from 12.08 (95%UI: 5.38–25.21) to 15.40 (95%UI: 6.91–

32.13) per 100,000 women during the same period. Additional details were provided in **Supplementary Tables S1-S3**.

### **Regional Trend in Prevalence, Incidence and YLDs of PCOS**

From 1990 to 2021, the High-income region consistently had the highest ASPR, ASIR and ASYR of PCOS, while the region of Central Europe, Eastern Europe, and Central Asia had the lowest (**Figure 1**). Further details on regional trends can be found in Supplementary Tables S4–S6. In 2021, the High-income Asia-Pacific region reported the highest age-standardized rates (ASPR: 5237.62 [95%UI: 3779.21–7307.15]; ASIR: 225.11 [95%UI: 160.59–317.34]; ASYR: 45.62 [95%UI: 20.81–92.93] per 100,000 women), whereas Central Europe had the lowest (ASPR: 228.93 [95%UI: 157.78–326.20]; ASIR: 8.97 [95%UI: 6.22–12.67]; ASYR: 2.00 [95%UI: 0.86–4.17] (**Table 1**). The largest increases in all three indicators occurred in Southeast Asia, while the smallest were in Tropical Latin America.

At the national level, PCOS burden varied substantially in 2021 (**Figure 2**). Between 1990 and 2021, Equatorial Guinea and the Maldives showed the largest increases in ASPR and ASIR, while Italy was the only country with a decrease across all three indicators. Further regional and national details are provided in **Supplementary Table S1-S3**. Rankings of the top 20 countries with the largest and smallest percentage changes in ASPR, ASIR, and ASYR were provided in **Supplementary Tables S7-S8**.

### **Trend in Prevalence, Incidence, and YLDs of PCOS by SDI Group**

The prevalence, incidence and YLDs of PCOS varied significantly across SDI quintiles

(Table 1 and Figure 1).

In 2021, the highest ASPR was observed in the high SDI quintile (3554.29 [95%UI: 2624.21–4816.07] per 100,000 women), while the lowest ASPR occurred in the low SDI quintile (714.31 [95%UI: 504.52–1007.4] per 100,000 women). During the 2000–2010 period, the middle SDI quintile surpassed the high-middle SDI quintile in ASPR, becoming the second highest after the high SDI quintile. The middle SDI quintile also experienced the largest increase in ASPR, rising by 67% (95%UI: 61%–75%) between 1990 and 2021.

In 2021, the highest ASIR was found in the high SDI quintile (144.89 [95%UI: 107.28–196.81] per 100,000 women), followed by the middle SDI quintile (127.26 [95%UI: 76.68–136.24] per 100,000 women), and the lowest ASIR occurred in the low SDI quintile (27.79 [95%UI: 19.81–38.87] per 100,000 women). The middle SDI quintile showed the greatest increase in ASIR, rising by 59% (95%UI: 53%–66%) between 1990 and 2021.

The highest ASYR in 2021 was in the high SDI quintile (31.37 [95%UI: 14.37–64.00] per 100,000 women), while the lowest was in the low SDI quintile (6.2 [95%UI: 2.67–13.05] per 100,000 women). Over the 2000–2010 period, the middle SDI quintile's ASYR surpassed that of the high-middle SDI quintile, mirroring the pattern seen in ASPR. The middle SDI quintile also recorded the largest increase in ASYR, rising by 67% (95%UI: 60%–75%) between 1990 and 2021.

### **Trend in Prevalence, Incidence, and YLDs of PCOS by Age Group**

In 2021, the peak number of prevalent cases across different age groups varied by SDI quintile. For the low-SDI and low-middle SDI quintiles, prevalence was highest in the 20–24

age group. In the middle and high-middle SDI quintiles, the peak shifted to the 30–34 age group, while in the high-SDI quintile, it occurred in the 35–39 age group. Incidence counts followed a different pattern, with the highest cases in the 15–19 age group for all SDI quintiles (ranging from 93,061 [95%UI: 57,538-147,952] to 280,317 [95%UI: 169,288–437,846]). YLDs mirrored the prevalence trends, peaking in the 20–24 age group for low-SDI and low-middle SDI quintiles and in the 30–34 age group for higher SDI quintiles (**Figure 3**).

Global trends showed a steady increase in prevalence across all age groups from 1990 to 2021. Notably, the intersection of different colored lines marks years when diagnostic criteria for PCOS were revised, including three changes specific to adolescents (15–19 years old). Incidence rates fluctuated but showed a clear upward trend in younger age groups, especially 15–19 years. YLD rates also increased continuously, reflecting trends similar to those of prevalence. For more detailed data, refer to **Supplementary Table S9**.

### **ARIMA prediction**

Figure 4 highlighted ARIMA model predictions, projecting a significant increase in the burden of PCOS over the next 24 years. By 2045, the ASPR, ASIR, and ASYR were expected to reach 2043.9, 71.9, and 17.9 per 100,000 women, respectively.

Age-specific projections for 2045 reveal notable disparities. Prevalence rates would be highest among women aged 20–44 years, while incidence rates would peak in the 15–19 (385.3 per 100,000) age groups. The YLD rate would be highest in the 20–24 age group, with

a projected value of 37.4 per 100,000 women. Further details were available in **Supplementary Table S11**.

