0021-7557/11/87-04/319
Jornal de Pediatria

Landfills as risk factors for respiratory disease in children

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Abstract

Objective: To investigate the relationship between exposure to a landfill site closed 6 years previously and respiratory symptoms in children aged up to 13 years.

Method: This was a cross-sectional study conducted in Várzea Paulista, in the state of São Paulo, Brazil. One adult in every household in a neighborhood close to the landfill and from a randomized sample of households in another neighborhood with similar socioeconomic characteristics but no landfill were interviewed and asked about respiratory symptoms and other variables relating to children aged up to 13. A logistic regression model was used to study this relationship.

Results: The likelihood of a child having respiratory symptoms was a function of -2.36 + 0.43 if the child was less than 2 years old; + 0.24 if the child lived in the landfill area; -0.67 if there was a computer at home; + 0.54 if firewood was burnt in the home in the last year; + 0.94 if the child was diagnosed with asthma; + 0.87 if the child visited a health service in the previous 30 days.

Conclusion: The authors conclude that living near to a landfill closed 6 years previously may be a risk factor for respiratory disease in children.

J Pediatr (Rio J). 2011;87(4):319-324: Landfill, health environmental, respiratory diseases.

Introduction

Children are the greatest victims of unhealthy environments.[1,2] Pollution, whether inside or outside of the home, is an important factor in defining an environment as unhealthy.[3-5] Pollution is made up of countless different components, including acids, organic compounds, metals and particles of dust and dirt. Particles with a diameter of less than 10 μm can enter the lungs and may remain in suspension for many days, thereby spreading over large areas on the wind. Particles with a diameter of less than 2.5 μm can remain in the air indefinitely. These elements enter the environment from many different sources.[6]

Waste produced by humans is a source of environmental contamination and a proportion of this waste is disposed of in landfills, particularly in urban areas. A landfill can be considered as a dynamic reactor, since chemical and biological reactions result in emission of gases; liquid effluents and mineralized waste.[7] Landfills are classified as one of three types depending on the type of waste.

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No conflicts of interest declared concerning the publication of this article.

Financial support: Secretaria Municipal de Saúde de Várzea Paulista, SP, Brazil.

Suggested citation: Corrêa CR, Abrahão CE, Carpintero MC, Anaruma Filho F. Landfills as risk factors for respiratory disease in children. J Pediatr (Rio J). 2011;87(4):319-24.

Manuscript submitted Nov 04 2010, accepted for publication Mar 16 2011.

doi:10.2223/JPED.2098

If the waste has any of the following characteristics then the landfill is classed as Type I: inflammability, corrosivity, reactivity, toxicity or pathogenicity. Type III landfills receive waste that does not exhibit any type of solubility whatsoever in distilled or ionized water and so does not affect potability. Examples of this type of waste are rocks, glass, bricks and certain plastics. Waste is taken to type II landfills if it does not meet the criteria for either of the other two types and, therefore, is not inert and may be soluble in water and biodegradable.[7,8]

Several different studies have investigated the impact on health of landfills and the waste they contain. In Belo Horizonte, MG, Brazil, Heller & Catapreta[9] found an increased prevalence of respiratory symptoms in children living close to areas with no regular rubbish collection, which results in greater exposure to waste. Gelberg[10] found that workers at landfills had increased prevalence of respiratory and dermatological symptoms than workers at other locations. Deloraine et al.[11] also found a positive association between living close to a landfill and having respiratory symptoms. In Finland, Pukkala & Pönkä,[12] found more cases of asthma and cancer among residents of houses built in a region that had had a landfill. Porta et al.[13] conducted a systematic review of studies dealing with the effects of landfill on human beings and highlighted some of the methodological difficulties faced by their authors when attempting to study the subject. These included analyses based on ecological studies; problems with quantifying exposure to a given source of pollution; and the presence of confounding variables.[13]

One alternative for overcoming these limitations is to compare the frequency of a health problem simultaneously in two different populations that are similar with the exception that one is exposed to a given source of pollution.[14]

Children are more vulnerable to their environments than adults and, for this reason, are a population that is more sensitive to the impact of pollution.[15] The respiratory system is among the organs and systems most exposed to the effects of the environment.[16]

Várzea Paulista is a municipality in the Brazilian state of São Paulo where a waste disposal facility was active from 1987 to 2006. The site was initially a simple dump and was later converted into a type II landfill. During the period in which it was active, the facility received 150,000 tons of waste annually from the towns of Várzea Paulista, Jundiaí, Campo Limpo Paulista, Vinhedo, Louveira and Cajamar, which had joined together to create an intermunicipal landfill consortium (CIAS). The Ministério Público (the public prosecutor's office) and the CIAS signed a conduct modification agreement the objectives of which included monitoring the health conditions of the population living near to the landfill. The objective of this study was to evaluate the risk of respiratory diseases in children aged up to 13 years living in the vicinity of the landfill.

