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Contribution of Peak Expiratory Flow as a Complementary Respiratory Assessment Tool in Children Aged 5 to 14 Years in the Kamina Health Zone: A Resource-Limited Setting

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Abstract

Introduction: Acute respiratory infections (ARIs) remain a significant cause of childhood morbidity in resource-limited settings. In the Kamina Health Zone of the Democratic Republic of the Congo, where a large proportion of the population lives in poverty and has limited access to specialized diagnostic services, the early identification of ARIs is a major challenge. Peak expiratory flow (PEF), a simple, rapid, and inexpensive tool, could be a useful complement to clinical assessment. This study evaluated the contribution of PEF to the identification of ARIs in children aged 5 to 14 years. An Acute Respiratory Infection (ARI) is defined by the presence of at least two of the following symptoms occurring within the 14 days prior to the investigation: cough, rhinorrhea, difficulty breathing, odynophagia or reported/measured fever. Une acute upper respiratory infection is an infection limited to the upper airways (rhinorrhea, nasal congestion, sore throat, earache, without signs of distress or pulmonary rales), while lower respiratory infection is an infection of the lower airways characterized by the presence of polypnea (respiratory rate > 25 to 30 cycles/min depending on age), intercostal retractions, abnormal lung auscultation (crackles, wheezes) or deep productive cough. **Methods:** A cross-sectional study was conducted with 283 children aged 5 to 14 years. Sociodemographic, clinical, and anthropometric data were collected, as well as peak expiratory flow (PEF) measurements obtained using a peak flow meter. A descriptive analysis was performed, followed by multivariate logistic regression to identify factors associated with the occurrence of acute respiratory infections (ARIs). Results are expressed as adjusted odds ratios (aORs) with their 95% confidence intervals. **Results:** The children were predominantly aged 9 to 14 years (65.4%) and male (53.7%). A recent acute respiratory infection was reported in 91.5% of participants, with a predominance of upper ARIs (76.7%). PEF was mainly between 100 and 200 L/min (84.1%). The test proved feasible, with 98.9% of measurements obtained on the first attempt. Multivariate analysis showed no significant association between PEF and the occurrence of ARI (ORa = 1.38; 95% CI: 0.55 - 3.45; $p = 0.490$). Similarly, sex, age, and anthropometric parameters were not significantly associated with the occurrence of ARI ($p > 0.05$). In contrast, PEF was significantly associated with growth variables, including age, weight, and height. **Conclusion:** Peak expiratory flow (PEF) is a feasible and well-accepted tool in children, but it is not a diagnostic marker for acute respiratory infections (ARIs). Its variations are primarily influenced by growth parameters. In resource-limited settings, it represents a useful complementary tool for respiratory function assessment, but it has no independent diagnostic value for ARIs.

Subject Areas

Global Health

Keywords

Peak Expiratory Flow, Respiratory Assessment, Children Kamina Health Zone

1. Introduction

Acute respiratory infections (ARIs) are among the leading causes of morbidity and mortality in children in low- and middle-income countries, particularly in sub-Saharan Africa, where they continue to represent a major public health challenge [1] [2]. In these settings, diagnosis most often relies on clinical assessment due to limited access to specialized examinations and effective diagnostic tools [3].

Peak expiratory flow (PEF) is a simple, rapid, and inexpensive functional test that indirectly assesses airway status [4]. Its usefulness is well-documented in the monitoring of chronic respiratory diseases such as asthma [5]. However, its use in screening for acute respiratory infections (ARIs) remains underexplored, particularly in sub-Saharan Africa, where studies have primarily focused on the epidemiology and management of these infections [6] [7].

ARIs can cause inflammation of the airways that may temporarily impair ventilatory performance and reduce peak expiratory flow (PEF) values [4]. However, the ability of this test to reliably identify children with ARIs remains uncertain. Therefore, evaluating its contribution appears necessary before any practical use in screening.

In the Kamina Health Zone, no data are currently available on the diagnostic value of PEF in children. This study aims to analyze the association between PEF values and the presence of ARIs in children aged 5 to 14 years, in order to assess the relevance of this tool as a complementary screening method in resource-limited primary healthcare settings.