## Discussion

The GBD series, drawn from diverse sources and continuously refined, is systematically modeled and validated to estimate the prevalence, incidence, and YLDs of various conditions, including PCOS. This study revealed a significant global increase in the burden of PCOS from 1990 to 2021, with prevalence nearly doubling from 36.7 to 69.5 million cases. Age-standardized prevalence, incidence and YLDs rose by approximately 27–28%. The High-income Asia-Pacific region had the highest rates, while Central Europe reported the lowest. The largest increases occurred in Southeast Asia, with the middle SDI quintile showing the greatest growth. Peak prevalence shifted to older age groups in high-SDI regions, while incidence remained highest in adolescents (15–19 years). Projections indicate a continued rise through 2045, highlighting the need for urgent public health action.

At the global level, ASIR, ASPR, and ASYR have all risen since 1990, consistent with the increasing global burden of PCOS reported in studies based on GBD 2017 and GBD 2019 (Liu et al., 2021; Safiri et al., 2022; Gao et al., 2023). While the biological mechanisms of PCOS remain unclear, dietary behaviors and exposure to environmental toxins (i.e., endocrine-disrupting chemicals, bisphenol A and PCBs, etc.) may interact with genetic predispositions to contribute to its rising incidence (Diamanti-Kandarakis et al., 2006; Merkin et al., 2016). Additionally, improved awareness and evolving diagnostic criteria—shifting from the 1990 hyperandrogenism-based criteria to the 2003 Rotterdam

criteria and the 2018 adolescent-specific guidelines—likely contribute to the observed increase in prevalence (Dumesic et al., 2015; Teede et al., 2018). PCOS is also associated with complications like cardiovascular disease, diabetes, and gynecological cancers, which, by worsening health outcomes, have led to a rise in YLDs (Pasquali and Gambineri, 2006; Nandi et al., 2014; Helvaci and Yildiz, 2020).

Our study identified significant regional differences in the burden of PCOS, with the highest burden observed in high-SDI quintile and the lowest burden in low-SDI region. Amiri et al. found no significant regional differences in PCOS prevalence by WHO region using either the NIH or Rotterdam criteria (Amiri et al., 2025). Nonetheless, their findings were derived exclusively from high-quality studies, which may limit the applicability of the results to regions with insufficient or low-quality data. In our study, the burden of PCOS was highest in regions with high SDI quintiles. This may be attributed to the higher diagnostic level of physicians in these countries, more advanced screening equipment, higher investment in PCOS management and research, and longer life expectancy (Liu et al., 2021; Zheng and Wang, 2022). Previous studies have demonstrated a strong association between low socioeconomic status (SES) and an increased risk of PCOS in high SDI countries, indicating that social inequalities persist despite these nations' advanced policies and technologies (Miazgowski et al., 2021). This may reflect limited access to quality healthcare and medical information for women with low SES, a challenge further exacerbated by lower educational attainment and SES (Adler and Newman, 2002; Nunes et al., 2014). Adverse health behaviors such as smoking, physical inactivity, and high-energy diets, which were more common in low-SES populations, further increase PCOS risk (Dobbie et al., 2023;

Gautam et al., 2023; Amiri et al., 2024). Notably, nearly half of the top 20 countries with the largest percentage increases in PCOS burden are low- and middle-SDI nations (**Supplementary TableS7**). This may be attributed to improved diagnosis rates and increased disease awareness in these countries from 1990 to 2021. However, compared to high SDI countries, low and middle SDI countries currently lack sufficient funding and technology to accurately assess the true burden of PCOS. Therefore, despite the higher burden reported in high SDI countries, we believe that the burden of PCOS in low and middle SDI regions may still be underestimated. For example, Ethiopia launched the Health Development Army (HDA) and Women's Development Army (WDA) in 2011, community-based initiatives aimed at improving women's health awareness and behaviors (Damtew et al., 2018; Liu et al., 2021). Our findings show that the increase in PCOS burden in Ethiopia exceeded the average for low-SDI countries, suggesting these policies may enhance PCOS detection and management. This underscores the need for greater investment in research, healthcare infrastructure, and policy support to address PCOS in low-SDI regions. This highlights the critical need for increased investment in research, healthcare infrastructure, and policy support to accurately assess and address the burden of PCOS in low-SDI countries.

In this study, the growth in the burden of PCOS was highest in medium- and high-SDI regions, with half of the top 20 countries with the largest percentage increases falling into these categories. Factors such as rapid socioeconomic development, improved healthcare systems, and enhanced education likely drive these trends (Liu et al., 2021; Motlagh Asghari et al., 2022; Gao et al., 2023). Data from the United Nations Population Division show that between 1990 and 2021, China and India's populations grew by 277 million and 549 million,

respectively, making them the largest contributors to global population growth and the most populous countries in our study. These two nations have notably driven the rising PCOS burden, especially among middle- and/or high-income countries (United Nations Department of Economic and Social Affairs, 2022; Yanget al., 2022; Li et al., 2024). Middle-SDI countries should draw lessons from high-SDI countries. For instance, the UK has increased its physician-to-population ratio, especially by expanding general practitioners to strengthen primary care (Duncan et al., 2015). In the US, the NIH Office of Research on Women's Health supports initiatives like the Women's Health Initiative, promoting evidence-based, personalized care for women, with a focus on underserved populations (Stuenkel and Manson, 2021). Japan, recognizing its population's vulnerability to weight-related diseases, has implemented targeted obesity control policies that have effectively reduced the PCOS burden (Ogawa and Gupta, 2024).

