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ORIGINAL ARTICLE

Prevalence of asthma and associated risk factors in schoolchildren from an area of indigenous population

Prevalencia de asma y factores de riesgo asociados en escolares provenientes de una zona de pueblos indígenas

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What do we know about the subject matter of this study?

Asthma is the most frequent chronic disease in childhood. National studies estimate a prevalence from 10.2 to 14.9%. These reports do not include children from the Araucanía Region.

What does this study contribute to what is already known?

This is the first asthma prevalence study conducted in the Araucanía Region, which has an important presence of indigenous people and high levels of contamination due to the use of firewood as the main heating method.

Abstract

The prevalence of asthma in Chile ranges from 10.2 to 14.9%. In previous studies, the Araucanía Region has not been included. **Objective:** To determine the prevalence of asthma in the school population of the Araucanía Region. **Subjects and Method:** The ISAAC questionnaires were used for asthma symptoms in addition to a questionnaire for recording sociodemographic data, belonging to the Mapuche ethnicity, type of heating, exposure to indoor air pollution, and family history. The Binomial Regression Model was used to evaluate the effect of each of the different variables of interest, adjusting by age groups (6-7 and 13-14 years). The model also evaluated the additive interaction between these variables and age. **Results:** 823 surveys were applied, where the prevalence of asthma was 14.2% and 23.2% in the 6-7 year old group and the 13-14 year old group, respectively. 43.7% de-

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clare to be Mapuche, 32.9% live in rural areas, and 81.4% use firewood as a heating method. Through binomial regression model analysis, where for the study group, living in the coastal commune was significantly associated with a lower prevalence of asthma (-13.2% [CI: -17.7 to -8.6]. The history of an asthmatic mother was significantly associated with a higher prevalence of asthma (17.9% [CI: 2.7 to 33.1]. Living in a rural area, to be Mapuche or the type of heating used, showed differences statistically significant (p 0.18, p 0.609 and p 0.480, respectively) **Conclusion:** 13-14 year-olds school children in the Araucanía Region presented a higher prevalence of asthma. There was an association with asthma in the mother where this increase is not associated with living in a rural area, to be Mapuche or type of heating.

Introduction

Asthma is the most common chronic disease in childhood and is the main cause of school absenteeism. The diagnosis of asthma is clinical and is characterized by a variable bronchial obstruction, totally or partially reversible with the use of bronchodilators[1]. The recognition of phenotypes will allow the establishment of functional and prognostic characteristics as well as the indication of personalized therapy[2]. There is evidence that suggests that exposures in indoor environments are important factors in the development and exacerbation of asthma[3]. Environmental triggers for asthma are poor housing, dampness, poor ventilation, and overcrowding which are common conditions in low-income and vulnerable housing[4,5,6,7].

The Global Asthma Network (GAN), established in 2012, followed up on the International Study of Asthma and Allergies in Childhood (ISAAC)[8], where it reported that the prevalence of asthma symptoms was increasing in many places, especially in low- and middle-income countries that also present a high severity[9]. In Bolivia, Solis[10] reports a prevalence of atopic asthma symptoms of 7.3% in participants from urban areas and 3.9% in those from rural areas, concluding the importance of evaluating the role of environmental factors in the development of asthma and allergies. In Brazil, in 2010, a study was conducted on the prevalence of asthma in a population of 3,216 schoolchildren, showing that asthma is a highly prevalent disease that should be addressed as a public health problem[11]. The study by Quadros et al[12]. carried out in Minas Gerais, Brazil, reports different prevalence according to the degree of severity of asthma, with 4.8% for those cases where more than four asthma episodes per year were reported and 4.2% for clinically diagnosed asthma. In Peru, Martín M et al[13]. in 2017, reported an asthma prevalence of 16.7%, of which only 52.5% of children with asthma were under medical treatment, thus demonstrating the limited availability of medications and access to medical services.

