

## ENVIRONMENTAL EPIDEMIOLOGY

# Household wood and charcoal smoke increases risk of otitis media in childhood in Maputo

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**Background** This study examined the association of otitis media in children <6 years old and the exposure to wood and charcoal smoke, as well as to other risk factors, in Maputo.

**Methods** Case-control study. In all 750 children matched by sex and age were enrolled in a hospital-community study. Cases were gathered from among children visiting the Central Hospital of Maputo with otitis media and controls were recruited in the same village as the cases. Conditional logistic regression was performed to evaluate, simultaneously, the effect of each risk factor.

**Results** Cases were more likely to have been exposed to tobacco smoke (OR = 1.51), to wood (OR = 1.85) and charcoal (OR = 1.50) household smoke, to short term breastfeeding (OR = 1.47), and to live in overcrowded conditions (OR = 1.49). Multivariate analysis stratified by age groups (younger and older than 2 years) showed that cases were more likely to be exposed to wood and charcoal smoke than controls, regardless of age. Among children aged >2 years, Eustachian tube dysfunction was evident (OR = 3.06) particularly in those living in less overcrowded conditions.

**Conclusions** Findings of this study are consistent with earlier studies that have reported an association between parental smoking, short duration of breastfeeding, and Eustachian tube dysfunction. The association with wood and charcoal smoke indicates that there is a need to educate people regarding the avoidance of exposing their children to this environmental hazard.

**Keywords** Otitis media, Eustachian tube, wood smoke pollution, tobacco smoke pollution, overcrowding, breastfeeding, case-control studies

Otitis media in childhood is one of the main reasons for seeking medical assistance at the primary health care level and it is the major source of deafness in Mozambique.

Although there is no reliable information on the incidence of otitis media in Mozambique, evidence from the Ear Nose and Throat (ENT) service at the Central Hospital of Maputo (CHM), shows that 35–40% of all patients observed in the last 5 years were suffering from otitis media or complications of that

pathology. Usually most of these patients visit the ENT services with complications or consequences already established. Long-term frequently registered effects include permanent perforation of the eardrum, hearing loss and impaired language development and communication skills. At that stage, the treatment is more expensive or locally unavailable requiring additional assistance from foreign countries. However, most of those people who need that kind of assistance cannot afford to pay for it. Thus, actions aimed at promoting preventive methods to reduce both the incidence and complications of otitis media are still an important health challenge in Mozambique.

In spite of the conflicting results, probably due to differences in methodological approaches, a number of studies have provided significant evidence of a relationship between the occurrence of otitis media and factors such as sex<sup>1</sup>, age,<sup>1,2</sup> short duration of breastfeeding,<sup>3–6</sup> Eustachian tube dysfunction (ETD),<sup>7–9</sup> parental smoking,<sup>10–15</sup> and upper respiratory infections.<sup>15–17</sup> However, very little information has been reported from developing countries, particularly from Africa.<sup>18,19</sup>

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To ascertain the most frequent risk factors implicated in otitis media among children in Maputo, a hospital-community based case-control study was designed.

The study was carried out in Maputo, the capital of Mozambique, a Southern African country with approximately 17 million inhabitants which is considered one of the poorest countries in the world. With a per capita gross national product of 80 USD, subsistence agriculture is the country's main economic activity; the illiteracy rate is 70% and the infant mortality rate is 120 per 1000.<sup>20</sup> Wood and charcoal are the main sources of energy, and babies <6 months are frequently exposed to the smoke as mothers usually carry them on their backs, even when cooking.

After independence from Portuguese colonialism in 1975, a National Health System (NHS) was established, aiming at the provision of basic health care for everyone, independent of their social and economic conditions. Priority was given to preventive medicine with particular emphasis on child and mother health care. Although relevant achievements were made in the primary health care system, due to the economic conditions in the country, scarcity of trained staff and lack of equipment in the health sector, and aggravated by the prolonged war which broke out one year after independence, no significant improvements were made in the other levels of health care; hearing care being one of the most affected areas. Currently, the country has no more than eight ENT specialists, and there are only three ENT services in the entire country. Consequently, most of the patients with complicated otitis media do not benefit from early or appropriate care, thus they reach the ENT services with severe complications already established. The identification of the risk factors frequently involved in the incidence and complications of otitis media, as well as the training of middle level health workers in the prevention and early detection of otitis media, may be one important way to reduce the incidence of otitis media and its complications.

