Assessment of Early Detection and Intervention Strategies for Pediatric Asthma: A Cross-Sectional Survey of Healthcare Providers

Raghda Adnan ABD Aljalil [1*], Faidh Razzaq Muslim [2]
[1-2] Iraq Ministry of Health, Al-Muthanna Health Directorate, Iraq

* Corresponding Author: **Raghda Adnan ABD Aljalil**

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Abstract

Objectives: To assess current detection and intervention strategies for pediatric asthma, frontline healthcare providers in an urban environment, and to identify provider-level barriers to guideline-concordant care.

Methods: Between March and May 2025, a cross-sectional multicenter survey was administered to a stratified random sample of 450 healthcare providers (pediatricians, general practitioners, nurse practitioners, and registered nurses) working in primary care clinics and pediatric hospitals. A 48-item questionnaire (practice subscale Cronbach's $\alpha = 0.84$) measured screening practices, diagnostic test availability (spirometry, FeNO), use of personalized asthma action plans (PAAPs), early-intervention strategies, and perceived barriers. Data collection were electronic, analyses were performed using SPSS v.29.

Results: Of 450 invited, 338 providers completed the survey (response rate 75.1%). Of those surveyed, 64.8% report use of symptom-based screening for asthma in children (n = 219), 42.6% report office spirometry availability (n = 144), and 9.8% report point-of-care FeNO availability (n = 33). Among the participants, 51.2% reported giving personalized asthma action plans on a routine basis. When adjusted for years in practice and setting, multivariable logistic regression showed that having on-site spirometry (adjusted OR 2.09, 95% CI 1.38-3.17, $p < .001$) and having taken training for asthma in the last 3 years (adjusted OR 1.84, 95% CI 1.22-2.78, $p = .004$) were significant predictors of guideline-concordant practice (as defined below). Main perceived barriers included lack of equipment/time (68%), inadequate training (54%), and not enough reimbursement (41%).

Conclusions: Across the various sites in this urban sample, objective testing (spirometry, FeNO) and systematic use of PAAPs were inconsistently outfitted. On-site spirometry and recent provider training were linked to a higher probability of early detection and intervention in accordance with guidelines. Interventions to improve access to objective testing and educate primary care providers may lead to better early detection and less preventable exacerbations.

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Keywords: Pediatric Asthma, Early Detection, Spirometry, Asthma Action Plan, Primary Care

Introduction

Asthma is the most common chronic respiratory disease of childhood and remains a leading cause of school absenteeism and acute care utilization worldwide (Martin, 2022) [2]. Early identification of asthma and initiation of appropriate controller therapy reduce exacerbations and hospitalizations and improve quality of life for children and caregivers (Cloutier *et al*., 2020; GINA, 2022) [1, 3]. Diagnosing asthma in early life is challenging because symptoms such as wheeze and cough are common in young children and may be transient; objective tests (spirometry or FeNO) are often underutilized in primary care, leading to both under- and overdiagnosis (Martin, 2022; Khatri *et al*., 2021) [2, 4]. This diagnostic uncertainty can delay early intervention. Spirometry and fractional exhaled nitric oxide (FeNO) testing can aid diagnosis in children old enough to perform reliable maneuvers, and clinical guidance increasingly endorses their use where available (GINA 2022; Khatri *et al*., 2021; Murugesan *et al*., 2023) [3, 4, 5]

