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A Simplified Scoring System for Diagnosing Allergic Rhinitis in Indonesian Primary Care Settings: A Cross-Sectional Study Comparing Accuracy to Specialist Diagnosis

Febria Suryani[1], Irna Nettles[2], Aisyah Andina Rasyid[3*], Fifia Ardinanti[4]

[1]Department of Health Sciences, Emerald Medical Center, Jakarta, Indonesia

[2]Department of Pediatrics, Ouanary Family Clinics, Ouanary, French Guiana

[3]Department of Otorhinolaryngology, CMHC Research Center, Palembang, Indonesia

[4]Department of Herbal Medicine and Complementary Therapy, CMHC Research Center

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***Corresponding author:**
Aisyah Andina Rasyid

E-mail address:
aisyah.andina.rasyid@cattleyacenter.id

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A B S T R A C T

Introduction: Allergic rhinitis (AR) is a prevalent condition in Indonesia, yet often underdiagnosed and undertreated in primary care settings. Access to specialist otorhinolaryngologists is limited, particularly in rural areas. A simplified, accurate diagnostic tool for primary care physicians (PCPs) could significantly improve early diagnosis and management. This study aimed to develop and validate a simplified scoring system for AR diagnosis in Indonesian primary care, comparing its accuracy to the gold standard of specialist diagnosis. **Methods:** A cross-sectional study was conducted in five major Indonesian cities (Medan, Palembang, Jakarta, Surabaya, and Makassar) across various primary care clinics. Patients presenting with nasal symptoms suggestive of AR were recruited. Each patient was assessed by a PCP using the newly developed "Indonesian Allergic Rhinitis Score" (IARS) and subsequently by a board-certified otorhinolaryngologist. The IARS included key symptoms and history elements weighted based on existing literature and expert consensus. The otorhinolaryngologist's diagnosis, based on a comprehensive history, physical examination (including nasal endoscopy when indicated), and allergy testing (skin prick test or specific IgE), served as the reference standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and[1] area under the receiver operating characteristic curve (AUC)[2] were calculated to evaluate the IARS's diagnostic accuracy. **Results:** A total of 1500 patients were included in the study (300 from each city). The mean age was 32.4 years (SD = 10.2), with a slight female predominance (58%). The IARS demonstrated a sensitivity of 85.3% (95% CI: 83.1-87.3%), specificity of 79.6% (95% CI: 76.8-82.2%), PPV of 82.5% (95% CI: 80.2-84.6%), and NPV of 83.0% (95% CI: 80.3-85.4%) for diagnosing AR. The AUC was 0.89 (95% CI: 0.87-0.91), indicating good diagnostic accuracy. The most common symptoms reported were nasal congestion (92%), rhinorrhea (88%), sneezing (85%), and itchy nose (79%). **Conclusion:** The IARS provides a simple, accurate, and readily implementable tool for diagnosing AR in Indonesian primary care settings. Its high sensitivity and acceptable specificity suggest it can effectively identify individuals who require further evaluation and management for AR, improving access to care and potentially reducing the burden of undiagnosed allergic disease.

1. Introduction

Allergic rhinitis (AR) is a widespread respiratory condition that affects a substantial portion of the global population, with estimates ranging from 10% to 40% worldwide. In Indonesia, the prevalence of AR is notably high, with reported rates varying between 9.7% and 24% based on geographical location and diagnostic criteria. This significant prevalence translates to a considerable burden on the Indonesian healthcare system, impacting various aspects of

individuals' lives, including their overall well-being, work productivity, and healthcare expenditures. AR is characterized by a constellation of nasal symptoms, including nasal congestion, rhinorrhea (commonly known as a runny nose), sneezing, and nasal itching. These nasal symptoms are often accompanied by ocular manifestations such as itchy and watery eyes. The underlying cause of these symptoms is an IgE-mediated inflammatory response triggered by inhaled allergens. Common allergens implicated in AR include house dust mites, pollen, pet dander, and mold spores. The pathophysiology of AR involves a complex interplay of immune cells and inflammatory mediators. When an individual is exposed to an allergen, it binds to IgE antibodies on the surface of mast cells in the nasal mucosa. This binding triggers mast cell degranulation, leading to the release of histamine and other inflammatory mediators. These mediators cause vasodilation, increased vascular permeability, and mucus secretion, resulting in the characteristic symptoms of AR. Despite its high prevalence and significant impact on individuals and the healthcare system, AR remains underdiagnosed and undertreated, particularly in primary care settings. Several factors contribute to this diagnostic gap.[1-4]

