UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES

RESEARCH PROTOCOL

Prevalence and risk factors associated with asthma in adults: a multi-country survey.

Submitted in fulfilment of the requirements for the degree

MASTER OF PUBLIC HEALTH (Epidemiology and Biostatistics)

In the

SCHOOL OF PUBLIC HEALTH AND FAMILY MEDICINE

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Department: School of Public Health and Family Medicine

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PREAMBLE

1. DECLARATION

I, **Rufaro Blessings Tsodzai**, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I further declare that this work was not published prior to my registration for the degree of Master of Public Health (Epidemiology and Biostatistics).

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2. ABSTRACT

Background: The Global Asthma Network conducted a parent study that gathered data at the population level on children in two specific age groups, as well as on the adult caregivers of those children. The scope of this dissertation will be specifically narrowed down to examining the prevalence of asthma and related risk factors among adult caregivers. The analysis will primarily focus on determining the strength of association between known risk factors that can cause or trigger asthma symptoms in adults. Additionally, the study aims to explore how these identified risk factors may vary across different WHO regions and individual countries.

Methods: Part A of this mini thesis presents the study protocol which outlines the literature review, rationale, aim and objectives of the study; the research methodology, analysis plan and ethical considerations. Part B is the journal-formatted manuscript which presents the results and discussion of the study findings in relation to other authors. Vancouver referencing style was used for this mini dissertation as required by the European Respiratory Journal (ERJ). Part C is the appendix section which presents some figures not included in the main paper, ethical approval, and instruction for authors.

This study utilizes individual-level data collected from the Global Asthma Network (GAN). The parent study was a large observational cross-sectional, multi-country and multi-center epidemiological study. This study was conducted in several countries around the world. Countries ranging from low, middle, and high income were included in the study with the intention being to obtain data on different risk factors associated with asthma. The study surveyed two age groups of children (13/14 and 6/7) years and adult caregivers of both age groups. Data were obtained from centers located in the different geographical areas within each country, centers participating in the study were recommended to follow a protocol prescribed by the Global Asthma Network Steering Group (GANSG).

Results: Among nineteen countries that took part in this study, 194,571 adults responded to the questionnaire related to asthma, eczema, and hay fever related symptoms. Out of 194,571 individuals, 89,315 (45.9%) were male and 105,256 (54.1%) were female. Countries which had highest participation rate was India and Mexico. Among adults that ever-had asthma, the highest proportion was from the Western Pacific region (8.8%), followed by Eastern Mediterranean region (8.5%), America (6.0%) and Europe (5.1%), while the lowest proportion was from South East Asia with (2.2%) and Africa (3.0%). From 12940 adults who reported to have current asthma symptoms (*experienced wheezing in the last 12 months*), the region with highest prevalence was Eastern Mediterranean (10.7%), followed by America (9.7%), Europe (8.3%) and Western Pacific (8.2%) region whereas lowest prevalence of current asthma symptoms was in South East Asia (3.6%) region. The analysis showed odds ratio for adult caregivers reported to reside in damp household was [1.64 (95% CI: 1.55 - 1.73)] for current wheeze, and [1.74 (95% CI: 1.61 - 1.89)] for severe asthma symptoms while exposure to moulds the OR was [1.35 (95% CI: 1.27 - 1.43)] for current wheeze, and [1.49 (95% CI: 1.37 - 1.63)] for severe asthma symptoms. The OR for biomass and solids as cooking fuel was 1.64 (95% CI: 1.43 – 1.88) and 1.19 (95% CI: 0.97 – 1.46) for severe asthma symptoms. Smoking OR for adult caregivers who self-reported as active adult smokers was 1.16 times as likely to report asthma symptoms.

Conclusion: The study observes high prevalence in the estimates and symptoms of asthma between the six WHO regions and nineteen countries that were part of the study sample. Associated risk factors for asthma varied across the WHO regions and significant relationship with high risk of reporting current and severe asthma symptoms were observed.

3. ACKNOWLEDGEMENTS

Firstly, l would like to thank God for the strength and good health. I would like to also thank my family for the love and support.

My deepest sincere appreciation goes to my supervisor, Prof. Maia Lesosky, for providing me guidance and support in the completion of this dissertation.

This endeavor would not have been possible without data, as such I am so grateful for the tremendous time and effort invested by the Global Asthma Network (GAN) team in collecting data from different countries and geographical locations and also making this data available for publication.

I would also want to thank the University of Cape Town for giving me a life-changing opportunity to pursue a career in Public Health (Epidemiology & Biostatistics) an opportunity that has played a pivotal role in my professional career development and growth.

4. LIST OF ABBREVIATIONS AND ACRONYMS

WHO	World Health Organisation
GAN	Global Asthma Network
GANSG	Global Asthma Network Steering Group
WHS	World Health Survey
LPG	Liquified Petroleum gas
NG	Natural gas
OR	Odds ratio
ERJ	European Respiratory Journal
IUATLD	International Union Against Tuberculosis and Lung Disease
ISAAC	International Study of Asthma and Allergies in Childhood
GAR	Global Asthma Report
CRD	Chronic Respiratory Disease
YLD	Years Lived with Disability
BOD	Burden of Disease
DALY	Disability Adjusted Life Years
ECRHS	European Community Respiratory Health Survey
NCD	Non Communicable Diseases

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PART A: RESEARCH PROTOCOL

1. Protocol Synopsis

1.1 Background

Asthma is a multifactorial non-communicable chronic respiratory disease that commonly starts in childhood and often progresses to adulthood driven by the interaction of both environmental factors and genetics [4]. Most of these risk factors act as allergens that contribute to the onset of asthma. These risk factors can be classified into three different categories namely: (a) environmental factors such as air pollution, pollens, mold/fungi, weather, (b) host factors including obesity, nutritional factors, infections, allergic sensitization, and (c) genetic factors like asthma susceptibility loci on genes [5]. Dharmage (2019) highlights that asthma usually starts in childhood but can manifest at any given age throughout one's life, with some individuals developing asthma for the first time as adults [5].

According to a WHO report of 2006, the annual mortality attributed to asthma alone ranged from 180,000 to 250,000 deaths [1, 3]. In 2018, Rahavi et al., carried out a study in Iran (Yazd Province) and the data obtained in 10 years reflected that nearly 10371 years of life lost (YLL) were consequences of asthma [4]. Between 2002 and 2011, YLL due to asthma was found to be high in females compared to males [4]. YLL is a component of the burden of disease that takes into consideration the mortality rate and age at death [4]. Another study by Dharmage (2019) reports that on a global scale, asthma was ranked 16th among the leading causes of YLD and number 28 among the leading cause that contributes to the burden of disease as measured by disability adjusted life years (DALY) [5].

Looking at the prevalence trends, it is becoming increasingly difficult to ignore the public health burden of asthma globally as the frequency of asthma seems to be on the rise across different regions of the globe. The prevalence of asthma has been on the rise for the past two to three decades in low- and middle-income countries, as well as in high-income countries. This rise has been attributed to rapid urbanization and industrialization in different parts of the world. As such, asthma has introduced more serious public health challenges and socio-economic affairs faced by the world, affecting more than 300 million individuals globally, while in Africa alone asthma prevalence is estimated to be affecting around 50 million people [1, 3]. Although there are still huge gaps in reporting asthma cases in Africa, the prevalence might be underestimated [1].

Several epidemiological studies and the World Health Organisation have projected from existing data that by 2025, the prevalence of asthma is more likely to increase by 100 million more cases, with a more notable increase in the industrialized countries [2]. For instance, in the USA, the number of persons with self-reported asthma was more than double between 1980 and 1996 as cases increased from 6.5 million to 14.5 million [2]. The research article published by Obel et al. 2017, highlighted that in the USA, the prevalence of asthma increased from 7.3% to 8.4% between the years 2001 to 2010 amongst the general population [1].

The Global Asthma Network (GAN) study is a multi-country epidemiological study of asthma, eczema and hay fever in children and adult caregivers. The adult questionnaire in the parent study focused on two exposures of interest namely the home environment and tobacco smoking. One interesting category under home environment extensively questioned was

cooking fuels. Based on the current knowledge, approximately 37% (roughly 2.6 billion) of the world population still relies on cooking stoves fueled by kerosene, biomass, and coal [8]. The majority of these people are in poor low- and middle-income countries [8]. These cooking and heating methods have been proven to be inefficient as they use fuels that produce high levels beyond acceptable limits of household indoor air pollution, mostly in poorly ventilated houses [8, 9]. Indoor air pollution contains health-damaging pollutants, such as minute soot particles (10 microns in size) that penetrate deep into the lungs [8, 9]. According to Landrigan (2017), in 2015 alone, 6.4 million worldwide deaths were caused by air pollution, and 2.8 out of 6.4 million deaths were attributed to household air pollution.

1.2 Rationale

Current evidence suggests that the prevalence of asthma varies significantly across different regions of the globe [6]. According to the Global Asthma Report (2018), this variation in prevalence could be attributed to how asthma is defined and identified with certainty among different countries, as a result, making it difficult to compare asthma prevalence across countries [6].

To date, there is scant worldwide data on the prevalence of asthma in adults. The last report on symptoms in adults to be published by the World Health Organization (WHO) was in 2003, when a World Health Survey was conducted [7]. According to Kuruvilla (2019) few studies conducted by the European Community Respiratory Health Survey (ECRHS) and the International Study of Asthma and Allergy in Childhood (ISAAC) were carried out to determine asthma prevalence trends among children and adults [6]. The main limitation of the ECRHS was that it narrowed its focus on mostly European centres and ISAAC was mostly concerned with adolescents and children. However, both studies reported similar findings, that is, the highest asthma rates in Westernized English-speaking countries, with the lowest rates reported in countries such as Italy and Greece as well as some Latin American countries [6]. Since asthma affects all age groups evidence also suggests higher prevalence and incidence of asthma are more noticeable in children whereas higher morbidity and mortality are more common in adults [5].

Global Asthma Network collected population level data on children in two age groups and on adult caregivers of those children. This dissertation limits its focus to adult caregivers in determining the prevalence of asthma and related risk factors. This analysis will also focus on estimating the strength of association of risk factors that are known to cause or induce asthma symptoms in adults and how these risk factors vary by WHO region and country.

2. AIMS AND OBJECTIVES

2.1 Aims

This study aims to determine the prevalence of asthma symptoms in adults and the prevalence of associated risk factors. The study will also determine the strength of the relationship between associated risk factors and asthma symptoms in adults. The study will also examine how these risk factors vary by WHO region.

2.2 Objectives

- To determine the prevalence of asthma symptoms by country and WHO region.

- To analyse the strength of association between measured risk factors for asthma symptoms in adults across WHO different regions and countries.
- To describe the variation in patterns of distribution of associated risk factors by country and WHO region.

3. Background

- The aim of this literature review is to explore, appraise and synthesise literature on the association between several risk factors associated with the development of asthma symptoms.
- The study also reviews existing literature on asthma symptoms in adults and this review will focus on selected studies to identify gaps in the literature that the proposal seeks to address.

3.1 Search method

This study searched relevant articles on several online search engines platforms such as PubMed, Biomed, Google Scholar, general internet search used to identify more literature and reports from World Health Organisation. The search key words were used to generate searches.

The search keywords used were “asthma or asthma prevalence or asthma symptoms”, “adults or older people”, “cross-sectional or survey or observational study”, “global or worldwide or international or global asthma network”, “phase I”, “cooking or heating fuels”, “moulds”, “damps”, “tobacco or smoking”. Search was only limited to articles published in English language with no limit on time the articles were published.

3.2 Introduction

Asthma is a chronic condition that affects both children and adults, in other words it appears in all age groups [2]. In an article “The public health implication of asthma” in 2005, the worldwide burden of disease for asthma in DALYs were reported to be similar to that for diabetes, liver cirrhosis and schizophrenia [2]. According to Asher et al., (2021) in 2017 the disability adjusted life years for asthma was reported to be 22.8 million [4, 5]. According to Dharmage et al., (2019) asthma was ranked 16th globally among the leading causes of years lived with disability (YLD) and 28th among the leading causes of burden of disease (BOD), as measured by DALYs [9, 10]. Approximately 300 million people have asthma worldwide, and it is predicted that a further 100 million people will be affected by the year 2025 [9].

Since asthma is a major global health problem, any meaningful public health intervention needs to be evidence based and backed up by up-to-date statistics of the underlying health issue [14]. The global epidemic of asthma around 1960s had been noted to be on the rise [19]. As a result of this observation, in the 1990s, it prompted several epidemiological studies to be carried out in some parts of the world to estimate global asthma prevalence, incidence, and identify determinants associated with asthma [19]. Among these epidemiological studies included three large multinational studies one in children International Study of Asthma and Allergies in Children (ISAAC) and the other two in adults, European Community Respiratory Health Survey (ECRHS) and World Health Survey (WHS) [17, 19].

