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Asthma and Geographical Altitude: An Inverse Relationship in Mexico

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ABSTRACT

Motivated by the great asthma-prevalence variation throughout the world, we analyzed the rate variation of medical services due to asthma in the 32 Mexican states at the Instituto Mexicano del Seguro Social (approximately 24 million insured subjects). In 1993, a total of 406,036 services were due to asthma, and state rates ranged from 53 to 476 × 10,000 insured subjects. A direct correlation ($p < 0.05$) was found for single-room house, ascariasis, and rubella rates, but the strongest (inverse) correlation was found for geographical altitude

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($r = -0.73$, $p < 10^{-5}$). Thus, in Mexico, geographical altitude affects the etiological factor(s) responsible for the development of asthma or for the triggering of asthma attacks.

INTRODUCTION

Asthma is a disease with a noticeably high prevalence worldwide. However, the prevalence rates vary greatly throughout the world, from negligible in some regions of northern Europe and Gambia (1,2), to up to 25% of the general population in countries such as New Zealand (3). The causes of these large differences among regions are unclear, though it seems reasonable to speculate that they may be explained by differences in biological (such as ethnicity, antigen load, and parasitism), socioeconomic (such as poverty and health education), geographical (such as humidity and temperature), or medical (such as access to health services and physician skills) conditions. Although it is evident that understanding the origin of such differences may provide important insights into asthma pathogenesis or into key factors affecting asthma development, this issue has not yet been sufficiently addressed. In a recent study in Mexico (4), we found that the rates of medical services due to asthma in the pediatric population also showed a great variation throughout the country. Thus, the rates of medical services for asthma in Mexico seem to reproduce the phenomenon observed in relation to asthma prevalence variation worldwide. In this context, in the present work data on all medical services provided to asthmatic patients of all ages by the largest health institution in Mexico were analyzed and correlated to several variables.

METHODOLOGY

Data from the Instituto Mexicano del Seguro Social (IMSS), which is the official medical assistance provider for nonfederal workers and their families (approximately 24 million insured subjects), were obtained for the entire year 1993. The number of outpatients visiting the family physician or specialist physician, as well as the number of emergency room visits and hospital discharges, were analyzed for each of the 32 Mexican states (including the Distrito Federal). Rates of medical services for asthma were calculated for each of these settings by dividing the number of medical services due to asthma by the number of insured subjects with a medical record registered at the institution in the same state and in the same year. The results were correlated with many sociodemographic and health services factors (1990 General Census of Population and Housing), main reportable diseases (1993, Dirección General de Epidemiología, Secretaría de Salud), and altitude over sea level (Instituto Nacional de Geografía, Estadística e Informática, Mexico). Most variables were selected because of their high prevalence in the general population and/or their potential involvement in the asthmatic process. Three reportable diseases (diabetes, high blood pressure, and trauma and poisoning) were also included as dummy variables. Altitude was calculated for every state by averaging the geographical elevations of its main cities. With this procedure, the number of cities considered in each state varied from one to eight (3.34 ± 0.34, mean $\pm$ SEM), which took into account $50.36 \pm 4.06\%$ of every state's population. Finally, for the evaluation of altitude, an additional analysis of its relationship with every medical setting was performed.

Data were analyzed by straight-line regression and Pearson's correlation. Statistical significance was set at two-tailed $p < 0.05$.

RESULTS

A total of 406,036 medical services motivated by asthma were provided by the IMSS in 1993 throughout the country, with a global rate of 170.8 $\times$ 10,000 insured subjects. How-