2. Methods

2.1. Study Design

This was a cross-sectional study conducted in a community setting, based on a quantitative approach. The objective was to assess, at a given time point, the characteristics of peak expiratory flow (PEF) as well as its main physiological, environmental, and clinical determinants, without experimental intervention [8].

From a population-based perspective, this approach provides a snapshot of PEF variations according to age and sex, while also allowing for the examination of its possible links with various individual and contextual factors. It thus falls within the framework of an epidemiological exploration of PEF determinants in real-world settings, where exposures and living conditions are naturally present. However, it is important to emphasize that the associations observed in this context do not allow for the inference of causal relationships between the variables studied [9].

2.2. Study Framework

The study was conducted in the Kamina Health Zone, located in the Haut-Lomami province of the Democratic Republic of the Congo. This zone encompasses urban, peri-urban, and semi-rural areas characterized by varying levels of access to healthcare. The widespread use of biomass fuels for cooking, often in poorly ventilated and densely populated dwellings, exposes the population to environmental risks that can affect respiratory health.

2.3. Study Population

The target population consisted of all children aged 5 to 14 years residing in the Kamina health zone. This age group was selected because of their ability to correctly perform the PEF maneuver and the clinical relevance of respiratory monitoring in this age group [10] [11]. Inclusion criteria included: age between 5 and 14 years, residence in the study area, and obtaining informed consent from parents or guardians [12]. Children unable to correctly perform the maneuver were excluded to ensure the reliability of the measurements.

2.3.1. Sampling and Recruitment (Sample Size and Justification)

The study was based on an initial community-based cluster sampling that included 384 households (and their children), a size calculated using Cochran's standard formula (1977). From this source sample, the subsample dedicated to the functional assessment of peak expiratory flow (PEF) was selected. PEF measurement was restricted to subjects aged 5 to 14 years due to the technical skill, understanding of instructions, and neuromuscular coordination required to perform a valid forced expiratory maneuver. Stratification by age group (5 - 7 years, 8 - 10 years, and 11 - 14 years) and sex was applied to ensure balanced representation of the pediatric population. Of the 384 children in the overall community sample, 101 were not eligible for the PEF test due to their age (children under 5 years old), an age group for which the forced expiratory maneuver cannot be reliably performed. Excluding these 101 ineligible children brings the final population retained and analyzed for peak expiratory flow to 283 children.

The study is based on a cross-sectional community survey that included 384 children. The sample size was calculated with a 95% confidence level (Z = 1.96), an expected proportion p, and a margin of error of 5% [13].

2.3.2. Data Collection and Statistic Analysis

Data were collected place from 28/05 to 07/06/2026.

From this initial sample, a specific subpopulation was created for PEF analysis using purposive selection. This subpopulation comprised only children aged 5 to 14 years who were able to correctly perform the maneuver, totaling 283 children [14].

Data collection relied on complementary tools. PEF was measured using a standardized peak flow meter, with three trials per child and retention of the best value obtained [11] [14]. Environmental, socioeconomic, and medical factors were collected using a structured questionnaire administered to parents, supplemented by anthropometric measurements (height, weight) according to standardized protocols [15].

Data collection adhered to the ethical principles of the Declaration of Helsinki, including obtaining informed parental consent, anonymizing data, and referring children with respiratory distress to appropriate care facilities [14].

Data were entered into KoboCollect and then analyzed using SPSS, R, or STATA software. The analysis combined descriptive and analytical statistics.

The analysis combined descriptive statistics and inferential tests (correlations, Student's t-test, ANOVA), followed by multiple linear regression to identify independent determinants of peak expiratory flow (PEF) [9]. The threshold for statistical significance was set at $p < 0.05$.