The best general estimate for adult asthma at the time was published by Global Initiative for Asthma (GINA) report in 2004 [17]. The data used was combination of two surveys one from ISAAC study between year 1992 – 1996 and ECRHS study between 1988 – 1994 [17]. The studies used different methods and asthma definitions and participants age groups [17]. As such, around 2002 – 2003 World Health Organization designed and launched the World Health Survey (WHS) [17]. WHS was a multi-country cross-sectional survey that employed standardized methods to collect data intended to provide a global prevalence estimate of asthma in adults within and between countries [17]. Seventy (70) out of 192 (36%) WHO member countries participated in the cross-sectional survey [17]. Individuals aged between 18 - 45 years were given questionnaires related to asthma and related symptoms. The survey used three asthma definitions to estimate the prevalence of asthma, self-reported doctor diagnosed asthma, clinical/treated asthma, and wheezing in the last 12 months [17]. The study results showed the global prevalence of clinical asthma in adults, including self- reported or physician diagnosed asthma and / or treatment for asthma, was 4.5%, varying by as much as 21-fold among 70 involved countries [17, 18]. The authors concluded because of the observed differences between countries a need for additional studies based on more sound methods to be done allowing comparisons and tailored interventions targeting specific changeable risk factors [17, 18].

An organisation named Global asthma network (GAN) was then formed in 2012. GAN conducted a multi-country survey using the International Study of Asthma and Allergies in Childhood (ISAAC) methods to find out the current prevalence and severity of asthma, rhinitis, and eczema to improve the management of asthma, particularly in low- and middle-income countries [11]. The survey collected data of associated factors for asthma, rhinitis and eczema in adolescents and their respective parents or caregivers [11].

Since its formation in 2012 a series of epidemiological studies have been conducted to address different research questions and add knowledge into the body of public health on asthma. For example, Urrutia-Pereira et al., (2021) study narrowed their focus on the prevalence of asthma symptoms and associated risk factors in adolescents and their parents but only in southern Brazil, looking at risk factors such as smoking, paracetamol, diet, and moulds [11]. Ellwood et al., (2020) on GAN phase I surveillance focused on geographical coverage and response rates [13]. In 2021, Asher et al., (2021) published a cross-sectional study focusing on worldwide trends in the burden of asthma in school-aged children, that is children aged 6 – 7 years and adolescents aged 13 – 14 years [14]. Another study in 2022 conducted by Mortimer et al., (2022), used GAN phase I study data to determine the burden of asthma, hay fever and eczema in adults, however this study did not include the risk factors associated with the three non-communicable diseases [16].

In another article by Alomary et al., (2022) the authors investigated on the prevalence of asthma symptoms and their associated risk factors among adults in Saudi Arabia [18]. The outcomes of interest were asthma- ever, current wheeze and severe asthma symptoms, while the associated risk factors of interest were current exposure to moulds and damps, heating house when cold, diet and tobacco use [18]. Although the article did report on various risk factors, however for heating it did not specify the type of heating fuel used for heating when cold [18].

Based on this review, little to no research exists that has been able to analyse the association by WHO region and country between multiple risk factors such as different cooking and heating fuels, moulds, damps and tobacco on asthma and asthma

symptoms development. This mini thesis seeks to bridge that gap and shed light on how these risk factors are associated with asthma and asthma symptoms.

4. Methodology

4.1 Study Design

This study will employ a secondary data analysis method utilizing data collected from the Global Asthma Network (GAN). The parent study was a large observational cross-sectional, multi-country and multi-centre epidemiological study.

4.2 Study Settings

The parent study was conducted in several countries around the world. Countries from the low, middle, and high income contributed data following a standard protocol described in the Global Asthma Network Phase I manual. The study surveyed two age groups of children, that is, (13/14 and 6/7) years of age as well as adults' caretakers or parents of both age groups. This analysis will use the data collected from adults' caretakers or parents. Data were obtained from centres located in the different geographical areas within each country, centres participating in the study were recommended to follow a protocol prescribed by the Global Asthma Network Steering Group (GANSG).

4.3 Study population and sampling

The population of interest in this study included parent(s)/guardians (s) of school children at contributing sites within a given geographical area. The sampling unit was a school for each age group and all parents/caretakers of the selected schools.

4.4 Data Collection methods and research procedures

Data was collected using a written international questionnaire. The written questionnaire's general outline included participants' names, age, date of birth, gender, the date of completing the questionnaire, optional questions on ethnicity, asthma management and environmental factors. These measures were then used to assess the prevalence and severity of asthma, rhinitis, and eczema in defined populations. For adults, only a written questionnaire (strongly recommended) was administered. The questionnaire developed for the parents/guardians of both the adolescents and children were based on asthma, rhinitis and eczema symptoms, management of asthma and environmental factors. The aim was to collect information on parent/guardian health. Both age groups 13/14-year-old and the 6/7-year-old group were asked to take home the adult questionnaires for their parent/s/guardian/s to complete about their health, lifestyle, and environment and return them to school. If the children were living with two parents, both parents if possible were recommended to complete the adult questionnaire.

4.5 Exposures of interest

In this study there were several adult exposures of interest namely, home environment that is, moisture or damp spots inside the house, range of cooking and heating fuels such as (electricity, liquified petroleum gas, natural gas, kerosene, biogas,

wood, charcoal, straw/grass, animal dung and agricultural crop residue) as well as cigarette smoking (frequency of smoking and quantity of cigarettes smoked per day).

4.6 Outcomes of interest

The primary outcome of interest is asthma and asthma symptoms, but the study will also include eczema and hay fever as they are related to non-communicable diseases.

4.7 Data management and analysis plan

Table 1: Outcome variables to be included in the analysis.

Variable name	Scale	Categories
Asthma	Numerical - count	Percentage/proportion
Eczema	Numerical - count	Percentage/proportion
Hay fever	Numerical - count	Percentage/proportion

Table 2: Individual-level data included in the analysis.

Variable name	Scale	Categories
Age (years)	Numerical – continuous	Mean (SD)/ Median (IQR)
Date of Birth	Continuous - interval	
Sex	Categorical – Binary	Male or Female
Smoking	Categorical – Binary	Yes or No
Educational level	Categorical	Primary school Secondary school College or higher
Current wheeze	Categorical	Yes or No
Symptoms of severe asthma	Categorical	Yes or No
Asthma confirmed by a doctor	Categorical	Yes or No
Asthma attack in the past 12 months	Categorical	Yes or No

4.7.1 Data Safety

Data obtained from questionnaires was entered into the computer with necessary statistical analysis capabilities and a copy of the data will be kept off-site in a protected environment.

4.7.2 Data Analysis

Data will be analysed using R-statistical software (R 4.2.0). Descriptive data analysis will be used to summarize the prevalence of the key asthma risk factors for each WHO region and countries belonging to the WHO regions. Six regions will be included namely, Africa included (2) countries, America (6), Eastern Mediterranean (2), Europe (5), South East Asia (2), and Western Pacific (2). Current wheeze defined as “Have you ever had wheezing or whistling in the chest in the past 12 months?”, will be used to estimate the prevalence of current asthma symptoms. Asthma ever defined as “Have you ever had asthma?”, will be used to estimate the prevalence of asthma. The prevalence data will be summarized as count and percentage of positive responses. For the association between asthma and related risk factors data will be assessed using the multi-level logistic mixed effects model.

5. Ethical Considerations

The parent study's ethical consideration was dependent on different research centres. Each research centre was responsible for obtaining its local ethical approval. However, this study will seek ethical approval from the University of Cape Town, Faculty of Health Sciences' research ethics committee. In particular, the following research ethics will be upheld.

5.1 Informed Consent

For the parent study ethical approval process, participants' consent was obtained by use of passive consent to ensure a high response rate. Therefore, this study will not require Informed Consent as it was obtained during the parent study.

5.2 Privacy and Confidentiality

For this study, the data is appropriately coded and anonymous. The data will be kept safe from unauthorized access, accidental loss, or destruction by encrypting the files in computers.

5.3 Risks and Benefits

There are no risks or direct benefits associated with this study. But given the proposed hypothesis is true, this will show the burden of disease, how risk factors vary by country, and the dangers associated with solid fuel usage indoors.

This mini thesis does not require collection of blood or biological sample and does not involve any invasive procedures, thus no physiological or psychological impact.

6. Logistics

This analysis might take over 6 months, as it includes data management, data analysis and the final write-up.

The table below shows the schedule of work activities for this proposed study.

	Timeline – 2022				
	Jan – Mar	Mar - Apr	Apr - May	May - Jul	Jul - Nov
Protocol submission to ethics	√				
Data cleaning		√	√		
Data analysis			√	√	
Thesis write-up				√	
Final write and submission					√

7. Budget

There are no direct or indirect additional costs required to carry out the proposed study.

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PART B. MANUSCRIPT

Title page

Prevalence and risk factors associated with asthma in adults: a multi-country survey.

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The target peer reviewed journal that was chosen to guide the formatting of this manuscript is the European Respiratory Journal (ERJ). The requirements set out in the instructions for authors are included as appendix in the appendices section. As per MPH guidelines, the co-authors are not listed in the main manuscript, but will be included on any arising publication.

1. ABSTRACT

Objectives: To determine the prevalence of asthma symptoms in adults analyse and the prevalence of associated risk factors. The study will also determine strength of the relationship between associated risk and asthma symptoms in adults. The study will also examine how these risk factors vary by WHO region.

Design: Multi-country cross-sectional study. **Setting**: The parent study was conducted in several countries around the world. Countries from the low, middle, and high income contributed data following a standard protocol described in the Global Asthma Network Phase I manual.

Participants: The population of interest in this study included parent(s)/guardians of school children at contributing sites within the selected geographical areas constituting the study sample.

Primary and secondary outcome measures: The primary outcome of interest was asthma, but the study also included eczema and hay fever as they are related to non-communicable diseases.

Results: Among 19 countries that took part in this, 194,571 adults responded to the questionnaire related to asthma, eczema, and hay fever related symptoms. Out of 194,571 individuals, 89,315 (45.9%) were males and 105,256 (54.1%) were females The analysis showed odds ratio for adult caregivers reported to reside in damp household was [1.64 (95% CI: 1.55 - 1.73)] for current wheeze, and [1.74 (95% CI: 1.61 - 1.89)] for severe asthma symptoms while exposure to moulds the OR was [1.35 (95% CI: 1.27 - 1.43)] for current wheeze, and [1.49 (95% CI: 1.37 - 1.63)] for severe asthma symptoms. The OR for biomass and solids as cooking fuel was 1.64 (95% CI: 1.43 – 1.88) and 1.19 (95% CI: 0.97 – 1.46) for severe asthma symptoms. Smoking OR for adult caregivers who self-reported as active adult smokers was 1.16 times as likely to report asthma symptoms.

Conclusion: The study observes high prevalence in the estimates and symptoms of asthma between the six WHO regions and nineteen countries that were part of the study sample. Associated risk factors for asthma varied across the WHO regions and significant relationship with elevated risk of reporting current and severe asthma symptoms were observed.

2. INTRODUCTION

The word "asthma" originated from the Greek meaning "short of breath" [19]. According to Bergmann, (2014) this term initially did not define a disease but was used to describe respiratory symptoms for several lung conditions [20]. In 1959 asthma was defined as a disease characterized by obstruction of airflow in the airways of the lungs and in 1992, that was the year asthma was defined as a chronic inflammatory disorder [22]. Asthma is widely known as a chronic respiratory non-communicable disease that affects both children and adults of all age groups [3, 20].

In a study conducted in 2016 by Loftus et al., 8.4% of people living in United States of America had asthma, with a yearly increase in asthma prevalence of 9.5% in children and 7.7% in adults [21]. Around 1960s a series of cross-sectional epidemiological studies were conducted, and the survey results showed a significant rise in asthma prevalence in some developed countries [2]. Since asthma is a condition that appears in all age groups, the study results in 1960s reported an increase in asthma prevalence in both children and adults [2, 3]. By 1990s further multi-country cross sectional surveys were conducted by International Study of Asthma and Allergies in Childhood (ISAAC) and International Union Against Tuberculosis and Lung Disease (ECRHS) (focused on adults in Europe) to determine worldwide asthma prevalence and identify risk factors associated with asthma [2]. ISAAC study consisted of 1.96 million children of two age groups 13-14 and 6-7 years, 306 research centres, 53 languages and 105 countries from all regions of the world, representing 86.9% of the world's population [22].

The first Global Asthma Report (GAR) publish ed in 2011 by the International Union for Tuberculosis and Lung Disease following a United Nations (UN) meeting on non-communicable diseases (NCD) focused on the prevalence data for asthma based on the largest epidemiological multi-country, multi-centre cross-sectional survey conducted by ISAAC [22, 26]. In this 2011 report the findings highlighted the rise in asthma prevalence globally especially in low-and middle-income countries affecting around 235 million individuals [22, 26]. In 2014, a second GAR was published by Global Asthma Network Steering Group (GANSG) giving an update on the global burden of asthma [23]. The report showed asthma prevalence was continually rising affecting approximately 334 million people globally of all age groups [23]. According to UN 2030 sustainable development goals (SDG) aimed at improving healthy lives and promote well-being for all ages, another GAR was published in 2018 by GANSG [24]. In this report, chronic respiratory diseases (CRD) were estimated to have affected one billion people with asthma as the largest contributor affecting 339 million people with 1000 people estimated of dying daily [24].

