

Estimating Pediatric Asthma Prevalence in Rural Senegal: A Cross-Sectional Survey

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Summary. Rationale: In Senegal, the prevalence of childhood asthma and utilization of appropriate asthma therapies is unknown. Methodology: We used the International Study of Asthma and Allergies in Childhood (ISAAC) survey instrument to assess childhood respiratory health in rural Senegal. We interviewed the caregivers of children aged 5 through 8 years of age in the four largest Niakhar villages in August 2012. Results: We interviewed 1,103 primary caregivers for 1,513 children, representing 91% of all age-eligible children in the study area. Overall, 206 (14%) children had wheeze at any time in the past, 130 (9%) had wheeze within the past year, and only 41 (3%) reported a clinical diagnosis of asthma. Among children with wheeze within the past year, 81 (62%) had symptoms of severe asthma. Nocturnal cough was reported in 186 (14%) children who denied any history of wheezing illness. Only four (3%) children with wheeze in the past year had ever received bronchodilator therapy. Children with wheeze in the past year were significantly more likely to seek medical care for respiratory symptoms and to be perceived as less healthy than their peers. Children of lower socioeconomic status were significantly more likely to have wheeze. Conclusions: Nearly one in ten children in Niakhar, Senegal had symptoms suggestive of asthma; however, few children have a diagnosis of asthma or use appropriate therapies. This study highlights an opportunity to raise community awareness of asthma in rural Senegal and to increase access to appropriate medical therapies. **Pediatr Pulmonol.** 2016; 9999:XX–XX. © 2016 Wiley Periodicals, Inc.

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INTRODUCTION

Globally, an estimated 334 million people have asthma, and it is the most common chronic disease among children worldwide.¹ The prevalence of asthma is increasing among children.² Symptoms of severe asthma disproportionately affect children in low- and middle-income countries (LMICs) compared to those in high-income countries (HIC).³

The vast majority of the data comprising the global asthma map for children comes from the International Study of Asthma and Allergies in Childhood (ISAAC), a multiphase, international study of asthma and allergies. Over three study phases since 1991, a total of 306 centers in 105 collaborating countries have contributed to the ISAAC dataset. However, there remains a paucity of data on childhood asthma prevalence in many LMICs, including much of West Africa. Only four centers in West Africa (Cote d'Ivoire, Guinea, Togo, Nigeria), were included in the most recent ISAAC study, all of which represented urban populations.³ In Senegal, childhood asthma symptom prevalence is unknown.

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In Africa, 40% of children who report symptoms of severe asthma have never been diagnosed with the disease.³ Inadequately controlled asthma is associated with significant global morbidity.^{4,5} However, asthma can be effectively controlled with appropriate medications when used regularly.^{6,7} Both inhaled bronchodilators and inhaled corticosteroids are designated essential medicines by the World Health Organization (WHO); however, availability remains limited in most LMICs.⁸

This study aims to report childhood asthma prevalence in the rural Niakhar region of Senegal, an area for which asthma data did not previously exist. Secondary objectives for this study include understanding how frequently symptomatic children are diagnosed with asthma by health providers and to describe the community use of health resources and asthma therapies for children with symptoms. The burden of disease, as reported in this study, is essential to heighten community and healthcare provider awareness, improve asthma diagnosis, and increase availability of essential medications in this region.

MATERIALS AND METHODS

Study Area and Population

Niakhar is an arid region in Western Senegal situated in the Sahel climate zone 135 km east of Dakar, Senegal. The population is predominantly ethnic Sereer (97%) and primarily Muslim (77%).⁹ Sereer is the primary language spoken. Formal education levels are low, as are literacy rates. Agriculture is the economic base for the community, with the majority of households growing millet and groundnuts. Meal preparation over an open fire with biomass fuels is common. The main residential unit is a compound formed by the clustering of one or multiple households, with each household accommodating a nuclear family unit of the extended patrilineal family. Thirty villages within the region have participated in a demographic surveillance system (DSS) coordinated by the Institut de Recherche pour le Développement (IRD) since 1983.⁹ The DSS is a member of the INDEPTH Network which sponsors longitudinal health and population research throughout Africa and Asia to inform health policy. We used the Niakhar DSS registry and census data to identify eligible survey respondents and to calculate population denominators for prevalence estimates.