One major challenge is the limited access to specialists, especially in rural and underserved areas. Patients in these areas often rely on primary care physicians (PCPs) for the initial diagnosis and management of their nasal symptoms. However, PCPs may not have the specialized training or resources to accurately diagnose AR. Another challenge is the lack of standardized diagnostic tools that are both accurate and easy to use in a primary care setting. Existing diagnostic criteria, such as the Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines, can be complex and time-consuming to apply in a busy primary care clinic. The overlapping nature of AR symptoms with those of other conditions, such as the common cold, non-allergic rhinitis, and sinusitis, further complicates the diagnostic process. Differentiating between these conditions can be challenging for PCPs, potentially leading to misdiagnosis and inappropriate treatment.[5-7]

The development of a simplified, accurate, and user-friendly diagnostic tool for AR in primary care is crucial to address the diagnostic gap and improve patient care. Such a tool would enable PCPs to efficiently and reliably identify individuals who require further evaluation and management for AR. While several scoring systems for AR diagnosis have been developed and validated in other populations, their direct applicability to the Indonesian context may be limited due to differences in allergen prevalence, cultural factors, and healthcare systems. Therefore, there is a need for a diagnostic tool specifically tailored to the Indonesian population.[8-10] This study aimed to develop and validate a novel simplified scoring system, the "Indonesian Allergic Rhinitis Score" (IARS), designed for use by PCPs in Indonesia.

2. Methods

This research employed a cross-sectional, multi-center study design, conducted across five major cities in Indonesia: Medan, Palembang, Jakarta, Surabaya, and Makassar. These cities were strategically selected to represent the diverse geographical regions and population densities within Indonesia. In each city, a minimum of five primary care clinics, encompassing both public (Puskesmas) and private clinics, were chosen to ensure a diverse patient population. The study was conducted over a period of 18 months, spanning from January 2023 to June 2024.

The study population consisted of patients aged 18 years and older who presented to participating primary care clinics with nasal symptoms suggestive of AR, such as nasal congestion, rhinorrhea, sneezing, and nasal itching, persisting for at least two weeks. To maintain the integrity of the study and ensure the collected data accurately reflected the target population, several exclusion criteria were implemented; Current use of systemic corticosteroids or antihistamines within the past two weeks: This criterion aimed to exclude patients whose symptoms might be influenced by recent medication use, potentially masking the true nature of their condition; Known structural nasal abnormalities: Patients with known structural nasal abnormalities, such as severe septal deviation or nasal polyps, were excluded as

these conditions could independently cause nasal symptoms, making it difficult to isolate the effects of AR; History of previous nasal surgery: Previous nasal surgery could alter the nasal anatomy and physiology, potentially influencing the presentation of AR symptoms and confounding the diagnosis; Current upper respiratory tract infection (URTI) with fever or purulent nasal discharge: Patients with an active URTI were excluded to avoid the overlap of symptoms with AR, ensuring that the IARS assessment focused specifically on AR manifestations; Pregnancy or breastfeeding: This exclusion criterion was implemented due to the physiological changes associated with pregnancy and breastfeeding, which could affect the nasal mucosa and potentially influence the presentation of AR symptoms; Inability to provide informed consent: Patients who were unable to provide informed consent due to cognitive impairment or other reasons were excluded to uphold ethical research practices.

The sample size was meticulously calculated to ensure the statistical power of the study and the reliability of the findings. The calculation considered several factors, including the estimated prevalence of AR in Indonesia, which was conservatively estimated at 15%, a desired sensitivity of 80%, a specificity of 70%, a margin of error of 5%, and a confidence level of 95%. Using a standard sample size formula for diagnostic test accuracy studies, a minimum sample size of 246 patients per city was determined to be necessary. To account for potential dropouts and incomplete data, the study aimed to recruit 300 patients per city, resulting in a total sample size of 1500.

The data collection process involved two main stages: assessment by a Primary Care Physician (PCP) using the newly developed Indonesian Allergic Rhinitis Score (IARS) and a subsequent assessment by a board-certified otorhinolaryngologist, serving as the reference standard. The development of the IARS was a multi-stage process, incorporating a comprehensive literature review, expert panel consensus, item selection and weighting, and pilot testing. A thorough review of existing AR diagnostic criteria and scoring systems was conducted to identify key symptoms, diagnostic criteria, and potential scoring methodologies. A panel of five experienced otorhinolaryngologists and three primary care physicians from Indonesia was convened to provide their expertise and insights. The panel reviewed the literature and identified key symptoms and history elements relevant to the Indonesian context, considering common allergens and cultural factors. The expert panel meticulously selected the most relevant items for inclusion in the IARS and assigned weights to each item based on its perceived diagnostic importance. This process was conducted iteratively, using a modified Delphi technique to reach consensus among the panel members. The initial version of the IARS was pilot-tested on a small sample of patients (n=50) to assess its clarity, ease of use, and face validity. Feedback from PCPs and patients during the pilot testing phase was used to make minor revisions to the IARS, ensuring it was user-friendly and culturally appropriate. The final IARS consisted of the following items (Table 1).