Our results indicated that, the burden of PCOS was highest among women aged 15–19 years across all SDI regions, with this age group showing a consistent upward trend over three decades, unlike other age groups with fluctuating trends. PCOS's strong genetic basis likely manifests during adolescence, with signs such as polycystic ovarian morphology, irregular menstruation, and acne (McAllister et al., 2015). These symptoms were often overlooked due to overlap with normal puberty, resulting to missed early diagnoses (Safiri et al., 2022). PCOS diagnosis in adolescents requires both oligo- or anovulation and hyperandrogenism, while ultrasound is not recommended due to low specificity, complicating accurate diagnosis (Peña et al., 2020). Therefore, our results should be interpreted with caution given these diagnostic challenges. The widely used Rotterdam

criteria have been criticized for lacking accuracy and specificity (Geisthövel and Rabe, 2007). Amiri et al. further showed that PCOS prevalence was highest using these criteria, raising concerns about overdiagnosis, especially in adolescents (Neven et al., 2024; Amiri et al., 2025). To reduce this risk, raising the follicular threshold for PCOM diagnosis, avoiding ultrasound in adolescents, and adopting a comprehensive approach that considers metabolic risks and patient concerns are recommended (Lauritsen et al., 2019; Witchel et al., 2019). Our findings also revealed higher prevalence and YLDs in older age groups, indicating most diagnoses occur in adulthood, often during pregnancy preparation (Kite et al., 2024). Missed early detection and treatment might exacerbate PCOS complications, including anxiety, depression, diabetes, metabolic syndrome, and infertility, impacting both individual well-being and global fertility rates (Pasquali and Gambineri, 2006; Damone et al., 2019). To address this, early screening should target high-risk groups, such as first-degree female relatives of PCOS patients, and further research into early biomarkers is needed (Azziz et al., 2016). Raising awareness is crucial, as exemplified by initiatives like the Office on Women's Health, PCOSAA, and PCOS Challenge, which utilize educational programs, events, and health screenings (Sinkford and Valachovic, 2014). Tools like the Monash University-developed AskPCOS app support self-diagnosis and education (Xie et al., 2018). In terms of treatment, First-line treatment includes combined oral contraceptives, supported by individualized weight-loss diets, cosmetic treatments for acne and hirsutism, and psychological counseling to alleviate the physical and emotional burden of PCOS (Ibáñez et al., 2017; Teede et al., 2018).

Projected data indicated that PCOS burden trends remain consistent across SDIs and age

groups. Although our data showed that some developed countries show a relatively slow increase in PCOS burden, this difference cannot yet be fully explained by ethnic or genetic factors (Li et al., 2013). Notably, Italy, Mexico, and New Zealand have shown the greatest success in reducing PCOS burden (**Supplementary Table S8**). Their strategies offer valuable insights for broader management efforts. For example, in 2010, Mexico's Ministry of Health recognized PCOS as a women's health priority and introduced national clinical guidelines covering diagnosis, prevention and treatment (Moran et al., 2010). Prevention and management strategies should be tailored to the prevalence and epidemiological characteristics of PCOS in different populations, promoting the development of context-specific approaches at the country level.

This study has several limitations. First, the study relies on GBD data, which reflect recognition of PCOS rather than actual epidemiologic data. Caution is needed when interpreting these estimates. For instance, Hatoum et al. reported significant underdiagnosis of PCOS in the U.S., U.K., and South Korea, with actual prevalence far exceeding recorded cases (Hatoum et al., 2025). Such under-recognition likely affects GBD data, potentially underestimating the true burden of PCOS in our results. Second, the GBD does not consider country-specific diagnostic criteria for PCOS, potentially introducing bias. Changes in diagnostic standards and testing methods between 1990 and 2021 may also affect prevalence estimates. Third, YLDs may be underestimated, as current calculations exclude metabolic syndrome, diabetes, and related conditions. Including these factors in future analyses will improve estimate accuracy. Finally, the GBD lacks etiological information on PCOS, so our interpretations of regional and national burdens were based on literature review, which, while

informative, might not fully capture the nuances required for targeted interventions.

## **Conclusion**

This study provided a comprehensive analysis of the global burden of PCOS from 1990 to 2021, revealing a significant rise in prevalence, incidence, and YLDs, particularly among adolescents aged 15–19 years. The burden was highest in high-SDI regions, while underreporting in low-SDI areas due to limited healthcare access remains a concern. Projections for 2045 suggested a continued increase, especially in younger populations. These findings highlight the need for early screening and diagnosis, particularly in adolescents, and for addressing socio-economic disparities to improve healthcare access in low- and middle-income regions. Future efforts should refine diagnostic criteria, explore environmental and genetic drivers, and develop targeted interventions to reduce the physical and psychological impacts of PCOS.

## **Data availability**

Data are available via the Global Health Data Exchange (GHDx) and its associated tools (<https://vizhub.healthdata.org/gbd-results/>)

## **Authors' roles**

Junxing Li and Yi Zhong were primarily responsible for the conceptualization of the study, data analysis, manuscript writing, and editing. Xin Wang and Li-Zi Lin assisted with the research methodology, data analysis, and manuscript revision. Yunxi Tang, Shaoguo

Liang, Wushu Chen, and Li-Li Liufu participated in the discussions. Qin Li and Xinqi Zhong supervised, project managed and approved the final manuscript.