Study Design and Eligibility

We performed a cross-sectional survey of asthma symptoms among children in rural Senegal using a written questionnaire adapted from the ISAAC instrument.¹⁰ The four largest villages in the Niakhar DSS were selected for participation in the survey; Diohine, Toucar, Ngayokhem, and Ngangarlame. Using the DSS registry, we identified 1,656 children in these villages in the 5–8-year-old age

range who were eligible to participate. We approached all households with eligible children in these villages for study participation and 1,513 were enrolled based on caregiver willingness to participate. Trained field workers verbally administered the survey to the primary caregiver for the child or children, who responded on their behalf. The study data collection began in August 2012 and lasted through September 2012.

Study Instrument

The study instrument used the core asthma questions from the ISAAC questionnaire which has been validated against both physician diagnosis and bronchial hyper-responsiveness.^{11,12} The three ISAAC phases used the questionnaire in children aged 6 to 7 and 13 to 14. Studies have employed this questionnaire in children of other ages, including the age range used in our study and have validated the questions for younger age groups, although not in a Senegalese population.^{13,14} Due to resource limitations, the ISAAC instrument was not independently validated in our specific study population. However, we used the French language version of the ISAAC questionnaire, directly provided by the ISAAC research team, which was used in neighboring francophone West African countries for the ISAAC studies. Public health experts from the Niakhar area made minor adaptations to the survey instrument to ensure questions were culturally appropriate, understandable, and accurate within the local context. Specifically, the words “in the last 12 months” were replaced with “since the last rainy season” to reflect the community’s use of seasonal patterns for timekeeping (Table 1). The survey was conducted ~12 months after the previous rainy season. We did not modify the core language used by the standard ISAAC survey. Additional questions regarding health perceptions, use of bronchodilators and health services, and air pollution exposures were also included.

Translation of non-ISAAC questions from English to French was performed by a bilingual, Senegalese study collaborator. These questions were back-translated by a different bilingual collaborator to English to confirm preservation of meaning, per ISAAC protocol.¹⁵ The written questionnaire was administered by trained field workers fluent in both French and Sereer. Given low literacy rates in this region, questions were read to participants in French and clarifications provided in Sereer if questions arose. Additionally, photographs of medications (oral and inhaled) were shown to participants given concerns that caregivers may not recognize medication names or descriptions.

Ethical Approval

Ethical approval for the study protocol was obtained from the University of Washington Institutional Review Board and the Senegal national ethics committee, Conseil

TABLE 1—Questionnaire Specifics

Question	Question aim	Notes
Has your child ever had wheezing or whistling in the chest at any time in the past?	Wheeze ever	ISAAC question
Has your child had wheezing or whistling in the chest since the last rainy season? ¹	Wheeze in past 12 months	Modified ISAAC question. Population does not use the calendar year to mark time. At time of survey, it had been 12 months since the last rainy season ¹
Since the last rainy season, how often, on average, has your child's sleep been disturbed due to wheezing? ¹	Asthma severity indicator	Modified ISAAC question ¹
Since the last rainy season, has wheezing ever been severe enough to limit your child's speech to only one or two words at a time between breaths? ¹	Asthma severity indicator	Modified ISAAC question ¹
Has your child ever had asthma?	Diagnosed asthma	ISAAC question
Since the last rainy season, has your child's chest sounded wheezy during or after exercise? ¹	Exercise-induced wheeze	Modified ISAAC question ¹
Since the last rainy season, has your child had a dry cough at night, apart from a cough associated with a cold or chest infection? ¹	Nocturnal cough	Modified ISAAC question ¹
Since the last rainy season, has your child seen a doctor or nurse for breathing problems? ¹	Healthcare utilization for respiratory illness	Three of four surveyed villages have a health center staffed by trained medical personnel
Has your child ever used Ventolin or Salbutamol?	Use of essential asthma medications	
Has your child ever used an inhaler?	Use of asthma medication delivery device	Photos of generic inhalers were shown to respondent

ISAAC, International Study of Asthma and Allergies in Childhood.

