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Prevalence of asthma in Portuguese adults - the EPI-ASTHMA study, a nationwide population-based survey

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ABSTRACT

Introduction: In 2010, 6.8% of the Portuguese adults had asthma. Contemporary studies employing more accurate methods are needed. We aimed to assess asthma prevalence in Portugal and to identify associated-factors.

Methods: A population-based nationwide study was conducted from May 2021 to March 2024. A multistage random sampling approach was applied to select adults from primary care. Stage 1 involved a telephone screening interview to collect socio-demographic and clinical data. Patients with an Adult Asthma Score (A2 Score) ≥1 were eligible for Stage 2, and 5% of those with an A2 Score = 0 were also invited to participate in Stage 2, which consisted of a diagnostic visit with a physical examination and diagnostic tests. We computed weighted asthma prevalence estimates and multivariable logistic regression models were used.

Results: A total of 7,556 participants completed Stage 1 and 1,857 Stage 2. The prevalence of asthma was 7.1% (95%CI = 6.3–8.0%), with slight differences by sex, age, and region. Education, family history of asthma, inhaler prescription, nasal/ocular symptoms, food allergies, and previous allergy skin tests were associated with an increased risk of asthma (R^2 = 33%). Asthma diagnosis could also be predicted by the A2 score, either on its own (R^2 = 43%) or in combination with family history and previous allergy skin tests (R^2 = 45%).

Discussion: Asthma affects 7.1% of Portuguese adults. Family history of asthma, nasal/ocular symptoms, and comorbid food allergy are associated with increased risk of asthma.

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KEYWORDS
Asthma; epidemiology; prevalence

Introduction

Asthma is a heterogeneous disease characterised by chronic airway inflammation.[1] It ranks among the 30 leading causes of disability-adjusted life-years for individuals under 24 and over 50 years.[2] In 2019, asthma

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affected 358 million individuals worldwide, with an estimated prevalence of current asthma of 5.4% (95%CI 3.23–8.97) among those aged 5–69 years.[3]

Asthma prevalence varies globally, with slightly higher rates in low- and middle-income countries compared to high-income countries.[3] The Global Health Data Exchange places Portugal among the countries with a higher age-standardised prevalence of asthma.[4] Understanding these regional differences requires updated and country-specific studies.[5,6]

Previous studies have estimated that the prevalence of asthma in Portugal ranges between 3.3% and 15%.[7] The last National Asthma Survey (InASMA) was conducted in 2010, and based on telephone interviews, estimated a prevalence of 6.8% (95%CI 6.0–7.7) for the general population.[8] Most Portuguese epidemiological studies have relied on non-standardised questionnaires targeting limited age groups. This approach is susceptible to recall bias, inherent to self-reported health data and fails to provide prevalence estimates applicable to the broader Portuguese population.[9] Smaller studies employed a mixed methodology that integrated physicians' knowledge about asthma diagnosis.[7,10] However, the adopted approach diverged from the step-by-step diagnostic process, which integrates personal and family history, signs and symptoms, and diagnostic tests.

The EPI-ASTHMA study addresses these limitations by adopting a stepwise diagnostic approach that mirrors clinical practice. It combines an initial questionnaire assessing symptoms with a comprehensive clinical evaluation, including lung function and exhaled nitric oxide testing.[11]

We aimed to estimate the prevalence of asthma in the Portuguese adult population and to identify factors associated with an asthma diagnosis.

Methods

Study design

EPI-ASTHMA is a nationwide, population-based study, investigating the prevalence of current asthma in the adult population. The study was conducted using a stage approach that mirrors clinical practice diagnostic methodology, as detailed on clinicaltrials.gov (NCT05169619) and in the study protocol.[11] This study was conducted between May 2021 and March 2024 and involved 38 primary care centres (PCC) within the Portuguese National Health Service (NHS), geographically distributed across the Portuguese Nomenclature of Territorial Units for Statistics – NUTS level 3 Regions. The description of the study follows the STROBE (The Strengthening the Reporting of Observational Studies in Epidemiology Statement: guidelines for reporting observational studies) statement.[12]

Setting and participants

We conducted a stratified random sampling of the population in mainland Portugal. There are 24 NUTS level 3 regions in mainland Portugal. Within each NUTS level 3 region (stratum), we included at least one PCC (cluster). A random sample of subjects aged 18 or over that were registered in the database of the 38 PCCs, received a telephone call invitation to enrol in the study (Stage 0). Subjects with any specific physical and/or cognitive disabilities that prevented them from: i) attending a diagnostic visit (e.g, bedridden), ii) cooperating with the study procedures (e.g., following instructions to perform lung function tests) and/or from understanding/answering the self-reported questionnaires (e.g., dementia, non-Portuguese speakers) were excluded. Stage 1 involved a telephone screening interview to collect socio-demographic and clinical data. Patients with an Adult Asthma Score (A2 Score) ≥1 were eligible for Stage 2, and 5% of those with an A2 Score = 0 were also invited to participate in Stage 2, which consisted of a diagnostic visit with a physical examination and diagnostic tests. The estimated sample size for Stage 1 was 7,141 individuals.[11] Considering an anticipated 50% drop-out rate upon invitation, at least 15 000 individuals were expected to be included in Stage 0.