At the time the 2018 Global Asthma Report was published, asthma was one of the leading top 20 causes of years lived with disability (YLD) and according to Dharmage et al., (2019) asthma was ranked 16th globally among the leading causes YLD [2, 24]. In an article "The public health implication of asthma" in 2005, the worldwide burden of disease for asthma in DALYs were reported to be similar to that for diabetes, liver cirrhosis and schizophrenia [3]. According to Asher et al., (2021) in 2017 the disability adjusted life years for asthma was reported to be 22.8 million and 28th among the leading causes of burden of disease (BOD), as measured by DALYs [2, 4-6].

Looking at the prevalence trends, it is becoming increasingly difficult to ignore the public health burden of asthma globally as the frequency of asthma seems to be on the rise across different regions of the globe. Asthma has introduced more serious public health challenges and socio-economic affairs faced by the world, estimated to affect more than 300 million individuals globally [2, 7]. The World Health Organization (WHO) report has projected from existing data that by 2025, the prevalence of asthma is more likely to increase by 100 million more cases, with a more notable increase in the industrialized countries [7, 8]. The fourth Global Asthma Report published in 2022 summarized the prevalence and severity of non-communicable diseases [25]. In this report, 70% of global deaths were due to NCDs with approximately 4 million deaths attributed to chronic respiratory diseases, 1 in 10 children having asthma symptoms, half having inadequately controlled symptoms with many not having access to essential asthma medication [25].

The Global Asthma report published in 2022 suggests that the prevalence of asthma is still on the rise and varies significantly across different regions of the globe [9, 25]. This variation in prevalence could be attributed to how asthma is defined and identified with certainty among different countries, as a result, making it difficult to compare asthma prevalence across countries [9].

The Global Asthma Network collected population level data on children in two age groups and on adult caregivers of those children as the adult group. This article narrows its focus on adult caregivers in determining the prevalence of asthma symptoms and risk factors. The analysis also focus on determining the strength of association of risk factors that are known to cause or induce asthma symptoms in adults and how these risk factors vary by WHO region.

3. METHODS

3.1 Study Design

This study employed a secondary data analysis method utilizing data collected from the Global Asthma Network (GAN). The parent study was a large observational cross-sectional, multi-country and multi-centre epidemiological study.

3.2 Study Settings

The parent study was conducted in several countries around the world. Countries from the low, middle and high income contributed to the overall study data following a standard protocol described in the Global Asthma Network Phase I manual. The study surveyed two age groups of children (13/14 and 6/7) years of age and adults' caretakers or parents of both age groups. This analysis will use the data collected from adults' caretakers or parents. Data were obtained from centres located in the different geographical areas within each country, centers participating in the study were recommended to follow a protocol prescribed by the Global Asthma Network Steering Group (GANSG).

3.3 Study population and sampling

The population of interest in this study included parent(s)/guardian(s) of school children at contributing sites within a given geographical area. The sampling unit for the parent study was a school for each age group and all parents/caretakers at the selected schools.

3.4 Data Collection methods and research procedures

Data were collected using a written international questionnaire. The written questionnaire's general outline included participants' names, age, date of birth, gender of the participant, the date of completing the questionnaire, optional questions on ethnicity, asthma management and environmental factors. These measures were then used to assess the prevalence and severity of asthma, rhinitis, and eczema in defined populations.

For adults, only a written questionnaire was administered. The questionnaire developed for the parents/guardians of both the adolescents and children were based on asthma, rhinitis and eczema symptoms, management of asthma and environmental factors. The aim was to collect information on parent/guardian health. Both age groups 13/14-year-old and the 6/7-year-old group were asked to take home the adult questionnaires for their parent/s/guardian/s to complete about their health, lifestyle and environment and return them to school. If the children were living with two parents, both parents if possible were recommended to complete the adult questionnaire.

3.5 Data analysis

Data were analysed for statistical analysis using R-statistical software (R4.2.0). Descriptive data analysis was used to summarize the prevalence of the key asthma risk factors for each WHO region and countries belonging to those regions. Six regions were included: Africa included (2) countries, America (6), Eastern Mediterranean (2), Europe (5), South East Asia (2), and Western Pacific (2). Current wheeze defined as "Have you ever had wheezing or whistling in the chest in the past 12 months?", was used to estimate the prevalence of current asthma symptoms. Asthma ever defined as "Have you ever had asthma?", was used to estimate the prevalence of asthma. The prevalence data was summarized in tables only including the count and percentage of positive responses.

For inferential data analysis the outcome variables were analysed as binary categorical variables. Different ranges of cooking and heating fuels were placed into 3 different categories namely, **Gases** (Liquified petroleum gas + Natural gas + Biogas + Kerosene), **Solids** (Coal/Lignite + Charcoal) and **Biomass** (Wood + Straw/Shrubs/Grass + animal dung + agricultural crop residue). The association between asthma and related risk factors was assessed using the logistic mixed effects model. The multi-level logistic regression model fitted centre as the random intercept to estimate the effects of the different risk factors on asthma. The estimated odds ratios were calculated from the model. These odds ratio was then graphically represented in forest plots refer to appendix A. For statistical significance a *p*-value of 0.05 and 95% confidence interval was used in this analysis.

3 RESULTS

A total of 194,571 individuals from 19 countries responded to the questions related to asthma, eczema, and hay fever related symptoms. Out of 194,571 individuals, 89,315 (45.9%) were males and 105,256 (54.1%) were females. Among the 19 countries that had the highest number of participation was India (44%), Mexico (24%), Kosovo (5.7%), Taiwan (4.9%), and Spain (3.6%). Among the 19 countries with lowest participation was Guatemala (0.6%), Brazil (0.5%), Cameroon (0.4%), Honduras (0.1%) and Argentina (< 0.1%).

In this study risk factors of interest were cooking and heating fuel, damps and moulds and tobacco. Table 2 and 3 summarises the proportions of cooking and heating fuel usage by WHO region and country. For the 6 regions that were included in the study cooking fuels that were reported to be mostly used in all the 6 regions were electricity, liquified petroleum gas and natural gas whereas for heating fuels electricity, natural gas and wood had highest usage proportion compared to other forms of fuels.

This research shows that 67% of the study participants in the European region reported usage of electricity as a source of cooking fuel with 97%, 81%, 69% and 64% from Greece, Russia, Spain, and Kosovo respectively. 87% of the participants from South East Asia region reported usage of LPG and 82% from the Eastern Mediterranean region reported usage of natural gas as a source of cooking fuel. Other forms of cooking fuels were not commonly reported as cooking fuel making up less than 1%, except for kerosene and wood. The study established that 16% and 34% in African region used wood and kerosene as cooking fuels respectively. Europe region reported 17.4% usage of wood, with Kosovo having the highest reported usage (38%) of wood as source of cooking fuel. Two regions had the highest usage of electricity as heating fuel, that is, Western pacific (59%) and Europe (43%), 39% reported usage of natural gas in Eastern Mediterranean region with Iran being the highest (80%), while 26.7% used wood in Europe region with Kosovo having highest proportion (54%) of wood usage for heating purposes.

At the time when the study was conducted 32% of the study participants in Western Pacific region reported they were living in a damp and mould household environment. The study revealed that 21% in Americas region reported were living in a damp environment and 11% were staying in a house with moulds. Africa region had 11% of participants reported were currently living in household with damps and Europe region had the least proportion (0.1%) of participants who reported exposure to a house with damps and moulds as shown in Table 4. This analysis has shown that 5979/24531 (24%) from Europe region reported to be active tobacco smokers at the time the study was conducted, making Europe region the highest region with active smokers compared to other WHO regions as illustrated in Table 5.

Regional prevalence for asthma related risk factors were calculated for each participating country as well as for each WHO region. Among participants that ever-had asthma, the highest proportion reported was from the Western Pacific region (8.8%), followed by Eastern Mediterranean region (8.5%), America (6.0%) and Europe (5.1%), while the lowest response was from South East Asia with (2.2%) and Africa (3.0%) as shown in Table 1. The study indicated that 12940 individuals who reported to have experienced wheezing in the last 12 months, the highest prevalence being reported from the Eastern Mediterranean (10.7%), America (9.7%), Europe (8.3%) and Western Pacific (8.2%) region whereas lowest prevalence of current asthma symptoms was reported in South East Asia (3.6%) region as illustrated in Table 1. Country estimates, as shown in table 1, top five countries with the highest prevalence for current asthma symptoms were Honduras (33%), Argentina (27%), Costa Rica (23%), Brazil (18%) and New Zealand (17%). For those that ever-had eczema, the countries with highest prevalence were Thailand (30%), Spain (23%), Greece (20%), New Zealand (19%) and Argentina (16%). While for countries with the highest hay fever included Thailand (46%), Taiwan (44%), New Zealand (43%), Costa Rica (43%) and Guatemala (42%) as captured in Table 1.

The association of asthma and risk factors was examined using multilevel logistic mixed effects model with centre as the fitted random intercept fully adjusted for cooking fuel, heating fuel, damps, moulds, and tobacco as predictors. Results from mixed effects model (table 6) showed the odds ratio of adults residing in these damp home environments were 1.64 (95% CI: 1.55 - 1.73) times as likely to report asthma symptoms and 1.74 (95% CI: 1.61 - 1.89) times as likely to report severe asthma symptoms while those exposed to moulds were 1.35 (95% CI: 1.27 - 1.43) times as likely to report asthma symptoms and 1.49 (95% CI: 1.37 - 1.63) times as likely to report severe asthma symptoms. The association with these household exposures was statistically significant at 5% level.

The use of biomass and solids as a source of cooking fuel was associated with the risk for reporting severe asthma symptoms 1.64 (95% CI: 1.43 – 1.88) and 1.19 (95% CI: 0.97 – 1.46) respectively. The association for using this type of fuel was statistically significant for biomass and non-statistically significant for solids as cooking fuel. For cooking fuels (electricity and gases), there was no association with the risk for reporting severe asthma symptoms. Smoking was associated with increased risk for reporting asthma symptoms. For the adults smoking (active smokers), the OR was 1.16 times as likely to report asthma symptoms.

The odds of heating using biomass as source of fuel increased risk of asthma symptoms and severe asthma symptoms by 18% and 11% respectively however the association was not statistically significant. Using gas as heating fuel increased odds of reporting current asthma symptoms [1.21 (95% CI: 1.11 – 1.32)] and 1.31(95% CI: 1.15 – 1.49) for reporting severe asthma symptoms and the relationship was statistically significant. For solid fuel the odds were 1.24 times (95% CI: 1.06 - 1.46) as likely for reporting current asthma symptoms and 1.35 times (95% CI: 1.06 - 1.72) as likely for reporting severe asthma symptoms.

Table 1: Prevalence estimates of asthma, eczema and hay fever related symptoms by WHO region and country.						
		Have you ever had asthma?	Have you had wheezing or whistling in the chest in the past 12 months?	Severe asthma symptoms.	Have you ever had eczema?	Have you ever had hay fever?
		Yes	Yes	Yes	Yes	Yes
WHO Region	Country	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)
Africa	Cameroon, N=860	26 (3,0%)	88 (10%)	31 (3,6%)	66 (7,7%)	253 (29,4)%
	Nigeria, N=2321	66 (2,8%)	131 (5,6%)	52 (2,2%)	249 (10,7%)	66 (2,8%)
Africa region	3181	92 (3,0%)	219 (6,9%)	83 (2,6%)	315 (9,9%)	319 (10,0%)
America	Argentina, N=88	14 (16%)	24 (27%)	11 (46%)	14 (16%)	30 (34%)
	Brazil, N=896	109 (12%)	164 (18%)	79 (8,8%)	34 (3,8%)	366 (41%)
	Costa Rica, N=3272	950 (29%)	748 (23%)	297 (9,1%)	438 (13%)	1402 (43%)
	Guatemala, N=1117	78 (7,0%)	164 (15%)	53 (4,7%)	135 (12%)	467 (42%)
	Honduras, N=254	69 (27%)	83 (33%)	53 (21%)	38 (15%)	61 (24%)
	Mexico, N=46399	1846 (4,0%)	3857 (8,3%)	1759 (3,8%)	1542 (3.3%)	3103 (6,7%)
Americas region	52026	3066 (6,0%)	5040 (9,7%)	2252 (4,3%)	2201 (4,2%)	5429 (10,4%)
Eastern Mediterranean	Iran, N=5948	163 (2,7%)	425 (7,1%)	139 (2,3%)	519 (8.7%)	1178 (20%)
	Saudi Arabia, N=6786	914 (14%)	932 (14%)	364 (5,4%)	860 (13%)	1001 (15%)
East Med region	12734	1077 (8,5%)	1357 (10,7%)	503 (4,0%)	1379 (10,8%)	2179 (17,1%)
Europe	Greece, N=1897	153 (8,1%)	124 (6,5%)	38 (2,0%)	372 (20%)	589 (31%)
	Kosovo, N=11093	139 (1,3%)	626 (5,6%)	211 (1,9%)	1114 (10%)	787 (7,1%)
	Poland, N=2220	108 (4,9%)	182 (8,2%)	73 (3,3%)	248 (11%)	596 (27%)
	Russia, N=2360	49 (2,1%)	142 (6,0%)	55 (2,3%)	134 (5.7%)	429 (18%)
	Spain, N=6961	809 (12%)	957 (14%)	330 (4,7%)	1597 (23%)	1733 (25%)
Europe region	24531	1258 (5,1%)	2031 (8,3%)	707 (2,9%)	3465 (14,1%)	4134 (16,9%)
South-East Asia	India, N=85024	1765 (2,1%)	2906 (3,4%)	1025 (1,2%)	8438 (9,9%)	8315 (9,8%)
	Thailand, N=5418	251 (4,6%)	346 (6,4%)	132 (2,4%)	1600 (30%)	2475 (46%)
S-E Asia region	90442	2016 (2,2%)	3252 (3,6%)	1157 (1,3%)	10038 (11,1%)	10790 (11,9%)
Western Pacific	New Zealand, N=3002	550 (18%)	518 (17%)	193 (6,4%)	572 (19%)	1294 (43%)
	Taiwan, N=9690	572 (6,0%)	518 (5,3%)	181 (1,9%)	1432 (15%)	4240 (44%)
West Pac region	12692	1122 (8,8%)	1036 (8,2%)	374 (2,9%)	2004 (15,8%)	5534 (43,6%)