¹ISAAC syntax "12 months" replaced by "since the last rainy season."

National de Recherche en Santé (CNER). We obtained assent from community leaders, religious leaders, and Ministry of Health officials for the Niakhar district. In alignment with cultural practice, field workers received verbal permission from compound heads prior to obtaining written informed consent from survey respondents.

Data Analysis

All questionnaire responses were entered into REDCap (Research Electronic Data Capture), a secure, web-based, data capture application hosted at University of Washington.¹⁶ Prevalence of asthma symptoms were directly calculated by dividing the number of children with symptoms of wheeze in the past 12 months by the total number of respondents. Consistent with previous ISAAC studies, severe asthma was defined as children who had four or more attacks of wheeze in past year or had one or more night per week of wheeze-related sleep disturbance or one or more episode of wheeze limiting speech in past year. We defined low socioeconomic status by house construction of mud or thatch and no access to electricity or television. The number of survey respondents was considered the true population denominator for children

aged 5 through 8 years in participating villages based on our high response rate and known DSS census data. Measures of association were presented as relative risks (RR). *P*-values were calculated with two-sided χ^2 test or Fischer's Exact test when counts were less than five. *P*-values of 0.05 or less were considered significant. All statistical analyses were performed using Stata Statistics Software version 13 (StataCorp LP, College Station, TX).

RESULTS

A total of 1,513 children aged 5 through 8 years were included in the survey, representing 91% of the 1,656 age-eligible children in the four participating villages, as documented by the DSS. Fifty percent (753) of the children were female. Each age was evenly represented and accounted for approximately a one-quarter of the sample (Table 2). Among the children, 778 (51%) were aged 6 through 7 years, the age range for which the ISAAC survey has been validated. There were 1,103 caregivers, all female, who answered survey questions on behalf of the children. The caregiver mean age was 36 ± 10 years.

Among the households, 137 (12%) had electricity, 136 (12%) had television, and 1,049 (95%) had a mobile phone. Most households, 973 (90%), were constructed of

TABLE 2—Characteristics of Study Participants

	Count	(%)
Children	N = 1,513	
Age (years)		
5	344	(23)
6	382	(25)
7	396	(26)
8	391	(26)
Female	753	(50)
Caregiver respondent	N = 1,103	
Age, mean [StdDev]	35.7	[10]
Female	1,103	(100)
Relationship to child		
Mother	890	(81)
Grandmother	105	(10)
Sister	10	(1)
Aunt	47	(4)
Other	1	(<1)
Household (HH) characteristics	N = 1,103	
No. of HHs in compound, mean [StdDev]	2.3	[1.8]
HH assets		
TV	136	(12)
Electricity	137	(12)
Access to running water	301	(27)
Mobile phone	1,049	(95)
Building material		
Walls		
Mud/thatch bricks	137	(13)
Cement	105	(10)
Zinc	10	(<1)
Mud and stick composite	836	(77)
Roof		
Pailles/straw	470	(60)
Zinc	320	(41)
Low socioeconomic status (SES) ¹	926	(61)
Smoker in the compound	654	(59)
Household fuel use ²		
Rainy season	N = 707	
Biomass fuel ³	702	(99)
Coal	0	(0)
Liquid propane gas	4	(<1)
Dry season	N = 667	
Biomass fuel ³	661	(99)
Coal	0	(0)
Liquid propane gas	5	(<1)

Due to incomplete responses, not all percentages add to 100.

¹SES defined by household building materials and household assets. Higher SES households used cement blocks and corrugated zinc as building materials and possessed a television or had access to electricity. Lower SES households used mud bricks, mud and sticks, and straw as building materials and lacked electricity or a television.

