

## Chapter 2

# Pollution and Lifestyle Causes of Asthma and Allergies Among School Children of Tamaulipas, Mexico in the U.S.–Mexico Border Region

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**Abstract** The prevalence of asthma, allergic rhinitis, and eczema in school children in the cities of Northeastern Mexican State of Tamaulipas and potential correlation with ambient pollution factors were studied using the International Study of Asthma and Allergies in Childhood (ISAAC) epidemiology research methodology Phase 1. The study indicates that asthma and rhinitis are more prevalent than eczema in both elementary and middle school children with rhinitis prevalence significantly higher in Reynosa elementary school children. Asthma was more prevalent in Nuevo Laredo middle school children than in the other cities' middle school children likely due to higher frequency of smoking among children as a very strong correlation was found between asthma occurrence and children smoking habits. Lead and pesticide intoxications are higher in middle school children than in elementary school children. Middle school children in Nuevo Laredo exhibit two or more time the pesticide intoxications than middle school children in Reynosa and Matamoros; however, the study indicates that Matamoros

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has the highest outdoor fumigation and Nuevo Laredo the lowest indoor fumigation. Indoor air quality may also be a factor as the study shows the combined results for the three cities of Matamoros, Reynosa, and Nuevo Laredo that 60 % of households use coal or wood for heating purposes, and 60 % of households use natural gas for cooking.

**Keywords** Air quality • Environmental health indicators • Health effects • Mortality cases • Mortality rates • South Texas-Northeastern Mexico border region

## 2.1 Introduction

The United States (U.S.)–Mexico border region have grown rapidly in the last few decades due to improved economy, rapid industrialization, greater trans-border linkages, and growth in population (Pick, Viswanathan, & Hettrick, 2001). The border population grew from 7 million in 1980 to 13 million in 2005. Since the implementation of the North American Free Trade Agreement (NAFTA) in 1993, the border regions have experienced an expansion of industrial complexes known as *maquiladoras* (Shi, Fernando, & Yang, 2009). The section of the border region between South Texas and Northeastern Mexico is an area of special interest since large cities, *colonias* and industries are located on both sides of the border (Mejía-Velazquez & Rodríguez-Gallegos, 1997). Rapid economic growth and increasing population in this border region have led to several environmental and health concerns.

Air pollution is a major environmental concern. Studies have suggested that air pollutants cause various adverse health effects. The effects of environmental air pollution are potentially more adverse on sensitive population such as children and elderly and make them more vulnerable and susceptible to environmental risk (International Study of Asthma and Allergies in Childhood [ISAAC], 1993; Mejía, Choy, Mengersen, & Morawska, 2011; Samoli, Nastos, Paliatsos, Katsouyanni, & Priftis, 2011). Children seem to be the most vulnerable to air pollution because their defense mechanism is not fully developed and they inhale a higher volume of air per body weight than adults. In addition they perform a greater level of physical activity and spend more time outdoors than adults (Salvi, 2007; Tabaku, Bejtja, Bala, Toci, & Resuli, 2011). At school children are exposed to emissions from sources within and outside the school. Studies have shown higher prevalence of illness among children attending schools near industrial and mobile sources (Mejía et al., 2011). The observed illnesses from air pollution in children include increased respiratory symptoms and diseases, aggravation of asthma, decrease in lung function, and school absenteeism (He et al., 2010). These effects have led to high health service costs in admissions and hospitalizations (Feitosa et al., 2011). Environmental health effects are commonly associated with smoking, air pollution, pesticides, and other toxic chemicals which have been identified as key unfavorable environmental pollutants by the United States Environmental Protection Agency (U.S. Environmental Protection Agency [U.S. EPA], 2006). Environmental health