3. Results

The study population was predominantly composed of children aged 9 to 14 years (65.4%), with a slight male predominance (53.7%). Most participants weighed between 18 and 38 kg (77.0%), while the height distribution was balanced between children measuring 105 - 130 cm (49.8%) and those taller than 130 cm (50.2%). A body mass index (BMI) below 25 kg/m^2 was observed in 98.9% of the children, reflecting an overall favorable nutritional profile. Finally, 91.5% of participants had experienced an acute respiratory infection within the 14 days preceding the survey, highlighting the prevalence of this condition in the study population (See **Table 1**).

Acute upper respiratory infections (ARIs) were by far the most common, accounting for 76.7% of cases compared to 23.3% for lower ARIs. The duration of symptoms was between 5 and 9 days in 36.0% of children and exceeded 9 days in 33.9%. The majority of participants (76.7%) had a body temperature ≤ 38˚C, while 23.3% had a temperature ≥ 38˚C. Furthermore, more than half of the children (51.6%) had a respiratory rate greater than 25 breaths per minute. These results highlight the predominance of upper ARIs, which are often associated with persistent symptoms and an increased respiratory rate (See Table 2).

Analysis of clinical characteristics in the 259 children with recent acute respiratory

Table 1. General and anthropometric characteristics of the studied population (N = 283).

Variables	Modalities	Frequency (n)	Percentage (%)
Sex	Female	131	46.3
	Male	152	53.7
Age	5 - 8 Years	98	34.6
	9 - 14 Years	185	65.4
Weight (kg)	18 - 38 kg	218	77.0
	>38 kg	65	23.0
Size (cm)	105 - 130 cm	141	49.8
	>130 cm	142	50.2
BMI (kg/m²)	<25	280	98.9
	≥25	3	1.1
ARI in the last 14 days	Yes	259	91.5
	No	24	8.5
Total		**283**	**100.0**

Table 2. Clinical and environmental characteristics of the children surveyed (N = 283).

Variables	Modalities	Frequency (n)	Percentage (%)
Type of ARI	Low IRAs	66	23.3
	High IRAs	217	76.7
Duration of symptoms	<5 Days	85	30.0
	5 - 9 Days	102	36.0
	>9 Days	96	33.9
Body temperature	≤38˚C	217	76.7
	≥38˚C	66	23.3
Respiratory rate	≤25 cycles/min	137	48.4
	>25 cycles/min	146	51.6
Total		**283**	**100.0**

Table 3. Feasibility of the peak expiratory flow (PEF) test and quality of children's cooperation.

Variables	Modalites	Frequency (n) N = 259	Percentage (%)
Type of ARI	high (upper)ARI	**199**	76.8
	lower ARI	**60**	23.2
Duration of symptoms	<5 days	**81**	31.3
	5 - 9 days	**93**	35.9
	>9 days	**85**	32.8
		N = 283	
Body temperature	≤38.0˚C (Afebrile/Low fever)	**217**	76.7
	>38.0˚C (High fever)	**66**	23.3
Respiratory rate	≤25 cycles/min (Normal)	**137**	48.4
	>25 cycles/min (Polypnea)	**146**	51.6

Note: For the type of ARI and the duration of symptoms, the denominator is N = 259 (only sick children). For temperature and respiratory rate, the denominator is N = 283 (all children examined). The distribution of peak expiratory flow shows a progressive decrease in the proportion of low PEF values over the course of the trials. It decreased from 42.4% in the first trial to 33.2% in the second, and then to 25.8% in the third trial. Conversely, the proportion of normal PEF values increased progressively, from 57.6% to 66.8%, and then to 74.2%. This trend reflects a gradual improvement in respiratory performance with repeated trials, consistent with a learning effect and improved execution of the maneuver.

infections (ARIs) showed a marked predominance of upper respiratory infections (199 cases, 76.8%), compared to 60 cases (23.2%) of lower respiratory infections (See Table 3).