Overcrowding, commonly due to the rapid urbanization which occurred during the war, has been frequently cited as a potential risk factor for poor health in very young children<sup>21–23</sup> including otitis media.<sup>24</sup> Apart from the above-mentioned risk factors, exposure of children to wood and charcoal smoke in the kitchen may be associated with increased rates of childhood otitis media in Maputo in the same way in which it has been shown to be an associated risk factor for the presence of respiratory symptoms.<sup>25–28</sup>

Thus, the objective of this study was to analyse the relations between wood and charcoal smoke as well as other factors reported in previous studies and the occurrence of otitis media in children <6 years old in Maputo. We selected this age group because a cross-sectional study describing the clinical and epidemiological profile of patients with otitis media visiting the ENT services at the CHM during 4 consecutive years has shown that 30.3% of patients in a sample of 4157 individuals with otitis media were children <6 years old.<sup>29</sup>

## Methods

A case-control study was conducted aiming at the comparison of groups with respect to the proportion having a history of exposure to the suspected risk factors. It was a hospital-community based

study in which cases were gathered from the ENT services at the CHM while the controls were recruited in the same village as cases.

Children <6 years old composed the study population. The diagnosis of otitis media was based on both clinical history and pneumo-otoscopy. In order to exclude sub-acute and chronic cases, only patients <6 years old who visited the CHM complaining of hearing impairment for <3 weeks were considered eligible to participate in the study as a case. They were included in the study if two or more of the following changes in the tympanic membrane were present: colour different from grey, appearance (opaque, dull, or with retro-tympanic hydro-air levels), position (full, bulging, or retracted) and mobility (decreased or absent). Children having type B tympanograms in one or both ears were classified as having middle ear effusion and included in the study. Children taking antibiotics during this same period (the study originally included the identification of the microbiological agents responsible for the infection), and those having cranio-facial anomaly, labio leporino, cleft palate as well as Down's Syndrome, were excluded.

Tympanometry and acoustic reflex measurements were accomplished using a portable tympanometer (Madsen Tympscreen hand-held Middle Ear).

Controls were recruited from the same village or neighbourhood of Maputo as cases and matched by age ( $\pm 4$  months) and sex. They were selected from among children without a history of hearing impairment in the 12 months prior to the study and submitted to the same examinations as the cases: otoscopic exam and impedantometry. The findings of ENT anomalies or any other disease were sent to the corresponding medical service of the Hospital of Maputo.

Regarding residential area, cases and controls were defined as living in the same neighbourhood when living in the same building, or when the distance between the houses of the case and respective control was  $\leq 150$  m. In addition to the fact that the legislation of Mozambique guarantees free access to the hospital system for all the population, Maputo and its environs are socially homogeneous because of their origin in the colonial era, thus socioeconomic biases which could condition access to the CHM were reduced. In principle, two cases per control were expected but this was not possible to achieve for all cases sampled.

A questionnaire was administered by two nurses, specially trained by the service's senior staff, to collect data on demographic characteristics, passive tobacco smoke, exposure to wood smoke, charcoal smoke, history of nasal allergies, respiratory illness history, nutritional status, and number people per room, from both cases and controls. The nurses were blind to case or control status of the children. The questionnaire was administered in Portuguese, but when language was a barrier, a nurse fluent in local languages administered the questionnaire. Infants were considered to have a respiratory illness if their mothers reported that upper respiratory tract infections had occurred more than three times in the past 12 months. ETD was measured by means of the evaluation of the tympanogram. Nutritional status was evaluated using standard protocols based on left-arm perimeter and clinical signs because it was not possible to take a weighing machine around the villages. They were classified as having a nutritional status of 'good' or 'not good'.

In the first step, analysis of all the variables separately was made by means of the program SPSS 10.<sup>30</sup> Bivariate analysis and

conditional logistic regression, adjusted by sex and age, was performed using the statistical package S-PLUS 4.5,<sup>31</sup> to examine the role of the multivariate risk factors and to evaluate the possible interactions between them.

Before starting the study, a group of 80 children was enrolled in a pre-test carried out by two senior ENT specialists. Based on a standard protocol, membrane findings were recorded and the reliability of the middle ear diagnosis was assessed performing inter-observer tests. The Kappa coefficient was calculated.