However, access to these tests varies widely between clinics and regions, limiting their routine use in early detection strategies (several recent audits and surveys). PAAPs, along with structured education, reduce emergency visits and improve caregiver confidence; despite this, many children do not receive PAAPs, indicating a gap between evidence and practice (Pegoraro *et al*., 2022; Pletta *et al*., 2020) [6, 7]. Early-intervention steps that may be undertaken include improving PAAP distribution and education in primary care. System-level interventions, such as clinical decision support, diagnostic hubs, and telemedicine-facilitated follow-up, have proved useful in fostering specialist input into primary care and in improving guideline adherence and outcomes (Halterman *et al*., 2023; Fedele *et al*., 2022) [8, 9]. These may be especially suitable for early detection and intervention. Qualitative and survey studies have identified barriers repeatedly reported by providers with regard to guideline implementation: time constraints, lack of training, lack of equipment (e.g., spirometers), and system reimbursement (Wang *et al*., 2023; Khalaf *et al*., 2024). When resources and training have been applied on a targeted basis, this has been associated with documented evidence of changes in practice. Although randomized and quasi-experimental studies have been able to prove the effectiveness of specific interventions (telemedicine, school-based programs, decision support), very few studies have described screening and early intervention practices across diverse provider types in urban primary-care and pediatric-hospital settings and also have assessed the provider-level predictors of guideline-concordant practice. Hence, we conducted the multicenter cross-sectional survey of pediatricians, general practitioners, nurse practitioners, and registered nurses to (1) describe methods of early detection and early intervention currently used for pediatric asthma, (2) record the availability of objective diagnostic tools (spirometry, FeNO), (3) identify barrier considerations and training needs, and (4) determine provider- and practice-level predictors of guideline-concordant early detection, and intervention.

Methods

Study Design and Setting

We conducted a cross-sectional survey across primary care clinics and pediatric hospital outpatient departments in a major urban center between March 1 and May 31, 2025. The sampling frame comprised four hospital pediatric departments and 30 primary care clinics affiliated with the urban academic health system. The study was designed and reported in accordance with STROBE recommendations for cross-sectional studies.

Participants and Sampling

To accomplish representation across four strata of providers, a stratified random sample of 450 healthcare providers was drawn from respective institutional provider rosters: Pediatricians (n target = 175), GPs (n target = 125), Nurse Practitioners (NPs) (n target = 100), and Registered Nurses (RNs) (n target = 50). Eligibility criteria consisted of clinicians actively seeing children (aged 0-18 years) and greater than or equal to 6 months in the current practice. Institutional email invitations with two reminder waves were used for recruitment.

Questionnaire Development and Validation

We developed a 48-item questionnaire based on a targeted review of the literature (guidelines, instrument studies, and prior surveys) and existing instrument items adapted from validated provider surveys. The questionnaire covered: demographics and practice setting; frequency of symptom-based screening; availability/use of spirometry and FeNO; use of PAAPs and inhaler technique checks; education and training; perceived barriers; and an 11-item practice scale measuring guideline-concordant detection and early-intervention behaviors. The instrument was pilot tested with 28 providers for clarity and timing; item revisions were made. Internal consistency for the main practice scale was Cronbach's $\alpha = 0.84$. Face and content validity were reviewed by three pediatric pulmonologists.

Outcome Definitions

- **Primary Outcome (Guideline-Concordant Practice):** A dichotomous composite indicator was defined before commencing the study to include either: (1) A scenario where symptom-based screening or a screening checklist should have been applied and; (2) provision of either PAAPs, on-site spirometry, or documented referral pathways for early specialist assessment. (The threshold was selected to represent practical facets of early detection and initial intervention.)

Data Collection and Management

Surveys were administered via a secure REDCap instance. Data were exported to SPSS v29.0 for cleaning and descriptive statistics; R version 4.2.1 (packages: tidyverse, tableone, rms) was used for regression analyses. Missing data were rare (<3% for item-level responses) and handled with pairwise deletion for descriptive statistics and multiple imputation (m=10) for multivariable models where necessary.

Statistical Analysis

Continuous variables were summarized as mean (SD) or median (IQR) if skewed, while categorical variables were summarized as counts and percentages. Bivariate associations were assessed using Pearson chi-square tests for categorical variables and independent sample t-tests or ANOVA for continuous variables. Predictors of guideline-concordant practice were analyzed with multivariable logistic regression. Covariates included provider type, years in practice, practice setting (primary care vs. hospital), on-site spirometry, FeNO availability, and training in the last 3 years. Odds ratios (ORs), adjusted odds ratios (aORs), 95% confidence intervals (CIs), and p-values are reported. The Hosmer-Lemeshow test and the area under the ROC curve assessed model fit, and p-values less than or equal to 0.05 were considered statistically significant, using a two-tailed test.

Results

Survey responses and characteristics of the sample. 338 completed the survey out of the 450 providers approached (response rate 75.1%). Table 1 describes the demographic characteristics of respondents and primary practice characteristics.