Data collection

During the telephone screening interview (Stage 1), socio-demographic (age, sex, education, geographic region, health sub-system[13] - special public and private insurance schemes), anthropometric (body mass

Table 1. Questions used during the screening interview to collect clinical information.

Variable	Positive answer to the question
Asthma family history	"Does anyone in your family have or ever had asthma?"
SR PD Chronic bronchitis	"Has a doctor ever told you that you have chronic bronchitis?"
Inhaler prescription in the previous year	"In the past 12 months, have you been prescribed any inhaler?"
Nasal symptoms	"Have you ever had a problem with sneezing, or a runny, or a blocked nose when you did not have a cold or the flu?"
Ocular symptoms	"In the past 12 months, have you had itchy eyes or watery eyes without having a cold?"
SR PD food allergy	"Has a doctor ever told you that you have food allergies?"
SR PD drug allergy	"Has a doctor ever told you that you have drug allergies?"
Skin allergy tests	"Have you ever had skin tests (allergy skin tests)?"
Blood allergy tests	"Have you ever had blood tests for allergy screening?"
Lung function tests:	"Have you ever had an examination to evaluate your breathing (ie, breathing ability), e.g., spirometry, blowing hard into a machine, or breathing in a booth? (Does not consider simply blowing into a tube)"

SR PD: self-reported physician diagnosis of food allergy

index) and clinical (smoking status, environmental tobacco exposure, asthma family history, inhaler prescription, comorbidities, and previous diagnostic tests) data were collected. The information on clinical variables was obtained using the questions presented in Table 1.

Participants also answered the Adult Asthma Score (A2 Score), a validated patient-reported outcome measure (PROM) with 8 questions (yes/no) to accurately identify asthma in epidemiological studies.[14] According to the original authors, an A2 Score ≥4 suggests the presence of asthma (positive predictive value of 93.3%), while a score of 0–1 suggests its exclusion (negative predictive value of 98.2%). In our study, participants were considered eligible for the diagnostic visit (Stage 2) if they had at least one positive response (A2 Score ≥1). A more conservative cut-off was employed to minimise the potential loss of asthma participants, as the A2 score has only been validated in the original population.[14] To estimate the potential error associated with our eligibility criteria, ~5% of those not eligible (A2 Score = 0) were randomly selected and also invited to participate in Stage 2.

During the diagnostic in-person visit (Stage 2), a comprehensive clinical assessment was conducted, including clinical history (e.g., comorbidities), blood cell count, inflammatory biomarkers testing (peripheral blood eosinophil counts, fractional exhaled nitric oxide-FeNO) and lung function tests (pre- and post-bronchodilator spirometry). The clinical assessment was conducted by a general practitioner (GP) from the participating PCC who received specific training on the study procedures. The diagnostic tests were performed by a team of experienced clinical physiologists using the same equipment throughout the study: Minispir S spirometer (MIR, Rome, Italy); NIOX VERO (Circassia AB, Uppsala, Sweden) and HemoCue (WBC DIFF analyser, HemoCue AB, Angelholm, Sweden). In total, 179 GPs and 5 clinical physiologists took part in the study. Additionally, a clinical researcher was involved at this stage to support the healthcare team and ensure the quality and harmonisation of procedures. At the end of the visit, the GP conducting the clinical assessment provided a diagnosis of i) current asthma; ii) possible asthma (when the diagnosis of current asthma was uncertain), or iii) not asthma. Diagnosis of current asthma followed GINA recommendations, relying primarily on the presence and pattern of respiratory symptoms (wheeze, shortness of breath, chest tightness, or cough) and supported by objective lung function findings like variable expiratory airflow limitation (as an increase of 12% and 200 mL from baseline in FEV1 or FVC),[15] high FeNO levels (>50 ppb)[16] and high peripheral blood eosinophil (above 0.3 microL).[17] The peripheral blood eosinophil cut-off was selected as it provides a valuable biomarker for identifying patients with severe eosinophilic asthma.[17] Current asthma was also considered in the presence of Asthma-COPD Overlap (ACO), and this information was recorded.

To check the consistency of the diagnostic classification, information from all participants with possible asthma and 10% of those confirmed with asthma or not asthma (from Stages 1 and 2) was reviewed by a GP from the central team (DB, CB, MJB or MR). To ensure the quality and consistency of the classification, an additional 20% of reviewed cases were re-evaluated by a physician with extensive experience in asthma diagnosis (JAF-allergist or JCS-GP). A consensus on the final diagnoses was reached during meetings involving the six physicians who were part of the diagnostic review process.