Methodology

Description of the study area

This was a cross-sectional study conducted in two different locations in the Várzea Paulista municipality. One of these was the area in which the class II landfill had operated until 6 years previously and which will be referred to as the landfill area. The other area, which will be referred to as the control, was chosen for the purposes of comparison. This area is a long way from the landfill and was recommended by the local sanitary surveillance authority because, according to their community health agents, its population had similar socioeconomic characteristics to the landfill area and the two road systems were also similar. Neither area was known to be exposed to any other source of environmental pollution.

Instrument

The investigators designed a questionnaire to be administered to the residents of the two neighborhoods chosen. Interviews were conducted by a professional, trained team and all interviewees signed an informed consent form.

The following variables were analyzed:

- Household located in landfill area or control area.
- Educational level of the child's guardian. This variable was collected as a single discrete figure and then categorized into more or less than 4 years of education completed successfully, since this is the upper cutoff used by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística [IGBE]) to classify adults as functionally illiterate.
- Child's age less than or greater than 2 years of age.
- Whether firewood had been burnt inside the residence during the previous year.
- Whether the residence had a cement floor.
- Whether the residence had a ceiling, or just a roof.
- Whether there was a microcomputer at the residence.
- Whether the child had suffered coughing, wheezing or shortness of breath during the 15 days prior to the interview.
- Whether a physician or healthcare professional had said that the child had bronchitis or asthma.
- The child's sex.
- Whether the child had used a medical service during the 30 days prior to the interview.
- Whether the residence had running water.
- Whether or not the residence was made of brick/masonry.
- Whether the mother or guardian smoked.

Study population

In the landfill area, one adult resident was interviewed for every household. In this area, therefore, a census was conducted. In the control area, a systematic sampling procedure was used, by which alternate residences were selected. Households were excluded if nobody was home on three visits, on three different days at three different times. The number of children investigated made it possible to test the hypothesis that there was a difference between the two areas, in terms of the variables studied, with alpha error of 5% and beta error of 20%.

Data were collected simultaneously in both neighborhoods during a 5-week period from October to December of 2007. Conducting the interviews simultaneously and in as short a time as possible were strategies employed to minimize the impact of climatic and seasonal factors on the study population, since the objective was to investigate the impact of the landfill. The objective was to select a control population that was as homogenous as possible, including in terms of exposure to sources of pollution, which is why a specific geographical area was chosen.

Statistical analysis

Variable 8 "Has the child suffered coughing, wheezing or shortness of breath in the last 15 days" was selected as the dependent variable or outcome, and the remainder were treated as predictive variables, all of which were treated as logical variables. Odds ratios adjusted with logistic regression were used to assess the associations between each of the predictive variables and the dependent variable. The variables used in the regression model were chosen on the basis of the association between the dependent variable and each predictive variable according to the chi-square test or Fisher's exact test. Variables that exhibited an association were included in the logistic regression model. The final model included those variables that continued to exhibit an association. The significance level utilized was 5%. Using the model we can calculate the probability of a child exhibiting respiratory symptoms during the previous 15 days when each of the predictive variables was present or absent. The test of deviance was employed in order to determine whether the number predicted by the model was close to the observed number of children.[17]

Statistical packages

Epi-Info version 6.04 was used for data entry and data were analyzed using SAS 9.1.

This project was approved by the Research Ethics Committee at the Medical Sciences School of the Universidade Estadual de Campinas (UNICAMP) and the results were presented to the CIAS.

Results

A total of 1,595 households were visited, 1,092 in the landfill area and 503 in the control neighborhood. The total number of children under 13 who lived in these households was 1,277. These children made up the study population: 895 of them lived in the landfill area and 382 lived in the control area.

All of these children lived in residences which had brick or masonry walls and which received treated water from the public water supply.

Table 1 shows a comparison between the numbers of children exhibiting each of the socio-sanitary variables, broken down by location of residence in the landfill or control area.

