Spirometry in Asthma Care: A Review of the Trends and Challenges in Pediatric Practice

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ABSTRACT: BACKGROUND: Given the rising incidence of noncommunicable diseases (NCDs) globally, especially bronchial asthma, there is the need to reduce the associated morbidity and mortality by adopting an objective means of diagnosis and monitoring.

AIM: This article aims to review the trends and challenges in the use of spirometry for managing childhood bronchial asthma especially in developing countries.

METHODS: We conducted a literature search of published data on the use of spirometry for the diagnosis of childhood bronchial asthma with special emphasis resource-poor countries.

RESULTS: Guidelines for the diagnosis and treatment of childhood asthma recommend the use of spirometry, but this is currently underused in both tertiary and primary care settings especially in developing countries. Lack of spirometers and proper training in their use and interpretation of findings as well as a dearth of asthma guidelines remains core to the underuse of spirometry in managing children with asthma. Targeting education of health care staff was, however, observed to improve its utility, and practical implementable strategies are highlighted.

CONCLUSIONS: Spirometry is not frequently used for asthma diagnosis in pediatric practice especially in resource-poor countries where the NCD burden is higher. Strategies to overcome the obstacles are implementable and can make a difference in reducing the burden of NCD.

KEYWORDS: spirometry, bronchial asthma, children, developing countries

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Introduction

There is a high burden of infectious respiratory diseases such as tuberculosis and human immunodeficiency virus–related lung diseases especially in sub-Saharan Africa.[1,2] However, there is a shift in focus to noncommunicable diseases (NCDs) such as cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes which rank as the 4th major contributors to NCD deaths.[3,4] Respiratory diseases account for up to 4 million deaths attributed to NCD; unfortunately, the distribution of NCD disproportionately affects resource-poor countries.[3,5,6]

Bronchial asthma constitutes a predominant respiratory NCD[7] and is a disorder characterized by variable airflow obstruction with airway hyperresponsiveness. It is the leading cause of chronic respiratory diseases in children in both developed and resource-poor countries.[5,8] In children, the diagnosis of asthma is usually based on historical information, ie, the symptomatic evidence of obstruction such as wheeze, cough, and dyspnea.[9,10] This subjective method may be further guided by country-specific guidelines where these exist. Pulmonary function tests are more sensitive than clinical symptoms or examination in making diagnoses of obstructive respiratory pathology.[11] Thus, in older children and adults, spirometry as recommended by several guidelines, has remained the gold standard for accurate diagnosis and repeatable measurement of lung function.[10–13] Children as young as 3 to 5 years have been able to perform acceptable spirometry as published reference range values for these age groups exist.[14–19] There are no absolute contraindications for spirometry testing in children, and spirometers are widely available at reasonable cost, with methods and result interpretation being comprehensively standardized.[20] Nevertheless, there is a clear gap between recommendations and practice in the use of spirometry especially in children with bronchial asthma as seen in resource-poor countries.

This article aims to review the trends and challenges in the use of spirometry for managing childhood bronchial asthma in developing countries.

Literature Search Strategy

Search terms used were "asthma," "NCD," "spirometry," "doctors," "pediatricians" as well as phrases such as "asthma diagnosis in children," "asthma guidelines and spirometry," "spirometry utilization," "asthma management in resource poor countries," "spirometry utilization by doctors," "primary health care and asthma management," "bronchial asthma diagnosis in Nigeria." We limited our search to articles written in English to avoid any ambiguity in the translated equivalent of the word "spirometry." Relevant publications identified were initially screened according to their title and the contents of their abstract. About 1000 articles relevant to our search scope were found and these included articles from and beyond Africa. Subsequently, we retrieved full-text articles considered relevant for inclusion in the reviews and analyzed them.