²Low response rate for this question, total number of respondents shown.

³Wood, dung, or crop residue.

mud bricks or composite of sticks and mud. Among households reporting fuel use, 99% used biomass fuel (wood, dung, or crop residue). Only one caregiver reported actively smoking tobacco, but 654 (59%) of the households included at least one person who smoked tobacco.

A total of 41 (3%) children had a diagnosis of asthma, while 130 (9%) had wheeze within the previous year and 206 (14%) had wheeze ever (Table 3). For children aged 6 through 7 years, 71 (9%) had wheeze within the past year and 113 (15%) had wheeze ever. Among children with no history of wheeze, 186 (14%) had nocturnal cough. Symptoms of severe asthma were identified in 81 children; representing a 5% prevalence among all respondents and 62% among children with current wheeze (Table 4). Among children with current wheeze, nocturnal wheeze disrupted sleep at least one night per week in 21 (16%) children and 70 (54%) children experienced wheezing severe enough to limit speech. The proportion of children with symptoms of severe asthma without an asthma diagnosis was 58% (n = 47).

Among the 130 children with wheeze in the past year, 53 (41%) had seen a healthcare provider for respiratory

TABLE 3—Prevalence of Asthma Symptoms

Question	Count	(%)
Prevalence of symptoms in the cohort		
Wheeze ever (among all respondents) ¹	206	(14)
Current wheeze (among all respondents) ¹	130	(9)
Exercise-associated wheeze in past year (among all respondents) ¹	149	(10)
Nocturnal cough in past year (among all respondents) ¹	296	(20)
Asthma diagnosis (among all respondents) ¹	41	(3)
Visits to health provider for respiratory illness in past year (among all respondents)		
None	1,404	(93)
1 to 2	73	(5)
3 to 4	22	(1)
5 or more	4	(<1)
Severity of illness among children who may have asthma		
No. of wheezing attacks in past year (among those with current wheeze) ¹		
None	4	(3)
1 to 3	104	(80)
4 to 12	17	(13)
More than 12	4	(3)
Sleep disturbance from wheeze in past year (among those with current wheeze) ¹		
Never	19	(15)
<1 night per week	89	(68)
1 or more nights per week	21	(16)
Speech limited by wheeze in past year (among those with current wheeze) ¹	70	(54)
Ever used bronchodilator (oral or inhaled)		
Among all respondents	13	(1)
Among those with current wheeze	4	(3)
Used an inhaler		
Among all respondents	5	(<1)
Among those with current wheeze	2	(2)

All respondents = total survey population (N = 1,513).

Current wheeze = report of wheeze within past 12 months (N = 130).

¹Question from International Study of Asthma and Allergies in Childhood (ISAAC) survey.

TABLE 4—Prevalence of Wheeze, Severe Asthma Symptoms, and Diagnosis of Asthma

	n	Percentage of outcome among all children in the study cohort, N = 1,513	Percentage of outcome among children with current wheeze, N = 130
All respondents	1,513	—	—
Current wheeze	130	9%	—
Asthma diagnosis ever	41	3%	32%
Current wheeze without asthma diagnosis	88	6%	68%
Symptoms of severe asthma ¹	81	5%	62%
Symptoms of severe asthma without asthma diagnosis	47	3%	36%

¹Severe asthma defined by children reporting wheeze in the past year who had ≥ 4 attacks of wheeze in past year or have ≥ 1 night per week of wheeze-related sleep disturbance or ≥ 1 episode of wheeze limiting speech in past year.

symptoms, but only four (3%) had ever used a bronchodilator (oral or inhaled). Children with wheeze in the past year were significantly more likely to seek medical care than their peers without reported wheeze (RR = 2.8; 95% CI, 1.6–5.0; $P < 0.01$) and children with current wheeze were perceived as significantly less healthy than their peers (RR = 2.1; 95% CI, 1.3–3.3; $P < 0.01$) (Table 5). Low socioeconomic status was significantly associated with increased risk of wheeze (RR = 1.3; 95% CI, 1.1–1.6; $P = 0.01$). Passive cigarette smoke exposure and helping with the open cooking fire were not associated with wheeze in the past year. Children living in a village with a medical clinic were no more likely to have an asthma diagnosis or receive treatment with bronchodilators than those in a village without a medical clinic.