In Chile, the results of the ISAAC conducted by Mallol in 2007[14] show a prevalence of 15% to 18% of asthma in schoolchildren aged 6 to 7 years. In schoolchildren between 13 and 14 years of age, it reports a prevalence of 9.8% to 15.5%. These results came from the analysis of data collected in 3 specific regions of Chile (south of Santiago, Valdivia, and Punta Arenas) which, although they have an important sample size, do not allow us to assess the particular characteristics of other populations in the country[15]. The Araucanía Region and the Mapuche ethnic group are not included in this study. Likewise, it showed that the prevalence of asthma evaluated through the questionnaire has significantly increased in Chilean adolescents in the last 8 years, and in the case of the 6-7 year-old group, the prevalence figures remained without significant changes during this period[14]. Regarding the Araucanía Region, there are no data on asthma prevalence. However, concerning indoor pollutants, a study carried out in kindergartens and daycare centers in Temuco and Padre Las Casas identified the main indoor pollutants as cigarettes (74.6%), coal (65.3%), dust (62.2%), and kerosene (54.2%), as well as outdoor pollutants such as smoke, vehicle combustion, soil-dust, and factory combustion[16].

The Araucanía Region also stands out for its sociodemographic characteristics, where 23.4% of the population declares itself to belong to the Mapuche ethnic group, with a rural percentage of 34%. The average per capita income is CLP 913,065. The forestry, farming, and livestock sector account for 20.6% of the land, mainly for forestry plantations (64.3%), cereals (18.5%), and fodder plants (9.8%). The unemployment rate is 7.6% in 2019 (INE).

In 2010, data from the SEREMI for the Environment in Temuco and Padre Las Casas showed that 80% of households use firewood for heating and/or cooking, which means an annual consumption of 654,000 m^3/year, due to the low temperatures recorded from March to September, lower sales price compared with other fuels, local availability of firewood, and cultural roots. This generates a significant increase in particulate matter 2.5 (PM2.5) during the fall-winter months. Therefore, in 2015, a decontamination plan was developed for the communes of Temuco and Pa-

dre Las Casas to improve the quality of firewood used, improving heaters, improving the thermal efficiency of homes, control of fixed and mobile sources, as well as the management of critical pollution episodes, education, and environmental compensation for nearby toxic emissions.

The particular characteristics of this region, namely the high percentage of rural population[17] and use of wood heating[18], allow us to hypothesize that ethnic and environmental factors may have an important effect on the prevalence of asthma in the school population of the Araucanía Region. Based on this hypothesis, the objective of this study is to determine the prevalence of asthma in schoolchildren in the Araucanía Region and risk factors for asthma, such as asthma in parents, schooling, sociodemographic factors, Mapuche ethnicity, urban or rural place of residence, type of heating, and exposure to cigarette smoke.

Material and Method

Cross-sectional analytical study with a statistical representation of the school population in relation to the prevalence of asthma symptoms and its comparison between risk groups. The population is composed of schoolchildren in first and second grade (level 1) and eighth grade and first grade of high school (level 2) in the region of La Araucanía during the fall and winter of 2017 and 2018. The ISAAC Phase I questionnaire[8] was used to determine the prevalence of asthma. In addition, a questionnaire was attached to record sociodemographic data, place of residence, Mapuche ethnicity, type of heating, exposure to indoor pollutants, and family history of asthma. The population was stratified by combining three geographical levels (coast, center, and mountain range) and two provinces that make up the region (Cautín and Malleco). Thus, there were 5 strata since the province of Malleco does not have communes in the coastal zone. The sampling was multistage random, where the sampling units were communes, educational establishments, and grades corresponding to each stratum. All school children in the selected grades were included.

The distribution of children by grade, educational establishment, and communes within each stratum was based on the 2015 enrollment database reported by the Center for Studies of the Ministry of Education. From the database, 456 establishments offering 1,490 grades in levels 1 and 2 and a total enrollment of 39,306 children were selected, in addition to 169 establishments offering 476 first grade of high school and a total enrollment of 15,708 children, and 108 establishments offering both levels of education were registered.

