Prevalence and risk factors associated with wheezing in the first year of life

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Abstract
Objective: to investigate the prevalence and risk factors associated with wheezing in infants in the first year of life.
Methods: this was a cross-sectional study, in which a validated questionnaire (Estudio Internacional de Sibilancias en Lactantes - International Study of Wheezing in Infants - EISL) was applied to parents of infants aged between 12 and 15 months treated in 26 of 85 primary health care units in the period between 2006 and 2007. The dependent variable, wheezing, was defined using the following standards: occasional (up to two episodes of wheezing) and recurrent (three or more episodes of wheezing). The independent variables were shown using frequency distribution to compare the groups. Measures of association were based on odds ratio (OR) with a confidence interval of 95% (95% CI), using bivariate analysis, followed by multivariate analysis (adjusted OR [aOR]).
Results: a total of 1,029 (37.7%) infants had wheezing episodes in the first 12 months of life; of these, 16.2% had recurrent wheezing. Risk factors for wheezing were family history of asthma (OR = 2.12; 95% CI: 1.76-2.54) and six or more episodes of colds (OR = 2.38; 95% CI: 1.91-2.97) and pneumonia (OR = 3.02; 95% CI: 2.43-3.76). For recurrent wheezing, risk factors were: familial asthma (aOR = 1.73; 95% CI: 1.22-2.46); early onset wheezing (aOR = 1.83; 95% CI: 1.75-3.75); nocturnal symptoms (aOR = 2.56; 95% CI: 1.75-3.75), and more than six colds (aOR = 2.07; 95% CI 1.43-3.00).
Introduction

Wheezing is a very common symptom in infants, which is usually accountable for a high demand of medical consultations and emergency care services, with relatively high rates of hospitalization. Along with acute respiratory infections, it plays an important role in infant mortality. In Latin America, approximately 100,000 children die in the first year of life due to acute respiratory infection, and a significant proportion of them have a history of wheezing. In Brazil, data from the Ministry of Health show that around 35% of infant hospitalizations in the first year of life in Brazil are due to respiratory diseases.

Nevertheless, the real extent of this problem remains unknown, as well as how many of these infants are actually asthmatic patients. The factors that establish the start, evolution, and prognosis of wheezing in infants have not yet been well defined. As it occurs in older children, it is likely that individual genetic and immunological patterns, associated with environmental factors, are responsible for most of the wheezing phenotypes in childhood. Most studies indicate a multifactorial etiology in the pathogenesis of wheezing in the first year of life, in addition to the close association with respiratory infections. However, how these different elements relate to each other is still the subject of much controversy.

The International Study of Wheezing in Infants (Estudio Internacional de Sibilancias en Lactantes [EISL]) was developed in order to determine the prevalence and risk factors associated with wheezing in infants in the first year of life. The EISL project evaluated the risk factors associated with wheezing in the first year of life in children from Latin America, Spain, and the Netherlands. Data showed a large variation in the prevalence and severity of wheezing at the centers, but with a tendency of higher prevalence and severity in Latin American children. The present study is part of the EISL project - phase 1.

This study aimed to determine the prevalence and risk factors associated with wheezing in infants in the first year of life, living in Fortaleza, Brazil, using the EISL protocol.

Methods

The present study was conducted in the city of Fortaleza, capital of the state of Ceará, Northeastern Brazil, as part of the EISL project - phase 1. The EISL is a cross-sectional, multicenter, international study with descriptive and analytical elements, developed to assess the prevalence, severity, and other characteristics of wheezing in infants in the first year of life from Latin America, Spain, and the Netherlands. It was designed to determine the association of wheezing...
with other respiratory diseases, especially pneumonia, and
to define the risk factors for wheezing in infants in their
first 12 months of life, similarly to the "International Study
of Asthma and Allergies in Childhood" (ISAAC).11

The study was performed in 26 of 85 primary care units,
selected at random and proportional to the demographic dis-
tribution in the six regions (regional executive secretariats
[RES]) of Fortaleza. Each RES has its unique characteristics
regarding geographic location (coastal region, peripheral
region), distribution of income, territorial occupation, and
extension.12

The study population comprised infants aged between
12 and 15 months, selected during routine consultations or
immunizations. Children with chronic diseases in other sys-
tems who presented any respiratory impact (neuropathies,
heart disease, severe somatic malformations and genetic
diseases, among others) were excluded.