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### **Conflict of interest**

The authors declare that there is no conflict of interests.

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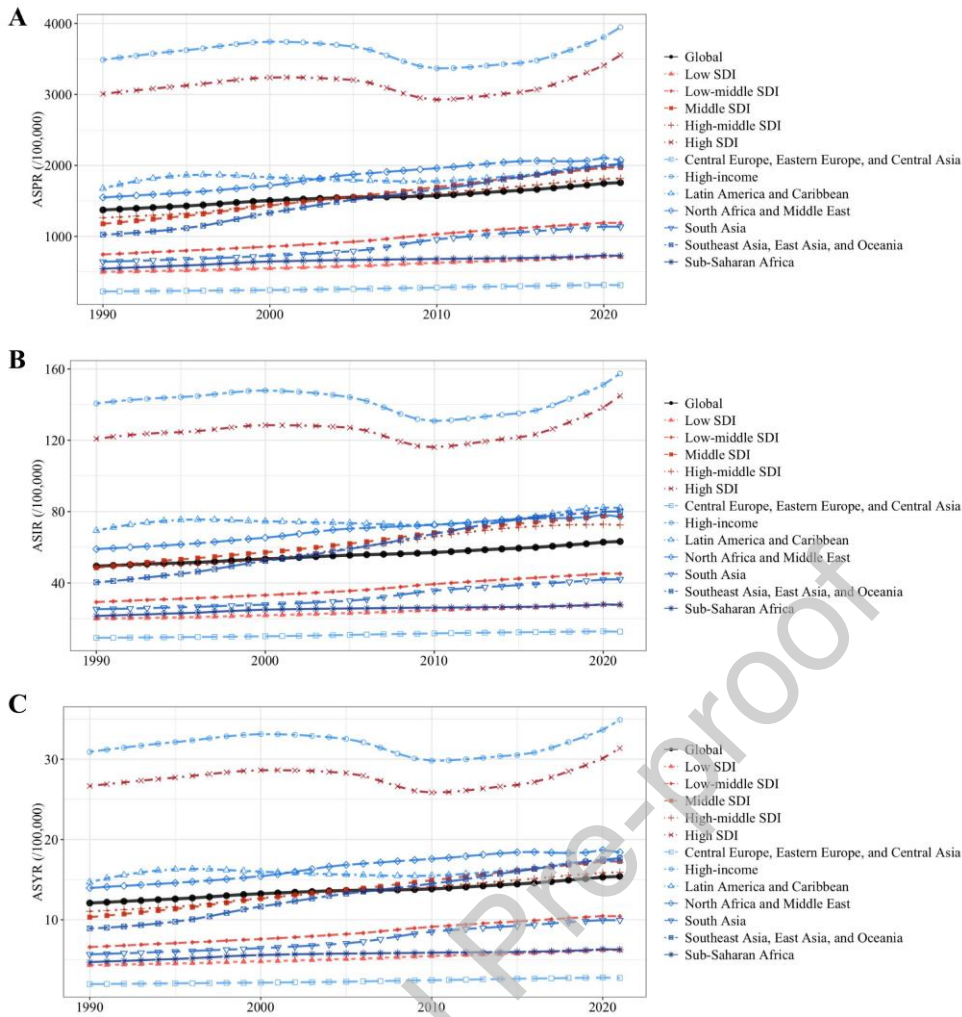
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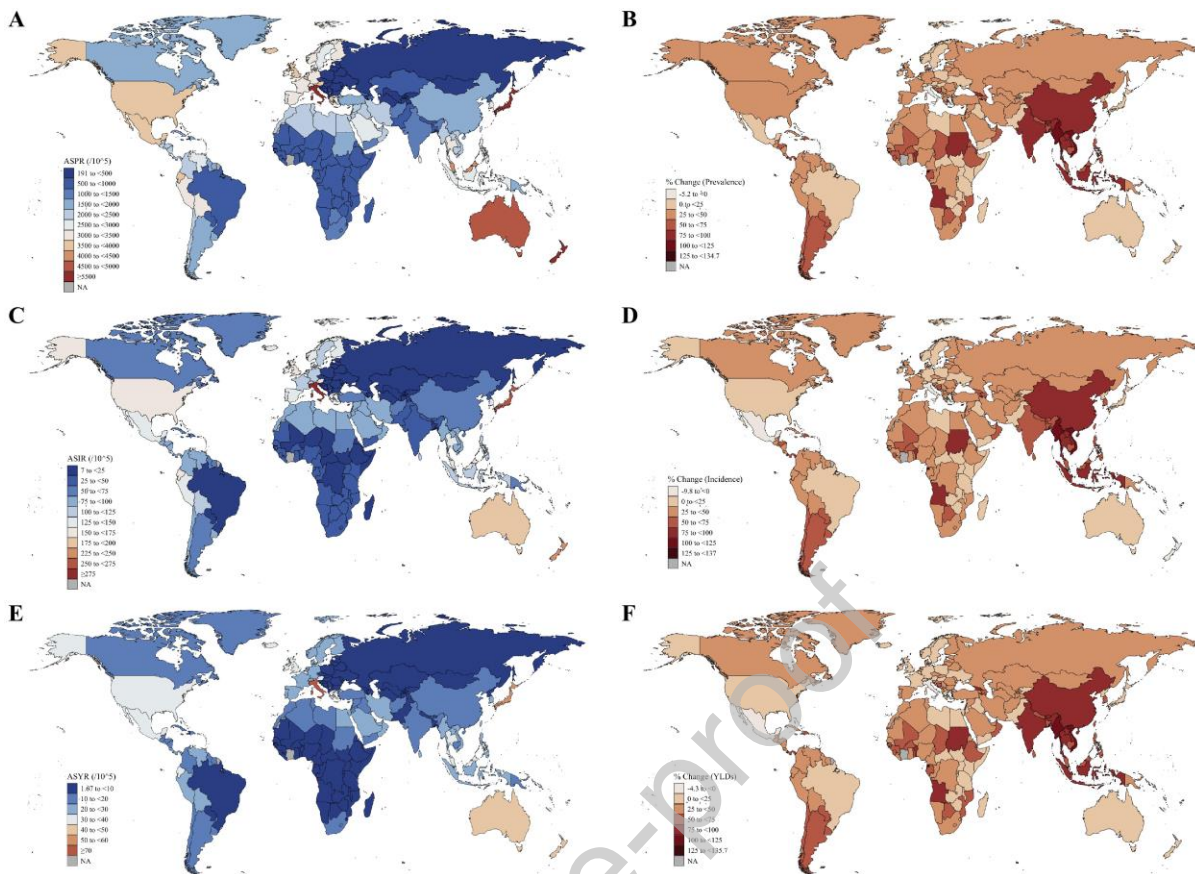