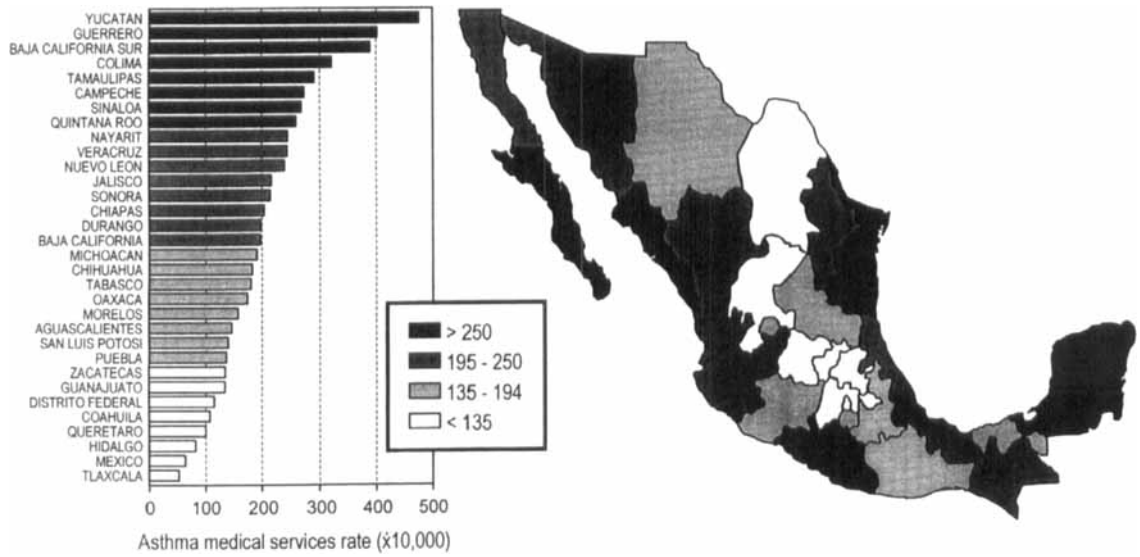

Figure 1. Rates of medical services for asthma in Mexican states. Data correspond to the total number of family physician or specialist physician consultations, emergency room visits, and hospital discharges, carried out during 1993 at the Instituto Mexicano del Seguro Social and divided by the number of insured subjects with a medical record registered at that institution in the same year.

ever, great variability of the asthma medical services rate was observed from state to state, which ranged from 53.0 to 476.1 × 10,000 insured subjects (Fig. 1). This wide variation was also encountered for each of the analyzed clinical settings. Calculated rates (×10,000 insured subjects) ranged from 10.2 to 189.8 for family physician initial visits, from 14.9 to 159.0 for family physician follow-up visits, from 8.3 to 114.4 for specialist physician consultations, from 10.6 to 174.0 for emergency room visits, and from 0.8 to 19.3 for hospital discharges.

Table 1 shows the correlation coefficients of asthma medical services rates related to selected variables. Positive correlation was found for single-room house rate ($r = 0.39$, $p < 0.05$), ascariasis rate ($r = 0.38$, $p < 0.05$), and rubella rate ($r = 0.43$, $p < 0.05$) variables. A strong negative correlation was found for geographical altitude, with an $r = -0.73$ ($p < 10^{-5}$, Fig. 2), i.e., the lower the geographical altitude, the higher the total asthma medical services rate. The regression formula was $y = 287.9 - 0.084x$, where y is the asthma medical services rate (×10,000 insured subjects), and x is the altitude in meters over sea level. This negative correlation with altitude persisted when asthma medical services rates were reanalyzed for every clinical setting. Thus, a significant negative correlation was found between altitude and family physician initial ($r = -0.57$, $p < 0.001$) and follow-up ($r = -0.62$, $p < 0.0005$) visits, specialist physician visits ($r = -0.53$, $p < 0.005$), emergency room visits ($r = -0.55$, $p < 0.005$), and hospital discharges ($r = -0.40$, $p < 0.05$).

DISCUSSION

In this work we found that rates of medical services for asthma in Mexico are inversely correlated to geographical altitude. According to the calculated formula, medical services due to asthma increase 8.4 × 10,000 insured subjects with every 100 m of altitude decrement. This finding is relevant per se because medical care providers and health programs decision-makers need to be aware of regions with high requirements of medical services for asthma patients. However, this finding may also constitute a useful tool in the search for factors related to the pathogenesis of asthma.