## Results

As a prior measure of diagnostic concordance between the two senior specialists participating in the study, we have calculated the Kappa coefficient between pneumo-otoscopy test results obtained in 30 cases, and 50 controls. The level of agreement was high ( $K = 0.91$ ; 95% CI: 0.86, 1.00).

In the case-control study, a total of 352 cases of otitis media fulfilling our inclusion criteria were identified. However, from among these, we lost 26 (7.4%), as we could not find their houses and 19 (5.4%) refused to participate in the study. Thus, only 307 cases were included in the study; 443 controls were selected as described previously. Of a total available group of

488 children, 9% refused to participate in the study. The sample thus consisted of 445 boys and 305 girls. The age of patients ranged from 6 to 56 months (median 32 months) while in the control group the age ranged from 6 to 60 months (median 36 months).

Regarding the source of energy used on the kitchen, 151 (49.2%) infants with otitis media were exposed to wood smoke and 34.2% to charcoal smoke whereas in the control group only 4.5% and 25.3% were exposed to wood and charcoal smoke, respectively (Table 1).

Regarding overcrowding, children were grouped ( $\leq 2$  people per room,  $> 2$  people per room) and we found that children with otitis media were more likely to live in rooms with  $\geq 2$  people per room (63.8%) compared with the control group (26.0%).

Although the differences found in breastfeeding practices between cases and controls were not statistically significant, in an analysis stratified by age at which interruption of breastfeeding occurred, we found children withdrawing before the age of 12 months were more frequently cases (Table 2).

In the multivariate analysis, factors such as source of energy, rhinitis, overcrowding, tube obstruction syndrome, and adenoiditis were adjusted for. On the other hand, assuming that during their first year children have some innate factors that favour the

**Table 1** Association between the risk factors and the fact of being case or control. Sex and age conditional odds ratios (OR)

Independent variables	Parameters	Controls		Cases		OR	95% CI
		N	%	N	%		
Indoor tobacco smoke	No	325	73.4	120	39.0	1	
	Yes	118	26.6	187	61.0	1.51	1.35, 1.69
Source of energy used in the kitchen	Others	311	70.2	51	16.6	1	
	Charcoal	112	25.3	105	34.2	1.50	1.39, 1.62
	Wood	20	4.5	151	49.2	1.85	1.57, 2.19
Overcrowding	$\leq 2$ /room	328	74.0	111	36.2	1	
	$> 2$ /room	115	26.0	196	63.8	1.49	1.31, 1.70
Breastfeeding	Yes	246	55.5	106	34.5	1	
	No	197	44.5	201	65.5	1.47	1.27, 1.71
Nutritional status	Good	435	98.2	248	80.8	1	
	Not good	8	1.8	59	19.2	1.54	1.34, 1.78
Eustachian tube dysfunction	No	439	99.1	184	59.9	1	
	Yes	4	0.9	123	40.1	1.81	1.62, 2.04
Respiratory tract infections	None	422	95.2	153	49.8	1	
	Adenoiditis	12	2.8	98	32.0	1.66	1.47, 1.87
	Rhinitis	9	2.0	56	18.2	1.52	1.31, 1.77

**Table 2** Duration of breastfeeding

Independent variables	Parameters	Controls		Cases		OR <sup>a</sup>	95% CI
		N	%	N	%		
Duration of breastfeeding	$> 18$ months	157	61.6	83	41.3	1	
	12–18 months	74	29.0	49	24.4	1.31	0.79, 2.01
	6–12 months	15	5.9	45	22.4	5.72	2.86, 11.43
	$\leq 6$ months	9	3.5	24	11.9	5.01	2.10, 12.32
<b>Total</b>		255	100	201	100		

<sup>a</sup> Odds ratio.

appearance of middle ear infection (decrease in passive antibody levels, immaturity of the immune system, the anatomical characteristics of the Eustachian tube), we performed the multivariate analysis stratifying children in two age groups: <2 and  $\geq 2$  years old. The distributions of the possible risk factors, according to the age groups established, can be seen in Table 3.