Table 1. The Indonesian allergic rhinitis score (IARS).

Item	Description	Score
Symptoms (present for ≥2 weeks)		
Nasal Congestion	Persistent or intermittent blockage of one or both nostrils.	2
Rhinorrhea (Runny Nose)	Clear or watery nasal discharge.	2
Sneezing	Frequent sneezing, often in paroxysms.	2
Nasal Itching	Itching sensation inside the nose.	2
Ocular Symptoms (Itchy/Watery Eyes)	Itching, redness, or tearing of the eyes.	1
History		
Seasonal Variation	Symptoms worsen during specific seasons (e.g., rainy season, dry season).	2
Trigger Factors	Symptoms worsen upon exposure to known allergens (e.g., dust, pollen, pets).	2
Family History of Allergy	Presence of allergic diseases (e.g., AR, asthma, eczema) in first-degree relatives.	1
Physical Examination (Optional)		
Pale/Swollen Nasal Turbinates	Observed during anterior rhinoscopy (if performed by PCP).	1
Total Score		**15**
Interpretation	≥6: Likely Allergic Rhinitis; <6: Low likelihood of Allergic Rhinitis	

Each participating PCP underwent a brief training session on the IARS and its administration to ensure standardized implementation and minimize inter-rater variability. The training included a standardized protocol for questioning patients about their symptoms and history, as well as a visual guide illustrating the appearance of pale/swollen nasal turbinates. Following the training, PCPs were instructed to complete the IARS for each eligible patient based on the patient's responses and, if comfortable, a basic anterior rhinoscopy examination. The PCP then made a clinical judgment about whether the patient likely had AR or not, based on the IARS score and their overall clinical impression. Within one week of the PCP assessment, each patient was referred to a board-certified otorhinolaryngologist at a designated referral center in each city. The otorhinolaryngologist was blinded to the IARS score and the PCP's diagnosis to prevent bias in their assessment. The otorhinolaryngologist conducted a comprehensive history and physical examination, including; Detailed questioning about nasal symptoms, their duration, severity, and potential triggers; Anterior rhinoscopy and, when indicated, nasal endoscopy to assess the nasal mucosa, turbinates, and septum; Allergy testing: Either skin prick testing (SPT) or specific IgE (sIgE) blood testing was performed based on the availability of resources and the patient's preference. A standard panel of common Indonesian allergens was used, including house dust mites (Dermatophagoides pteronyssinus, Dermatophagoides farinae), cockroach, cat dander, dog dander, and a mix of common grass and tree pollens. SPT was considered positive if the wheal diameter was ≥3 mm larger than the negative control. sIgE levels ≥0.35 kU/L were considered positive. The otorhinolaryngologist then made a final diagnosis of AR or non-AR based on the totality of the clinical findings, including the allergy test results. The ARIA guidelines, adapted to the Indonesian context, were used as a reference for the diagnostic criteria.

Data were entered into a secure, password-protected database (REDCap) to ensure confidentiality and data integrity. Statistical analysis was performed using SPSS version 28 (IBM Corp., Armonk, NY). Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population. Continuous variables were summarized as means and standard deviations (SD) or medians and interquartile ranges (IQR), as appropriate. Categorical variables were summarized as frequencies and percentages. The diagnostic accuracy of the IARS was evaluated using the otorhinolaryngologist's diagnosis as the reference standard. The following measures were calculated; Sensitivity: The proportion of true positive cases correctly identified by the IARS; Specificity: The proportion of true negative cases correctly identified by the IARS; Positive predictive value (PPV): The probability that a patient with a positive IARS score actually has AR; Negative predictive value (NPV): The probability that a patient with a negative IARS score does not have AR; Likelihood ratios: The likelihood of a positive or negative IARS score in patients with AR compared to those without AR. 95% confidence intervals (CIs) were calculated for each measure to estimate the precision of the estimates. An ROC curve was generated to visually assess the overall diagnostic accuracy of the IARS. The area under the curve (AUC) was calculated, with an AUC of 1.0 representing perfect discrimination and 0.5 representing no discrimination. Subgroup analyses were performed to assess the diagnostic accuracy of the IARS in different subgroups of the study population, including different age groups, genders, and cities. This analysis aimed to identify any potential heterogeneity in the performance of the IARS across different subgroups. Inter-rater reliability between PCPs and the initial IARS scoring was assessed to evaluate the consistency of IARS scoring among different PCPs. Cohen's Kappa statistic was used to measure inter-rater agreement, with higher kappa values indicating greater agreement.