For this study, the sample size estimate considers cluster sampling, with a design effect of 1.3, which is the value assigned by empirical criterion since the value of the corresponding intraclass correlation coefficient is unknown. The sample size is 770 schoolchildren (stage I), considering an absolute precision in the estimation of asthma symptoms of 4 percentage points, expected prevalence of 50% (which maximizes the sample size), and 95% of confidence interval. Subsequently, the Binomial Regression Model was used to evaluate the effect of each of the different variables of interest, adjusting for age groups (6-7 and 13-14 years). The model also evaluated the additive interaction between these variables and age. This allows to evaluate the statistical significance of the difference in the prevalence of the different variables of interest, adjusted by age group. Due to the sample size, it was not possible to adjust for more than one variable at a time. When significant differences in prevalence were detected, they were expressed in percentage points, point prevalence, and confidence intervals.

The sampling considered a proportional distribution at all sampling stages, randomly selecting 10 of the 30 municipalities in the region, including Temuco and Padre Las Casas, due to their relative importance regarding population and contamination characteristics. These 12 communes represent 37.5% of the parishes in the region and concentrate 63.5% of the enrollment of the two levels. It was agreed to include, in each selected commune, at least one elementary or middle school, and at least one grade per educational level. The educational establishments and grades were selected by simple random sampling at each level.

The legal representative of each selected school was contacted and invited to participate in the study through an informative letter. Subsequently, contact with the selected school or schools was requested. Only two establishments did not agree to participate despite having been visited personally and were replaced by an establishment selected at random, among those with similar characteristics in terms of size (number of grades and enrollment).

The surveys were tested in the first sampled establishments, adjusting them to the field reality without major changes to the original format.

The study has the approval of the Ethics Committee of the Araucanía Sur Health Service and all parents signed informed consent and children the assent for those in 8th grade and 1st grade of high school.

In this first stage, we focused on estimating prevalence and adjusting the recording instruments for the characterization of the housing. In the second stage, in order to correlate prevalence with the risk factors described in the literature and measured in this study, we plan to expand the sample to achieve at least 80% of statistical power.

Results

823 surveys were analyzed among schoolchildren in the Araucanía Region, distributed in 10 communes, from the provinces of Malleco (n: 648) and Cautín (n: 175). Of the total of students, 638 (77.5%) live in central communes, 47 (5.7%) in the mountain range, and 138 (16.8%) in the coastal zone. 32.9% (n: 271) live in rural areas and 43.7% declared themselves to belong to the Mapuche ethnic group. The most used heating method was firewood (81.4%). Table 1 describes other variables analyzed, such as indoor smoking, presence of pets, parental schooling, and family history of asthma.

The prevalence of asthma was 14.2% in the 6-7 year-old group and 23.2% in the 13-14 year-old group. In the 6-7 year-old group, 27.1% presented coughing at night and 13.4% exercise-induced cough. In the 13-14 year-old group, 26.9% presented coughing at night and 15% exercise-induced cough (table 2).

A binomial regression model analysis was performed (table 3) which showed statistically significant differences in prevalence between the groups of 6-7 years and 13-14 years (9pp, 95%CI: 3.7 to 14.3), adjusted for each of the variables studied. In this analysis for the total group studied, living in a coastal commune was significantly associated with a lower prevalence of asthma (-13.2 pp, 95%CI: -17.7 to -8.6). On the other hand, the history of a mother with asthma was statistically significantly associated with a higher prevalence of asthma in the schoolchildren studied (17.9pp, 95%CI: 2.7 to 33.1). Living in a rural area, belonging to a Mapuche ethnic group, type of heating, and exposure to cigarette smoke at home showed statistically significant differences (p 0.18, p 0.61, p 0.48, and p 0.72 respectively).