effects of asthma and allergies such as rhinitis, dermatitis, and eczema among children have been increasing globally for the past few decades (Leung, Ko, & Wong 2012; Peñaranda, Aristizabal, García, Vásquez, & Rodríguez-Martínez, 2012). This increasing trend can be attributed to changes associated with environmental and lifestyle changes during this modernization period. Indoor air pollution caused from the use of wood or coal burning for cooking or heating purposes can also cause significant particle pollution (Leung et al., 2012). The environmental health effects of asthma, rhinitis, and eczema, particularly in children, in the border region have not been studied sufficiently. ISAAC is a worldwide epidemiological research program established to study prevalence, severity, and variations in childhood asthma and allergies such as rhinitis and eczema at the population level, comparison of these diseases worldwide, monitor and obtain baseline measures for assessment of future trends, and provide a framework for further etiological research into genetic, lifestyle, environmental, and medical care factors affecting these diseases (ISAAC; Peñaranda et al., 2012). ISAAC was the first investigation carried out worldwide using standardized written and video questionnaires to study and generate a global map of childhood asthma and allergies such as rhinitis and eczema and to monitor future trends in these diseases (Behbehani et al., 2000; Pegas et al., 2011).

The present study is focused on determining the prevalence of asthma, rhinitis, and eczema in school children by applying a modified ISAAC questionnaire for the cities of Matamoros, Reynosa, and Nuevo Laredo in the State of Tamaulipas in Northeastern Mexico. Several studies have demonstrated that children can be screened for asthma and allergies by applying the ISAAC questionnaire at both the elementary and middle school ages (Peroni, Piacentini, Bodini, & Boner, 2009). The populations of Tamaulipas have grown from about 720,000 in 1950 to 2,750,000 in 2000, which is about a 400 % increase for that period (Pick et al., 2001). The ISAAC questionnaire methodology was chosen for this study because environmental and health information is incomplete and not readily available for this region. Three cities in the state of Tamaulipas were selected for investigation, Matamoros, Reynosa, and Nuevo Laredo. Table 2.1 summarizes the population growth and Fig. 2.1 shows the location of these cities within the South Texas-Tamaulipas border region.

The increase in the population of Tamaulipas can be attributed to domestic migration due to the relative economic prosperity resulting from the increasing U.S.–Mexico commercial flow and the jobs created by the *maquiladoras* industry. These cities also serve as holding zones for migration to the United States (Pick et al., 2001).

The research aimed to determine the prevalence of asthma, rhinitis, and eczema in children living in the selected cities located in Tamaulipas, determine the potential causes, and draw conclusions from comparisons between schools. This research also intended to establish a baseline for assessment of future trends in the prevalence of these diseases and to provide a framework for further epidemiological research of factors affecting these diseases such as genetics, lifestyle, environment, and medical care.

**Table 2.1** Population growth of Tamaulipas cities, 1930–2020 (Pick et al., 2001)

Cities	1930	1950	1970	1990	2020 projected	Annual growth rate
Matamoros	9,733	45,846	140,660	303,295	736,891	4.8
Reynosa	4,840	34,087	140,480	282,666	658,403	5.5
Nuevo Laredo	21,636	57,668	152,325	219,465	633,770	3.8



**Fig. 2.1** Location of Tamaulipas cities in the Northeastern Mexico-Texas border region

## 2.2 Methodology

### 2.2.1 ISAAC Study Phases

The ISAAC study typically has three phases as described in Table 2.2 (ISAAC, 1993).

### 2.2.2 Selection of the Study Population

This study concentrated on Phase I of the ISAAC study design phases. Phase I is a compulsory core study designed to assess the prevalence and severity of asthma and allergic diseases in the defined population. The population in this study consisted of approximately 3,000 children aged 6–7 and 13–14 years old attending elementary and middle schools in the three border cities of Matamoros, Reynosa, and Nuevo Laredo in the Mexican State of Tamaulipas. Children participating in the survey were selected at random from those meeting the age criterion identified from the

**Table 2.2** ISAAC study design phases

Phase I	A compulsory core study designed to assess the prevalence and severity of asthma and allergic disease in defined populations
Phase II	Study will be developed to investigate possible etiological factors, particularly those suggested by the findings of Phase I, and involves more detailed studies of etiological factors and clinical examination of subgroups of children
Phase III	A repetition of Phase I will be initiated after a period of 3 years

schools' class registers. It is recognized that there may be some children outside the specified age ranges in each class chosen. These children will be included in the data collection, but will be excluded from analysis for the international comparison. The younger age group (6–7 years of age) was chosen to give a reflection of the early childhood years when asthma is common and admission rates are particularly higher. The older age group (13–14 years of age) was chosen to reflect the period when mortality from asthma is more common. As explained in the next section, the parents or the children themselves were asked to complete the ISAAC questionnaire on asthma, rhinitis, and eczema.