Ethical considerations

The study followed the tenets of the Declaration of Helsinki. All participants provided voluntary oral consent during an initial telephone call invitation (Stage 0) and a screening interview (Stage 1). Participants in the in-person diagnostic visit (Stage 2) also provided written informed consent. Ethical approvals were obtained from the Regional Health Administrations of North (CE/2022/117), Center (27/2021), Lisbon and Tagus Valley (2775/CES/2022), Alentejo (11/CE/2022) and Algarve (1/2022); and from the Local Health Units of Matosinhos (38/CES/JAS) and Alto Minho (38/2021).

Statistical analysis

Participants's characteristics were described with means and standard deviations (SD) or medians and interquartile ranges (IQR; range from 25th to 75th percentile) for normal and non-normally distributed continuous variables, respectively. Categorical variables were described using absolute and relative frequencies.

Prevalence estimates were weighted to generalise the findings to the nationwide Portuguese population. Populational-level data by NUTS level 3, sex, and 5-year age strata were obtained from the 2021 Census.[18] A two-stage stratified cluster sampling design was implemented. Firstly, we calculated base weights to account for the probability of selection of each subject within each cluster (PCCs) and stratum (NUTS level 3). Secondly, we calculated post-stratification weights consisting of ratio adjustments to population controls at the individual level, to adjust for the true sex and age distribution of the target population (weights took into account sex and 5-year age strata in each sampling stratum), thus partially correcting for nonresponse and noncoverage bias. Sensitivity analysis to account for the possible diagnosis bias during Stage 1 (eligibility based on A2 score) and Stage 2 (diagnosis performed by a large group of GPs, asthma diagnosis not considering ACO) were performed.

To investigate factors associated with asthma diagnosis (dependent variable) we built univariable and multivariable weighted logistic regressions that included variables potentially associated with asthma such as age, sex, education, region, body mass index, health subsystem, smoking status, environmental tobacco smoke exposure, family history of asthma, chronic bronchitis, inhaler prescription in the previous year, nasal symptoms, ocular symptoms, physician-diagnosis of food allergies, physician-diagnosis of drug allergies, previous skin allergy tests, previous blood allergy tests, previous lung function tests, A2 score. Since the A2 score is derived from a multivariable model consisting of 8 self-administered questions and was used as eligibility criteria in our study, models with and without considering A2 score were built. Results were presented as odds ratios (OR) and their respective 95% Confidence Intervals (95%CI). For the initial model, all covariates with a p-value of <0.25 were included. The overall models were evaluated using the goodness-of-fit tests (Hosmer-Lemeshow test) and Nagelkerke's R^2. The final models (with and without considering A2 score) were selected based on the best combination of these results. The discriminative/predictive power of the models was evaluated by ROC curve analysis. The level of significance considered was 0.05. Statistical analyses were performed using R (version 4.3.2; R Foundation for Statistical Computing, Vienna, Austria) and IBM SPSS Statistics (version 29.0.1; IBM Corporation, Armonk, NY).

Results

Participants' characteristics

In Stage 0, 22075 subjects were invited, of whom 12 520 accepted to participate (acceptance rate of 56.7%). Figure 1 shows the study flowchart. Following the study sample size estimation, 7556 participants completed the screening interview and were enrolled in the study (Table 2) and 2173 (28.8%) were eligible for further assessment in a clinical visit. The clinical visit (Stage 2) was completed by 1857 participants, of which 518 were diagnosed with asthma.

Prevalence of asthma

The national prevalence of adult asthma was 7.1% (95%CI 6.3–8.0), with regional variations (NUTS level 2), and sex and age group differences, as summarised in Table 3. The Centre region exhibited the highest