The search sought to find out whether spirometry as a diagnostic tool is being used in children with asthma especially in resource-poor settings. We also searched whether the equipment for spirometry is available in facilities caring for children. We further researched on the health structure in resource-poor countries to find out whether they are organized enough to engage in equipment-based diagnosis of asthma especially in children and whether there are country-specific guidelines or statements that help decide on how asthma diagnosis should be made in children. Further search included existing expertise in spirometry use and interpretation in children in tertiary and primary health care facilities in resource-poor countries. Analyses for the existence of spirometry centers or dedicated system of referral to a higher level of care when the equipment is not available and the possible solutions that have been applied were also done.

Spirometry as a Diagnostic Tool

Spirometry measures how an individual inhales or exhales volumes of air as a function of time.[21] Various types of spirometers exist depending on whether the in-built physiologic mechanics measure lung volume or airflow changes or both.[22] Indications for use in children include history or physical examination findings suggestive of lung dysfunction such as wheezing, cough, family history of lung disease, recurrent chest infections, and presence of other abnormal diagnostic tests such as chest radiograph and arterial blood gas analysis. Other indications include disease severity assessment for already known/existing lung diseases, assessment of effectiveness of therapeutic intervention over time, and preoperative assessment for thoracoabdominal surgery or if the child will be under the effect of anesthesia for a long period after any surgery.[11,23] In children, evaluation of bronchial asthma, however, remains the most common indication for spirometry.[23–25]

The diagnosis of asthma using spirometry involves interpreting the values of forced expiratory volume in the first second of expiration (FEV_1), forced vital capacity (FVC), and the ratio of FEV to FVC obtained from the spirometer. A reduction in FEV_1 relative to the FVC will result in a low FEV_1/FVC, typical of obstructive ventilatory defects such as bronchial asthma, chronic obstructive pulmonary disease (COPD), and emphysema. When the FEV_1/FVC ratio remains normal or high (typically > 80%) with a reduction in both FEV_1 and FVC, it suggests a restrictive defect such as interstitial lung disease, respiratory muscle weakness, and thoracic cage deformities such as kyphoscoliosis.[26] The use of reversibility testing further confirms the diagnosis of asthma where more than 12% difference is noted between the pre- and post-bronchodilator test results.[22,26,27]

Spirometry in Pediatric Practice: Global Trends and Challenges

Despite the importance of spirometry, studies from several countries (developed and developing) show that it is frequently underused in both tertiary and primary care settings which cater for both adult and pediatric populations.[28–37]

In a survey on physicians' practices with children with asthma, done in the United States by Finkelstein and colleagues, they reported that less than a quarter of the physicians surveyed use spirometry in evaluation and diagnosis of asthma in children.[31] Furthermore, Dombowski et al showed that about half of family physicians and pediatricians in their study used spirometry in their clinical practice and less than a quarter used spirometry for all guideline-recommended situations with significantly more family physicians than pediatricians reporting the use of spirometry in their practice.[32] In Belgium, some authors observed that in the preceding 2 years to their study, only about 30% of study participants with obstructive lung disease managed in primary care settings had been evaluated with spirometry.[33] In the study by Mash et al[35] in South Africa, primary health care facilities in Western Cape province were audited to determine performance level in terms of availability and use of asthma diagnostic tools, frequency of use of reliever medications, and adequacy of dose of inhaled corticosteroids. The findings showed that about 60% of facilities had a functional peak flow meter, out of which only 23% had peak expiratory flow rates recorded at routine visits. This study[35] specifically made no mention of availability and usage of spirometry in their setting.

In making a diagnosis of asthma, symptoms, clinical findings, and response to asthma medications are all important methods, but spirometry remains the more objective method for asthma diagnosis.[10–13] These findings therefore underscore the problems of asthma diagnosis which include nonavailability of diagnostic tools and lack of usage of these tools.

Nonusage of spirometry in resource-poor countries may not be entirely attributable to its nonavailability. Sometimes, lack of physicians' knowledge on the importance and usefulness of spirometry in asthma diagnosis can account for this utility gap.