The schools selected for the study represent major city sectors and proximity to existing risk factors such as industrial parks, open landfills, pollution emission point sources, and high-traffic roads with high mobile source emissions. In each city 12 elementary and 12 middle schools were selected. It was the intent to distribute 2,400 questionnaires per city, with the goal of collecting 30 %. Wherever possible, the schools selected had equivalent children populations.

### **2.2.3 Legal, Ethical, and Logistic Considerations**

With the Public School Secretary's authorization, private and public school directors were contacted for individual authorization. Once the directors gave their approval to the project, the children parents were asked for their consent to respond to the questionnaire or for their child to respond to the questionnaire. For the elementary school children (6–7 years of age), informative parental meetings were held in elementary schools to provide them full disclosure related to the project, including how to complete the ISAAC questionnaire by fully explaining the associated set of instructions. The parents answered the questionnaires at home and returned them to the school. For the middle school children (13–14 years of age), the ISAAC questionnaire was answered by them in their school under the supervision of their classroom teacher. Prior to answering the questionnaires the middle school children received a brief informative lecture on respiratory diseases and their preventive measures.

### **2.2.4 ISAAC Self-Answered Questionnaire Data**

The prevalence of diseases among school children was determined through the modified ISAAC questionnaire, intended for parents of 6–7 year old elementary school children and for 13–14 year old middle school children themselves. Both questionnaires had identical questions, the only difference was that one of the questionnaires was answered by the parents of the elementary school children and the other questionnaire was answered by the middle school children themselves. The modification of the original ISAAC questionnaire consisted of additional questions asking for chemical intoxications such as lead intoxication due to use of paints at home, pesticide intoxication due to use of pesticides and use of indoor insecticide aerosols and burn-sticks, indoor and outdoor fumigation in the vicinity of the home, and type of indoor combustion sources used for heating and cooking purposes. No lead intoxication or lead paint use confirmation was performed; only the self-answered data from questionnaire was used for evaluation. The questionnaire also gathered other information, such as children's place of birth, personal health, and indoor and outdoor risk factors.

### **2.2.5 Data Analysis**

The questionnaire recovery efficiency was determined from the total number of distributed questionnaire and the ones that were returned fully answered. Only the returned fully answered questionnaires were used for data analysis.

## **2.3 Results and Discussion**

Data recovery varied between elementary and middle schools, but remained constant between cities. The elementary school children's questionnaire was sent to their homes for completion and had a recovery rate of 30 %. The middle school children questionnaire were distributed and completed in the classroom during the school day and had a recovery rate of 90 %.

Figures 2.2, 2.3, and 2.4 show maps of Nuevo Laredo, Reynosa, and Matamoros, respectively, subdivided into areas and zones. The figures also indicate school and industry locations.

Table 2.3 indicates the number of ISAAC questionnaire collected from the elementary and middle schools by city.

In this epidemiological study, prevalence was determined as a measure of the proportion of children in schools who had one or more of the studied diseases at the particular time the ISAAC questionnaire was administered. Table 2.4 shows the percentage of children reporting respiratory diseases such as asthma, rhinitis,