Results of the multivariate analysis for children <2 years old are summarized in Table 4. It can be seen that cases are more likely to be associated with wood and charcoal smoke exposure (OR = 3.09), as well as with adenoiditis (OR = 1.57). The same was observed regarding ETD (OR = 1.53) and overcrowding (OR = 3.47). Statistically significant associations between overcrowding and exposure to tobacco smoke and with breastfeeding were seen. Thus, only in the case of improved conditions of

overcrowding, i.e. with <2 people per room, were the clinical history of tobacco smoke exposure (OR = 2.81) and short-term breastfeeding (OR = 2.50) observed to be more relevant. For rhinitis, the association is borderline significant. In this case, the factor only has an effect, although at the limit of being relevant, for children living in more overcrowded conditions (OR = 1.67; 95% CI: 0.97, 2.87).

Regarding the group of children aged >2 years, results are summarized in Table 5. Exposure to wood and charcoal smoke, and adenoiditis are also important in this group. However, other factors also appeared to be relevant in this age group, such as rhinitis (OR = 1.94), overcrowding (1.83), and exposure to tobacco smoke (OR = 1.61). It was seen that the interaction between overcrowding and ETD was borderline significant ( $P = 0.052$ ).

**Table 3** Distribution of risk factors according to age group

Variables	Parameters	Age (months)				OR <sup>a</sup>	95% CI
		$\leq 24$		$> 24$			
		N	%	N	%		
Indoor tobacco smoke	No	339	60.1	106	57.0	1	
	Yes	225	39.9	80	43.0	0.88	0.63, 1.23
Source of energy used in the kitchen	Others	255	45.2	107	57.5	1	
	Charcoal	174	30.9	43	23.1	1.70	1.14, 2.54
	Wood	135	23.9	36	19.4	1.57	1.02, 2.42
Overcrowding	$\leq 2$ /room	330	58.5	109	58.6	1	
	$> 2$ /room	234	41.5	77	41.4	1.00	0.72, 1.41
Breastfeeding	Yes	321	56.9	22	11.8	1	
	No	243	43.1	164	88.2	0.10	0.06, 0.16
Nutritional status	Good	511	90.6	172	92.5	1	
	Not good	53	9.4	14	7.5	1.27	0.69, 2.35
Eustachian tube dysfunction	No	461	81.7	162	87.1	1	
	Yes	103	18.3	24	12.9	1.51	0.93, 2.44
Adenoiditis	No	472	83.7	168	90.3	1	
	Yes	92	16.3	18	9.7	1.82	1.07, 3.11
Rhinitis	No	523	92.2	162	87.1	1	
	Yes	41	7.8	24	12.9	0.53	0.31, 0.90

<sup>a</sup> Odds ratio.

**Table 4** Results of conditional logistic regression. Children <2 years old

Parameters	Coefficients	SE (coef.)	P	OR <sup>a</sup>	95% CI
Source of energy: charcoal or wood	1.130	0.222	<0.001	3.09	2.00, 4.78
Eustachian tube dysfunction: yes	0.427	0.168	0.011	1.53	1.10, 2.13
Adenoiditis: yes	0.450	0.172	0.009	1.57	1.12, 2.20
Overcrowding: $> 2$ /room	1.244	0.335	<0.001	3.47	1.80, 6.69
Tobacco smoke: yes	1.032	0.273	<0.001	2.81	1.64, 4.80
Rhinitis: yes	-0.463	0.478	0.334	0.63	0.25, 1.61
Breastfeeding: no	0.914	0.268	<0.001	2.50	1.47, 4.22
Overcrowding: $> 2$ /room: Tobacco smoke: yes	-0.819	0.336	0.015		
Overcrowding: $> 2$ /room: Rhinitis: yes	0.975	0.562	0.083		
Overcrowding: $> 2$ /room: Breastfeeding: no	-0.676	0.334	0.043		

<sup>a</sup> Odds ratio.

**Table 5** Results of conditional logistic regression. Children >2 years old

Parameters	Coefficients	SE (coeff.)	P	OR <sup>a</sup>	95% CI
Source of energy: charcoal or wood	1.155	0.232	<0.001	3.18	2.01, 5.01
Rhinitis: yes	0.664	0.190	<0.001	1.94	1.34, 2.82
Overcrowding: >2/room	0.606	0.243	0.013	1.83	1.14, 2.95
Adenoiditis: yes	0.397	0.199	0.046	1.49	1.01, 2.20
Tobacco smoke: yes	0.477	0.183	0.009	1.61	1.13, 2.30
Eustachian tube dysfunction: yes	1.119	0.319	<0.001	3.06	1.64, 5.72
Overcrowding: >2/room: Eustachian tube dysfunction: yes	-0.754	0.388	0.052		

<sup>a</sup> Odds ratio.