The nature of the factor(s) associated to alti-

Table 1. Correlation Coefficients of Selected Variables Versus Rates of Medical Services for Asthma in Mexico

	r	*p*
Sociodemographic factors		
Birth rate	−0.13	0.94
Educational attainment rate	0.03	0.87
Earthen-floor house rate	0.19	0.30
Income	0.08	0.66
Population density	−0.21	0.25
Population growth rate	0.13	0.48
Rural/urban population ratio	−0.07	0.70
Single-room house rate	0.39	0.027
Health services		
All-causes mortality rate	−0.27	0.13
Asthma mortality rate	0.27	0.13
Hospital beds rate	0.12	0.51
Physician rate	0.11	0.55
Selected diseases		
Acute respiratory infections rate	0.33	0.065
Ascariasis rate	0.38	0.032
Childhood undernutrition rate	0.10	0.59
Dermatomycoses rate	0.30	0.095
Diabetes rate	0.23	0.21
High blood pressure rate	0.17	0.35
Pneumonia rate	0.17	0.35
Pulmonary tuberculosis rate	0.34	0.057
Rubella rate	0.43	0.014
Trauma and poisoning rate	−0.03	0.89
Varicella rate	0.24	0.19
Geographical factors		
Altitude	−0.73	0.0000019

tude and responsible for the variation in asthma medical services rates is unclear, but it is interesting to note that it must be strong enough to overcome some conditions already known to affect asthma. For example, urban air pollution with diesel exhausts or ozone seems to favor sensitization to allergens and exacerbations of asthma, respectively (5,6). Nevertheless, in our study the Distrito Federal (which includes most of Mexico City, perhaps the most polluted city in the world) was ranked only sixth among the states with lowest asthma medical services rates (115.2 × 10,000), whereas some states with negligible air pollution had the greatest asthma medical services rates (Yucatán, 476.1 × 10,000; Guerrero, 401.7 × 10,000; and Baja California Sur, 389.2 × 10,000). Likewise, inhalation of air with a high water content can diminish or prevent one of the commonest asthma exacerbations, exercise-induced asthma (7), and thus coastal regions should have low asthma medical services rates. Nevertheless, in our study this was not the case; in fact, the opposite results were found.

It was demonstrated that indoor antigenic load, mainly from house-dust mites (8), is a key factor determining the presence and severity of asthma. House-dust mites require a high humidity content in the air (75%–80% relative humidity) and temperature between 25 and 28°C in order to optimally thrive (9), and probably due to these reasons their proliferation decreases as the geographical altitude increases (10–13). In fact, it was claimed that house-dust mites barely survive in places at high geographical altitude (>1500 m above sea level). This last postulate seems to be true in places such as Davos, Switzerland (1560 m), Misurina, Italy (1756 m), or Los Alamos, New

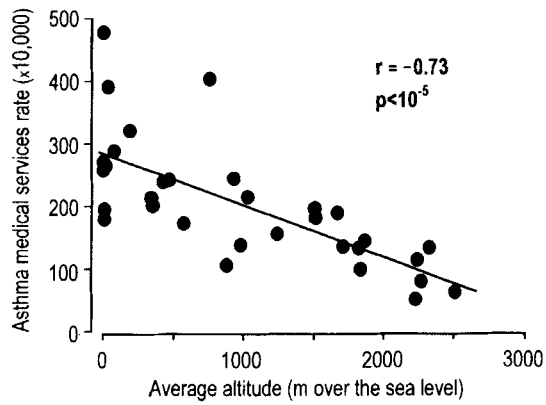

Figure 2. Relationship between altitude and rate of medical services provided to asthmatic patients. Altitude is the averaged geographical elevation above sea level of up to eight main cities of each Mexican state, including the Distrito Federal. Data correspond to the total number of family physician or specialist physician consultations, emergency room visits, and hospital discharges, carried out during 1993 at the Instituto Mexicano del Seguro Social and divided by the number of insured subjects with a medical record registered at that institution in the same year.