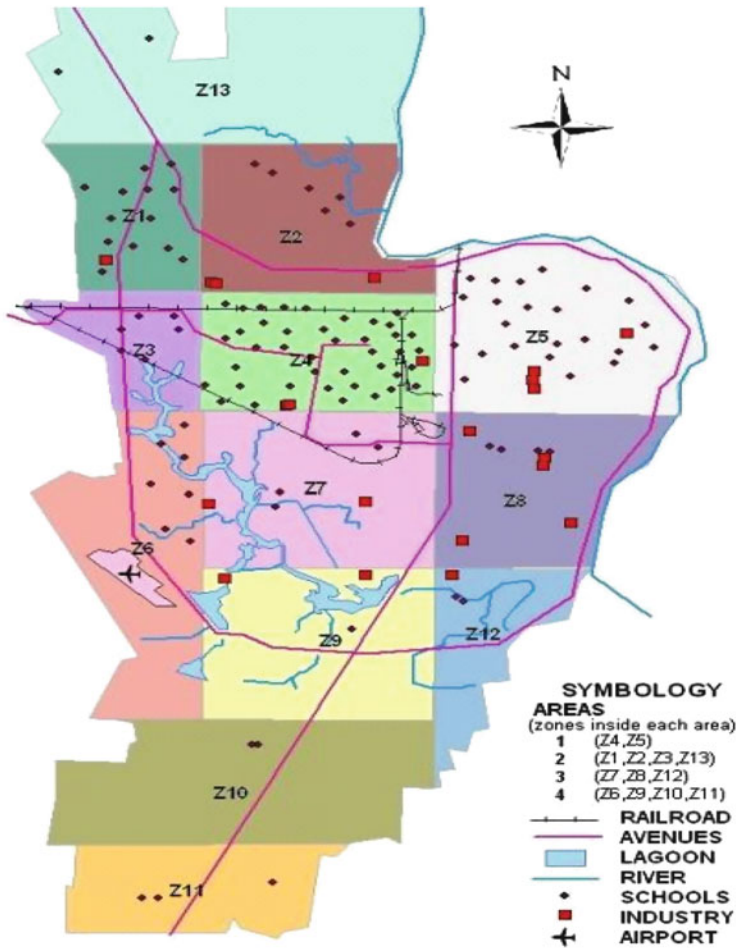


Fig. 2.2 Nuevo Laredo areas and zones with school and industry locations

and eczema on their ISAAC questionnaire. Table 2.5 shows the number of cases of respiratory diseases by age group.

Figure 2.5 shows the prevalence values of various respiratory diseases such as asthma, rhinitis, and eczema by age group for the selected Tamaulipas cities.

The data indicates that the prevalence of asthma and rhinitis is higher than eczema in both elementary and middle school children. Asthma was more prevalent in middle school children in Nuevo Laredo and Reynosa while more prevalent in elementary school children of Matamoros. Rhinitis was more prevalent in elementary school children in Reynosa and Matamoros. In Nuevo Laredo it was more prevalent in middle school children. The prevalence of rhinitis was highest in Reynosa’s elementary school children. Eczema appeared to be more prevalent in elementary school children than in middle school children.