Discussion

Our results show a 23.2% of prevalence of asthma in schoolchildren aged 13-14 years, higher than that reported by Mallol, which was 14.9% in the same group of school children. In the Dirceu Solé[19] and Martin[20] studies, no higher prevalence was observed in the 13-14 years age group. In the binomial regression model, there was no association of higher prevalence of asthma with Mapuche ethnicity, rurality, and type of heating, which had been our initial working hypothesis. In our study, rurality was not associated with increased asthma prevalence. A study in Bolivia[10] reports higher prevalence in urban vs. rural areas (21.7 vs. 16.4).

Regarding the history of maternal asthma, in our sample it was statistically significant, which is in line with what is reported in the literature. In 2017, a systematic review by Castro-Rodriguez et al that included 33 primary studies concludes that maternal history of asthma triples the risk of asthma in childhood. It is important to mention that in our study the history of maternal asthma was obtained by self-report which, as reported in the literature, could influence compared with the medical diagnosis of maternal asthma[21]. Therefore, further research is needed to determine the cause of this higher prevalence compared with the ISAAC study in Chile[14].

Regarding the type of heating, our results show that firewood is mostly used. This has led to the communes of Temuco and Padre Las Casas being among the most polluted in Latin America[16], promoting the creation of regional policies to reduce the polluting effect of firewood, favoring the use of certified low-moisture firewood and the replacement of heaters for less polluting systems. It is also important to mention that the levels of particulate matter in the cities studied fluctuate significantly during the day, with increases in the afternoon due to heating patterns. This could be related to an increase in coughing at night as a symptom of asthma. New studies could be oriented to determine variation in bronchial inflammation, for example, through fractional exhaled nitric oxide, according to time of day. Due to the global nature of the problem in the region, the single use of a less polluting indoor method would not be able to reduce the risk of pollution damage since children are exposed to high levels of pollution in their school and outdoor environment.

On the other hand, Mapuche ethnicity was not shown to be a factor that modifies the prevalence of asthma. This could be due to the fact that the way to determine Mapuche ethnicity was self-reporting, following the way of determining Mapuche ethnicity used in population censuses (National Statistics Institute, INE). Further studies would be necessary to evaluate whether any genetic variant may be associated with a higher prevalence of asthma.

Human activities have increased atmospheric concentrations of carbon dioxide (CO2) and other greenhouse gases, modifying the geo-climatic characteristics in industrialized cities. Pollution increases the permeability of the respiratory mucosa and aeroallergens reaching the peripheral airways can induce asthma in sensitized patients[22].

The ISAAC study (in children aged 6-7 and 13-14 years) in Spanish cities located in the coastal and valley areas showed that the prevalence of asthma was significantly higher on the coast[23]. In our study, we report a lower prevalence of asthma in schoolchildren living in the coastal zone (Carahue and Puerto Saavedra), which could be explained by the fact that it is a non-industrialized zone, with a lower population density, a small automobile fleet, the main activity is artisanal fishing, the diet has a strong fish and seafood compo-

Table 1. Sociodemographic characteristics by group of age n(%)

Characteristics		Age (years)		Total
		6-7 (n = 417)	13-14 (n = 406)	(n = 823)
Province Cautín		390 (93.5)	258 (63.6)	648 (78.7)
Rural		108 (26.0)	163 (40.2)	271 (32.9)
Zone	Center	329 (78.9)	309 (76.1)	638 (77.5)
	Mountain	33 (7.9)	14 (3.5)	47 (5.7)
	Coast	55 (13.2)	83 (20.4)	138 (16.8)
Mapuche Ethnic group		178 (42.7)	182 (44.8)	360 (43.7)
Heating system	Wood burning	328 (78.6)	342 (84.2)	670 (81.4)
	Gas	33 (7.9)	8 (2.0)	41 (5.0)
	Kerosene	11 (2.6)	12 (3.0)	23 (3.0)
	Electric /Pellet	35 (8.4)	13 (3.2)	48 (5.8)
	brazier, stove	6 (1.4)	19 (4.7)	25 (3.0)
Clothes drying inside the home		179 (42.9)	181 (44.6)	360 (43.7)
Intra-domiciliary tobacco		17 (4.1)	82 (20.2)	99 (12.0)
Pets inside the house		129 (30.9)	254 (62.6)	383 (46.5)
Mother with incomplete high school education		101 (24.2)	234 (57.6)	335 (40.7)
Asthma in the mother		27 (6.5)	11 (2.7)	38 (4.6)