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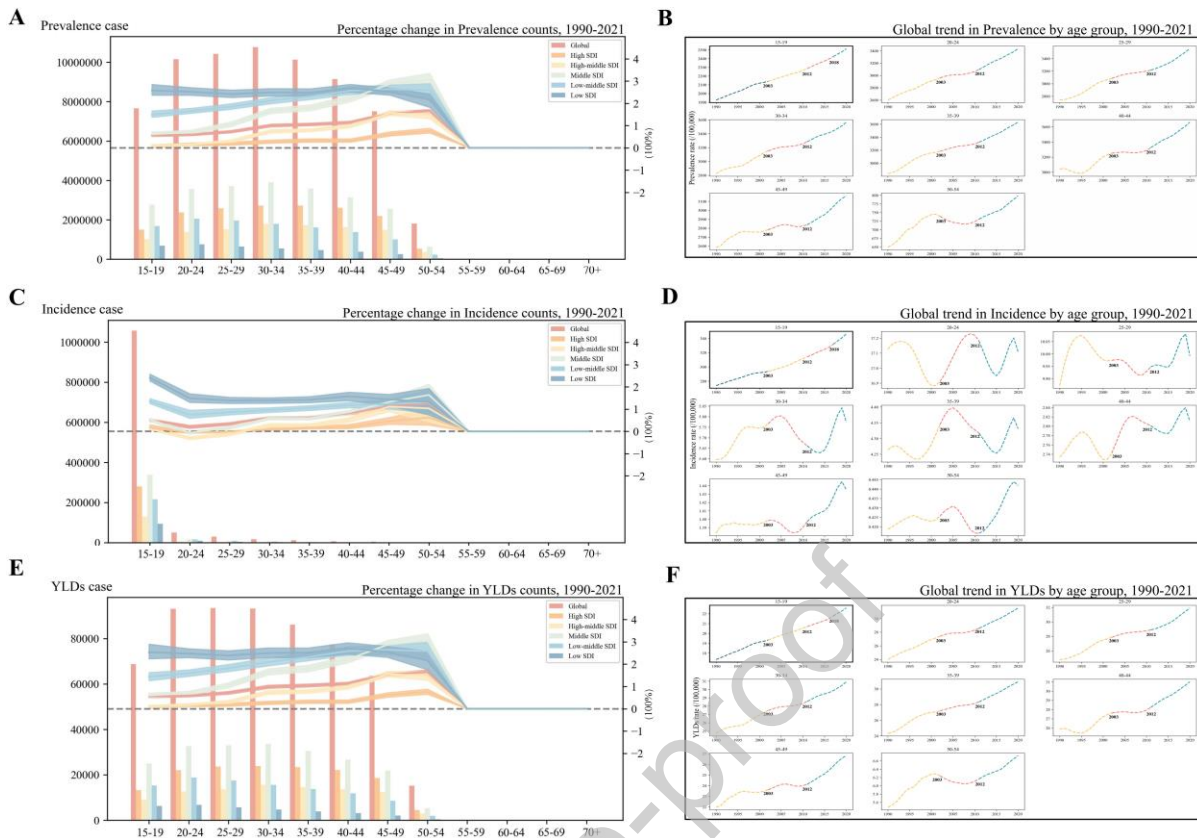
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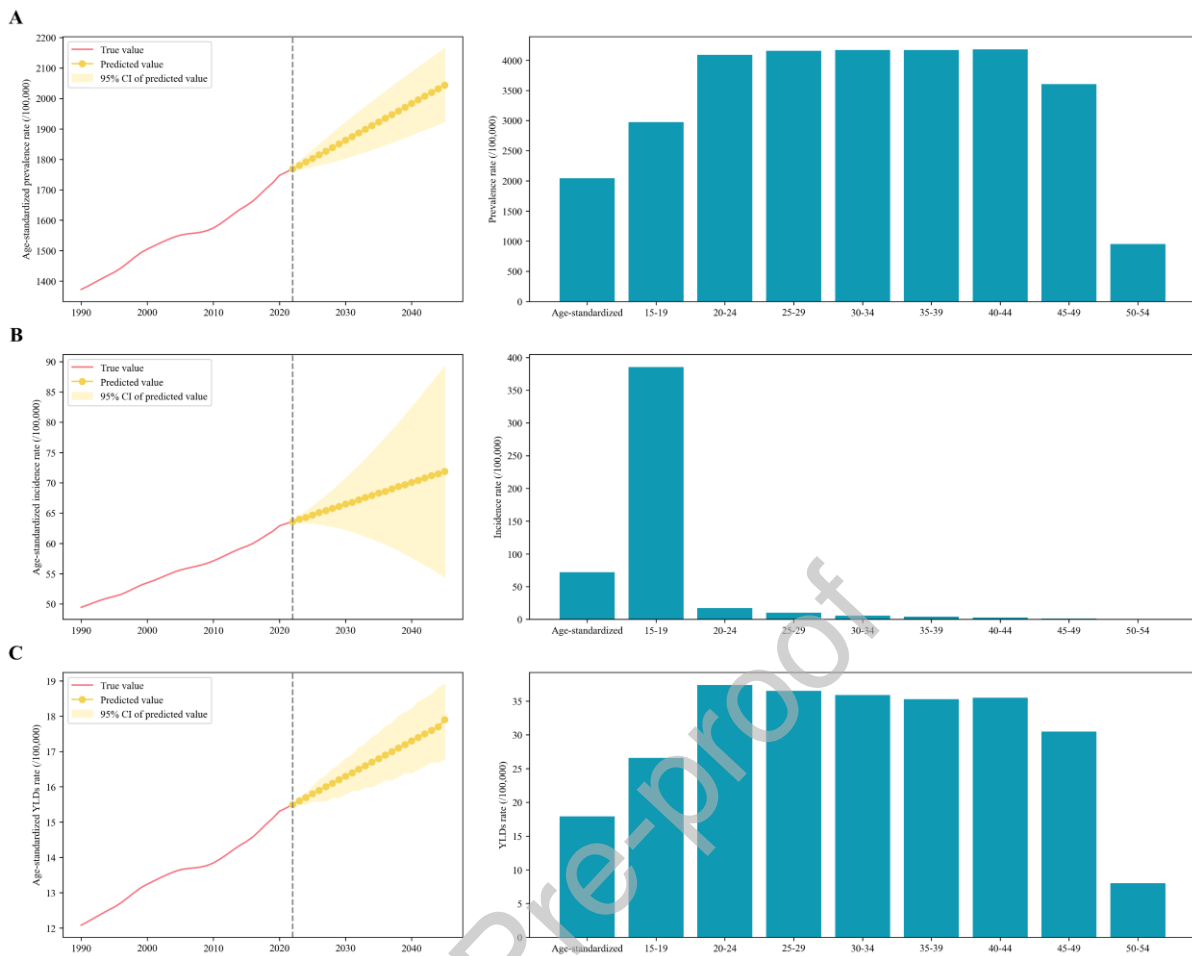
**Figure 1** Age-standardized prevalence (A), incidence (B), and YLDs (C) rate for PCOS (per 100,000 women) from 1990 to 2021, by Socio-Demographic Index (SDI) region and Global Burden of Disease study region.