Elsewhere in Ivory Coast, 41% of the physicians studied by Ngom et al[36] were not using spirometry as they were totally unaware of the usefulness of FEV measurements in making a diagnosis of asthma in both pediatric and adult patients. In a related study conducted in Southeast Nigeria with the aim of

Table 1. The 7-point implementable strategies on the utility of spirometry based on global trends.

	AUTHORS (COUNTRY)	IMPLEMENTABLE STRATEGY FOR THE UTILITY OF SPIROMETRY
1	Ait-Khaled et al (Denmark and several developing countries)[28]	Improved staff training and education on use of spirometry
2	Masekela et al (South Africa)[23] and Erhabor et al (Nigeria)[44]	Having country-specific asthma guidelines and spirometry guidelines, especially for children
3	Mohammad et al (Syria)[29]	Adoption of GINA guidelines in countries without their own asthma guidelines
4	Tan and Aït-Khaled[45]	Stepping down guideline use even at the primary health centers in resource-poor countries
5	Imad and Yasir (Sudan)[46]	Setting up new model specialized center for asthma
6	World Health Organization (WHO)[47]	WHO programs that target NCD reduction: the Practical Approach to Lung Health (PAL) program integrates asthma and COPD care into the National Tuberculosis Program
7	Quanjer et al[48] (Caucasians, African Americans, North and Southeast Asian population)	Application of the new GLI all-age reference equation and expression of spirometry values as *z* scores to enable equitable comparisons across data

Abbreviations: COPD, chronic obstructive pulmonary disease; GLI, Global Lung Initiative; GINA, Global Initiative on Asthma; NCD, noncommunicable disease.

assessing appropriate treatment of asthma by medical practitioners, Ayuk et al[37] reported that only 34% of doctors in their study population used any lung function measures to make a diagnosis of asthma while none made use of spirometry. However, this study did not assess whether the medical practitioners were aware of the importance of spirometry and the availability of the instrument.

The underuse of spirometry in children is also evident in some published studies in Nigeria.[38–40] For instance, the reports by Desalu et al[39] in Ilorin, Southwest Nigeria and Nwosu et al[40] in Enugu, Southeast Nigeria showed that in their retrospective analyses on spirometry use, very few children were part of the pool of study participants for both studies: 3.4% (4/119) and 3.5% (8/226), respectively. It stands to reason that there were most likely more children in those hospitals who had asthma or other chronic respiratory diseases requiring spirometry evaluation but had not presented for the procedure. This highlights the fact that children may not be routinely referred on a regular basis for spirometry, as well as the likelihood that the need for spirometry in children is not well recognized.

Challenges noted with the use of spirometry in children may, however, contribute to underuse among clinicians. Some of them include the difficulty children may have with understanding the instructions well enough to cooperate with the procedure because most require repeated demonstrations and visual feedback. Second, although young children can perform acceptable spirometry without necessarily exhaling for up to 6 seconds, as reaching a plateau may be considered sufficient, it is usually difficult for children to inhale maximally and expire for standard 6 seconds without coughing.[41] Furthermore, a lot may border on the feasibility of obtaining reliable measurements in a busy clinical practice especially as children may require more time to get acceptable spirometry. The notable difficulty is worse in the preschool age. A look at studies in the developed world shows, for instance, that Gaffin et al[42] conducted a real-world assessment of spirometry feasibility in 248 preschoolers in a busy pediatric pulmonary function laboratory. Only 54% were capable of performing spirometry that was acceptable and repeatable based on American Thoracic Society (ATS)/European Respiratory Society (ERS) preschool spirometry recommendations. The older pediatric age group may find the task of forceful expiration less daunting.[43] Children 5 years and older may thus be more suited to perform the forceful spirometry maneuver for more reliable outcome. The outcome can further be enhanced by having dedicated and supportive training for physicians particularly those who attend to children. A longitudinal study in Denmark did demonstrate that improved education of staff enhanced the use of spirometry in hospital outpatients with COPD, thus showing the importance of staff training[28] (Table 1).