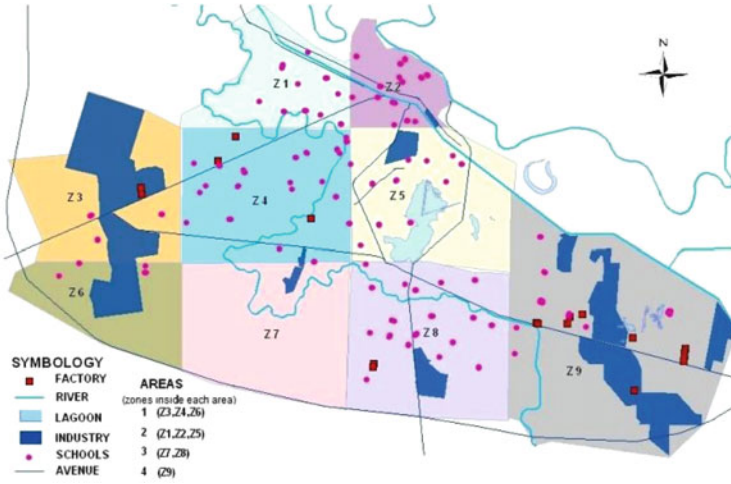


Fig. 2.3 Reynosa areas and zones with school and industry locations

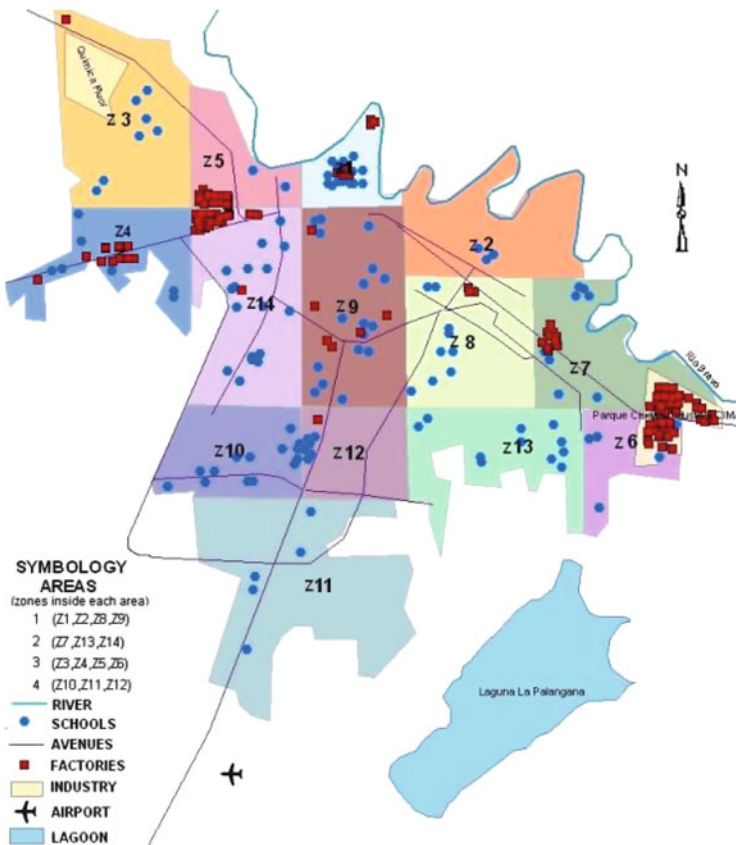


Fig. 2.4 Matamoros areas and zones with school and industry locations



**Table 2.3** Total number of ISAAC questionnaire collected

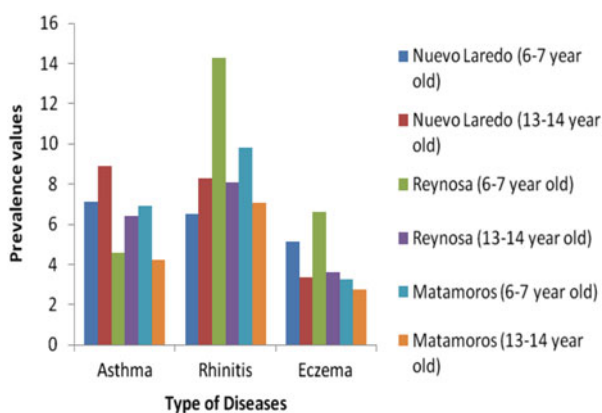
City	Elementary school	Middle school	Total
Nuevo Laredo	155	629	784
Reynosa	197	1,145	1,342
Matamoros	275	1,015	1,290
Total	627	2,789	3,416

**Table 2.4** Children survey percentage results by respiratory disease

	% reporting	Without disease	With disease	Do not know
Total	Asthma	93.82	6.18	
	Rhinitis	64.89	8.23	26.87
	Eczema	96.49	3.51	
Nuevo Laredo	Asthma	91.45	8.55	
	Rhinitis	64.96	7.93	27.11
	Eczema	96.3	3.7	
Reynosa	Asthma	93.88	6.12	
	Rhinitis	64.42	8.97	26.61
	Eczema	95.97	4.03	
Matamoros	Asthma	95.19	4.81	
	Rhinitis	65.34	7.65	27.01
	Eczema	97.13	2.87	

**Table 2.5** Number of cases by respiratory disease by age group and city

	Nuevo Laredo		Reynosa		Matamoros	
	6-7 years of age	13-14 years of age	6-7 years of age	13-14 years of age	6-7 years of age	13-14 years of age
Asthma	11	56	9	73	19	43
Rhinitis	65	215	28	92	27	71
Eczema	8	21	13	41	9	28