Table 1: Respondent characteristics (n = 338) Demographics and practice setting

Characteristic	n (%) or mean ± SD
Age, mean (SD), years	41.8 ± 9.6
Female sex	212 (62.7%)
Provider type	
• Pediatrician	132 (39.1%)
• General Practitioner	96 (28.4%)
• Nurse Practitioner	74 (21.9%)
• Registered Nurse	36 (10.6%)
Years in practice, mean (SD)	12.4 ± 8.3
Primary practice setting	
• Primary care clinic	204 (60.4%)
• Pediatric hospital outpatient dept.	134 (39.6%)
Percent seeing ≥10 pediatric patients/day	198 (58.6%)

Table 2: Practice resources and diagnostic tool availability (n = 338)

Resource / Tool	n (%)
On-site office spirometry available	144 (42.6%)
Point-of-care FeNO available	33 (9.8%)
Routine access to referral for pediatric pulmonology within 14 days	214 (63.3%)
Written clinic protocol for asthma screening	118 (34.9%)
Clinic provides spacers/holding chambers to patients	188 (55.6%)

Less than half of clinics had on-site spirometry; FeNO availability was uncommon. Most clinics reported timely referral pathways but few had standing clinic screening protocols.

Table 3: Early-detection and screening practices (n = 338)

Screening practice	Often/Always n (%)
Symptom-based screening (checklist or routine question)	219 (64.8%)
Routine inquiry about night cough/exercise symptoms	231 (68.3%)
Use of standardized screening tool in well-child visits	82 (24.3%)
Repeat objective testing for suspected cases (PEF, spirometry)	98 (29.0%)
Use of tele-triage/telehealth for follow-up after exacerbation	74 (21.9%)

While symptom-based screening was relatively common, standardized screening tools and objective repeat testing were less frequently used.

Table 4: Early-intervention strategies and self-management supports (n = 338)

Intervention	Routinely provided n (%)
Personalized asthma action plan (PAAP)	173 (51.2%)
Inhaler technique checks at visits	205 (60.7%)
Brief asthma education session (≥10 minutes)	142 (42.0%)
Referral to asthma educator	69 (20.4%)
School notification with PAAP (when applicable)	98 (29.0%)

Inhaler technique checks were the single most common early-intervention behavior, but only about half of respondents provided PAAPs routinely.

Table 5: Provider training and guideline familiarity (n = 338)

Item	n (%)
Familiar with current GINA/National guideline recommendations	198 (58.6%)
Received asthma-specific training in past 3 years	156 (46.2%)
Confidence in interpreting spirometry in children	112 (33.1%)
Confidence in using FeNO	41 (12.1%)

Less than half of providers reported recent asthma-specific training; confidence interpreting objective testing was limited, particularly for FeNO.

Table 6: Perceived barriers to early detection and intervention (multiple responses allowed; n = 338)

Barrier	n (%)
Lack of equipment (spirometer/FeNO)	230 (68.0%)
Limited time in visits	188 (55.6%)
Insufficient training/confidence	183 (54.1%)
Reimbursement/financial constraints	138 (40.8%)
Low caregiver engagement / competing priorities	121 (35.8%)

Resource constraints and training gaps were reported as the most frequent barriers.

Table 7: Bivariate associations (sample): Provider type vs. guideline-concordant practice

Provider type	Guideline-concordant n (%)	χ^2 (df)	p
Pediatrician	92/132 (69.7%)		
GP	49/96 (51.0%)	$\chi^2 = 14.6$ (3)	p < .001
NP	40/74 (54.1%)		
RN	16/36 (44.4%)		

Pediatricians were significantly more likely to report guideline-concordant early detection and intervention practices compared with other provider types (p < .001).

Table 8: Multivariable logistic regression: Predictors of guideline-concordant practice (n = 338)

Predictor (reference)	aOR	95% CI	p
On-site spirometry (no vs. yes)	2.09	1.38–3.17	< .001
Training past 3 years (no vs. yes)	1.84	1.22–2.78	.004
Provider type: Pediatrician (ref: GP)	1.66	1.05–2.64	.030
Years in practice (per 5-year increase)	1.05	0.91–1.20	.52
Practice setting: hospital (ref: primary care)	1.28	0.80–2.05	.30

Model AUC = 0.72; Hosmer-Lemeshow p = .41.