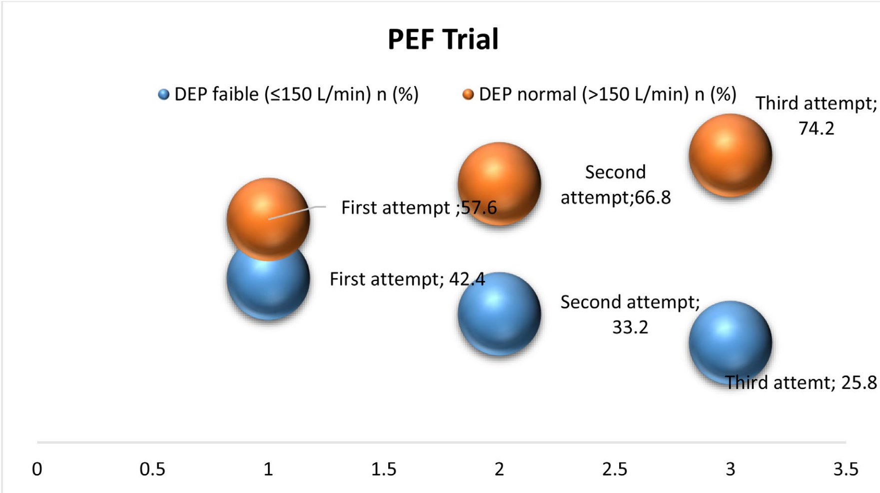
The distribution according to the duration of symptoms in the sick children (N = 259) ranged from acute forms lasting less than 5 days (n = 81, 31.3%), intermediate forms lasting 5 to 9 days (n = 93, 35.9%), to prolonged forms lasting more than 9 days (n = 85, 32.8%).

Regarding the physiological parameters measured in the entire sample (N = 283), 66 children (23.3%) had a temperature above 38.0˚C at the time of examination. Finally, an increased respiratory rate (>25 cycles/min) was observed in more than half of the children in the cohort (n = 146, *i.e.* 51.6%).

Analysis of factors associated with peak expiratory flow (PEF) adjusted for predicted values (adjusting for age, sex, and height) reveals that the majority of children have intermediate or reduced PEF, with 52.7% classified in the Yellow Zone (50% - 79% of predicted) and 8.1% in the Red Zone (<50% of predicted) (See Figure 1).

Respiratory function impairment (PEF < 80%) is significantly more frequent in younger children (5 - 8 years), where only 25.5% reach the Green Zone, compared to 46.5% in children aged 9 - 14 years (OR = 0.38; 95% CI: 0.18 - 0.79; p = 0.009).

Similarly, stunting in height and weight negatively influences adjusted PEF: children shorter than 130 cm and weighing less than 38 kg have a significantly reduced probability of having a normal PEF (≥80%) compared to taller and heavier children ($p = 0.002$ and $p = 0.014$, respectively). In contrast, no significant difference was observed based on sex ($p = 0.482$) or BMI ($p = 0.724$) once PEF was adjusted using theoretical equations (See Table 4).



Note: DEP Faible: low PEF; DEP Normal: Normal PEF.

Figure 1. Evolution of peak expiratory flow (PEF) values during the three trials.

Table 4. Sociodemographic and anthropometric factors associated with peak expiratory flow (PEF) in the children studied (N = 283).

Variables	Modalites	Red Zone (<50%) n (%)	Yellow Zone (50% - 79%) n (%)	Green Zone (≥80%) n (%)	Total (N = 283)	OR (CI 95%)	p value
Age	5 - 8 years	12 (12.2)	61 (62.2)	25 (25.5)	98	0.38 (0.18 - 0.79)	**0.009**
	9 - 14 years	11 (5.9)	88 (47.6)	86 (46.5)	185	1 (Reference)	
Sex	Female	10 (7.6)	71 (54.2)	50 (38.2)	131	0.82 (0.47 - 1.43)	0.482
	Male	13 (8.6)	78 (51.3)	61 (40.1)	152	1 (Reference)	
Weight (kg)	18 - 38 kg	20 (9.2)	122 (56.0)	76 (34.9)	218	0.42 (0.21 - 0.84)	**0.014**
	>38 kg	3 (4.6)	27 (41.5)	35 (53.8)	65	1 (Reference)	
Size (cm)	105 - 130 cm	16 (11.3)	84 (59.6)	41 (29.1)	141	0.39 (0.21 - 0.72)	**0.002**
	>130 cm	7 (4.9)	65 (45.8)	70 (49.3)	142	1 (Reference)	
BMI (kg/m²)	<25 kg/m²	22 (7.9)	147 (52.5)	111 (39.6)	280	0.65 (0.06 - 7.21)	0.724
	≥25 kg/m²	1 (33.3)	2 (66.7)				