Table2: Prevalence of reported cooking fuel usage by country and region

		No food cooked	electricity	Liquified petroleum gas	Natural gas	Biogas	Kerosene	Coal/lignite	Charcoal	wood	Straw/grass	Animal dung	Agricultural crop residue
		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WHO Region	Country	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)
Africa	Cameroon, N=860	11 (1.3%)	60 (7.0%)	233 (27%)	481 (56%)	40 (4.7%)	64 (7.4%)	57 (6.6%)	293 (34%)	346 (40%)	10 (1.2%)	1 (0.1%)	12 (1.4%)
	Nigeria, N=2321	34 (1.5%)	424 (18%)	342 (15%)	1057 (46%)	107 (4.6%)	1018 (44%)	32 (1.4%)	183 (7.9%)	162 (7.0%)	16 (0.7%)	16 (0.7%)	30 (1.3%)
Africa region	3181	45 (1,4%)	484 (15%)	575 (18%)	1538 (48%)	147 (4,6%)	1082 (34%)	89 (2,8%)	476 (15%)	508 (16%)	26 (0,8%)	17 (0,5%)	42 (1,3%)
America	Argentina, N=88	1 (1.1%)	4 (4.5%)	6 (6.8%)	77 (88%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Brazil, N=896)	27 (3%)	56 (6,3%)	331 (37%)	463 (52%)	0 (0%)	0 (0%)	1 (0,1%)	8 (0,9%)	16 (1,8%)	0 (0%)	1 (0,1%)	1 (0,1%)
	Costa Rica, N=3272	9 (0.3%)	1940 (59%)	255 (7.8%)	1194 (37%)	46 (1.4%)	3 (<0.1%)	2 (<0.1%)	4 (0.1%)	60 (1.8%)	5 (0.2%)	2 (<0.1%)	0 (0%)
	Guatemala, N=1117	6 (0.5%)	73 (6.5%)	629 (56%)	383 (34%)	16 (1.4%)	2 (0.2%)	10 (0.9%)	2 (0.2%)	39 (3.5%)	2 (0.2%)	1 (<0.1%)	1 (<0.1%)
	Honduras, N=254	9 (3.5%)	155 (61%)	30 (12%)	18 (7.1%)	19 (7.5%)	9 (3.5%)	4 (1.6%)	3 (1.2%)	19 (7.5%)	5 (2.0%)	4 (1.6%)	3 (1.2%)
	Mexico, N=46399	240 (0.5%)	3016 (6.5%)	26828 (58%)	15715 (34%)	171 (0.4%)	49 (0.6%)	18 (<0.1%)	283 (0.6%)	754 (1.6%)	44 (<0.1%)	13 (<0.1%)	65 (0.1%)
Americas region	52026	292 (0,6%)	5244 (10,1%)	28079 (54%)	17850 (34%)	252 (0,5%)	63 (0,1%)	35 (<0,1%)	300 (0,6%)	888 (1,7%)	56 (0,1%)	21 (<0,1%)	70 (0,1%)
Eastern Mediterranean	Iran, N=5948	0 (0%)	0 (0%)	0 (0%)	4890 (82%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Saudi Arabia, N=6786	68 (1.0%)	1700 (25%)	0 (0%)	5578 (82%)	0 (0%)	0 (0%)	127 (1,9%)	0 (0%)	70 (1.0%)	26 (0.4%)	17 (0.3%)	30 (0.4%)
East Med region	12734	68 (0,5%)	1700 (13,4%)	0 (0%)	10468 (82%)	0 (0%)	0 (0%)	127 (1,0%)	0 (0%)	70 (0,5%)	26 (0,2%)	17 (0,1%)	30 (0,2%)
Europe	Greece, N=1897	8 (0.4%)	1838 (97%)	60 (3.2%)	73 (3.8%)	1 (<0.1%)	41 (2.2%)	3 (0.2%)	0 (0%)	6 (0.3%)	0 (0%)	0 (0%)	0 (0%)
	Kosovo, N=11093	117 (1.1%)	7103 (64%)	155 (1.4%)	844 (7,6%)	61 (0.5%)	49 (0.4%)	44 (0.4%)	400 (3,6%)	4235 (38%)	34 (0.3%)	9 (0.1%)	78 (0.7%)
	Poland, N=2220	8 (0,4%)	807 (36%)	233 (10,5%)	1268 (57,1%)	107 (4.8%)	1 (<0,1%)	24 (1,1%)	183 (8,2%)	34 (1,5%)	1 (<0,1%)	0 (0%)	0 (0%)
	Russia, N=2360	0 (0%)	1914 (81%)	0 (0%)	449 (19%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Spain, N=6961	186 (2.7%)	4783 (69%)	1601 (23%)	342 (5.0%)	5 (<0.1%)	0 (0%)	2 (<0.1%)	1 (<0.1%)	5 (<0.1%)	1 (<0.1%)	1 (<0.1%)	6 (<0.1%)
Europe region	24531	319 (1,3%)	16445(67%)	2049 (8,4%)	2976 (12%)	174 (0,7%)	91 (0,4%)	73 (0,3%)	584 (2,4%)	4280 (17,4%)	36 (0,1%)	10 (<0,1%)	84 (0,3%)
South-East Asia	India, N=85024	756 (0,9%)	5121 (6,0%)	73854 (87%)	4890 (5,8%)	2256 (2,7%)	3522 (4,1%)	1010 (1.2%)	674 (0,8%)	6157 (7,2%)	1001 (1,2%)	1556 (1,8%)	771 (0,9%)
	Thailand, N=5418	227 (4,2%)	1910 (35%)	4419 (82%)	170 (3,1%)	8 (0,1%)	5 (0,1%)	13 (0,2%)	240 (4,4%)	27 (0,5%)	5 (0,1%)	3 (0,1%)	3 (0,1%)
S-E Asia region	90442	983 (1,1%)	7031 (7,8%)	78273 (87%)	5060 (5,6%)	2264 (2,5%)	3527 (3,9%)	1023 (1,1%)	914 (1,0%)	6184 (6,8%)	1006 (1,1%)	1559 (1,7%)	774 (0,9%)
Western Pacific region	New Zealand, N=3002	11 (0.4%)	2302 (77%)	635 (21%)	615 (20,5%)	18 (0,6%)	0 (0%)	0 (0%)	6 (0,2%)	10 (0,3%)	0 (0%)	0 (0%)	0 (0%)
	Taiwan, N=9690	893 (9.2%)	971 (10%)	2034 (21%)	6420 (66%)	26 (0.3%)	13 (0.1%)	2 (<0.1%)	1 (<0.1%)	5 (<0.1%)	3 (<0.1%)	2 (<0.1%)	2 (<0.1%)
West Pac region	12692	904 (7,1%)	3273 (26%)	2669 (21%)	7035 (55%)	44 (0,3%)	13 (0,1%)	2 (<0,1%)	7 (0,1%)	15 (0,1%)	3 (<0,1%)	2 (<0,1%)	2 (<0,1%)

Table3: Prevalence of reported heating fuel usage by country and region

		electricity	Liquified petroleum gas	Natural gas	Biogas	Kerosene	Coal/lignite	Charcoal	wood	Straw/grass	Animal dung	Agricultural crop residue
		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WHO Region	Country	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)
Africa	Cameroon, N=860	74 (8,6%)	30 (3,5%)	62 (7,2%)	7 (0,8%)	8 (0,9%)	6 (0,7%)	54 (6,3%)	74 (8,6%)	4 (0,5%)	2 (0,2%)	4 (0,5%)
	Nigeria, N=2321	138 (5,9%)	9 (0,4%)	49 (2,1%)	11 (0,5%)	79 (3,4%)	7 (0.3%)	33 (1,4%)	23 (1,0%)	3 (0,1%)	2 (0.1%)	9 (0,4%)
Africa region	3181	212 (6,7%)	39 (1,2%)	111 (3,5%)	17 (0,5%)	87 (2,7%)	13 (0,4%)	87 (2,7%)	97 (3,0%)	7 (0,2%)	4 (0,1%)	13 (0,4%)
America	Argentina, N=88	43 (48.9%)	0 (0%)	19 (21.6%)	0 (0%)	0 (0%)	0 (0%)	1 (1,1%)	2 (2.3%)	0 (0%)	0 (0%)	0 (0%)
	Brazil, N=896)	208 (23.2%)	6 (0.7%)	18 (2.0%)	2 (0.2%)	0 (0%)	17 (1.9%)	11 (1.2%)	113 (12.6%)	2 (0.2%)	0 (0%)	1 (0.1%)
	Costa Rica, N=3272	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Guatemala, N=1117	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Honduras, N=254	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Mexico, N=46399	5321 (11.5%)	992 (2,1%)	1762 (3,8%)	44 (<0,1%)	3 (<0,1%)	4 (<0,1%)	27 (<0,1%)	287 (0,6%)	3 (<0,1%)	2 (<0,1%)	3 (<0,1%)
Americas region	52026	5572 (10.7%)	998 (1.9%)	1799 (3.5%)	46 (<0.1%)	3 (<0.1%)	21 (<0.1%)	39 (<0.1%)	402 (0.8%)	5 (<0.1%)	2 (<0.1%)	4 (<0.1%)
Eastern Mediterranean	Iran, N=5948	0 (0%)	0 (0%)	4773 (80%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Saudi Arabia, N=6786	3706 (54.6%)	99 (1,5%)	188 (1.8%)	13 (0,2%)	86 (1.3%)	94 (1.4%)	33 (0,5%)	82 (1.2%)	19 (0,3%)	9 (0,1%)	54 (0,8%)
East Med region	12734	3706 (29.1%)	99 (0.8%)	4961 (39.0%)	13 (0.1%)	86 (0.7%)	94 (0.7%)	33 (0.3%)	82 (0.6%)	19 (0.1%)	9 (<0.1%)	54 (0.4%)
Europe	Greece, N=1897	697 (37%)	33 (1,7%)	514 (27%)	7 (0,4%)	920 (49%)	0 (0%)	1 (<0,1%)	139 (7,4%)	0 (0%)	0 (0%)	0 (0%)
	Kosovo, N=11093	3811 (34%)	102 (0.9%)	163 (1.5%)	31 (0,3%)	9 (<0,1%)	87 (0.8%)	319 (2.9%)	5991 (54%)	67 (0,6%)	6 (<0,1%)	54 (0,5%)
	Poland, N=2220	375 (17%)	32 (1%)	477 (21%)	4 (0.2%)	2 (<0.1%)	423 (19%)	19 (0.9%)	190 (8.6%)	0 (0%)	0 (0%)	2 (<0.1%)
	Russia, N=2360	924 (39%)	0 (0%)	1 (<0,1%)	71 (3.0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (<0,1%)	0 (0%)	0 (0%)
	Spain, N=6961	4640 (67%)	389 (5.6%)	344 (4.9%)	11 (0,2%)	38 (0,6%)	4 (<0,1%)	2 (<0,1%)	236 (3.4%)	0 (0%)	1 (<0,1%)	4 (<0,1%)
Europe region	24531	10447 (43%)	556 (2.3%)	1037 (4.2%)	124 (0.5%)	969 (4.0%)	514 (2.1%)	341 (1.4%)	6556 (26.7%)	68 (0.3%)	7 (<0.1%)	60 (0.2%)
South-East Asia	India, N=85024	8210 (9.7%)	1425 (1.7%)	422 (0.5%)	294 (4,7%)	288 (0.3%)	1343 (1.6%)	273 (0.3%)	5316 (6.3%)	682 (0.8%)	852 (1.0%)	219 (0.3%)
	Thailand, N=5418	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
S-E Asia region	90442	8210 (9.1%)	1425 (1.6%)	422 (0.5%)	294 (0.3%)	288 (0.3%)	1343 (1.5%)	273 (0.3%)	5316 (5.9%)	682 (0.8%)	852 (0.9%)	219 (0.2%)
Western Pacific region	New Zealand, N=3002	2114 (70%)	195 (6,5%)	188 (6,3%)	9 (0,3%)	5 (0,2%)	7 (0,2%)	8 (0,3%)	416 (14%)	5 (0,2%)	5 (0,2%)	5 (0,2%)
	Taiwan, N=9690	5339 (55%)	36 (0,4%)	48 (0,5%)	10 (0,1%)	221 (2,3%)	3 (<0,1%)	14 (0,1%)	19 (0,2%)	2 (<0,1%)	1 (<0,1%)	2 (<0,1%)
West Pac region	12692	7453 (59%)	231 (1.8%)	236 (1.9%)	19 (0.2%)	226 (1.8%)	10 (<0.1%)	22 (0.2%)	435 (3.4%)	7 (<0.1%)	6 (<0.1%)	7 (<0.1%)