Specific guidelines for the diagnosis and treatment of asthma in childhood, including the Global Initiative on Asthma (GINA) guideline,[49,50] recommend the use of spirometry every 1 to 2 years or more frequently and always at the following times in asthma management: at the initial assessment, after treatment is initiated and symptoms have stabilized, and during periods of progressive deterioration or improvement of symptoms.[49,50] Furthermore, of current relevance in spirometry-based diagnosis of lung function abnormality is the more inclusive Global Lung Initiative all-age reference equations,[48] endorsed by the ERS and ATS which ought to be applied when interpreting findings from spirometry assessment. Global Lung Initiative reference equations were obtained from 33 countries and from most continents (except Africa) and have provided more standardized measurements which are adjusted according to sex, age group, ethnic groups, FEV_1, and FVC. These have streamlined the interpretation of

spirometry results within and among populations worldwide.[48] Global Lung Initiative has also recommended that the spirometry reports in children should be expressed in *z* scores to enable equitable comparisons across data. On application of this, and on a bigger scale, the lack of spirometry guiding principles and asthma guidelines remains a rate-limiting factor in spirometry use. Global Asthma Report 2013, in a survey on the use of asthma guidelines, reported that asthma management guidelines were used in 89% of the 96 countries that responded to the survey. Exclusive use of "self-owned" national guidelines was greater in high-income countries than in low-income and middle-income countries. This contrasted in comparison with use of internationally adoptable guidelines, such as GINA, use of which was higher in low-income and middle-income countries. In Africa, specifically, only about 6 countries had official, published asthma guidelines,[51] with Nigeria recently publishing their own guideline.[44] This is a step in the right direction. A few African countries such as South Africa have taken the further step to have spirometry guidelines[23] (Table 1). Where such guidelines exist and they are adhered to, the diagnosis and management of asthma including spirometry use will most likely be enhanced. Adoption of guidelines and adherence to them are thus important steps in improving outcomes of patients with asthma. Resource-poor countries without an official national guideline can then be encouraged to adopt the GINA guidelines where recommended use of spirometry is included.[50] This will raise a lot of awareness on the proper role of spirometry in the diagnosis of childhood bronchial asthma and the improvement of asthma outcomes that will eventually reduce NCD burden. This has proven to be possible in developing countries where children may not have access to tertiary health care facilities.[28–30]

In many developing countries, the primary health care centers are one of the major health care facilities where children with asthma are treated, and in such countries, adequate equipment and access to health insurance are 2 important determinants of adequacy of asthma care.[52] For instance, a study in Algeria showed that of all the children who had asthma, up to 9% of them were seen in the primary health care facilities.[52] In yet another multicenter study of children seen in the primary care clinics in Syria, the survey revealed that among attendees who were above 6 years, up to 13% had a diagnosis of asthma.[29] This buttresses the fact that children with asthma are being seen on a regular basis in primary care facilities. Substantial application of guidelines that streamline asthma management may therefore be difficult to implement if primary care centers are not included in the bigger picture of asthma care. If one bears in mind that the goal of guideline implementation is to translate evidence-based asthma management recommendations into real-life practice to improve patient health, the possibility of spirometry application in such settings will not appear too far-fetched.

Guideline applications have been shown to be feasible in resource-poor settings.[45] In a pilot program conducted in a General Hospital in Syria, to test the feasibility of providing systematic follow-up of patients with uncontrolled asthma,[29] GINA guidelines were followed and the patients were noted to have achieved better asthma control. Following the success of that pilot program, it was concluded that implementation of asthma guidelines is quite possible in primary care settings in developing countries.[29] One may argue that the free-of-charge nature of the clinic may have been the major boost to patient turn out. However, country-specific guidelines, if made available to the primary care centers, will likely raise awareness on asthma management in children for the doctors who work at that level of the health sector and thus encourage efforts by all stakeholders to further add spirometry as a necessary pathway in making asthma diagnosis in children.