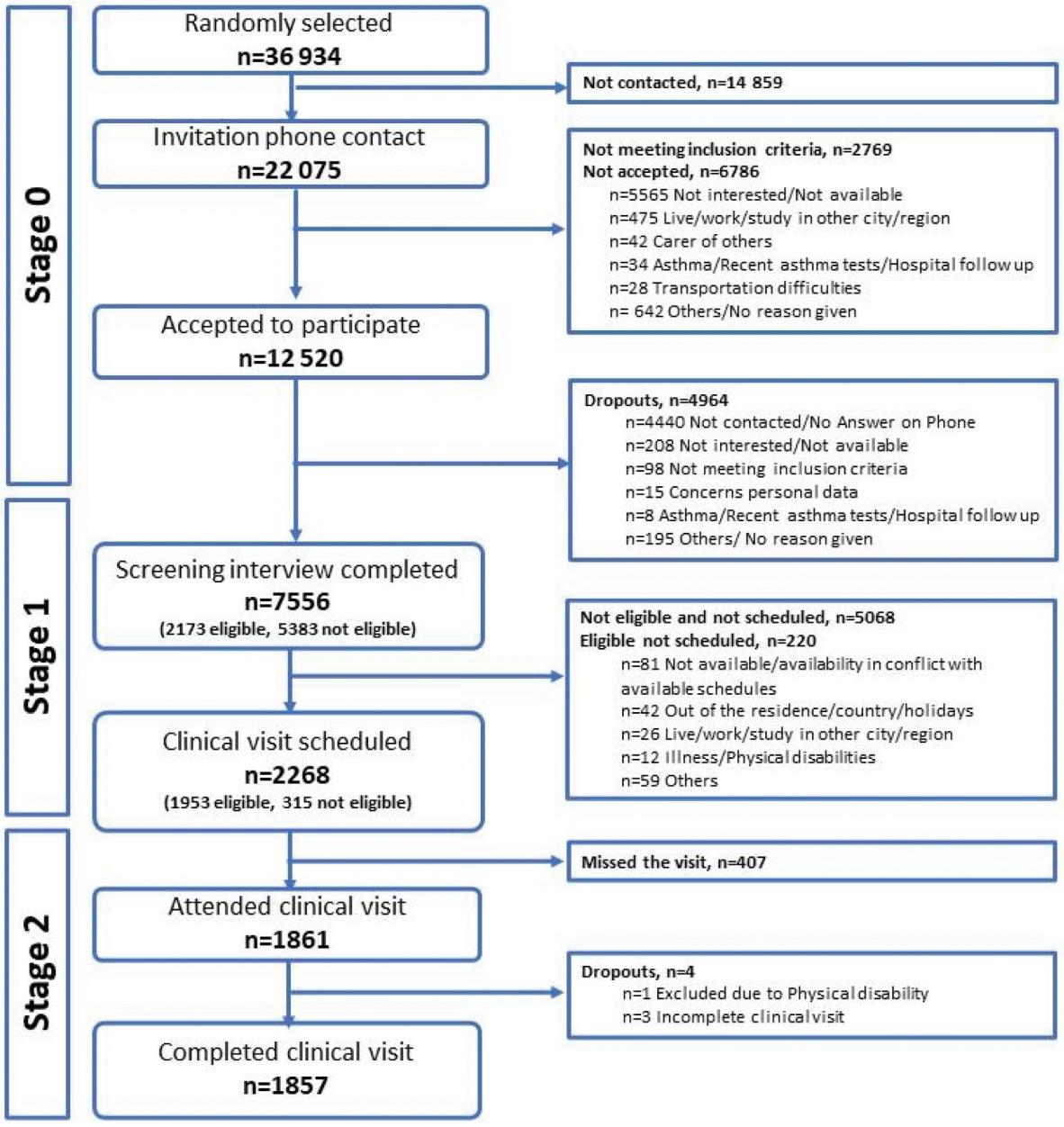

Figure 1. Study flowchart. Eligible (A2 score ≥1) and not eligible (A2 score = 0).

prevalence (9.6%; 95%CI 7.1–12.5), whereas the lowest was recorded in the Alentejo region (4.7%; 95%CI 2.6–8.2). Asthma was more prevalent in women (7.6%; 95%CI 6.4–9) compared with men (6.6%; 5.5–7.8) in all regions, except in Algarve. Asthma prevalence had the highest rates among individuals aged 18–49 years (7.1%; 95%CI 5.8–8.7) and those aged 65 and older (7.4%; 95%CI 6.4–8.7). Results of the sensitivity analysis performed to account for the possible diagnosis bias during Stages 1 and 2 are available as supplementary material.

Factors associated with asthma diagnosis

The presence of asthma was associated with the education level (OR 0.68; 95%CI 0.52–0.90), family history of asthma (OR 1.61; 95%CI 1.25–2.08), having an inhaler prescribed in the previous year (15.50; 95%CI 11.63–20.66), the presence of nasal (1.32; 95%CI 0.90–1.93) and ocular symptoms (OR 1.69, 95%CI 1.22–2.33), food allergy (OR 1.16; 95%CI 0.64–2.09), and having allergy skin tests performed previously (OR

Table 2. Participants characteristics (n = 7556).