Table4: Prevalence of reported exposure to damp/moulds by country and region

		Damp at this moment	Damp during pregnancy of this child	Damp during 1st year of this child	Damp at some other time	Mould at this moment	Mould during pregnancy of this child	Mould during 1st year of this child	Mould at some other time
		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
WHO Region	Country	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)	Count (n%)
Africa	Cameroon, N=860	245 (28%)	105 (12%)	99 (12%)	150 (17%)	191 (22%)	86 (10%)	73 (8%)	122 (14%)
	Nigeria, N=2321	112 (5%)	94 (4%)	84 (3,6%)	173 (7,5%)	86 (3,7%)	81 (3,5%)	80 (3,4%)	138 (5,9%)
Africa region	3181	357 (11%)	199 (6,3%)	183 (5,8%)	323 (10,2%)	277 (8,7%)	167 (5,2%)	153 (4,8%)	260 (8,2%)
America	Argentina, N=88	26 (30%)	24 (27%)	25 (28%)	43 (49%)	22 (25%)	16 (18%)	17 (19%)	23 (26%)
	Brazil, N=896)	162 (18%)	29 (3,2%)	22 (2,5%)	251 (28%)	136 (15,2%)	22 (2,5%)	9 (1,0%)	237 (26,5%)
	Costa Rica, N=3272	919 (28%)	716 (22%)	759 (23%)	1216 (37%)	631 (19%)	524 (16%)	584 (18%)	971 (30%)
	Guatemala, N=1117	269 (24,1%)	290 (26%)	332 (29,7%)	392 (35,1%)	172 (15,4%)	205 (18,4%)	233 (20,9%)	288 (25,8%)
	Honduras, N=254	33 (13%)	24 (9,4%)	27 (10,6%)	39 (15,4%)	26 (10,2%)	21 (8,3%)	34 (13,4%)	39 (15,4%)
	Mexico, N=46399	9321 (20%)	4157 (9%)	4914 (11%)	9345 (20%)	4748 (10%)	2004 (4%)	2542 (5%)	5970 (13%)
Americas region	52026	10730 (21%)	5240 (10%)	6079 (12%)	11286 (22%)	5735 (11%)	2792 (5%)	3419 (7%)	7528 (14%)
Eastern Mediterranean	Iran, N=5948	586 (10%)	320 (5,4%)	349 (5.9%)	642 (11%)	171 (2,9%)	155 (2,6%)	160 (2,7%)	235 (4%)
	Saudi Arabia, N=6786	256 (3,8%)	128 (1,9%)	167 (2,5%)	275 (4,1%)	98 (1.4%)	48 (0.7%)	63 (0,9%)	128 (1,9%)
East Med region	12734	842 (6,6%)	448 (3,5%)	516 (4,1%)	917 (7,2%)	269 (2,1%)	203 (1,6%)	223 (1,8%)	363 (2,9%)
Europe	Greece, N=1897	418 (22%)	138 (7.3%)	225 (12%)	516 (27%)	292 (15%)	81 (4.3%)	144 (7.6%)	367 (19%)
	Kosovo, N=11093	273 (2%)	346 (3,1%)	361 (3.3%)	866 (7,8%)	287 (2,6%)	317 (2,9%)	333 (3.0%)	845 (7,6%)
	Poland, N=2220	356 (16%)	257 (12%)	350 (16%)	454 (20%)	295 (13%)	218 (10%)	288 (13%)	383 (17%)
	Russia, N=2360	57 (2.4%)	119 (5.0%)	176 (7.5%)	163 (6.9%)	149 (6.3%)	158 (6.7%)	139 (5.9%)	115 (4.9%)
	Spain, N=6961	1147 (16%)	523 (8.1%)	576 (8.3%)	1656 (24%)	658 (9,5%)	313 (4.5%)	369 (5.3%)	1167 (17%)
Europe region	24531	2251 (0,1%)	1383 (0,1%)	1688 (0,1%)	3655 (0,1%)	1681 (0,1%)	1087 (<0,1%)	1273 (0,1%)	2877 (0,1%)
South-East Asia	India, N=85024	8529 (10%)	3881 (4,6%)	3743 (4,4%)	5283 (6,2%)	4922 (5,8%)	2154 (2,5%)	2432 (2,9%)	3774 (4.4%)
	Thailand, N=5418	1134 (21%)	543 (10%)	632 (12%)	715 (13%)	814 (15%)	328 (6%)	387 (7%)	489 (9%)

S-E Asia region	90442	9663 (11%)	4424 (5%)	4375 (5%)	5998 (7%)	5736 (6%)	2482 (3%)	2819 (3,1%)	4263 (4,7%)
Western Pacific region	New Zealand, N=3002	643 (21%)	556 (19%)	603 (20%)	902 (30%)	711 (24%)	552 (18%)	591 (20%)	904 (30%)
	Taiwan, N=9690	3456 (36%)	1548 (16%)	1550 (16%)	1916 (20%)	3354 (35%)	1473 (15%)	1488 (15%)	1927 (20%)
West Pac region	12692	4099 (32%)	2104 (17%)	2153 (17%)	2818 (22%)	4065 (32%)	2025 (16%)	2079 (16%)	2831 (22%)

Table 5: Prevalence estimates of reported smokers by WHO region and country.

		Active smokers (tobacco at this moment)		
		Not at all	Less than daily	Daily
WHO Region	Country	Count (n%)	Count (n%)	Count (n%)
Africa	Cameroon, N=860	721 (84%)	22 (2.6%)	8 (0.9%)
	Nigeria, N=2321	2080 (90%)	10 (0.4%)	8 (0.3%)
Africa region	3181	2801 (88%)	32 (1.0%)	16 (0.5%)
America	Argentina, N=88	67 (76%)	15 (17%)	6 (6.8%)
	Brazil, N=896	685 (77%)	32 (3.6%)	96 (11%)
	Costa Rica, N=3272	3094 (95%)	71 (2.2%)	102 (3.1%)
	Guatemala, N=1117	980 (88%)	91 (8.1%)	16 (1.4%)
	Honduras, N=254	207 (82%)	8 (3.1%)	19 (7.5%)
	Mexico, N=46399	33038 (71%)	8245 (18%)	3240 (7.0%)
Americas region	52026	38071 (73%)	8462 (16%)	3479 (6.7%)
Eastern Mediterranean	Iran, N=5948	4310 (73%)	206 (3.5%)	250 (4.2%)
	Saudi Arabia, N=6786	5623 (83%)	171 (2.5%)	578 (8.5%)
East Med region	12734	9933 (78%)	377 (3.0%)	828 (6.5%)
Europe	Greece, N=1897	1250 (66%)	141 (7.4%)	505 (27%)
	Kosovo, N=11093	5427 (49%)	769 (6.9%)	1961 (18%)
	Poland, N=2220	1654 (75%)	144 (6.5%)	395 (18%)
	Russia, N=2360	2019 (86%)	34 (1.4%)	307 (13%)
	Spain, N=6961	3361 (48%)	498 (7.2%)	2811 (40%)
Europe region	24531	13711 (56%)	1586 (6.5%)	5979 (24%)
South-East Asia	India, N=85024	71748 (84%)	6028 (7.1%)	3594 (4.2%)
	Thailand, N=5418	5041 (93%)	124 (2.3%)	141 (2.6%)
S-E Asia region	90442	76789 (85%)	6152 (6.8%)	3735 (4.1%)
Western Pacific	New Zealand, N=3002	2534 (84%)	119 (4.0%)	312 (10%)
	Taiwan, N=9690	7775 (80%)	439 (4.5%)	1366 (14%)
West Pac region	12692	10309 (81%)	558 (4.4%)	1678 (13%)

Table 6: Odds ratio results of logistic mixed effects model on the association of asthma and related risk factors.

	Have you had wheezing or whistling in the chest in the past 12 months?	Severe asthma symptoms	Have you ever had asthma?	Have you ever had eczema?	Have you ever had hay fever?
	OR (95% CI)	OR (95% CI)	OR (95%CI)	OR (95% CI)	OR (95% CI)
Reference: No					
Electricity	1.19 (1.13 - 1.25)	1.16 (1.07 - 1.25)	1.28 (1.20 - 1.36)	1.23 (1.18 - 1.28)	1.45 (1.40 - 1.50)
Cooking Fuel: Reference: No					
solid_cook	1.04 (0.90 - 1.20)	1.19 (0.97 - 1.46)	1.05 (0.88 - 1.27)	0.99 (0.89 - 1.10)	1.02 (0.92 - 1.13)
gases_cook	0.93 (0.88 - 0.99)	0.96 (0.88 - 1.05)	0.97 (0.91 - 1.04)	1.01 (0.96 - 1.07)	1.12 (1.07 - 1.17)
biomas_cook	1.48 (1.35 - 1.61)	1.64 (1.43 - 1.88)	1.34 (1.19 - 1.51)	1.46 (1.36 - 1.57)	1.23 (1.15 – 1.32)
Heating Fuel: Reference: No					
Solid_heat	1.24 (1.06 - 1.46)	1.35 (1.06 - 1.72)	1.12 (0.91 - 1.38)	1.56 (1.41 - 1.74)	1.32 (1.19 - 1.47)
gases_heat	1.21 (1.11 - 1.32)	1.31 (1.15 - 1.49)	1.12 (1.01 - 1.24)	1.10 (1.02 - 1.19)	1.37 (1.28 - 1.46)
biomas_heat	1.18 (1.07 - 1.30)	1.11 (0.95 - 1.29)	1.14 (1.01 - 1.29)	0.79 (0.74 - 0.85)	0.97 (0.90 - 1.04)
Damps Reference: No	1.64 (1.55 - 1.73)	1.74 (1.61 - 1.89)	1.52 (1.42 - 1.62)	2.27 (2.17 - 2.38)	1.76 (1.69 - 1.84)
Moulds Reference: No	1.35 (1.27 - 1.43)	1.49 (1.37 - 1.63)	1.29 (1.21 - 1.39)	1.23 (1.17 - 1.29)	1.29 (1.23 - 1.35)
Tobacco Reference: Non-smokers	1.16 (1.13 - 1.18)	1.11 (1.07 - 1.16)	0.98 (0.95 - 1.01)	1.05 (1.03 - 1.08)	0.96 (0.94 - 0.98)
WHO Region Reference: Africa					
America	1.46 (0.61 – 3.53)	1.89 (0.90 – 3.94)	2.08 (1.18 – 3.66)	0.39 (0.22 – 0.69)	0.96 (0.54 – 1.69)
Eastern Mediterranean	1.61 (0.56 – 4.60)	1.70 (0.61 – 4.68)	2.15 (0.84 – 5.52)	1.77 (0.61 – 5.15)	2.49 (1.16 – 5.36)
Europe	0.69 (0.29 – 1.67)	0.72 (0.32 – 1.58)	0.68 (0.34 – 1.33)	1.18 (0.63 – 2.21)	1.10 (0.60 – 2.03)
Western Pacific	1.07 (0.36 – 3.12)	1.08 (0.35 – 3.30)	3.28 (1.12 – 9.63)	1.64 (0.57 – 4.76)	5.48 (1.82 – 16.5)
South East Asia	0.50 (0.20 – 1.22)	0.50 (0.23 – 1.09)	0.81 (0.48 – 1.37)	1.24 (0.74 – 2.07)	1.28 (0.77 – 2.11)

Key:
gases = "Liquified petroleum gas + Natural gas + Biogas + Kerosene";
Solid = "Coal/Lignite + Charcoal";
Biomass = "Wood + Straw/shrubs/grass + animal dung + agricultural crop residue"

4 DISCUSSION

This study examined the prevalence of asthma symptoms, risk factors and how this prevalence varied by country and WHO region. This study also examined the association and the strength of the relationship between the risk factors and asthma symptoms among adults in nineteen countries that took part in this study. Data were collected using a written international questionnaire. The questionnaire developed was based on asthma, rhinitis and eczema symptoms, management of asthma and environmental factors.