**Figure 2** National burden of PCOS. (A) Age-standardized prevalence rate (ASPR); (B) Percentage change in ASPR ; (C)Age-standardized incidence rate (ASIR); (D)Percentage change in ASIR; (E) Age-standardized YLDs rate (ASYR); (F) Percentage change in ASR of YLDs



**Figure 3** Figure 3 Age-SDI-Specific Counts and Percentage Changes (1990 - 2021) and Age-Time Trends of Rates for PCOS Globally. (A) Prevalence counts in 2021 and their percentage change (100%) during 1990 - 2021. (B) Prevalence rate. (C) Incidence counts in 2021 and their percentage change (100%) during 1990 - 2021. (D) Incidence rate. (Note: The incidence rate for the 15 - 19 age group ranges from 160 to 360, while rates for all other age groups fluctuate within approximately 0.5.) (E) YLDs counts in 2021 and their percentage change (100%) during 1990 - 2021. (F) YLDs rate.



**Figure 4** ARIMA prediction of PCOS burden globally in the next 24 years. (A) Age-standardized prevalence rate (ASPR) from 1990 to 2045 and estimates of prevalence by age in 2045; (B) Age-standardized incidence rate (ASIR) from 1990 to 2045 and estimates of incidence by age in 2045; (C) Age-standardized YLDs rate (ASYR) from 1990 to 2045 and estimates of YLDs by age in 2045.



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### **Key Message**

This study provided a comprehensive analysis of the global burden of PCOS from 1990 to 2021, revealing a significant rise in prevalence, incidence, and YLDs, highlighting the need for early screening and diagnosis, particularly in adolescents, and for addressing socio-economic disparities to improve healthcare access in low- and middle-income regions.

Table1 Burden of PCOS, 1990–2021, by Socio-Demographic Index (SDI) region and Global Burden of Disease study region.