Characteristics	Total n= 7556	Asthma n=518	No asthma n=7038
Age[a], M[p25-p75]	51[40–64]	52[41–65]	51[40–64]
Age groups[a]			
18–49 years	3499 (46.3%)	229 (44.2%)	3270 (46.5%)
50–64 years	2186 (28.9%)	150 (29.0%)	2036 (28.9%)
≥65 years	1863 (24.7%)	139 (26.8%)	1724 (24.5%)
Female[b], n(%)	4329 (57.3%)	322 (62.2%)	4007 (56.9%)
Education[c], n(%)			
≤9 years	2901 (38.4%)	221 (42.7%)	2680 (38.1%)
10–12 years	2170 (28.7%)	145 (28.0%)	2025 (28.8%)
>12 years	2478 (32.8)	152 (29.3%)	2326 (33.0%)
NUTS level 2 region			
North	2741 (36.3%)	182 (35.1%)	2559 (36.4%)
Centre	1278 (16.9%)	105(20.3%)	1173 (16.7%)
Lisbon MA	2823 (37.4%)	186 (35.9%)	2637(37.5%)
Alentejo	369 (4.9%)	19 (3.7%)	350 (5.0%)
Algarve	345 (4.6%)	26 (5.0%)	319 (4.5%)
BMI kg/m^2[d], M[p25-p75]	25.5[22.9–28.6]	26.4[23.4–29.4]	25.5[22.9–28.5]
BMI[d] classification, n(%)			
Underweight (<18.5kg/m^2)	136 (1.8%)	7 (1.4%)	129 (1.8%)
Normal weight (18.5–24.9kg/m^2)	3172 (42%)	192 (37.1%)	2980 (42.3%)
Overweight (25–29.9kg/m^2)	2925 (38.7%)	199 (38.4%)	2726 (38.7%)
Obese (≥30kg/m^2)	1302 (17.3%)	120 (23.2%)	1182 (16.8%)
Health subsystem, n(%)[d]	3984 (52.7%)	254 (49.0%)	3730 (53.0%)
Smoking status[e]			
Never smoker, n(%)	4270 (56.5%)	290 (56.0%)	3980 (56.6%)
Former smoker, n(%)	1381 (18.3%)	104 (20.1%)	1277 (18.1%)
Current smoker, n(%)	1886 (25.0%)	123 (23.7%)	1763 (25.0%)
Unit packs-year [f], M[p25-p75]	13 [4.8–27.0]	13.5[4–28.6]	13 [4.8–27.0]
Environmental tobacco smoke exposure[g], n(%)	1308 (17.3%)	118 (22.8%)	1190 (16.9%)
Asthma family history[h], n(%)	2609 (34.5%)	301 (58.1%)	2308 (32.8%)
Chronic bronchitis[d], n(%)	252 (3.3%)	75 (14.5%)	177 (2.5%)
Inhaler prescription in the previous year[i], n(%)	721 (9.5%)	310 (59.8%)	411 (5.8%)
Nasal symptoms[j], n(%)	3849 (50.9%)	402 (77.6%)	3447 (49.0%)
Ocular symptoms[k], n(%)	2785 (36.9%)	345 (66.6%)	2440 (34.7%)
Food allergy[j], n(%)	383 (5.1%)	50 (9.7%)	333 (4.7%)
Drug allergy[k], n(%)	769 (10.2%)	72 (13.9%)	697 (9.9%)
Previous diagnostic tests			
Skin allergy tests[l], n(%)	1767 (23.4%)	271 (52.3%)	1496 (21.3%)
Blood allergy tests[e], n(%)	1014 (13.4%)	164 (31.7%)	850 (12.1%)
Lung function tests[d], n(%)	2294 (30.4%)	351 (67.8%)	1943 (27.6%)
A2 score classification, n(%)			
Asthma excluded (0–1)	6011 (79.6%)	51 (9.8%)	5960 (84.7%)
Possible asthma (2–3)	851 (11.3%)	153 (29.5%)	698 (9.9%)
Probable asthma (≥4)	694 (9.2%)	314 (60.6%)	380 (5.4%)

Abbreviations: A2 score = Adult Asthma Score; BMI = body mass index; *M* = Median; MA = Metropolitan Area; NUTS, Nomenclature of Territorial Units for Statistics; *p* = Percentile. Notes: [a]8 missing values; [b]2 missing values; [c]7 missing values; [d]29 missing values; [e]19 missing values; [f]95 missing values; [g]21 missing values; h 37 missing values; i 30 missing values; j 10 missing values; k 12 missing values; l 9 missing values.

2.00; 95%CI 1.59–2.53) (Model 1, Table 4). This model explained 33.0% (Model 1, Nagelkerke R^2) of the variance in asthma diagnosis, with an acceptable predictive power (AUC = 0.86, 95%CI = 0.85–0.88). The predictive power was higher when considering A2 score classification, either alone (Nagelkerke R^2 = 43%, AUC = 0.90, 95%CI = 0.88–0.91) or in conjunction with family history of asthma and having allergy skin tests performed previously (Model 2, Nagelkerke R^2 = 45%, AUC = 0.91; 95%CI = 0.90–0.93).

Discussion

Our findings reveal that the overall prevalence of adult asthma in Portugal is 7.1% (95%CI 6.3–8.0), with slight variations by sex, age group, and region. In addition, our study identified key clinical and sociodemographic factors associated with asthma.

Based on our findings, approximately 700,000 adults living in mainland Portugal have asthma.[18] In 2010, the National Asthma Survey reported a similar prevalence of 6.8% (95%CI 6.0–7.7).[8] The consistency of these estimates, despite the use of different methodologies, suggests that asthma prevalence in Portugal has

Table 3. Prevalence of asthma by sex, age group, and NUTS level 2 regions.