The risk factors of interest were household exposures such as cooking fuel, heating fuel, damps, moulds, and tobacco smoking. The analysis showed significant variation across WHO region and country on the type of cooking and heating fuel reported to be used as source of energy. In the African region, for instance, the most prevalent reported cooking fuel was natural gas (48%), for Americas region it was LPG (54%), Eastern Mediterranean region reported high usage of natural gas (82%), European region reported 67% usage of electricity, South-East Asia region reported 87% usage of LPG and Western Pacific reported 55% usage of natural gas.

Among these six WHO regions, natural gas and LPG appears to be the most reported used cooking fuel, with countries like Argentina, Iran and Saudi Arabia having the highest reported proportion of natural gas consumption whereas India and Thailand reported to rely mostly on LPG. In all the six WHO regions, there was very little variation in prevalence of the type of fuel used for heating. However, all regions seemed to rely mostly on electricity as the main source of heating fuel compared to other heating fuels. Countries like New Zealand (70%), Spain (67%), Taiwan (55%) and Argentina (49%) have the highest prevalence of electricity consumption for heating purposes.

There was also notable variation across the regions in adults who reported to be living in household environments with damps and moulds. For example, the adult population residing in the Western Pacific region had the highest prevalence of exposure to damps (32%) and moulds (32%). Taiwan has the highest proportion whereas adults residing in the Europe region having lowest prevalence of 0.1% who reported to be exposed to mould and damp household environment. African and American region also had a high proportion of adults exposed to damps and moulds in their homes. The prevalence estimates of active tobacco smokers appeared to vary considerably across regions with the European region having the highest percentage of active smokers, which is adults who smoke on daily basis followed by the Western Pacific and Eastern Mediterranean regions. Africa has the lowest reported proportion of reported active adult smokers making 0.5% for both Cameroon and Nigeria.

For household exposures, the proposed hypothesis was that exposure to cooking fuel, heating fuel, moulds/damps and tobacco smoking in the home environment were associated with increased risk of reporting asthma symptoms. Urrutia-Pereira et al., (2021) showed that adults in Brazil who were exposed to moulds in the living rooms and who are active smokers had increased risk of having asthma symptoms [11]. Data analysis outputs revealed that adults living in damp and mouldy home environment had increased risk of reporting asthma symptoms as well as severe asthma symptoms. The study findings on the association of adult self-reported active smokers and asthma symptoms also correlated with that of Urrutia-Pereira et al., (2021), showing that active smokers had a higher risk of reporting asthmatic symptoms [11]. However,

Urrutia-Pereira et al., (2021) found no association between different types of cooking fuel and asthma, indicating that different types of cooking fuels cannot be regarded as a risk factor for reporting asthma [11]. However, this study found a statistically significant relationship among adults who reported use of biomass as cooking fuel and asthma symptoms/severe asthma symptoms whereas for solid fuel there was an association, but it was not statistically significant.

Wong et al., (2013) investigated the association of asthma and a range of cooking fuels [13]. In their findings, the authors reported the use of fuels that produce open fire as cooking fuel increased risk of asthma symptoms, whereas for gas as source of fuel and asthma symptoms they reported no evidence of an association [13]. Another cross-sectional study on the association between biomass fuel exposure and asthma symptoms conducted in Nigeria highlighted approximately three quarters of the rural population relied on biomass as source of cooking fuel and exposure to biomass was associated with increased odds of asthma symptoms [12]. The authors also highlighted the association of biomass fuel and asthma symptoms varied by gender and noted the strength of association being stronger and statistically significant in male than in females [12]. However, this article did not examine if the difference in strength or association of asthma symptoms and risk factors did vary by gender [12].

In an attempt to find the effects smoke produced by biomass or solid cooking fuel on self-reported asthma among adult men and women residing in India, the study reported that the risk of asthma was significantly higher in adult women exposed to smoke produced by biomass and solid cooking fuels compared those who reported the use cleaner cooking fuels [15]. The researchers also investigated the combined effects or interaction of biomass fuel, solid fuel and tobacco smoke on the risk asthma symptoms, the results showed a significant increased risk among adult women compared to men [15]. However, this current mini thesis did not examine the combined effects or interaction between the risk factors and self-reported asthma symptoms to allow comparison with other published articles.

For shows adults who seif- reported to have wheezing or whistling in the chest, who reported of using electricity as cooking fuel had a higher odds ratio (OR = 1.19, 95% CI: 1.13 - 1.25) compared to those who self-reported to use solid fuels (OR = 1.04, 95% CI: 0.90 - 1.20), gases (OR = 0.93, 95% CI: 0.88 - 0.99), and biomass (OR = 1.48, 95% CI: 1.35 - 1.61). Suggesting that individuals using electricity for cooking may have a higher likelihood of experiencing wheezing or whistling in the chest in the past 12 months compared to those who self-reported using other cooking fuels. Similar to wheezing, adults who self-reported to have severe asthma symptoms using electricity as cooking fuel had a slightly higher odds ratio (OR = 1.16, 95% CI: 1.07 - 1.25) compared to those who reported to use solid fuel (OR = 1.19, 95% CI: 0.97 - 1.46), gases (OR = 0.96, 95% CI: 0.88 - 1.05), and biomass (OR = 1.64, 95% CI: 1.43 - 1.88). This indicated that individuals who self-reported using electricity for cooking may be more likely to experience severe asthma symptoms compared to those using other cooking fuels. Lastly, adults who self-reported to ever had asthma using electricity as cooking fuel also showed a higher odds ratio (OR = 1.28, 95% CI: 1.20 - 1.36) compared to solid fuel (OR = 1.05, 95% CI: 0.88 - 1.27), gases (OR = 0.97, 95% CI: 0.91 - 1.04), and biomass (OR = 1.34, 95% CI: 1.19 - 1.51), suggesting that individuals who have used electricity for cooking may have a higher likelihood of having a history of asthma compared to those using other cooking fuels.

The unexpected outcome of higher odds ratios for electricity compared to other forms of cooking fuels in the provided table 6 may be attributed to several factors. Here are a few possible explanations:

- Sample Bias: The data used to generate the odds ratios may not be representative of the general population.
- Confounding Variables: There might be confounding variables that were not accounted for in the analysis.

In another case-referent study the authors investigated the relationship between the risk of adult-onset asthma and certain household environment exposures such as moulds, tobacco smoke and wood stove [16]. The study results indicated a positive association between occurrence/presence of asthma and exposure to moulds (odds ratio = 2.2, 95% CI 1.4-3.5), tobacco smoke (OR = 2.4, 95% CI 1.4-4.1), and presence of a wood stove. (OR = 1.7, 95% CI 1.2–2.5).[16] This article also found a positive association between asthma symptoms and tobacco smoking and moulds exposure. However, in 2002, a study on adult exposure to gas stove use or woodstove and asthma was conducted, the study did not find any apparent association between gas or wood usage and asthma related symptoms [17].

A study conducted in Tembisa and Kempton Park South Africa reported by Shirinde et al., (2014), showed children residing in household that use gas for heating purposes had increased risk of wheezing [18]. In this study results also showed heating fuel odds among adults who self-reported using solids, biomass, and gases as source of heating fuel had increased risk of current asthma symptoms and severe asthma symptoms. However, the association between current asthma symptoms and severe asthma symptoms with use of biomass as heating fuel was not statistically significant and that of gases was statistically significant.

Regional and country specific prevalence were previously published by Mortimer et al., (2021) [14]. For this article, prevalence estimates were provided for completeness in table 1. The data reflected Western Pacific region had the highest asthma ever prevalence and South-East Asia having the lowest prevalence, however variation by country showed that countries in the Americas region such as Costa Rica and Honduras had the highest prevalence of asthma ever at 29% and 27% respectively. The prevalence of current wheezing was highest in the Eastern Mediterranean region. Honduras proved to be the country with the highest prevalence at 33% and the lowest in the South-East Asia region with India having the lowest prevalence at 3.4%. In the Americas region, the highest prevalence of severe asthma symptoms was reported in all six countries in comparison to the rest of the world. The prevalence for the other two related non communicable disease eczema and hay fever was 10% or more in most of the regions with highest in the Western Pacific region at 15.8 % for eczema fever and 43.6% for hay fever respectively. These figures still show that the burden of disease is still present and varies across various parts of the region.

The model also showed the importance of geographical location in the reporting of asthma symptoms. WHO region was used to assess if an association existed with the risk of reporting current asthma symptoms and severe asthma symptoms. The risk of reporting current asthma symptoms was 2.06 times (95% CI: 0.90 - 4.69) more likely in Americas region and 1.94 times (95% CI: 0.68 - 5.53) in the Eastern Mediterranean region compared to Europe region (0.85 (0.34 - 2.11)), Western Pacific region (0.93 (0.28 - 3.09)) and Southeast Asia (0.52 (0.27 - 1.00)) where the odds of reporting current asthma symptoms was less likely to occur. The odds of reporting severe asthma symptoms increased by 2.91 times (95%

CI: 1.43 - 5.92)] in the Americas region, 2.16 (95% CI:0.91 - 5.11)] in the Eastern Mediterranean region, whereas the odds of reporting severe asthma symptoms decreased 0.50 times (95% CI: 0.28 - 1.01)] in the Southeast Asia region and for Europe and Western Pacific region there was no association. Some of these differences compared to Africa region were both statistically and non-statistically significant at 5% level.

One of the strengths in this study was the standardized written questionnaires, that were used to collect data which makes it possible to allow country-to-country comparison. However, this study had limitations, being a cross-sectional study, whose results were based on self-reported answers and the level of knowledge of adult caregivers who participated in the survey. The observed association of this type of observational study cannot be used to establish or determine causal relationships.

5 CONCLUSION

In conclusion, the current study observed high prevalence in the estimates and symptoms of asthma on WHO regions and countries that constituted the study sample. The study also observed a significant association between asthma symptoms and exposure to moulds, damps, tobacco smoking, heating, and cooking fuel such as biomass.

6 COMPETING INTERESTS

The authors declare that there are no conflicting interests between them.

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PART C. APPENDICES

Appendix A: Forest plots figures representing graphical display of estimated odds ratios.

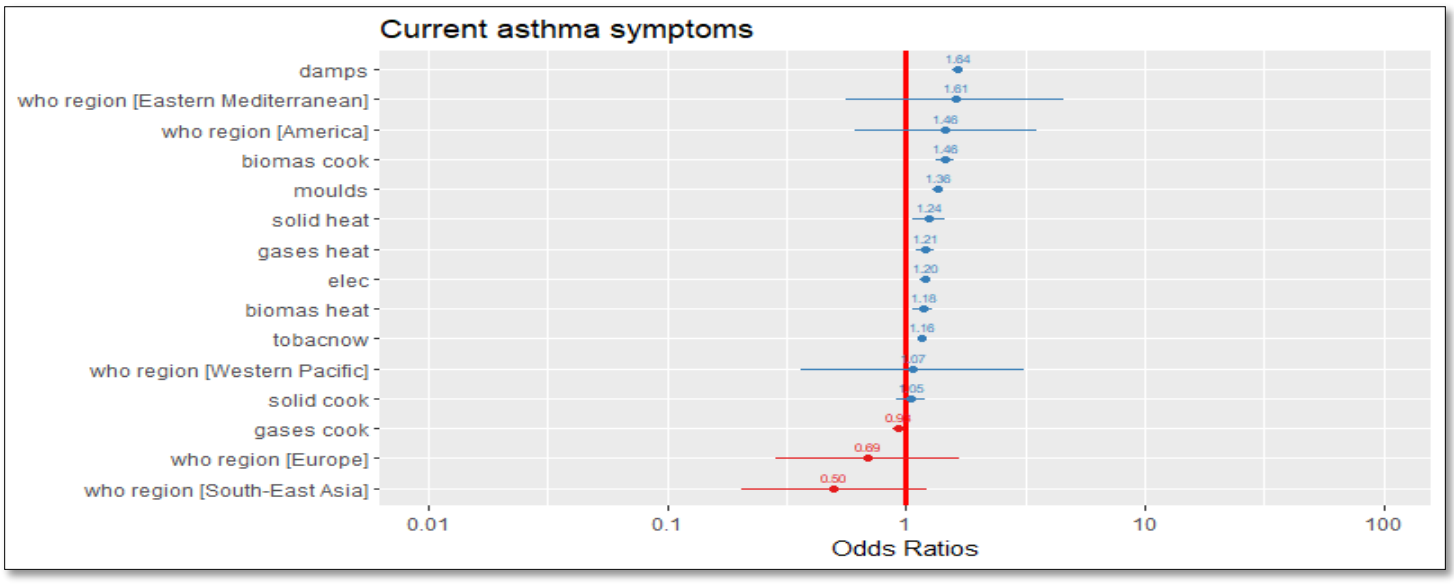

Figure 1: Forest plot representation of Table 6. Confidence interval band below 1 represents factors associated with decreased odds of reporting current asthma symptoms while confidence interval above 1 denotes factors associated with increased odds of reporting current asthma symptoms. Confidence interval crossing 1 represents no association. Logistic mixed effects model with statistical significance ($p<0.05$) and 95% CI was the model used to generate the odds ratios.