Data collection was conducted from December of 2006
to December of 2007 using the written questionnaire (WQ)
of EISL as the collection tool, which was standardized and
validated for the local environment (Brazilian culture) after
being translated into Brazilian Portuguese.13 The WQ-EISL
comprises questions regarding demographic characteristics,
wheezing, respiratory infections, and risk factors, namely:
- gender, age, ethnicity, birth weight and height, current
  weight and height, type of delivery, maternal schooling,
- characteristics of wheezing, medication use, hospitaliza-
  tion, association with pneumonia, and environmental and
  family factors, among others.

The questions are very sensitive, and are based on clinical
practice as well as on international studies on infants, to
ensure comparable information on the epidemiological and
clinical issues related to this disease.

The dependent variable, wheezing, was defined in this
study as the presence of wheezing or bronchitis in the first
12 months of the child’s life, and categorized as occa-
sional (up to two episodes of wheezing) or recurrent (three
or more episodes of wheezing). The independent vari-
ables (exposure) were grouped according to demographic,
socioeconomic, environmental, family, and clinical charac-
teristics.

Data analysis

Data were organized in a standard format; data entry was
performed using EPI INFO, version 3.5.1, and data analysis
was conducted using STATA, version 10. The variables were
shown using the distribution of frequencies and Pearson’s
chi-squared test was used to compare groups of infants.
Measures of association were based on odds ratio (OR) with a
95% confidence interval (95% CI), with bivariate analysis fol-
lowed by multivariate analysis (logistic regression-adjusted
OR). In the univariate analysis, the association between each
explanatory variable and the dependent variable (wheezing)
was investigated separately, which was used as a selection
criterion for the independent variables used in the final
model. Then, these variables were included in the logistic
regression model (adjusted OR), which evaluated the effect
of the selected variables on the outcome. In this case, the
influence of each explanatory variable was controlled by the
effect of the others, eliminating potential confounders.

The study was approved by the Ethics Committees of
the Universidade Federal do Ceará (No. 734/06 and COMEPE
protocol 238/06) and of the Universidade Federal de São
Paulo (No. 0804/09), in accordance with the Declaration of
Helsinki. The research protocol was approved by the Health
Secretariat of Fortaleza. Voluntary and anonymous partici-
pation was guaranteed by the informed consent given before
the interviews.

Results

The study included 2,732 infants, of whom 1,024 (37.7%) had
wheezing episodes in the first 12 months of life; 16.2%
of these had recurrent wheezing, with three or more crises
in the first year of life.

Around 57% of the wheezing infants were males, and
60% were of black or mixed-race ethnicity. The mothers
of these infants had low educational level, 70% had no paid
work, 18% were smokers, and 13% smoked during preg-
nancy. The wheezing infants had twice the incidence of
family history of asthma when compared to non-wheezing
infants, and three times greater history of colds and pneu-
monia. Table 1 shows the comparative analysis of wheezers
and non-wheezers according to the demographic, socioeco-
omic, environmental, family, and clinical characteristics
of the study population.

Recurrent wheezers had more severe symptoms, noctu-
urnal symptoms, and visits to emergency rooms and
hospitalizations for wheezing and pneumonia, when com-
pared to infants with occasional wheezing. Around 60% of
recurrent wheezers had the first crisis of wheezing before 4
months of age, 41.9% had over six episodes of colds in the
first year of life, 36.3% had pneumonia in the first year of
life, and 50.9% had a family history of asthma (Table 2).

The comparative analysis between the groups identified
several isolated factors that were then evaluated separately
regarding the outcome (wheezing). The univariate analy-
sis identified possible risk and protective factors. Then, the
independent variables were selected to constitute the logis-
tic regression model (adjusted OR), in order to control and
eliminate possible confounding variables.

There was an association of wheezing with male gender,
low maternal education, family history of asthma and der-
matitis, mold in the household, and maternal smoking dur-
ing and after pregnancy. There was also a significant associa-
tion of wheezing with dermatitis and high number (six or more)
of cold and pneumonia episodes in the first year of life. Matern-
al breastfeeding lasting less than four months was also a
risk factor, as shown in Fig. 1.

The main risk factors associated with recurrent wheezing
were familial asthma, early onset of wheezing, nocturnal
symptoms, over six episodes of colds, asthma diagnosis, and
severe symptoms (Fig. 2).