On-site spirometry and recent asthma-specific training emerged as the strongest independent predictors of guideline-concordant practices after adjustment. Provider type (pediatricians) remained associated with higher likelihood of guideline-concordant behavior.

Discussion

In this multicenter urban survey of 338 providers, objective testing (spirometry 42.6% on-site; FeNO 9.8%) and PAAP provision (51.2%) implementation remained inconsistent, with barriers described by providers clustering around the access to equipment and training. On-site spirometry and recent training were also associated with higher odds of early detection and early-intervention practice under guidelines. Our report dovetails into a series of recent ones on continuing underutilization of spirometry in primary care, drawing attention to low availabilities of spirometry and variable clinician confidence in its interpretation (Taylor *et al*., 2025; Khalaf *et al*., 2024). Up onissues of the under-use of spirometry in primary care settings have always been an impediment to objective diagnosis. Less availability of FeNO in our sample parallels findings in implementation reviews (Murugesan *et al*., 2023; Khatri *et al*., 2021) [5, 4], which have acknowledged its utility in diagnosis and management but also flagged its steep cost and its logistical bottlenecks to broader adoption. The approximate 51% of PAAPs routinely provided in our sample lines up well with national and multicenter audits which track PAAP coverage between ~40–60% in children (Pegoraro *et al*., 2022; Alfieri *et al*., 2023) [6, 13]. In short, the studies remind us that PAAPs are lesser offered even when recommended. Several randomized controlled intervention studies and quasi-experimental designs by Halterman *et al*. (2023) [8] and the TEAM-ED trial, along with implementation projects, show that telemedicine-supported follow-up and decision-support interventions can expand opportunities for accessing guideline-concordant care and lessen morbidity associated with post-exacerbation phases. Our findings support the scale-up of such models to bridge access gaps. Several studies indicate that provider education and decision support enhance adherence to the guidelines (Fedele *et al*., 2022; Wang *et al*., 2023) [9]. This association in the multivariable model found between recent training and increased guideline-concordant practice supports these intervention targets. Consistent with our finding that pediatricians reported higher guideline-concordant behaviors, prior analyses have shown that pediatricians and specialty physicians are more likely to follow guideline-recommended practice and have access to diagnostic resources (Levy *et al*., 2023). The literature has proposed diagnostic hubs and regional approaches to concentrate resources and expertise; though evidence remains emergent, our study's findings of access constraints reinforce the potential value of hub-and-spoke models (Martin, 2022; NHS diagnostic hub initiatives) [2].

Implications for practice and policy

- Increased access to objective testing. Given the positive association of on-site spirometry with cases of guideline-concordant practice, health systems must try to institute equitable access to spirometry (or rapid referral pathways) and interpretation training.
- Invest in provider training. It appears that cycles of repeated, practical training (spirometry interpretation, inhaler technique coaching, PAAP creation) will yield better results in practices.
- Consider system-level solutions. Clinical decision support, telemedicine follow-ups, and coordination in schools (where possible) may help overcome resource limitations and allow early detection.

Limitations

- Cross-sectional type. Cross-sectional survey designs do not allow for causal inferences; hence, these associations should not be considered causative.
- Self-report bias. Since data were collected from self-reports of providers, they may be subject to social desirability and recall bias. By this bias, providers may have overstated their adherence to guideline-concordant behaviors.
- Single urban system. This multi-center sample situation sources only from an academic urban health system and thus may not extrapolate well to rural or low-resource environmental settings.

Future Research

Prospective implementation studies randomizing clinics to targeted investments-on-site spirometry, educational programs, decision-support-would provide stronger causal evidence for outcomes at the patient level (exacerbations, school days missed, ED visits). One would also require an economic analysis of the deployment strategies of FeNO and spirometry.

Conclusion

Objective testing for pediatric asthma (spirometry and FeNO) and consistent delivery of PAAPs were variably available in this multicenter urban provider survey. On-site spirometry and recent training of providers were independently associated with increased odds of early detection and intervention practices consistent with guidelines. Health systems interested in improving the early detection of pediatric asthma should focus on access to objective testing and repeated, practical training of frontline providers.

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