DISCUSSION

In this cross-sectional survey, nearly one in ten children aged 5 through 8 years had symptoms consistent with asthma. This compares with estimates from urban West African populations where prevalence ranged from almost 6% for children of similar ages to a range of 13% to 19% for older adolescents.^{13,17,18} In accordance with the ISAAC studies, the prevalence of asthma symptoms was defined by presence of wheeze in the previous 12 months.¹⁹ However, calculation of prevalence based on current wheeze does not capture all asthma presentations, such as nocturnal cough, a common asthma manifestation.²⁰ In this study, 14% of children reported to never have wheezing had nocturnal cough, suggesting the true prevalence of asthma may be higher than our study reports.

TABLE 5—Association Between Health Outcomes Among Children With Wheeze in Past Year

Health variable	RR (95% CI)	P-value*
Asthma diagnosis	3.66 (1.49–9.00)	<0.001
Nocturnal cough	2.31 (1.59–3.34)	<0.001
Perceived as less healthy than peers	2.10 (1.33–3.31)	<0.001
Seeks healthcare for respiratory symptoms	2.77 (1.55–4.98)	<0.001
Helps with cooking fire	0.95 (0.77–1.17)	0.66
Smoker in compound	1.10 (0.88–1.38)	0.38
Lower socioeconomic status (SES) ¹	1.31 (1.07–1.60)	0.01

¹SES defined by household building materials and household assets. Higher SES households used cement blocks and corrugated zinc as building materials and possessed a television or had access to electricity. Lower SES households used mud bricks, mud and sticks, and straw as building materials and lacked electricity or a television. *P-values calculated by χ^2 or Fisher's Exact test when sample counts < 5 . To account for potential non-independence of data, linear regression with clustering by household using Huber–White Sandwich estimators was performed. The significance of associations did not change.

Childhood asthma prevalence is often higher in urban communities compared to their rural counterparts.^{21,22} The mechanism by which the environment influences asthma susceptibility is unknown, but modulation of the developing immune system by early exposure to antigens and infections is a leading hypothesis.²¹ This rural–urban disparity has been most extensively studied in rural European farming communities so the comparability to a subsistence West African farming community with minimal livestock presence is uncertain. However, the available evidence would suggest that asthma prevalence may be even higher than our study reports, for more urban regions of Senegal.

Presence of symptoms of severe disease is arguably more clinically significant than current wheeze alone. While the more sensitive metric of current wheeze is widely accepted as the standard for epidemiologic studies of asthma prevalence, the severe symptoms of wheeze-related sleep disturbance and speech limitation are highly specific for methacholine bronchial hyperresponsiveness, a more objective measure of asthma.²³ The prevalence of severe asthma symptoms was high in this population. The proportion of children with sleep-disturbing or speech-limiting wheezing attacks was 16% and 53%, respectively, among those with current wheeze. This is consistent with findings from ISAAC showing that the burden of severe asthma symptoms tends to be higher in low-income countries relative to HIC.³ In our study, the number of speech-limiting wheezing attacks is more than triple the other severity indicators. Among other studies using the ISAAC questionnaire, speech-limiting wheeze is frequently the most commonly reported symptom of severe disease.^{18,19}

Clinician diagnosis of asthma was very low (3%) relative to prevalence of current wheeze and high proportion of severe symptoms among the children. This disparity between symptoms and diagnosis is well characterized in other studies from LMICs and consistent with our findings.^{3,24,25} There may be a deficit in understanding or awareness among clinicians responsible for making this diagnosis.²⁶ Decreased access to medical services in LMICs may account for low rates of diagnosis, however in our study, there was no difference in prevalence of asthma diagnosis between children living in villages with and without medical clinics. Children with wheeze sought medical care more often, suggesting missed opportunities for diagnosing asthma. Communicable diseases remain the health priority in most LMICs and may dominate clinicians' focus when evaluating children with wheeze, possibly leading to under-diagnosis.²⁷ This community may not perceive wheeze as a concerning symptom and caregivers may only seek medical care when symptoms are severe. The data support this given 68% of children with current wheeze lack an asthma diagnosis, compared to 36% of children with symptoms of severe asthma.