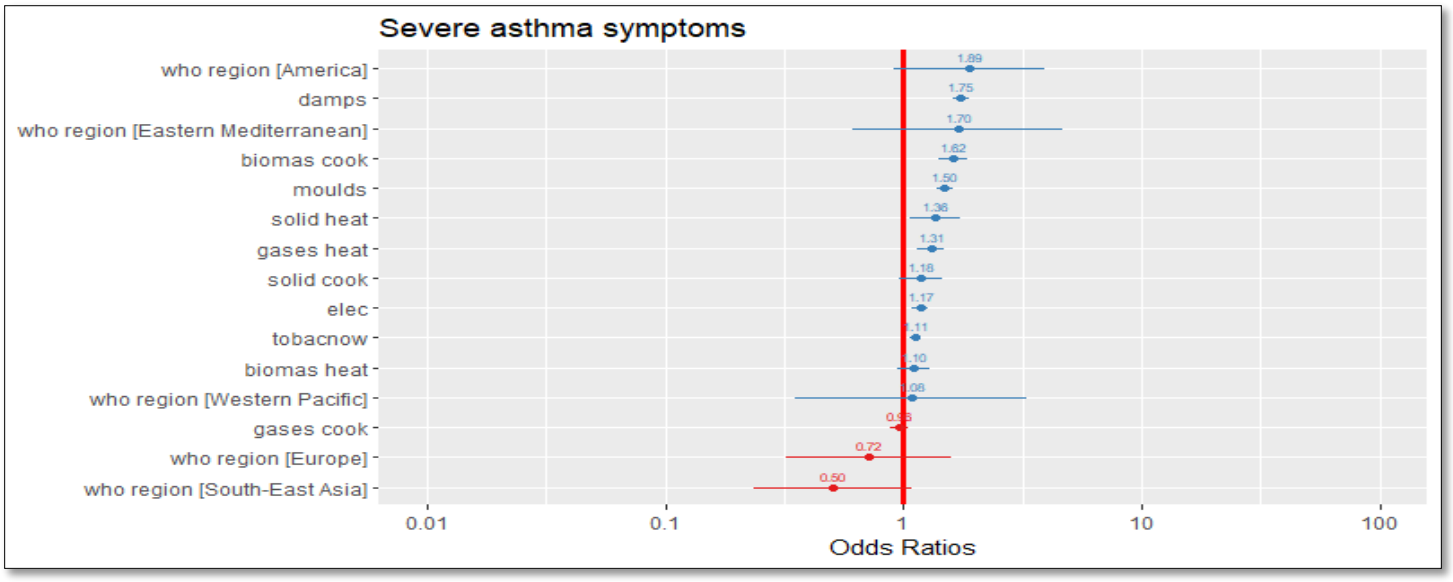

Figure 2: Forest plot representation of Table 6. Confidence interval band below 1 represents factors associated with decreased odds of reporting severe asthma symptoms while confidence interval above 1 denotes factors associated with increased odds of reporting severe asthma symptoms. Confidence interval crossing 1 represents no association. Logistic mixed effects model with statistical significance ($p<0.05$) and 95% CI was the model used to generate the odds ratios.

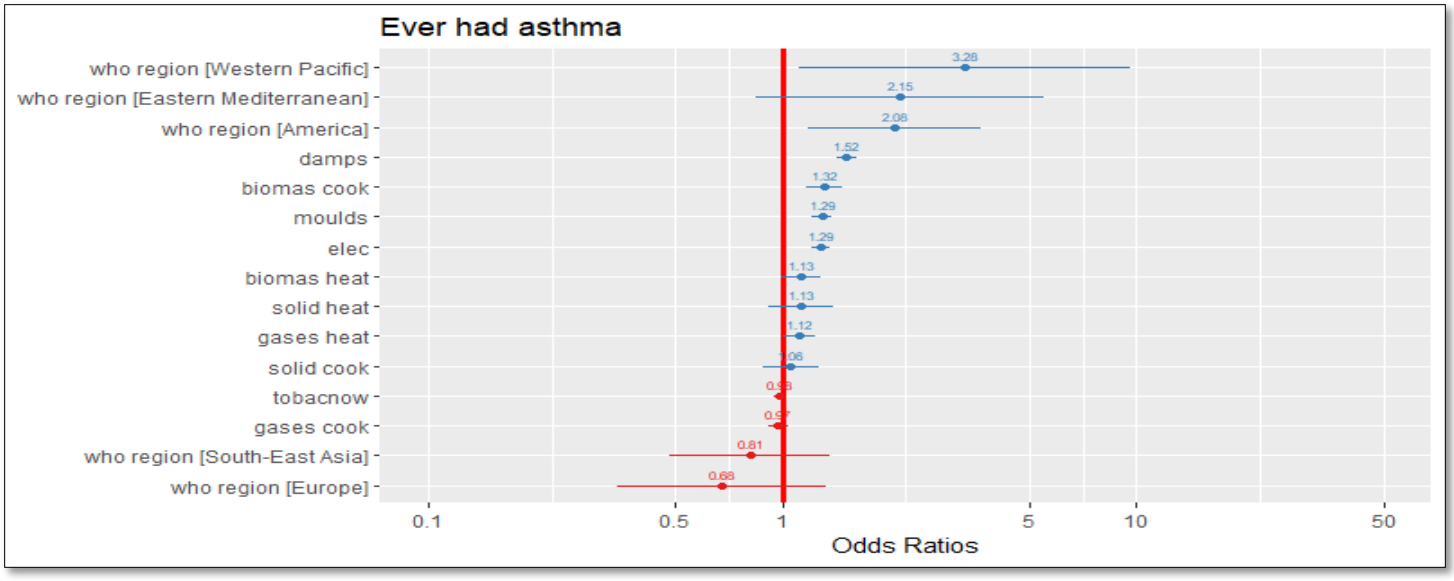

Figure 3: Forest plot representation of Table 6. Confidence interval band below 1 represents factors associated with decreased odds of reporting asthma ever while confidence interval above 1 denotes factors associated with increased odds of reporting asthma ever. Confidence interval crossing 1 represents no association. Logistic mixed effects model with statistical significance ($p<0.05$) and 95% CI was the model used to generate the odds ratios.

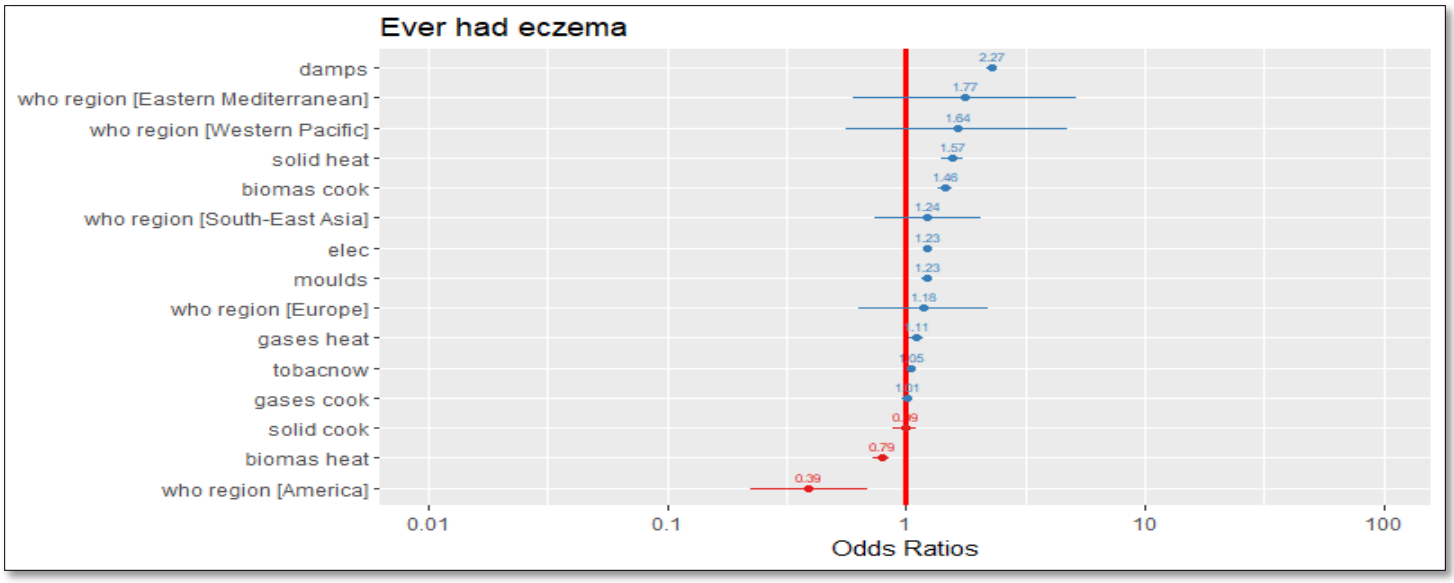

Figure 4: Forest plot representation of Table 6. Confidence interval band below 1 represents factors associated with decreased odds of reporting eczema ever while confidence interval above 1 denotes factors associated with increased odds of reporting eczema ever. Confidence interval crossing 1 represents no association. Logistic mixed effects model with statistical significance ($p<0.05$) and 95% CI was the model used to generate the odds ratios.

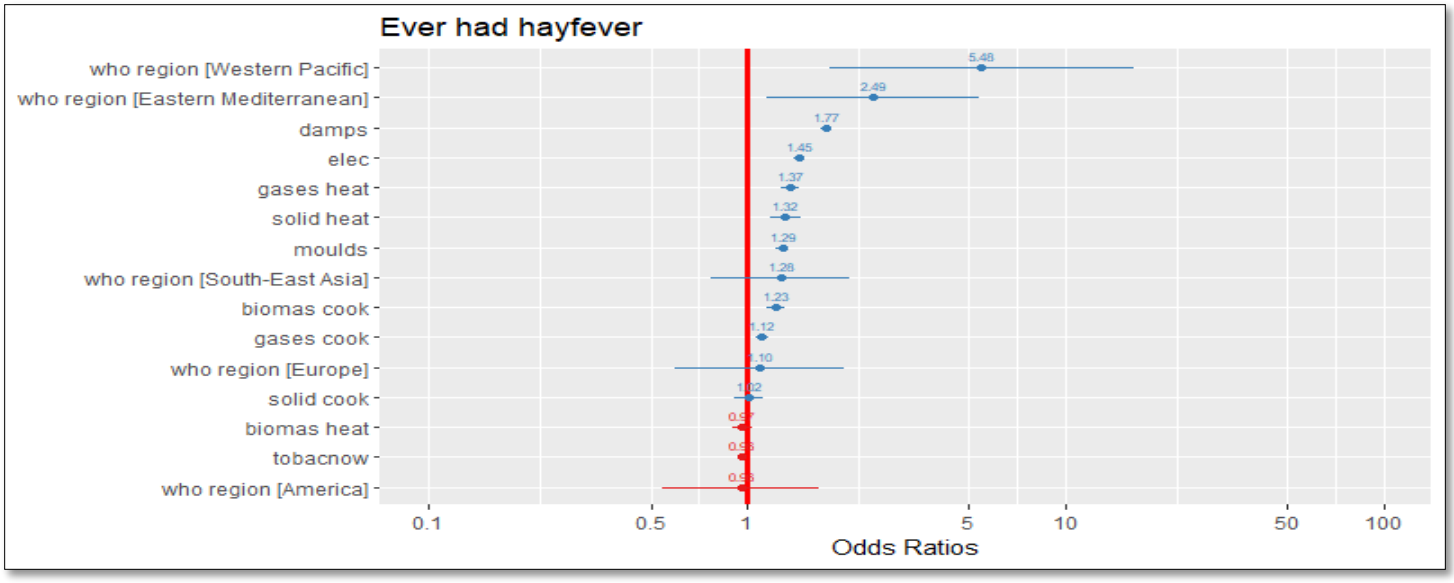

Figure 5: Forest plot representation of Table 6. Confidence interval band below 1 represents factors associated with decreased odds of reporting hay fever ever while confidence interval above 1 denotes factors associated with increased odds of reporting hay fever ever. Confidence interval crossing 1 represents no association. Logistic mixed effects model with statistical significance ($p<0.05$) and 95% CI was the model used to generate the odds ratios.

Appendix B: Ethics approval for this dissertation

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room 45 E-52-E-Floor- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-submissions@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

24 May 2022

HREC REF: 281/2022

Prof M Lesosky
Division of Epidemiology & Biostatistics
5.39 Falmouth Building-FHS
Email: maia.lesosky@uct.ac.za
Student: Tsdruf001@myuct.ac.za

Dear Prof Lesosky

PROJECT TITLE : PREVALENCE AND RISK FACTORS ASSOCIATED WITH ASTHMA IN ADULTS: A MULTI-COUNTRY SURVEY-
(MPH CANDIDATE-MR RUFARO TSODZAI)

Thank you for your response letter, addressing the issues raised by the Faculty of Health Sciences Human Research Ethics Committee (HREC).

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19. Please refer to guidance letter dated 02 February 2022 on our website:
http://www.health.uct.ac.za/fhs/research/humanethics/forms

Approval is granted for one year until the 30 May 2023.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the student: Mr Rufaro Tsodzai will also be involved in this study.