However, asthma diagnosis at primary care level may be faced underdiagnosing asthma in children, related to lack of objective assesment.[28,53,54] In a study conducted in Syria, 27% of patients had evidence of reversible obstruction by spirometry, but only 13% had been previously diagnosed by the primary care practitioners using clinical evaluation.[28] In another survey done in a new model specialized center set up for asthma in Sudan,[46] most patients who were previously undiagnosed were noted to have abnormal spirometry with more than half having an FEV_1 that was 60% or less of their predicted value. This further highlights the importance of guideline recommendations on the additional use of spirometry in deciding who truly has asthma. This practicable way of setting up such a center at the primary care level if well-structured and properly harnessed in developing countries can help bridge the gap for the utility of spirometry in children.[46]

Other World Health Organization (WHO) programs that have targeted NCD reduction include the Practical Approach to Lung Health program[47] which integrates asthma and COPD care into the National Tuberculosis Program that can also be useful. It entails initiating a respiratory disease dispensary at a primary care level which is equipped with peak flow meters, pulse oximeters, and spirometers. This was tried in Syria with success and can be adopted in other resource-poor countries so that spirometry use for children can be further optimized.

The WHO recommends that at least a peak flow meter should be available in the most remote health care centers with readiness for spirometry referral to health care centers or bigger equipped hospitals.[55] Desalu et al[38] showed an unfortunate situation where big teaching hospitals in Nigeria, with both adult physicians and pediatricians as staff, had only 38% and 29.4%, respectively, of peak flow meters and spirometers in these major tertiary facilities. This finding underscores the difficulty inherent in making objective asthma diagnoses in tertiary care settings, both for adult and pediatric patients.

Beyond the scenario at the primary health care level and in facilities that may not have the necessary equipment is also the situation where spirometers are available but are not put to use. For example, a study involving general practitioners in Australia found that of the 75% who reported having a spirometer in their place of practice, only 12% had used it to review their patients with asthma.[56] Similar reports were also noted in

primary care in Sweden, Spain, and United States.[55] In Africa, where the ratio of pediatrician to patient load is high with very few respiratory physicians, the use of a time-consuming procedure such as spirometry may be hampered. In Nigeria, a study found an average of less than 1 (0.8) adult respiratory physicians per hospital in the 68 tertiary hospitals surveyed.[57] It is therefore imperative that when addressing spirometry training for doctors, it should also be extended to include pediatricians, technicians, and nurse assistants who may form the manpower required to help with spirometry in a busy clinic setup.

Knowledge for proper use and interpretation was also notable obstacles to utility. In an ongoing research by Ayuk and coworkers[58] in Nigeria, reveal that familiarity with use of spirometer among pediatric residents in Nigeria was poor, as only 18.2% of those who participated were familiar with the spirometer. In another survey, by Desalu et al[59] in Nigeria, only 18.7% of adult physicians reported being confident in interpreting spirometry results. Furthermore, both published data[60–62] and personal communications cited challenges with equipment standardization, calibration, and appropriate performance even in centers where spirometers were available. Sometimes, the spirometry reports used were not repeatable or reproducible and thus should not have been acceptable for accurate interpretation. There is need therefore to lay emphasis on proper teaching on spirometry in both undergraduate and postgraduate training if its use is to be optimized in asthma diagnosis.

Conclusions

Spirometry is not frequently applied in children to make an asthma diagnosis, especially in resource-poor countries. The lack of equipment, proper training on spirometry, its interpretation, and lack of asthma guidelines remains core to underuse of spirometry in managing children with asthma. These must be tackled to make a difference in the management of bronchial asthma, which has remained a major contributor to NCD.

Author Contributions

ACA: Concept, design, definition of intellectual content, literature search, manuscript preparation, manuscript editing and manuscript review, final approval of the version to be published.

SNU: Definition of intellectual content, literature search, manuscript editing and manuscript review, final approval of the version to be published.

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