Discussion

Many studies worldwide have observed a high prevalence
of wheezing during the first years of life. The first inter-
national comparison of EISL14 studied over 30,000 children
from 17 centers in Europe and Latin America, including eight
in Brazil. The recently published data demonstrated that
There is a great variability in the prevalence and severity of wheezing in the different centers, but with a tendency to higher prevalence and severity in children from Latin America. The prevalence of wheezing in that study, considering the total study population, was 45.2%, 20.3% of which corresponded to recurrent wheezing. When the data was stratified for Latin America, the prevalence was 47.3% and 21.4% for wheezing and recurrent wheezing, respectively, and for Europe, 34.4%, and 15.0%, respectively. In Brazil, the prevalence of wheezing in the first year of life ranged between 43% and 63.6%, and 21.9% and 36.6% for occasional and recurrent wheezing, respectively. The values observed here show great variability; this difference is possibly associated with differences in climatological, environmental, and socioeconomic characteristics of different regions.

This study observed a prevalence of 37.7% for occasional wheezing and 16.2% for recurrent wheezing; this prevalence

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Comparative analysis between wheezers and non-wheezers in the first year of life, according to the demographic, socioeconomic, family, and clinical characteristics.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
<td>Wheezer 1,024 (37.66%) n (%)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>586 (57.2)</td>
</tr>
<tr>
<td>Female</td>
<td>439 (42.7)</td>
</tr>
<tr>
<td>Birth weight (kg)</td>
<td>3.259 kg (SD = 0.6)</td>
</tr>
<tr>
<td>Current weight (kg)</td>
<td>10.5 kg (SD = 0.1)</td>
</tr>
<tr>
<td>Birth height</td>
<td>49.4 cm (SD = 2.6)</td>
</tr>
<tr>
<td>Current height</td>
<td>75.2 (SD = 3.4)</td>
</tr>
<tr>
<td>Start of wheezing (months)</td>
<td>4.7 (SD = 3)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>423 (41.1)</td>
</tr>
<tr>
<td>Black</td>
<td>601 (58.4)</td>
</tr>
<tr>
<td>Asian</td>
<td>5 (0.5)</td>
</tr>
<tr>
<td>Maternal schooling</td>
<td></td>
</tr>
<tr>
<td>Elementary school</td>
<td>463 (45.0)</td>
</tr>
<tr>
<td>Incomplete high school</td>
<td>346 (33.6)</td>
</tr>
<tr>
<td>Complete high school and college/university</td>
<td>220 (21.4)</td>
</tr>
<tr>
<td>Three or more siblings</td>
<td>66 (6.4)</td>
</tr>
<tr>
<td>Five or more persons in the household</td>
<td>516 (50.15)</td>
</tr>
<tr>
<td>Paid work (mother)</td>
<td>247 (24.0)</td>
</tr>
<tr>
<td>Attends daycare</td>
<td>37 (3.6)</td>
</tr>
<tr>
<td>Mold in the household</td>
<td>330 (32.1)</td>
</tr>
<tr>
<td>Air pollution</td>
<td>751 (73.0)</td>
</tr>
<tr>
<td>Smokers in the household</td>
<td>540 (52.7)</td>
</tr>
<tr>
<td>Mother is a smoker</td>
<td>187 (18.2)</td>
</tr>
<tr>
<td>Mother smoked during pregnancy</td>
<td>134 (13.0)</td>
</tr>
<tr>
<td>Pet in the household (currently)</td>
<td>679 (74.2)</td>
</tr>
<tr>
<td>Kitchen in the household</td>
<td>1204 (70.7)</td>
</tr>
<tr>
<td>Cell phone in the household</td>
<td>455 (44.2)</td>
</tr>
<tr>
<td>Updated vaccination schedule</td>
<td>1024 (100)</td>
</tr>
<tr>
<td>C-section delivery</td>
<td>432 (42.2)</td>
</tr>
<tr>
<td>Early weaning</td>
<td>450 (43.7)</td>
</tr>
<tr>
<td>Breastfeeding for less than four months</td>
<td></td>
</tr>
<tr>
<td>Family history of asthma</td>
<td>431 (41.9)</td>
</tr>
<tr>
<td>Family history of rhinitis</td>
<td>436 (42.6)</td>
</tr>
<tr>
<td>Family history of dermatitis</td>
<td>186 (18.2)</td>
</tr>
<tr>
<td>Atopic dermatitis</td>
<td>604 (59.0)</td>
</tr>
<tr>
<td>Six or more colds</td>
<td>282 (27.4)</td>
</tr>
<tr>
<td>Age at start of colds &lt; 4 months</td>
<td>456 (44.5)</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>310 (30.3)</td>
</tr>
<tr>
<td>Hospitalization due to pneumonia</td>
<td>171 (16.7)</td>
</tr>
</tbody>
</table>