Please quote the HREC REF 281/2022 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

HREC.ref281.2022

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637. Institutional Review Board (IRB) number: IRB00001938 NHREC-registration number: REC-210208-007
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2020), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

HREC.ref281.2022

Appendix C: Instructions for authors for the target journal

European Respiratory Society (ERJ)

Manuscript preparation top
Presentation of manuscripts should be consistent with the Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals, as recommended by the International Committee of Medical Journal Editors (ICMJE).
Brief requirements for journal articles are summarised in the following table. The requirements are outlined in more detail below.

Article type	Word limit	Figures and tables*	References	Online supplement	Abstract
Original research	3000	8	40	Accepted	Yes, 250 words
Editorials	1500	2	30	Not accepted	No
Review and series articles	5000	5	200	Accepted	Yes, 250 words
Research letters	1200	1	15	Not accepted	No
Correspondence	800	1	10	Not accepted	No
Task force reports, guidelines and consensus statements	8000	15	250	Accepted	Yes, 250 words

*The number of figures and tables in the above summary refers to the combined number; for example, letters can have either one figure or one table, not one of each.
For further general guidance on how to write papers, please refer to: Sterk PJ, Rabe KF. The joy of writing a paper. Breathe 2008; 4: 224-232, and guidelines for authors on how to write scientific articles to be published in English at www.ease.org.uk/publications/author-guidelines
Authors are reminded that they should not imply that any opinions or views expressed in their article are those of the journal.

General

- Write the manuscript in UK English.
- The manuscript file you submit must be saved in rich text format (.rtf) or as a Microsoft Word document (.doc or .docx).

- Describe abbreviations and unusual terms at the first time of use.
- Symbols as defined by the ad hoc working group of the Commission of the European Communities (see Eur Respir J 1993; 6: Suppl. 16) are recommended.
- Système International (SI) units are recommended.
- Equations should be created as normal text.

Title page

- Provide a concise and informative title, limited to 90 characters (including spaces).
- Include a list of all contributing authors names in full and all of their affiliations, with a clear indication of who is associated with each institution.
- Supply the full correspondence details for one corresponding author, including e-mail address. The corresponding author indicated in the manuscript does not necessarily need to be the submitting author. Shared first and/or last authorship, indicated by a footnote to the author list, is permitted for academic credentials. The journal strictly allows only one corresponding author, with exceptions limited only to ERS documents/guidelines jointly developed with other societies, for which shared corresponding authorship has been agreed upon with the publications office and editors prior to submission.
- Provide a 256-character (including spaces) summary of the "take home" message of your paper, which can be used to publicise your study *via* social media.

Tables

- Insert tables into the main text document, before the references, using the Table function in your word processing package. Do not supply tables in a separate file.
- Number tables consecutively with Arabic numerals.
- Limit data to a sensible number of significant figures.
- Avoid large tables if possible. Large tables are difficult to display on small screens or A4 printouts.
- Provide a clear footnote for each table, making sure all abbreviations and symbols used are defined.
- For reference numbering schemes, citations made in tables should continue in numerical order from the point in the main body text where the table is first cited.

Figures

FILE FORMAT AND METADATA

- Figures must be uploaded as separate files, not as part of the main manuscript text document. During the upload process, you should fill in the “Caption/legend” box including the figure number and legend, so that reviewers know which figure they are looking at. Alternatively, you may add the figure captions at the end of the main manuscript text.
- Figures should be limited to a maximum of four panels.

- Supply line-art figures in EPS, Adobe Illustrator (.ai) TIFF, JPEG or PNG format. Please ensure image files are not layered and that the image size does not exceed 180 x 230mm. Graphs or bar charts may be supplied in Excel or similar spreadsheet format.
- Supply halftone and photographic images in TIFF, PNG, JPEG or EPS format. Minimum resolution should be 300 dpi at the final typeset size (90 mm to 180 mm wide).
- As an alternative to the above, you can supply figures as a single- or multi-page PDF. However, you must include figure legends within the PDF, as our submission software will not add them.
- If your halftone or photographic image features text or arrows marking out particular features, you may wish to supply an additional copy as a layered Adobe Photoshop (.psd) file, labelled as "Supporting document (not for publication)". This helps our production staff to ensure optimal reproduction of your figure.
- If your figures were originally created in another format that contains extra information (e.g. embedded data in an Excel graph), consider supplying them as supplementary material (Original Research Articles and Review articles only).

SIZE AND QUANTITY

- Figures constitute a key element of manuscripts submitted to the ERS research journals. However, figures should be limited (both in size and number) to those required to show the essential features described in the manuscript.
- Avoid large figures comprising many individual parts: as a maximum, each individual figure must fit to a single PDF page of the journal, with sufficient space for its accompanying caption.
- If you have a large number of figures, consider publishing some of them as an online supplement.

FIGURE PRESENTATION

- All submitted figures must be clearly named and numbered.
- Whether for images, drawings or graphs, use no more than four panels for a single figure. These should be labelled as a), b), c) and d).
- In photographic and halftone images, show only the areas of interest with enough surrounding area for orientation purposes.
- Radiographic images should be of high quality and combined into one array, such as posteroanterior and lateral views. Each panel should be sized identically.
- When several photographic or halftone images of a given type are being shown, please reproduce them all at the same magnification.
- Photomicrographs must have internal linear scale markers (scale bars), since the size and magnification may be altered when the figure is printed or displayed on screen.
- Images should correspond in appearance to the tonal relations of the original radiograph (*i.e.* showing the bones white on a dark background), with the patient's right to the observer's left. CT scans and magnetic resonance images should employ the internationally accepted 'view from below'.

- Label your images such that all important details are clearly marked, but avoid obscuring large areas of the images with excessive labelling.
- Use a sans serif font (such as Arial or Helvetica) for labelling, and ensure that the font is legible, of reasonable size and uniform throughout all the figures in your manuscript.
- Ensure that bar charts and graphs have a white background, with no shading or gridlines.
- Use colour or greyscale shading on bar charts and graphs (different weights can be used, e.g. from 0% (white) to 100% (black) for purposes of differentiation), in preference to hatching and patterning.
- Do not use three-dimensional effects in the presentation of bar charts.
- For reference numbering schemes, citations made in figures should continue in numerical order from the point in the main body text where the figure is cited.

GUIDELINES FOR HANDLING IMAGE DATA

- If an image has been enhanced electronically, please explain the alterations that have been made and submit the original image along with the enhanced one. Keep an electronic set of original images, since our reviewers might ask you to modify their content and the display modus.
- The Council of Science Editors has established four basic guidelines for handling image data, which authors submitting to the ERS research journals are urged to comply with. 1) No specific feature within an image may be enhanced, obscured, removed or introduced. 2) Adjustments of brightness, contrast or colour balance are acceptable if they are applied to the whole image and as long as they do not obscure, eliminate or misrepresent any information present in the original. 3) The grouping of images from different parts of the same gel, or from different gels, fields or exposures must be made explicit by the arrangement of the figure (*e.g.* by using dividing lines) and in the text of the figure legend. 4) If the original data cannot be produced by an author when asked to provide it, the acceptance of the manuscript may be revoked.

CAPTIONS

- Provide a clear caption for each figure.
- Captions should be brief and not repetitive of information given in the text.
- All abbreviations should be expanded.
- Where appropriate, captions should include the imaging technique used, the body part imaged and any noteworthy details.
- Mention any use of internal scale bars.

Acknowledgements

- Acknowledgements should be grouped into a single paragraph placed after the Discussion section.
- Only acknowledge people who have made substantial contributions to the study, and provide the affiliation of those you name.
- Provide the names and affiliation details of members of collaborating bodies.

- Financial support for the study should be acknowledged in a separate support statement; financial support provided to individuals must be disclosed on the conflict of interest declaration.

References

- Number references consecutively in the order in which they first appear in the text, using full-sized Arabic numerals in square brackets to cite references.
- The first three authors should be listed followed by et al.
- References should contain at all the information shown in the following examples:

  1. Bannerjee D, Khair OA, Honeybourne D. Impact of sputum bacteria on airway inflammation and health status in clinical stable COPD. Eur Respir J 2004; 23: 685-692.

  2. Bourbon J, Henrion-Caude A, Gaultier C. Molecular basis of lung development. In: Gibson GJ, Geddes DM, Costable U, Sterk PJ, Corrin B, eds. Respiratory Medicine. 3rd Edn. Edinburgh/Philadelphia, Elsevier Science, 2002; pp. 64-81.

- Documents published online, and individual web pages, should be listed in the reference list, not in the text, and only used when an original citation is unavailable; citations should contain at all the information shown in this example (include the author of the webpage, its title, the URL on which the cited material can be found, and the dates on which the webpage was last accessed by you, and on which it was last updated):

  3. WHO. Severe Acute Respiratory Syndrome (SARS). www.who.int/csr/sars/en/index.html. Date last updated: June 1 2004. Date last accessed: June 1 2004.

- References to websites as a whole or sections of websites (rather than particular pages or documents on a website) should be included directly in the text:

  ...data was sourced from the WHO Global Health Observatory (www.who.int/gho/en/)...

- Works that have not yet been accepted for publication and personal communications should not appear in the reference list. These should be mentioned directly in the text.
- A copy of any paper cited as "in press" and not yet available online should be uploaded to the submission platform as supporting material.

Original articles top

Original articles should not exceed 3000 words (you do not need to include the abstract, references, tables and figure captions in this word count). If your manuscript exceeds this limit, please state the final word count and explicit reasons for exceeding the limit in your covering letter.

The total number of figures and/or tables should be limited to no more than eight. Large figures with more than four parts should be avoided: these can be presented as online supplementary material. More information regarding figures can be found above.

Abstract

Please provide an abstract of 250 words or fewer, which is easily understood without reference to the text (see Ann Intern Med 1987; 106: 598-604).

The abstract should have four separate paragraphs, which correspond to: the question addressed by the study; materials/patients and methods; results; and the answer to the question. One or two sentences of background information can be included in the opening paragraph if necessary. The question and answer should be the same as those in the text.

Graphical abstracts can be accepted and will be published as supplementary material. Graphical abstracts must be submitted for peer review and cannot be provided after acceptance.

Include only the most important numbers and results, and avoid using abbreviations.

Introduction

In the introduction, state the question you asked (or hypothesis to be tested) and your considerations leading to the formulation of the question. Give only pertinent references.

Material and methods

STUDY SUBJECTS OR ANIMALS

- Clearly describe how the subjects or experimental animals were identified, including the control subjects when used. For animals, see Laboratory Animals 1985; 19: 106-108.
- Clearly state the eligibility criteria for cases and controls in observational studies, or for subjects in clinical trials.
- When reporting studies on human subjects, authors should indicate whether the study procedures were approved, or were exempt from review, by the responsible national or institutional review committee. If no formal ethics committee was available, a statement indicating that the research was conducted according to the principles of the World Medical Association Declaration of Helsinki should be included. Written informed consent must also have been obtained from all subjects and this must be clearly indicated in the paper. See also guidance on the reporting of clinical trials, below.
- Animal experimentation must have been performed according to the Declaration of Helsinki conventions for the use and care of animals.
- Provide details of the species and/or strain and number of animals involved in the study.
- The editors will reject work that does not conform to acceptable ethical criteria.

STUDY DESIGN

- Clearly state the main study objective(s).
- Consider sample size and whether you have enough subjects to reliably address the research question.
- Manuscripts reporting clinical trials should include details of the sample size calculation (*i.e.* the expected effect size, power, level of statistical significance and one- or two-sided test).
- For systematic reviews, make sure that the keywords used to search electronic medical databases cover different terminology (for example, tumour or cancer) and spelling (for example, randomised or randomized).

METHODS

- Provide an overview of the main tests or experiments.
- Describe the methods and apparatus in sufficient detail to allow other workers to evaluate or reproduce the tests/experiments.
- For methods that have been published before, provide a reference only, or a reference and brief description.

- Identify drugs and chemicals, including generic name, dosage and route of administration.
- Provide manufacturers' names and addresses (city and country) for equipment, drugs, chemicals and software as necessary, but not in a separate section.

ANALYSIS

- Clearly state and define the main outcome measure(s).
- Briefly state the statistical methods used during the analysis if they are standard. Describe any new methods and justify their use.
- In the case of single- or multicentre trials with blinded intervention, the code must have been broken at the end of the study in the presence of the responsible investigator of each centre. The code and the data will then be available to each participating centre. The first author should make provisions so that if needed, the data are available to the editors for independent statistical analysis.
- Seek advice from a statistician on the appropriate methods of analysis and whether results have been interpreted correctly.

Results

- Keep the results section brief.
- Describe the baseline characteristics or condition of patients or animals.
- Focus on the important results, *i.e.* those that help to address the research question.
- Present most data in figures or tables, not in the text. Use the text to emphasise or summarise the most important observations.

Discussion

- At the beginning of the discussion, summarise the main results, and show how they have addressed the research question.
- Make sure that the conclusions are consistent with the results and are pertinent to the research question.
- Describe the limitations of the study and/or analysis, and discuss their possible implications for the conclusions.
- Emphasise the new and important aspects of the study.
- Try to explain contradictory or unexpected results, or discrepancies with previous findings.