This interaction indicates that the effect of ETD was relevant only among children living in improved conditions of overcrowding (OR = 3.06), but not among those who lived in worse overcrowding conditions (OR = 1.44; 95% CI: 0.90, 2.31).

## Discussion

The findings of this study are consistent with earlier studies which have reported an association between parental smoking,<sup>10–12,15</sup> upper tract respiratory infection,<sup>17,32</sup> short duration of breastfeeding,<sup>3,10,11,33</sup> and ETD with otitis media.<sup>7,8,34</sup>

Some studies reporting an association with passive smoking found the relationship only with mothers who smoked heavily.<sup>35</sup> A cumulative, dose dependent effect of passive smoking has also been reported to support the hazard effect of environmental tobacco smoke on children's health, including middle ear infections.<sup>10–12</sup> Our results demonstrated a consistent pattern of positive association between exposure to tobacco smoke and middle ear infection in the cases, particularly in children <2 years old. Although only approximately 6% of women in our sample are smokers, 61% of children with otitis media are exposed to indoor tobacco smoke. On the other hand 49.2% are exposed to wood smoke and 34.2% charcoal smoke. We could not estimate the concentrations of respirable suspended particulate matter in the kitchens under study, but there is a high risk that children in Maputo are exposed to them as wood and charcoal are the main source of energy for cooking in many homes. It may be argued that this is frequent in rural areas, but unfortunately it is also the case in the peripheral areas of the town, as well as in some houses within the town, as most people cannot afford to pay electricity or gas bills.

Some researchers have reported that short duration of breastfeeding is associated with middle ear infections. The cutoff point used in some studies is the fourth month of age and exclusive breastfeeding has also been considered.<sup>4,17,18</sup> In Mozambique the majority of women breastfed their babies for at least 18 months.<sup>20</sup> Since the establishment of the NHS, the Ministry of Health and community women's organizations have been educating mothers about the important role of breastfeeding in preventing diseases. Thus, in our sample very few women reported breastfeeding for less than 6 months in either group, cases or controls. Nevertheless, shorter duration of breastfeeding was more common among cases than controls.

Due to the rapid urbanization and lack of housing, overcrowding is common in Maputo and it is not unusual to find

≥3 people sharing the same room. Our study showed that children living in houses where the average number of people per room is >2 were more likely to have otitis media. This can be interpreted as an indirect economic indicator, and probably factors other than overcrowding alone are involved. However, the relationship between overcrowding and respiratory tract infection has been reported, independently of potential confounders, including socioeconomic indicators. In this study we found that rhinitis was important in children >2 years old; in children <2, the results did not show a positive association with rhinitis but when adjusting for overcrowding, changes occurred in the estimates of the coefficients and the odds ratio increased to 2.6.

We found, as others have,<sup>34</sup> that ETD is an important risk factor. In our study there was an interaction between ETD and overcrowding. This interaction is probably due to respiratory infections that may occur in poorly ventilated rooms, leading to changes in the mucociliary system<sup>9</sup> in the Eustachian tube and consequently to otitis media. This increased likelihood was mainly among children >2 years old.

In spite of these results, one should be aware of the limitations of this study. As a case-control study in which cases were recruited in the CHM, study participants are not representative of the pattern of the disease in the community as most cases of otitis media are treated at the primary health care level. On the other hand, although data collected on breastfeeding history was restricted to children <4 years old to reduce recall bias, some mothers may have reported in accordance with the recommendations of the Ministry of Health rather than reporting exactly what they have done, so some bias was probably also introduced through this variable. We collected data on the number of people per room, but it was difficult to collect data about the size of the rooms and their ventilation.

The results of this study suggest that overcrowding, malnutrition, and short duration of breastfeeding are risk factors to be taken into account in Maputo. However, to make conclusions on that, further studies should be conducted. The provided evidence, that exposure of children to environmental wood, charcoal, and tobacco smoke is associated with otitis media in childhood, also requires more accurate studies where measurement of the exposure could be made. However, health education concerning breastfeeding practices as well as carrying babies on back while cooking with wood or charcoal, could be useful for the communities to reduce the risk of their children suffering from otitis media.

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