Location	Prevalence (95%UI)			Incidence (95%UI)			YLDs (95%UI)		
	Num_2021	ASR_2021	Percentage change (100% in ASR 1990-2021)	Num_2021	ASR_2021	Percentage change (100% in ASR 1990-2021)	Num_2021	ASR_2021	Percentage change (100% in ASR 1990-2021)
Global	69473252 (49531420-95724479)	1757.83 (1253.36-2421.26)	0.28 (0.25-0.31)	2301506 (1655989-3167178)	63.26 (45.41-87.28)	0.28 (0.25-0.31)	607757 (272745-1268607)	15.40 (6.91-32.13)	0.27 (0.24-0.31)
Low SDI	3938251 (2745130-5589751)	714.31 (504.52-1007.40)	0.43 (0.37-0.50)	205458 (144224-291380)	27.79 (19.81-38.87)	0.38 (0.33-0.45)	34425 (14800-72773)	6.20 (2.67-13.05)	0.43 (0.36-0.50)
Low-middle SDI	12118405 (8434181-17027257)	1188.74 (828.69-1668.94)	0.60 (0.53-0.67)	481689 (338286-670310)	45.20 (31.82-62.95)	0.54 (0.48-0.60)	106510 (46621-223925)	10.43 (4.56-21.89)	0.58 (0.52-0.66)
Middle SDI	24613370 (17452532-34074254)	1971.07 (1395.79-2724.23)	0.67 (0.61-0.75)	812669 (572964-1126100)	77.38 (54.44-107.63)	0.59 (0.53-0.66)	214899 (95593-450662)	17.26 (7.68-36.24)	0.67 (0.60-0.75)
High-middle SDI	11180895 (7874795-15590881)	1817.62 (1277.35-2529.47)	0.44 (0.39-0.49)	305810 (216061-424908)	72.52 (51.14-101.53)	0.47 (0.42-0.51)	97184 (43255-205404)	15.91 (7.10-33.31)	0.44 (0.39-0.49)
High SDI	17573920 (12981151-23876521)	3554.29 (2624.21-4816.07)	0.18 (0.13-0.26)	494212 (367072-670948)	144.89 (107.28-196.81)	0.20 (0.14-0.28)	154313 (70664-314967)	31.37 (14.37-64.00)	0.18 (0.12-0.25)
Central Europe, Eastern Europe, and Central Asia	622787 (434069-875289)	312.73 (216.79-443.56)	0.39 (0.32-0.49)	18894 (13680-26281)	12.77 (9.10-17.89)	0.37 (0.31-0.45)	5436 (2312-11468)	2.75 (1.17-5.80)	0.39 (0.32-0.48)
Central Europe	119149 (82050-168514)	228.93 (157.78-326.20)	0.23 (0.10-0.38)	3175 (2221-4441)	8.97 (6.22-12.67)	0.22 (0.10-0.35)	1033 (443-2157)	2.00 (0.86-4.17)	0.23 (0.10-0.38)
Eastern Europe	265679 (185374-381763)	264.99 (182.67-381.43)	0.28 (0.22-0.34)	7596 (5458-10593)	10.86 (7.64-15.38)	0.27 (0.21-0.32)	2324 (970-4890)	2.35 (0.97-4.92)	0.28 (0.21-0.35)
Central Asia	237959 (163368-333465)	483.56 (330.71-678.72)	0.39 (0.29-0.49)	8122 (5654-11356)	18.79 (13.06-26.29)	0.37 (0.27-0.47)	2079 (887-4470)	4.24 (1.81-9.10)	0.38 (0.28-0.50)