Mexico (2195 m) (14–16). Unfortunately, in Mexico there are no comparative studies to determine the house-dust mite concentration at different altitudes. However, in our clinical practice in Mexico city (2240 m) we found a relatively high prevalence of skin test positivity to dust mite antigen (>43%) among children with asthma, and a higher proportion (>50%) was found in Quito, Ecuador (2800 m) (17). Moreover, the presence of *Dermatophagoides* mites was recently demonstrated in a Venezuelan community at 2040–2600 m (18). All of these data suggest that house-dust mites proliferate well even at high altitudes. Therefore, it is possible that in Mexico the progressive increment in asthma medical services rate that we observed as the geographical altitude decreased could reflect the progressive increment of house-dust mite concentration.

Our study yielded contrasting results when some conditions for which a relationship with asthma has been already described were evaluated. For example, it was suggested that poverty (19,20), living in an urban setting (21), and low educational level (20,22) are all conditions leading to a higher prevalence of asthma. In our study, however, none of these variables seemed to be related to asthma, because income, rural/urban population ratio, and educational attainment, respectively, did not correlate with asthma medical services rates. Note, however, that single-room house rate, which could be taken as an indicator of poverty, was positively correlated to the asthma medical services rate.

Studies concerning the relationship between asthma and intestinal parasitism, a common health problem in developing countries, have yielded conflicting results. Some results suggest that parasitism is inversely related to the frequency of asthma (2), possibly via a saturation of mast cell Fc_ε receptors. Many other studies, however, show that intestinal parasitism is more frequent in asthma patients, suggesting that parasites cause polyclonal activation of immunoglobulin-E (IgE)-producing cells, thus increasing the amount of IgE induced by airborne allergens (23,24). Our study supports this last concept, because we found that the higher the ascariasis rate, the higher the rate of medical services given to asthma patients. On the other hand, it was recently postulated that viral or bacterial infections, including tuberculosis, could diminish the development of allergies by reinforcing the immune responses mediated by the lymphocyte TH_1 subset (25,26). Our results showed an opposite trend, because rubella (and also in a marginal fashion acute respiratory infections and pulmonary tuberculosis) had a direct correlation with asthma medical services rate. The reason for this discrepancy is unclear and deserves further investigation.

The study also revealed a lack of association between asthma medical services rate and some indexes of health services. Thus, the greater proportion of cases in certain states does not depend on a greater number of medical facilities or physicians, which would make the diagnosis of asthma more feasible. Likewise, mortality from asthma was also devoid of statistically significant correlation. At first glance this last finding might suggest that the altitude-dependent factor is only related to the development of asthma but does not determine its severity. However, a closer examination of data, as mentioned above, revealed that an inverse correlation also exists between altitude and either emergency room visits or hos-

pital discharges due to asthma. Because these hospital-based services receive the most severe cases of asthma exacerbations, this suggests that severity is also influenced by altitude.

A potential shortcoming of this part of our study is that data on sociodemographic factors, health services, and selected diseases were obtained from national statistics corresponding to the entire Mexican population, whereas data on asthma medical services were obtained from IMSS, an institution offering medical services to about one-fourth of the total population. Thus, it is possible that data on tested variables do not match closely the conditions of the institutional population covered by IMSS. In spite of this disadvantage, because of the large number of individuals included in the study, our results seem to be strong enough to support the conclusions. Moreover, this drawback is not present for geographical altitude, the variable with the closest correlation to asthma medical services rate. By contrast, our study was performed in a population of relatively homogeneous ethnicity (because the Mexican population has no clearly delimited races, which occur in other countries), and it was carried out in a single nationwide institution. Thus, differences in race and in data collection may be discarded as causal factors of the asthma medical services rate variability.

Finally, a provocative study (27) found that staying in a very high altitude (>4500 m) for a period as short as 72 hr diminishes the airway hyperresponsiveness to hypo-osmolar challenge in patients with mild asthma. Evidently, this time period is so short that the changes in airway responsiveness must be due to factors (such as atmospheric conditions or physiological adaptation) other than modification of the antigen load. The possible role, if any, of these factors in the variability of asthma medical services rate awaits clarification by further studies.

CONCLUSIONS

Our results demonstrated that in Mexico, geographical altitude affects some factor(s) responsible for asthma development or for the triggering of asthma attacks. Although house-dust mite concentration may constitute one of these factors, many other conditions could be involved and deserve further investigation.

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