Multivariate analysis revealed no statistically significant association between peak expiratory flow (PEF) and the occurrence of acute respiratory infection (ARI) after adjusting for sociodemographic and anthropometric factors. Children with a PEF between 100 and 200 L/min did not differ significantly from those with a PEF ≥ 250 L/min in terms of ARI risk (ORa = 1.38; 95% CI: 0.55 - 3.45; p = 0.490). Similarly, no significant association was observed for sex, age, weight, or height ($p > 0.05$ for all variables). This result primarily reflects the small proportion of subjects without ARI (n = 24), which limits the statistical power of the multivariate model.

Indeed, with only 24 healthy children (not affected by ARI), the number of events per variable (EPV) is restricted, which limits the power of the multivariate analysis and explains the width of the confidence intervals.

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Similarly, no statistically significant association was observed between sex, age, weight, or height and the occurrence of acute respiratory infection ($p > 0.05$ for all variables).

4. Discussion

In the Kamina health zone, the study population consisted primarily of children aged 9 to 14 years (65.4%), with a slight male predominance (53.7%). This demographic structure is similar to that observed in several studies conducted in African settings, where school-aged children represent a group particularly vulnerable to respiratory infections due to their social interactions and often unfavorable environmental conditions [16] [17]. The majority of children weighed between 18 and 38 kg (77.0%), with a balanced distribution of height (49.8% between 105 and 130 cm and 50.2% over 130 cm). Nutritional status assessment based on the age- and sex-specific BMI Z-score (WHO standards) showed that the vast majority of children had a normal weight (87.6% between −2SD and +1SD), while undernutrition (<−2SD) affected 5.3% of subjects and overweight/obesity (>+1SD) affected 7.1%. Despite this generally satisfactory nutritional status, the very high proportion of children who had recently experienced an acute respiratory infection (91.5%, n = 259) indicates a heavy respiratory morbidity burden in this region.

Among children with acute respiratory infections (ARIs) (N = 259), upper respiratory tract infections were largely predominant (76.8%, n = 199), compared to 23.2% (n = 60) for lower respiratory tract infections, consistent with epidemiological patterns observed in resource-limited countries [16] [18]. The duration of symptoms exceeded five days in more than two-thirds of the children (35.9% from 5 to 9 days and 32.8% more than 9 days), suggesting a sometimes prolonged course, possibly related to delayed access to care or limited access to health facilities. Regarding the parameters assessed across the entire sample (N = 283), although the majority of children did not present with a high fever (76.7% with a temperature ≤ 38.0˚C), more than half had a respiratory rate greater than 25 breaths per minute (51.6%), indicating clinically significant respiratory impairment requiring close attention during community follow-up.

The peak expiratory flow (PEF) test was generally well accepted, with good cooperation in 67.1% of children (and moderate cooperation in 30.7%) and near-universal success on the first attempt (98.9%). The raw values observed covered the entire measured range: 74.9% of children had a PEF < 200 L/min, 9.2% were in the 200 - 249 L/min range, and 15.9% reached ≥ 250 L/min, which corresponds to physiological variations related to age and lung development [19]. Analysis based on the percentage of predicted theoretical PEF (adjusted for age, sex, and height) confirms the feasibility of measuring PEF in a community setting in Kamina [18]. The lack of a significant association detected in the multivariate model between PEF and the risk of AKI (aOR = 1.38; p = 0.490) stems primarily from the small number of healthy controls without ARI (n = 24) (Table 5), limiting statistical power without invalidating the functional relevance of the tool.

Table 5. Relationship between peak expiratory flow and the risk of acute respiratory infection in children: multivariate logistic regression model adjusted for sociodemographic and anthropometric factors (N = 283).