High-income	19292373 (14307736-26099262)	3946.73 (2914.89-5347.81)	0.13 (0.08-0.20)	559844 (414855-759802)	157.39 (116.26-212.41)	0.12 (0.06-0.19)	169721 (78001-348649)	34.90 (15.94-71.42)	0.13 (0.07-0.20)
Australasia	701618 (500341-974913)	4786.95 (3430.23-6607.27)	0.16 (0.02-0.33)	21493 (15428-29607)	202.25 (145.07-278.86)	0.16 (0.02-0.34)	6104 (2757-12633)	41.77 (18.75-86.35)	0.16 (0.02-0.33)
High-income Asia Pacific	4104983 (2922773-5775182)	5237.62 (3779.21-7307.15)	0.10 (0.05-0.16)	107171 (75694-152114)	225.11 (160.59-317.34)	0.17 (0.10-0.24)	35521 (16037-72064)	45.62 (20.81-92.93)	0.10 (0.05-0.16)
High-income North America	6362238 (4742962-8324162)	3729.48 (2777.89-4876.97)	0.25 (0.11-0.48)	203413 (150005-271138)	149.79 (111.27-197.64)	0.26 (0.11-0.51)	56162 (25718-113710)	33.02 (15.20-66.90)	0.24 (0.10-0.46)
Southern Latin America	667605 (469022-956761)	1892.50 (1326.86-2707.18)	0.60 (0.47-0.74)	21574 (15330-30970)	74.53 (52.77-106.57)	0.59 (0.46-0.75)	5894 (2575-12248)	16.74 (7.33-34.66)	0.59 (0.46-0.76)
Western Europe	7455929 (5232259-10460557)	3942.92 (2761.02-5529.65)	0.11 (0.07-0.15)	206192 (145654-286689)	154.64 (109.19-215.84)	0.08 (0.04-0.11)	66042 (29857-136985)	35.16 (15.84-72.77)	0.11 (0.07-0.15)
Latin America and Caribbean	6353275 (4457452-8841849)	1998.61 (1401.44-2781.11)	0.19 (0.16-0.23)	221380 (155475-309629)	82.16 (57.63-115.20)	0.18 (0.15-0.22)	55163 (24274-114672)	17.37 (7.66-36.07)	0.18 (0.14-0.23)
Andean Latin America	1172865 (808337-1649166)	3333.66 (2301.61-4690.91)	0.38 (0.26-0.51)	42635 (29473-60429)	134.14 (92.65-190.70)	0.34 (0.24-0.47)	10129 (4424-21177)	28.78 (12.57-60.15)	0.37 (0.25-0.51)
Caribbean	360982 (245137-520033)	1485.97 (1008.31-2136.92)	0.25 (0.19-0.32)	11962 (8144-16730)	55.61 (37.61-78.19)	0.25 (0.19-0.32)	3162 (1382-6648)	13.03 (5.70-27.37)	0.24 (0.17-0.31)
Central Latin America	4072957 (2852241-5662452)	2967.64 (2076.22-4124.04)	0.10 (0.06-0.15)	143014 (100629-200291)	115.89 (81.09-162.25)	0.08 (0.04-0.12)	35314 (15578-73736)	25.74 (11.36-53.72)	0.09 (0.05-0.14)
Tropical Latin America	746472 (514677-1057463)	610.00 (419.25-869.52)	0.09 (0.04-0.15)	23769 (16611-32960)	24.90 (17.12-35.01)	0.07 (0.02-0.12)	6558 (2825-13831)	5.38 (2.33-11.29)	0.08 (0.03-0.14)
North Africa and Middle East	6673431 (4672056-9434543)	2075.28 (1453.41-2932.69)	0.34 (0.27-0.41)	242427 (171058-342785)	77.15 (54.45-109.17)	0.31 (0.24-0.37)	59116 (26477-125707)	18.40 (8.24-39.14)	0.32 (0.24-0.39)
South Asia	11291117 (7950086-15832640)	1135.87 (799.70-1591.05)	0.77 (0.66-0.91)	416258 (299377-573874)	42.08 (29.94-58.32)	0.66 (0.56-0.77)	98947 (43231-207059)	9.94 (4.34-20.79)	0.75 (0.64-0.88)
Southeast Asia, East Asia, and Oceania	10520028 (7378814-14809823)	2020.68 (1418.60-2842.16)	0.97 (0.86-1.09)	357262 (254499-495461)	80.13 (56.57-111.88)	0.98 (0.86-1.10)	92606 (41149-191024)	17.66 (7.82-36.61)	0.98 (0.87-1.11)

East Asia	10490359 (7423408-14808757)	1548.43 (1085.52-2170.68)	0.83 (0.72-0.95)	268459 (190157-373877)	58.63 (41.20-82.32)	0.82 (0.69-0.94)	89991 (39442-185702)	13.38 (5.91-27.61)	0.85 (0.73-0.96)
Oceania	124484 (86570-177516)	1772.65 (1232.67-2531.47)	0.39 (0.25-0.50)	5301 (3692-7440)	69.33 (48.42-97.52)	0.40 (0.26-0.52)	1084 (471-2286)	15.41 (6.71-32.47)	0.38 (0.25-0.51)
Southeast Asia	4105398 (2847893-5851631)	2842.65 (1993.15-3997.51)	0.87 (0.74-1.00)	211681 (149539-300888)	110.11 (77.87-153.89)	0.87 (0.73-1.01)	35693 (15432-75335)	25.06 (11.1-51.68)	0.86 (0.73-0.99)
Sub-Saharan Africa	444121 (305192-640542)	727.03 (512.13-1029.50)	0.33 (0.29-0.39)	23872 (16638-33976)	27.83 (19.82-39.20)	0.29 (0.25-0.35)	3862 (1674-7931)	6.28 (2.72-13.22)	0.33 (0.28-0.39)
Central Sub-Saharan Africa	1438942 (1001297-2063339)	673.86 (465.36-968.69)	0.51 (0.39-0.66)	76605 (53945-108541)	26.20 (18.46-36.97)	0.49 (0.36-0.63)	12497 (5381-26310)	5.82 (2.51-12.02)	0.52 (0.37-0.70)
Eastern Sub-Saharan Africa	480390 (328945-679589)	669.17 (472.35-949.85)	0.30 (0.25-0.35)	18378 (12888-26038)	26.26 (18.57-36.96)	0.27 (0.22-0.32)	4158 (1795-8746)	5.77 (2.49-12.17)	0.29 (0.24-0.36)
Southern Sub-Saharan Africa	1741945 (1209889-2493011)	1094.76 (749.33-1548.05)	0.26 (0.20-0.32)	92826 (65226-132561)	42.33 (29.66-59.97)	0.25 (0.19-0.31)	15177 (6522-32236)	9.47 (4.10-19.92)	0.25 (0.18-0.32)
Western Sub-Saharan Africa	21134871 (14915244-29770987)	722.68 (508.32-1026.25)	0.44 (0.37-0.52)	631022 (446529-876768)	27.80 (19.81-39.19)	0.39 (0.32-0.46)	183681 (81028-380200)	6.24 (2.69-13.23)	0.44 (0.37-0.54)

Abbreviation: UI=Uncertainty interval