	North % (95%CI)	Centre % (95%CI)	Lisbon MA % (95%CI)	Alentejo % (95%CI)	Algarve % (95%CI)	All regions % (95%CI)
Male						
18–49 yrs	5.4(3.3–8.5)	12.5(7.7–19.5)	6.7(4.5–9.8)	0.8(0.2–4.2)	11.6(7.9–16.7)	7.0(5.5–8.9)
50–64 yrs	5.6(4.6–6.9)	6.1(2.5–14.0)	5.8(3.2–10.4)	a	9.2(8.2–10.4)	5.7(4.3–7.5)
≥65 yrs	7.8(3.9–14.8)	8.2(3.5–18.0)	6.2(3.5–10.8)	1.9(0.3–11.7)	1.8(0.7–4.7)	6.7(4.5–9.6)
All age groups	6.0(4.6–7.8)	9.5(7.2–12.5)	6.4(4.5–8.9)	0.9(0.6–1.4)	8.3(8.2–8.5)	6.6(5.5–7.8)
Female						
18–49 yrs	6.4(4.9–8.1)	8.1(3.9–16.2)	7.6(5.2–10.9)	8.5(6.2–11.6)	6.2(2.3–15.6)	7.2(5.8–8.9)
50–64 yrs	6.4(4.2–9.6)	12.0(7.4–19.0)	7.0(4.9–9.9)	9.8(5.5–16.9)	7.7(2.2–23.3)	7.8(6.1–9.9)
≥65 yrs	11.1(7.1–17.0)	9.9(8.7–11.4)	5.6(4.1–7.5)	7.0(3.4–13.9)	a	8.1(6.3–10.3)
All age groups	7.6(5.8–10.0)	9.7(6.2–14.8)	6.9(5.4–8.7)	8.4(5.2–13.3)	4.8(3.8–6.0)	7.6(6.4–9.0)
All sex						
18–49 yrs	5.9(4.3–8.0)	10.2(5.8–17.3)	7.1(5.2–9.8)	4.5(3.3–6.1)	8.9(5.2–14.7)	7.1(5.8–8.7)
50–64 yrs	6.0(4.8–7.7)	9.2(6.1–13.6)	6.4(5.0–8.2)	5.1(3.2–7.9)	8.4(4.5–15.3)	6.8(5.8–7.9)
≥65 yrs	9.6(7.5–12.3)	9.1(6.6–12.5)	5.8(4.4–7.7)	4.6(1.5–12.8)	b	7.4(6.4–8.7)
All age groups	6.9(5.9–8.0)	9.6(7.1–13.0)	6.6(5.4–8.2)	4.7(2.6–8.2)	6.5(5.8–7.3)	7.1(6.3–8.0)

Abbreviations: NUTS, Nomenclature of Territorial Units for Statistics. Notes: a - no asthma diagnosis in this sub-group; b – 1 asthma case in this sub-group.

remained stable over the past decade. Compared to other European countries, Portugal has a moderate prevalence of asthma; Serbia has the lowest prevalence (3.1%) and the UK has the highest (10.1%).[6] Table 5 summarises the prevalence of asthma in in both European and non-European countries with the largest Portuguese-descendant communities. The epidemiological stability of asthma in Portugal, combined with its mid-range position within Europe and the world, underscores the relevance of ongoing efforts for accurate diagnosis. Regular surveillance through periodic health surveys and real-world data analysis from healthcare centres databases are possible strategies to monitor asthma prevalence trends.[19]

The prevalence of asthma seemed to be slightly higher in females than in males. This result was expected based on females' unique characteristics such as dysanaptic lung growth throughout life, and hormonal and genetic specificities that may predispose them to asthma.[20,21] Asthma prevalence showed a U-shaped distribution across age groups, with the highest rates observed among individuals aged 18–49 years (7.1%; 95%CI 5.8–8.7) and those aged 65 and older (7.4%; 95%CI 6.4–8.7), as reported in previous studies.[22] Although not statistically significant, this elevated prevalence among older adults aligns with findings from previous national studies, which also report higher asthma rates in older populations.[8,23,24] Regarding geographical distribution, a higher prevalence seemed to be present in the Centre region, while the Alentejo region had the lowest prevalence. Interestingly, this regional distribution reflects the previously observed regional heterogeneity in asthma hospitalisations, which were more frequent in the districts of the Centre of Portugal.[25] In addition, Portugal mainland exhibits two types of climate: Csa (a temperate climate characterised by hot and dry summers primarily in regions south of the Montejunto-Estrela mountain system, such as Alentejo and Algarve) and Csb (a temperate climate with mild and dry summers, found throughout most of the Central-Northern region).[26] Given the lower prevalence of asthma in warm and dry regions, this may help explain the findings in Alentejo.[27] However, these minor regional differences should be interpreted with caution. The data from Alentejo are particularly sensitive to the absence of asthma diagnoses in our sample of men aged 50–64 years. Outdoor air pollution and climate may be associated with the development of asthma[28] and could be additional factors explaining these potential regional differences.[29] Future asthma epidemiological studies could include the analysis of these parameters.