Among children with current wheeze, very few (3%) had ever utilized basic asthma medication in the form of bronchodilators, oral or inhaled. Less than 2% of children with asthma symptoms had ever used an inhaler, suggesting that the vast majority of the children had never been treated with inhaled corticosteroids, the mainstay of asthma treatment.²⁸ Inhaled corticosteroids are not generally available in this community. While these medications are on the WHO Essential Medication List for children, our findings are consistent with lack of drug availability in other LMICs.⁸ Senegalese health centers routinely stock intravenous corticosteroids or oral beta-agonists to be administered during an acute asthma exacerbation, but inhaled bronchodilators and corticosteroids are not widely available. This suggests a focus on treating acute symptoms rather than chronic disease management. Further efforts to increase the availability of these controller medications in the Niakhar region is needed.

The study should be interpreted in the context of its limitations. Our study used the ISAAC questionnaire for children outside of the validated age range of 6 through 7 years. However, when we calculated prevalence estimates for the subset of children aged 6 through 7, they were comparable to our estimates for the broader age range. The survey was administered in French, the national language of Senegal; however, many Niakhar residents primarily speak Sereer. We used highly trained field workers who were fluent in both languages; however, there may have been residual misunderstanding. The four largest villages within Niakhar may not be representative of other rural Senegalese populations. There are inherent limitations of cross-sectional surveys that include recall bias and absence of objective measures, such as spirometry, for

the outcome of interest. Written symptom-based questionnaires to assess asthma prevalence are known to have limitations.²⁹ Due to study resource limitations, we could not incorporate the ISAAC videos that demonstrate wheezing, nor independently validate the ISAAC instrument in our specific study population. We attempted to mitigate the limitations of a symptom-based questionnaire, particularly one used in a non-English speaking, low-literacy community, by including photos where appropriate (i.e., of inhalers and oral medications), using highly trained, bilingual field workers, and using the core ISAAC instrument which is a widely accepted tool for assessing childhood asthma prevalence in culturally and linguistically diverse communities. Despite these limitations, symptom-based questionnaires are still considered highly valid tools for epidemiologic studies of asthma prevalence.^{12,30,31}

The strengths of this study include the use of standardized asthma questions from the ISAAC survey that allows comparison to data from other countries. The prevalence estimates from this study are based on a response rate of 91% of all eligible children, nearly the true population denominator for the surveyed villages. As a result, the prevalence estimates from this study are direct calculations using the population denominator.

CONCLUSIONS

The results of this study suggest asthma is under-diagnosed and undertreated in children in rural Senegal. The disparity, particularly between the high prevalence of severe asthma symptoms and asthma diagnosis, emphasizes an opportunity for public health intervention. This study provides Senegalese health policy-makers important data on childhood asthma burden that previously did not exist. The results of this study support increased local resource allocation for this childhood disease. Further study on diagnostic and management practices, availability of appropriate medications, and community awareness of asthma are warranted in this population.

AUTHORS' CONTRIBUTIONS

LGH had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the analysis. VSF and KMN contributed substantially to data interpretation and writing of the manuscript. YD, AN, AD, and JRO contributed substantially to development of study design, data collection and analysis, data interpretation, and writing of the manuscript.

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DISCLAIMER

The findings and views expressed in this article are those of the authors alone and do not necessarily reflect those of their institutions, the position or policy of the Department of Veterans Affairs, or the United States Government.

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