**Fig. 2.5** Prevalence values of respiratory and allergic diseases by age group and selected city

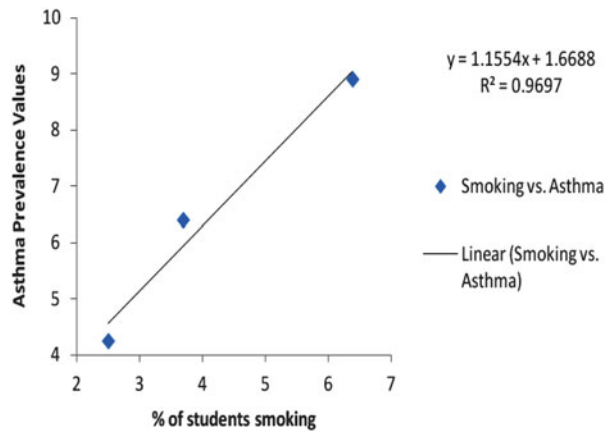
**Table 2.6** Children (13–14 years of age) smoking habits from ISAAC questionnaire

Number of cigarettes/day	Total (%)	Nuevo Laredo (%)	Reynosa (%)	Matamoros (%)
1	3.96	6.38	3.69	2.5
1–20	1.12	1.52	1.14	0.83
>20	0.69	0.61	0.57	0.83

**Table 2.7** Percentage of coughing after tobacco smoke exposure

	Total	Nuevo Laredo	Reynosa	Matamoros
No	42.69	43.96	44.34	40.28
Sometimes	28.18	32.97	24.21	28.06
Yes	29.13	23.08	31.45	31.67

**Fig. 2.6** Correlation between cigarette smoking and asthma prevalence



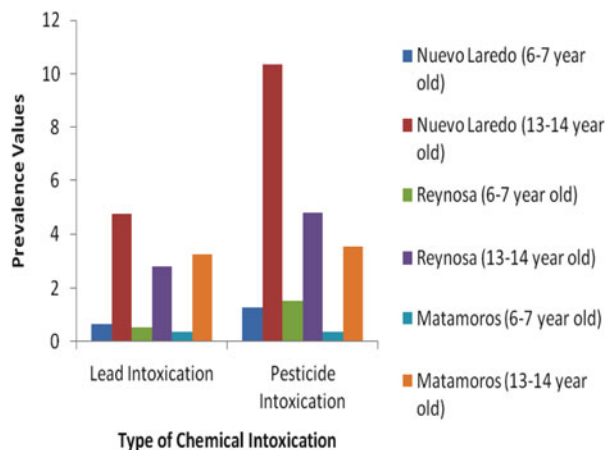
The middle school children’s ISAAC questionnaire also explored the risk of respiratory diseases associated with cigarette smoking among children (13–14 years of age). Table 2.6 shows the children smoking habits for the cities of Nuevo Laredo, Reynosa, and Matamoros. The table indicates that most children smokers have only one cigarette a day. It also indicates that children in the middle schools of Nuevo Laredo reported more tobacco use than in Reynosa and Matamoros.

Table 2.7 shows the percentage of children coughing as a tobacco smoke side effect. Data indicated that more than 50 % of the middle school children reported coughing after tobacco smoke exposure for all the selected Tamaulipas cities.

Figure 2.6 shows the correlation between the percentage of children smoking one cigarette a day and asthma prevalence among children in the middle school based on ISAAC questionnaire data.

A very strong correlation ( $R^2 = 0.9697$ ) between cigarette smoking and asthma prevalence among middle school children (13–14 years of age) was indicated by these data. Since a higher percentage of middle school children in Nuevo Laredo smoke, this could be the reason for the high asthma prevalence amongst these children.