The distribution of children was similar in both areas in terms of: sex; diagnosis of asthma made by a physician or healthcare professional; attendance at a health service during the previous year; proportion of children less than 2 years old; and type of floor.

In the landfill area there were a greater proportion of children who suffered coughing or wheezing in the previous 15 days; whose parents were functionally illiterate; and whose mothers smoked.

In the control area there were a greater proportion of children who: lived in households which had a computer; lived in households where firewood has been used during the previous year; and lived in homes with no ceiling.

Associations were then evaluated between the dependent variable: "exhibited respiratory symptoms during the previous 15 days" and the other socio-sanitary variables. The results for these associations, according to the chi-square test or Fisher's exact test, are shown in Table 2.

A forward logistic regression was performed in order to study the associations between the predictive variables and the defendant variable. The following variables remained in the final model: diagnosis of asthma; age below 2 years; computer at home; living in the landfill area; and having burnt firewood inside during the previous year. The final model was as follows:

The likelihood of the child exhibiting coughing or bronchitis during the previous 15 days was -2.36 + 0.43 if the child was less than 2 years old; + 0.24 if the child lived in the landfill area; -0.67 if there was a computer at home; + 0.54 if firewood was used in the previous year; + 0.94 if the child had been diagnosed as asthmatic; + 0.87 if the child had visited a health service in the previous 30 days. Deviance = 0.21.

This number shows that the number of children estimated by the model is not different from the number of children observed.

Therefore, the likelihood of a child who lived in the landfill area exhibiting coughing or wheezing during the

previous 15 days was 1.3 (*e* to the power of 0.24) times greater than the likelihood of a child living in the control area exhibiting the same symptom.

Table 3 shows the distribution of the conditional odds ratios for the dependent variable and each of the predictive variables that remained in the final model.

Discussion

The objective of this study was to determine whether living in a neighborhood where a landfill site had been closed 6 years previously was a risk factor for acute respiratory symptoms in children. Within the conditions under which this study was conceived and carried out, we found that

Table 1 - Number of children exhibiting the study variables, by location of residence and comparisons between distributions according to the chi-square test, Várzea Paulista, 2007

Variables	Total number of children (n = 1,277)	Children living in the landfill area (n = 895)	Relative frequency	Children living in the control neighborhood (n = 382)	Relative frequency	p
Physician-diagnosed bronchitis or asthma	229	170	18.97	59	15.45	0.13
Head of household completed less than 4 years' education	412	307	34.3	106	27.7	0.001
Child less than 2 years old	421	295	32.92	126	32.98	0.98
Computer in home	265	171	19.08	94	24.61	0.02
Used firewood to cook during previous 12 months	56	32	3.58	24	6.28	0.03
Home has cement floor	23	13	1.45	10	2.6	0.15
Home has no ceiling	429	233	26	196	51.31	< 0.001
Mother smokes	139	102	11.38	37	9.68	0.037
Child suffered coughing or wheezing during previous 15 days	156	123	13.73	33	8.6	0.009
Child attended a medical service during 30 days prior to interview	510	370	41.4	140	36.6	0.11
Male child	686	483	53.97	203	53.14	0.78

Table 2 - Results of chi-square test or Fisher's exact test for associations between the dependent variable "exhibited respiratory symptoms" (0 = did not have respiratory symptoms; 1 = had respiratory symptoms) with socio-sanitary variables

Socio-sanitary variables	Child had respiratory symptoms (n = 156)	No respiratory symptoms (n = 1,121)	p
Physician-diagnosed bronchitis or asthma	74	154	< 0.05
Lives in landfill area	123	772	0.01
Head of household completed less than 4 years' education			0.87*
Child less than 2 years old	77	344	< 0.001
Computer in home	19	246	0.004
Used firewood to cook during last 12 months	13	43	0.01
Home has cement floor*	2	21	0.6*
Home has no ceiling	50	379	0.66*
Mother smokes	19	120	0.58*
Male child	89	597	0.37*
Child attended a health service less than 30 days prior to interview.	99	411	< 0.001

* Not significant.