Both clinical and sociodemographic factors were found to be associated with asthma. Family history of asthma, inhaler prescription in the previous year, presence of nasal/ocular symptoms, food allergies, and having performed allergy skin tests were associated with an increased odds ratio for the presence of asthma, which is in line with previous research.[8,30] Many patients, even without a definitive asthma diagnosis, are prescribed inhalers in acute clinical situations (e.g., upper respiratory tract infections) and/or during complex clinical scenarios.[31,32] Past prescription of inhalers and having performed diagnostic tests to detect allergies may support a clinical suspicion of asthma and aid in detecting undiagnosed cases.[1,33] Our findings are consistent with the National Asthma Survey, which also identified rhinitis, sinusitis and food allergies as linked to asthma.[8] Educational level emerged as an independent sociodemographic factor significantly associated with asthma diagnosis.[34] Participants with more than 12 years of education exhibited a lower

Table 4. Prevalence of 'asthma' and logistic regression models with crude and adjusted Odds Ratios (OR).

Characteristics	Asthma % (95%CI)	Crude OR (95% CI)	Model 1 Adjusted OR (95%CI)	Model 2 Adjusted OR (95%CI)
Age groups				
18–49 years	7.1 (5.8–8.7)	1.00 (REF)		
50–64 years	6.8 (5.8–7.9)	0.95 (0.77–1.17)		
≥65 years	7.4 (6.4–8.7)	1.05 (0.78–1.43)		
Sex				
Male	6.6 (5.5–7.8)	1.00 (REF)		
Female	7.6 (6.4–9.0)	1.17 (0.90–1.51)*		
Education				
≤9 years	7.7 (6.8–8.7)	1.00 (REF)	1.00 (REF)	
10–12 years	7.3 (5.7–9.3)	0.94 (0.71–1.26)	0.93 (0.63–1.39)	
>12 years	6.2 (5.0–7.7)	0.79 (0.61–1.02)*	**0.68 (0.52–0.90)****	
Region				
North	6.9 (5.9–8.0)	1.00 (REF)		
Centre	9.6 (7.1–13.0)	1.44 (.99–2.10)*		
Lisbon MA	6.6 (5.4–8.2)	0.96 (0.73–1.27)		
Alentejo	4.7 (2.6–8.2)	0.67 (0.36–1.24)		
Algarve	6.5 (5.8–7.3)	0.94 (0.77–1.16)		
BMI[9] classification				
Underweight (<18.5kg/m^2)	4.2 (1.6–10.5)	0.66 (0.23–1.88)*		
Normal weight (18.5–24.9kg/m^2)	6.2 (5.1–7.6)	1.00 (REF)		
Overweight (25–29.9kg/m^2)	7.4 (6.4–8.5)	1.20 (0.96–1.50)*		
Obese (≥30kg/m^2)	9.4 (8.0–11.1)	**1.57 (1.20–2.05)****		
Health subsystem				
No	7.6 (6.5–8.8)	1.00 (REF)		
Yes	6.7 (5.7–7.8)	0.87 (0.73–1.05)*		
Smoking status				
Never smoker	7.0 (6.2–8.0)	1.00 (REF)		
Former smoker	6.2 (5.1–7.5)	0.87 (0.70–1.08)*		
Current smoker	8.4 (6.3–11.3)	1.22 (.86–1.71)*		
Environmental tobacco smoke				
No	6.7 (5.9–7.7)	1.00 (REF)		
Yes	9.1 (7.4–11.2)	**1.39 (1.08–1.79)****		
Asthma family history				
No	4.8 (4.0–5.8)	1.00 (REF)	1.00 (REF)	1.00 (REF)
Yes	11.5 (10.2–13.0)	**2.59 (2.11–3.18)*****	**1.61 (1.25–2.08)*****	**1.33 (1.06–1.66)*****
Chronic bronchitis				
No	6.4 (5.6–7.2)	1.00 (REF)		
Yes	28.9 (22.0–36.8)	**2.21 (1.63, 2.99)*****		
Inhaler prescription in the previous year				
No	3.3 (2.8–3.9)	1.00 (REF)	1.00 (REF)	
Yes	43.4 (38.7–48.4)	**22.62 (17.84–28.68)*****	**15.50 (11.63–20.66)*****	
Nasal symptoms				
No	10.4 (9.1–12.0)	1.00 (REF)	1.00 (REF)	
Yes	3.8 (2.9–4.8)	**2.99 (2.27–3.94)*****	1.32 (.90–1.93)*	
Ocular symptoms				
No	4.1 (3.5–4.9)	1.00 (REF)	1.00 (REF)	
Yes	12.4 (10.7–14.3)	**3.30 (2.67–4.08)*****	**1.69 (1.22–2.33)****	
Food allergy				
No	6.7 (6.0–7.6)	1.00 (REF)	1.00 (REF)	
Yes	14.3 (9.9–20.3)	**2.31 (1.54–3.47)*****	1.16 (.64–2.09)	
Drug allergy				
No	6.9 (6.0–7.8)	1.00 (REF)		
Yes	9.3 (7.1–12.0)	**1.39 (1.02–1.90)****		
Skin allergy tests				
No	4.5 (3.8–5.3)	1.00 (REF)	1.00 (REF)	1.00 (REF)
Yes	15.2 (13.0–17.7)	**3.77 (3.06–4.66)*****	**2.00 (1.59–2.53)*****	**1.72(1.37–2.16)*****
Blood allergy tests				
No	5.7 (4.9–6.6)	1.00 (REF)		
Yes	15.8 (13.7–18.1)	**3.13 (2.53–3.86)*****		
Lung function tests				
No	3.4 (2.8–4.1)	1.00 (REF)		
Yes	15.4 (13.3–17.8)	**5.17 (3.96–6.75)*****		
A2 score classification				
Asthma excluded (score 0–1)	0.9 (0.7–1.3)	1.00 (REF)		1.00 (REF)
Possible asthma (score 2–3)	18.5 (15.9–21.3)	**24.21 (15.96–36.73)****		**21.89 (14.30–33.51) *****
Probable asthma (score ≥4)	45.9 (40.1–51.9)	**90.80 (57.13–144.31)****		**74.37 (46.32–119.39)*****