Table 2. Asthma Symptom Questionnaire in Schoolchildren of the region of La Araucanía. n (%)

Symptoms	Age group (years)		Total
	6-7 años	13-14 años	(n = 823)
Wheezing ever	199 (47.7)	124 (30.5)	323 (39.3)
Wheezing in the past 12 months	107 (25.7)	81 (20.0)	188 (22.8)
Coughing with exercise	56 (13.4)	61 (15.0)	117 (14.2)
Night cough	113 (27.1)	109 (26.9)	222 (27.0)
Diagnosis of asthma, ever	59 (14.2)	94 (23.2)	153 (18.6)

nent, and it has a warmer temperate and rainy climate. The long-term influence of climatic variables such as temperature or humidity on the prevalence of asthma has yet to be extensively investigated.

This is the first study on asthma prevalence carried out in the Araucanía Region, which allows us to project future research in the line of epigenetic studies, effects of environmental pollution on lung function, and study of asthma severity in Mapuche and non-Mapuche population. The limitation of the study is inherent to a survey study, which could explain the low self-reporting of indoor smoking (12%) (table 1). A study conducted in Brazil[24] analyzing 2 populations reports 12.5% and 13.5%, respectively, for indoor smoking.

Conclusions

There is a higher prevalence of asthma in schoolchildren aged 13-14 years in the Araucanía Region. There is an association with asthma in the mother and this increase is not associated with living in a rural area, belonging to a Mapuche ethnic group, or type of heating.

Table 3. Binomial Regression Model. N° of cases (prevalence %), Parameters estimation and p values.

Biodemographic factors		Age (years)		p value[C] / IC95%
		6-7	13-14	
Zone	Center	49 (14.9)	81 (26.2)	Reference group
	Mountain	9 (27.3)	2 (14.3)	0.326
	Coast	1 (1.8)	11 (13.3)	-13.2 [-17.7 a -8.6]
	IC95%[E]	10.6 [5.8 a 15.5]		
Household location	Rural	15 (13.9)	30 (18.4)	0.189
	Urbane	44 (14.2)	64 (26.3)	
	IC95%[E]	9.3 [3.9 a 14.6]		
Ethnic group	No Mapuche	34 (14.2)	55 (24.6)	0.609
	Mapuche	25 (14.0)	39 (21.4)	
	IC95%[E]	9.0 [3.7 a 18.0]		
Heating system	Wood burning (for cooking or heating)	49 (14.9)	75 (21.9)	0.480
	Gas	2 (5.9)	2 (25.0)	0.090
	Kerosene	0 (0)	8 (42.1)	0.470
	Electric /Pellet	6 (15.4)	8 (21.0)	Reference group
	Brazier, stove	2 (18.2)	1 (8.3)	0.406
	IC95%	8.1 [2.7 a 13.4]		
Mother with Asthma	Yes	7 (25.9)	6 (54.5)	17.9 [2.7 a 33.1]
	No	52 (13.3)	88 (22.3)	
	IC95%[E]	9.4 [4.2 a 14.7]		
Intra-domiciliary tobacco	Yes	2 (11.8)	21 (25.6)	0.717
	No	57 (14.3)	73 (22.5)	
	IC95%[E]	8.7 [3.2 a 14.2]		
Total	n (Prevalence%)	59 (14.2)	94 (23.2)	
	IC95%	9.0 [3.7 a 14.3]		

[E]Confidence interval difference in asthma prevalence (percentage points, pp) between the 13-14 and 6-7 years of age, adjusted by biodemographic factor. [C]Confidence interval difference in asthma prevalence (pp) between categories of biodemographic factors, adjusted for age groups.The additive interactions between the age groups and the characteristics were not significant, there is no synergistic or antagonistic effect between the factors listed here and the age groups.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

Financial Disclosure

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