Variable	Modalities	aOR	95% CI	p-value
DEP (L/min)	100 - 200 L/min	1.38	0.55 - 3.45	0.490
	≥250 L/min (Reference)	1.00	—	—
Sex	Female	0.92	0.42 - 1.98	0.834
	Male (Reference)	1.00	—	—
Age (years)	5 - 8 years	1.25	0.48 - 3.22	0.640
	9 - 14 years (Reference)	1.00	—	—
Weight (kg)	18 - 38 kg	0.88	0.39 - 1.98	0.754
	>38 kg (Reference)	1.00	—	—
Size (cm)	105 - 130 cm	0.81	0.34 - 1.92	0.630
	>130 cm (Reference)	1.00	—	—

In the context of Kamina, where acute respiratory infections represent a significant proportion of morbidity and access to further investigations remains limited, peak expiratory flow (PEF) testing appears to be a simple, feasible, and useful tool for assessing respiratory function in children. However, its use should remain complementary to clinical examination, as it cannot, on its own, identify acute respiratory infections. These observations are consistent with international recommendations that position PEF as a tool for functional monitoring rather than diagnosis [16] [18].

5. Conclusions

In the Kamina health zone, this study aimed to assess the feasibility of peak expiratory flow (PEF) measurement in children, analyze its association with acute respiratory infections (ARIs), and describe the characteristics of the pediatric population studied. It also determined PEF values in children in this zone, thus providing previously unavailable local reference data.

The results show a very high frequency of acute respiratory illness (91.5%), predominantly upper respiratory tract infections (76.8%), reflecting a significant respiratory morbidity burden. PEF measurement proved simple to perform and well-tolerated, with 98.9% of measurements usable on the first attempt, and excellent feasibility observed across subsequent trials. However, no significant multivariate association was found between PEF and the occurrence of AKI due to the small number of healthy controls (n = 24), confirming that this tool primarily reflects ventilatory function and lung growth (strongly related to age and height, $p < 0.05$).

This study makes a significant contribution to understanding the use of peak expiratory flow (PEF) in real-world settings, particularly in resource-limited environments like Kamina. It confirms the value of PEF as a simple, reproducible tool suitable for assessing respiratory function in children, while highlighting its limitations as a screening tool for acute respiratory infections (ARIs). It also provides local PEF values for children, useful for clinical practice and measurement interpretation.

However, several limitations must be noted, including the cross-sectional design, which does not allow for establishing causal relationships; the dependence of measurements on the child's cooperation; the small sample size of healthy children, which limits the power of the adjusted analysis; and the lack of biological confirmation of acute respiratory infections (ARIs), which may limit diagnostic accuracy.

It is recommended that peak expiratory flow (PEF) be integrated into primary healthcare in Kamina as a tool for assessing respiratory function in addition to clinical examination, but not as a diagnostic test for ARIs. It is also necessary to strengthen the training of healthcare providers, promote the prevention of respiratory infections in children, and reduce environmental risk factors. Finally, establishing local reference curves for PEF is essential to improve its clinical interpretation and use in daily practice.

Author Contributions

Conceptualisation and methodology: Chancelle Nasoro Abiba, Georges Banza Maloba, Guillaume Ngoie Mwamba, Celestin Muleka Kimpanga and Oscar luboya Numbi; Software: Chancelle Nasoro Abiba, Georges Banza Maloba; Validation: Hancelle Nasoro Abiba, Oscar Luboya Numbi and Celestin Muleka Kimpanga; Formal analysis: Simon Ilunga Kandolo and Michel Kabamba Nzaji; Investigation: Chancelle Nasoro Abiba; Resources: Chancelle Nasoro Abiba; Data curation: Simon Ilunga Kandolo; Writing review and editing: Chancelle Nasoro Abiba, Simon ilunga Kandolo and Georges Banza Maloba; Visualisation: Chancelle Nasoro Abiba, Simon ilunga Kandolo, Georges Banza Maloba, Celestin Muleka Kimpanga and Oscar Luboya Numbi; Project administration: Chancelle Nasoro Abiba; Funding acquisition: Chancelle Nasoro Abiba. All authors read and agreed to the published manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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