Abbreviations: A2 score = Adult Asthma Score; BMI = body mass index; MA = Metropolitan Area; OR = odds ratio; 95%CI = 95% confidence interval. *$p < 0.25$; **$p < 0.05$; ***$p < 0.001$. Significant results in bold. Multivariable logistic regression model 1 included education, asthma family history, inhaler prescribed in the previous year, nasal symptoms, ocular symptoms, food allergy, and skin allergy tests. Multivariable logistic regression model 2 included asthma family history, skin tests and A2 score classification.

Table 5. Prevalence of asthma in countries with larger Portuguese communities.

Europe	Prevalence (%)
France[6]	7.22
Germany[6]	4.55
Switzerland[6]	7.29
United Kingdom[6]	10.07
Spain[6]	4.95
Other continents	
Brazil[6]	5.13
USA[6]	11.25
Venezuela[6]	4.06
Canada[6]	5.32
South Africa[6]	4.27

risk of asthma. This finding aligns with previous research indicating that individuals with lower educational attainment are at higher risk of developing asthma and respiratory symptoms.[8,35] This association may result from disparities in environmental conditions, healthcare access, and lifestyle factors affecting asthma risk. Screening for these identified factors during routine medical appointments can enhance the identification of asthma and improve timely management strategies.

The A2 score emerged as the strongest variable associated with asthma diagnosis in our study, demonstrating a high predictive value both when considered alone (Nagelkerke $R^2 = 43\%$) and when adjusted for other variables (Nagelkerke $R^2 = 45\%$). The A2-score is a PROM with excellent measurement properties for including or excluding individuals with asthma, being a pioneering tool in epidemiological studies involving adults.[14] Its external validity was high, as it has been previously described.[36] No other tool of this kind has been tested on a population as large and representative.[37,38] Our results confirm A2 score as a valuable asthma screening tool in primary care settings.

Strengths and limitations

Epi-Asthma is the first nationwide population-based study in Portugal to determine the prevalence of asthma following a stepwise diagnostic approach similar to clinical practice. This approach involved symptom evaluation, clinical assessment, and lung function testing. We employed a stratified random sampling method based on age and sex, drawing participants from PCC registries, thereby closely mirroring the demographic composition of the Portuguese adult population. Despite these efforts, we acknowledge that the inclusion of minority and underrepresented groups may still be limited. A multistage family cluster stratified sampling approach accounting also for socio-economic status could further enhance representativeness in future epidemiological studies.

The diagnostic tests (Stage 2) were conducted by an experienced team and the same equipment to ensure high clinical test quality and standardisation throughout the study. Although the large number of GPs involved in the clinical assessment visit and asthma diagnosis (Stage 2) could introduce variability in data collection, this was mitigated by ensuring that all participating physicians received prior training and ongoing support from a clinical researcher. Moreover, a two-step review process by the central team physicians further enhanced data reliability. The sensitivity analysis showed minimal differences in the asthma estimates across different scenarios, which increases our confidence in the accuracy of the presented asthma estimates.

Some participants assessed at stage 2 were already receiving inhaled corticosteroid treatment and in these cases bronchodilator response results were less informative to define an asthma diagnosis. Nevertheless, as explained above, the diagnosis of asthma was based on a comprehensive clinical assessment and did not rely solely in spirometry measures. The inclusion of patients with clinical characteristics suggestive of ACO slightly increased asthma prevalence estimates, particularly due to overlapping phenotypes observed in elderly individuals. We acknowledge potential biases from participant selection and memory recall. However, our efforts to ensure a representative national distribution and provide continuous professional education helped to minimise these biases.

Conclusions

EPI-ASTHMA study provides a robust and up-to-date estimate of adult asthma prevalence in Portugal. Furthermore, it identifies key clinical and sociodemographic factors, and a valuable PROM, to aid in diagnosing asthma in routine clinical practice.

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Data availability statement

All data supporting the findings are available from the Faculty of Medicine of University of Porto for all interested researchers who meet the criteria for access to confidential data. Because these data include patients' personal information, the Ethical Committees that approved the study does not recommend that such data be made public unnecessarily. Please contact Cristina Jácome, the corresponding author at cjacome@med.up.pt, or the Faculty of Medicine of University of Porto at fmup@med.up.pt to request the data.

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