Table 3 - Distribution of the conditional odds ratios for the dependent variable and each of the predictive variables that remained in the final model

Variable	Estimated parameter	Conditional OR
Child less than 2 years old	0.43	1.53
Child lives in landfill area	0.24	0.79
Computer at home	-0.67	0.51
Firewood burnt at home during previous 12 months	0.54	1.71
Child diagnosed as asthmatic	0.94	2.5
Child visited a health service during previous 30 days	0.87	2.39

OR = odds ratio.

there was such a risk and that its magnitude is 1.3 times. Therefore, a child who lives in the neighborhood where the landfill used to be had a 50% greater likelihood of having exhibited coughing or wheezing during the 15 days prior to the interview than a child who lived in the control neighborhood.

Several studies have dealt with the effect that landfill sites can have on people's health.[9,10] Few however have dealt with respiratory diseases and we only found one article dealing with the effects of a deactivated landfill, which reported similar results to ours.[11]

A diagnosis of asthma had a strong association with respiratory symptoms during the previous 15 days and it is salient to point out that the proportion of children who visited a health service during the previous 30 days did not differ between neighborhoods. It can therefore be inferred that the children have equal access to a service at which such a diagnosis could have been made. Wehrmeister & Peres[18] reported a prevalence of asthma in children from 0 to 9 years that was similar to that which was found in this study. The association between history of asthma and presenting respiratory symptoms is compatible with the conception of asthma as an inflammatory disease in which there is bronchial hyperreactivity and to which children become susceptible as a result of small stimuli, particularly when they are younger than 2 years old.

Several different studies have shown an association between parental educational level, smoking mothers, sex of the child and asthma.[15,18,19] Within the conditions in which this study was planned and discussed, we can state that no associations were detected between smoking mothers, sex of the child or parental education and an increased likelihood of the child exhibiting coughing or wheezing during the 15 days prior to the interview and that these variables are not confounding factors in the associations detected by the logistic regression model. Maia et al.[20] also failed to detect any association between passive smoking and presence of respiratory symptoms in children. The failure to detect an association between these variables and the likelihood of a child having suffered respiratory symptoms during the previous 15 days may be because of some or other characteristic of the methods employed in this study. In this study, questionnaires were administered in both areas simultaneously and over as short as possible a period of time in order to avoid interference from factors related to climate and disease seasonality.[21] It is therefore possible that associations with these particular variables may not have been detected because they include some type of interaction with climate or with time of year.[22] Another hypothesis is that these variables were classified as logical and it is possible that they manifest along a continuum. For example, we classified mothers as smokers or non-smokers and did not take account of the number of cigarettes smoked per day, but it is possible that respiratory manifestations could be a function of the number of cigarettes smoked per day.

Other studies have investigated the use of firewood at home and its association with increased likelihood of exhibiting respiratory symptoms and have reported results similar to those found here.[3,23,24] In addition to being a source of pollution, the use of this type of fuel indoors may be an indication that these families do not have the purchasing power to use bottled gas and are therefore poorer.

Owning a computer is a variable that was inversely associated with respiratory symptoms during the previous 15 days. In contrast with what was observed in this study, it is in more developed countries, whose populations have greater access to computers, that the greatest prevalence rates of asthma among adolescents are found.[25] This suggests that owning a computer is an indicator of socioeconomic status. Although it recognizes that this is an item that is strongly linked to culture and lifestyle, the Brazilian Association of Market Research Companies (Associação Brasileira de Empresas de Pesquisa [ABEP]) does not consider it is a good indicator for socioeconomic classification.[26] One hypothesis to explain the functioning of this item is that a family which has a computer has greater access to culture, a better lifestyle or is a member of social networks. All of these are factors which would, individually or in conjunction, contribute to reducing the prevalence of respiratory symptoms.

The results of the study have shown that living in the landfill area was associated with the presence of respiratory symptoms in children aged 0 to 13 years. Is the landfill the cause of this association? Within the scope of this research, the landfill might be associated with the presence of respiratory symptoms because it is a dynamic reactor that eliminates material[7] that is known to be associated with airway irritation.[27] Total reduced sulfur merits special attention since it is one of the most important products emanating from landfills and because it acts on the respiratory system.[7,27,28]

The data from this study should be considered in conjunction with those of studies that have investigated other variables. Such variables could range from those used to produce a genetic profile of the population,[29] through those that define the area of study in terms of the presence of particulate material,[30] to other conditions, such as violence and culture.[31,32]

The development of cities demands different forms of waste management. It is important that societies recognize this waste and its impact, and adopt a position on its final destination, remembering that this waste is a product of the system of production that these same societies have adopted and on the basis of which they live.

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