SD, standard deviation. *p-value (Pearson’s chi-squared test).
of recurrent wheezing is below that found in other studies using the EISL protocol, especially in Brazil.

The identification of the determinants of wheezing in infants has been the subject of several studies. In fact, several factors appear to play a decisive role in the triggering and maintenance of wheezing in infants, such as genetic, immunological, and environmental variables, as well as infection and maternal breastfeeding, among others.

This study showed a significant association of wheezing with respiratory infection for all types of wheezing. Respiratory infections are common in childhood and have an important role in infant morbimortality. They require several outpatient clinic visits, hospital admissions, and consequently increase public health care costs in many countries. There appears to be an important association between respiratory infections, particularly those caused by viruses, and the pathogenesis of wheezing in childhood.

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**Table 2** Comparison between infants that are occasional and recurrent wheezers, according to the clinical features and family history.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Occasional wheezer &lt; three crises n = 580 (%)</th>
<th>Recurrent wheezer ≥ three crises n = 444 (%)</th>
<th>p&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male gender</td>
<td>309 (53.3)</td>
<td>277 (37.6)</td>
<td>0.003</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>149 (25.7)</td>
<td>161 (36.3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hospitalization due to pneumonia</td>
<td>79 (13.6)</td>
<td>92 (20.7)</td>
<td>0.003</td>
</tr>
<tr>
<td>Hospitalization due to bronchitis</td>
<td>29 (5)</td>
<td>165 (37.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Passive smoking</td>
<td>307 (52.9)</td>
<td>233 (52.5)</td>
<td>0.885</td>
</tr>
<tr>
<td>Maternal smoking</td>
<td>92 (15.9)</td>
<td>95 (21.4)</td>
<td>0.024</td>
</tr>
<tr>
<td>Mother smoked during pregnancy</td>
<td>68 (11.7)</td>
<td>66 (14.9)</td>
<td>0.140</td>
</tr>
<tr>
<td>History of asthma in the family</td>
<td>205 (35.3)</td>
<td>226 (50.9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>History of rhinitis in the family</td>
<td>255 (43.9)</td>
<td>181 (40.8)</td>
<td>0.305</td>
</tr>
<tr>
<td>History of dermatitis in the family</td>
<td>98 (16.9)</td>
<td>88 (19.8)</td>
<td>0.229</td>
</tr>
<tr>
<td>Dermatitis</td>
<td>331 (57.1)</td>
<td>273 (61.5)</td>
<td>0.154</td>
</tr>
<tr>
<td>Six or more colds</td>
<td>96 (16.5)</td>
<td>186 (41.9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Age at start of colds &lt; 4 months</td>
<td>204 (35.2)</td>
<td>252 (56.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Age of wheezing &lt; 4 months</td>
<td>182 (37.7)</td>
<td>238 (60.7)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Updated vaccination schedule</td>
<td>580 (100)</td>
<td>444 (100)</td>
<td>0.451</td>
</tr>
<tr>
<td>C-section delivery</td>
<td>244 (42.1)</td>
<td>188 (42.3)</td>
<td>0.930</td>
</tr>
<tr>
<td>Use of bronchodilator</td>
<td>461 (82.6)</td>
<td>371 (85.3)</td>
<td>0.257</td>
</tr>
<tr>
<td>Use of inhaled corticoids</td>
<td>120 (23.7)</td>
<td>89 (22.9)</td>
<td>0.786</td>
</tr>
<tr>
<td>Use of antileukotrienes</td>
<td>23 (4.9)</td>
<td>10 (2.9)</td>
<td>0.152</td>
</tr>
<tr>
<td>Visits to the emergency room</td>
<td>360 (62.1)</td>
<td>346 (77.9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Severe episodes</td>
<td>374 (47.2)</td>
<td>278 (62.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Hospitalization due to wheezing</td>
<td>75 (12.9)</td>
<td>117 (26.3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Diagnosis of asthma</td>
<td>59 (10.2)</td>
<td>91 (20.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Frequent nocturnal symptoms</td>
<td>930 (16.0)</td>
<td>185 (41.7)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Maternal breastfeeding &lt; 4 months</td>
<td>163 (31.5)</td>
<td>145 (35.8)</td>
<td>0.634</td>
</tr>
</tbody>
</table>

<sup>a</sup> p-value (Pearson's chi-squared test).