**Fig. 2.7** Prevalence of chemical intoxication due to lead and pesticide use



**Table 2.8** Prevalence of fumigation by cities

Fumigation	Nuevo Laredo		Reynosa		Matamoros	
	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor
Once a week	33.75	37.38	44.21	32.93	42.18	34.07
2–3/week	39.12	49.22	27.3	46.34	17.52	47.35
Daily	27.13	13.4	28.49	20.73	40.52	18.58

Figure 2.7 shows prevalence of self reported chemical intoxication among elementary and middle school children in the selected Tamaulipas cities due to lead and pesticide use. As previously noted, parents of elementary school children (6–7 years of age) completed the ISAAC questionnaire, while the middle school students (13–14 years of age) completed the form themselves.

It was observed that lead and pesticide intoxication was higher in middle school children (13–14 years of age) than in elementary school children (6–7 years of age) for all three cities. Middle school children in Nuevo Laredo showed two or more times the pesticide intoxication when compared to the middle school children in Reynosa and Matamoros.

Table 2.8 shows prevalence of outdoor and indoor fumigation for Nuevo Laredo, Reynosa, and Matamoros obtained from the ISAAC questionnaire data. On a daily basis, outdoor fumigation was more common than indoor fumigation, but the opposite was reported for the 2–3 times of fumigation per week for the selected Tamaulipas cities. Matamoros reported the highest outdoor fumigation on a daily basis, and Nuevo Laredo reported lowest indoor fumigation on a daily basis.

Table 2.9 shows the prevalence of different combustion sources used indoors in the cities of Nuevo Laredo, Reynosa, and Matamoros. The combined results for the three cities shows 60 % of households use coal or wood for heating purposes, and 60 % of households use natural gas for cooking purposes.

**Table 2.9** Indoor combustion sources by cities, based on ISAAC questionnaire

	Fuel use	Natural gas	LP gas	Coal/wood	Other
Nuevo Laredo	Cooking	34.26	39.2	23.46	3.09
	Water heater	1.83	39.14	58.41	0.61
Reynosa	Cooking	36.08	29.26	29.55	5.11
	Heater	1.44	20.69	77.3	0.57
Matamoros	Cooking	28.57	37.01	30.52	3.9
	Water heater	1.43	26.53	71.43	0.61

## 2.4 Conclusions

This study addressed the prevalence of the environmental health effects of asthma, rhinitis, and eczema, specifically in the school children residing in three cities located in the Northeastern Mexican State of Tamaulipas located along the South Texas border region. The study was based on the ISAAC questionnaire methodology Phase I since there was a scarcity of health statistic data readily available for Tamaulipas. The resulting outcomes were based on the ISAAC questionnaires answered by the parents of elementary school children (6–7 years of age) and by the middle school children (13–14 years of age) in the cities of Nuevo Laredo, Reynosa, and Matamoros.

Results of the ISAAC questionnaire data indicate that asthma and rhinitis were more prevalent than eczema in both elementary and middle school children for the selected Tamaulipas cities. Rhinitis prevalence was significantly higher in Reynosa elementary school children than any other schools for all cities. Asthma was more prevalent in Nuevo Laredo middle school children than any of the middle schools in Reynosa and Matamoros. This could be due to the higher percentage of children smoking in middle schools of Nuevo Laredo since a very strong correlation ( $R^2 = 0.9697$ ) between asthma prevalence values and percentage of children smoking was determined.

The data indicated that lead and pesticide intoxication was higher in middle school children than in elementary school children for all three cities. Middle school children in Nuevo Laredo showed two or more times the pesticide intoxication when compared to middle school children in Reynosa and Matamoros.

For all the cities in this study, the results indicated that outdoor fumigation was more common than indoor fumigation on a daily basis, but the opposite can be seen for the 2–3 times of fumigation per week. On a daily basis, Matamoros reported the highest outdoor fumigation while Nuevo Laredo reported lowest indoor fumigation. The data also indicated that the combined results for all three cities shows 60 % of households use coal or wood for heating purposes, and 60 % of households use natural gas for cooking purposes.

The results of the ISAAC questionnaire provided evidence for the prevalence of asthma, rhinitis, and eczema in the elementary and middle school children in the three cities located in Tamaulipas and the environmental health effects of pesticide fumigation and indoor combustion sources.

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