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**Figure 1** Factors associated with wheezing in the first year of life. aOR, adjusted odds ratio.
The EISL showed a significant association between the occurrence of colds in the first three months of life and wheezing in infants in countries from Europe and Latin America, especially those with recurrent wheezing.18

Other factors also contribute to the risk of wheezing. In this study, a correlation was observed between wheezing and low maternal education, male gender, family history of asthma, and dermatitis. Several studies indicate genetics as a determinant factor for allergic diseases.19,20 The EISL demonstrated a statistically significant association between wheezing and factors such as family history of asthma and rhinitis.18 It also showed the association of wheezing with the male gender, especially in European countries when compared to Latin America.19 The male gender has been identified as a risk factor for wheezing during the first years of life in several studies.21

Other factors also contribute to the risk of wheezing in infants. In this study, early weaning, defined as maternal breastfeeding lasting less than four months, appeared as a risk factor. Breastfeeding is widely promoted as an important factor in reducing the risk for atopy and asthma; however, the evidence for this effect is still very conflicted.22

A prospective study performed in New Zealand with approximately 1,000 children indicated that breastfeeding is not a protective factor and may even increase the risk for atopy.23 Other studies, in contrast, have demonstrated that exclusive breastfeeding has a significant protective effect against the development of recurrent wheezing, asthma, and atopy. However, this protective effect appears to be mediated by nutrients and individual protection mechanisms and, to a lesser extent, to factors related to atopy.24

This study demonstrated an association between wheezing and maternal smoking during and after pregnancy. The harmful effects of smoking on children’s health are well known, but their potential impact on early lung development is less clear.25 It is difficult to separate the effects of pre- and postnatal exposure, as most women who continue to smoke during pregnancy (approximately 30% worldwide) do not stop the habit after the child is born.18

However, assessments conducted before any postnatal exposure have shown significant changes in lung function in newborns whose mothers smoked during pregnancy, and the persistence of tobacco exposure in the postnatal period probably increases the risk of respiratory diseases.27 A study conducted in Spain with over 20,000 children and adolescents demonstrated that environmental tobacco smoke is associated with a higher prevalence of asthma symptoms, particularly if the mother or both parents smoke.28

In the present study, infants with recurrent wheezing episodes had early-onset wheezing, severe episodes, difficulty breathing, nocturnal symptoms, family history of asthma, and a medical diagnosis of asthma. The EISL found similar results, especially in Latin American countries18 and in Brazilian cities.29

Some potential limitations of this study were identified, such as the very homogeneous study population (mostly low-income) and its cross-sectional design, which could possibly influence the results. In addition, interviews with parents or caregivers about events that occurred during the infants’ first year of life may depend on the ability of respondents to recall facts, especially regarding questions that contain a high degree of subjectivity, such as the those related to family history.

Another important possible limitation was the evaluation of outcomes (wheezing) in this study, which was based on information collected during interviews rather than on medical records. However, the fact that the present study is multicenter and that all the data come from different national and international centers may minimize these limitations.

In summary, this study demonstrated a prevalence of recurrent wheezing in the city of Fortaleza that is below...
those found in other studies using the EISL protocol, especially in Brazil. It also evidenced a strong association of wheezing with a history of respiratory infections, asthma, and atopic dermatitis in the family. Moreover, it demonstrated that infants with over three episodes of wheezing had difficulty breathing, severe episodes, nocturnal symptoms, and a medical diagnosis of asthma.

This study indicates a multifactorial pathogenesis of wheezing in the first year of life, which is closely related to respiratory infections. Considering that many cases of asthma present the initial symptoms early in the first year of life, it should be a priority of public health policy to know the prevalence and risk factors of this disease, in order to develop control and treatment strategies that impact on morbidity and mortality of these diseases, and improve the quality of life of these children and their families.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgements

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References