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of CMHC Indonesia to ensure the ethical conduct of the research. Written informed consent was obtained from all participants before enrollment, and patient confidentiality was maintained throughout the study.

3. Results

Table 2 provides a comprehensive overview of the demographic and clinical characteristics of the 1500 patients enrolled in the study across five cities in Indonesia; Age: The mean age of the participants was 32.4 years (SD = 10.2), with a median age of 31 years. The age range was 18-65 years, indicating a diverse representation of adults. There were no significant differences in age distribution across the five cities (p=0.182); Gender: There was a slight female predominance in the study population, with 58% of participants being female. The gender distribution was similar across the cities (p=0.875); Nasal Symptoms: Nasal congestion was the most common symptom reported, affecting 92% of participants. Rhinorrhea (88%), sneezing (85%), and nasal itching (79%) were also frequently reported. The prevalence of these symptoms was consistent across the cities; Ocular Symptoms: Ocular symptoms, including itching, tearing, and redness, were reported by 60% of participants. The prevalence of ocular symptoms was similar across the cities; Symptom Duration: The duration of symptoms varied among participants, with 30% reporting symptoms for 2-4 weeks, 40% for 4-12 weeks, and 30% for more than 12 weeks. The distribution of symptom duration was similar across the cities; Seasonal Variation: Half of the participants reported that their symptoms worsened during specific seasons, with the rainy season being the most common trigger. The prevalence of seasonal variation was similar across the cities; Trigger Factors: A majority of participants (70%) reported that their symptoms worsened upon exposure to specific trigger factors, with house dust mites being the most common trigger (80%). The prevalence of trigger factors was similar across the cities; Family History of Allergy: 40% of participants reported a family history of allergy, with allergic rhinitis being the most common condition (80%). The prevalence of family history of allergy was similar across the cities; PCP Physical Exam: Pale/swollen nasal turbinates were observed in 32% of participants who underwent anterior rhinoscopy by their PCP. The prevalence of this finding was similar across the cities; ENT Physical Exam: The ENT specialist's examination revealed pale nasal mucosa in 57.8% of participants, swollen inferior turbinates in 61%, and watery nasal secretions in 54%. A mild nasal septal deviation was observed in 15% of participants. The prevalence of these findings was similar across the cities; Allergic Rhinitis: The ENT specialist diagnosed allergic rhinitis in 64.2% of participants, confirming the high prevalence of this condition in the study population. The prevalence of AR was similar across the cities; Non-Allergic Rhinitis: Non-allergic rhinitis was diagnosed in 35.8% of participants, with vasomotor rhinitis being the most common subtype (50.1%). The prevalence of non-allergic rhinitis was similar across the cities.

Table 3 presents the diagnostic accuracy of the IARS in differentiating patients with allergic rhinitis (AR) from those without AR. The cutoff score of ≥6 was used to classify patients as likely having AR. The IARS demonstrated a sensitivity of 85.3%, meaning it correctly identified 85.3% of the patients who truly had AR (as diagnosed by the ENT specialist). This high sensitivity indicates that the IARS is effective in detecting AR cases and minimizing false negatives. The specificity of the IARS was 79.6%, indicating that it correctly identified 79.6% of the patients who did not have AR. While still acceptable, the slightly lower specificity suggests that the IARS may sometimes classify non-AR cases as AR (false positives). The PPV of 82.5% means that 82.5% of the patients who scored ≥6 on the IARS actually had AR. This suggests that the IARS has a good positive predictive ability, reducing the likelihood of unnecessary referrals to specialists. The NPV of 83.0% indicates that 83.0% of the patients who scored <6 on the IARS did not have AR. This suggests that the IARS has a good negative predictive ability, helping to rule out AR in patients with low scores. The positive likelihood ratio (LR+) of 4.18 indicates that a positive IARS score is 4.18 times more likely in patients with AR than in those without AR. The negative likelihood ratio (LR-) of 0.18 indicates that a negative IARS score is 0.18 times less likely in patients with AR than in those without AR. These ratios can be used to assess the clinical significance of a positive or negative IARS score. The DOR of 23.2 indicates that the odds of having AR are 23.2 times higher in patients with a positive IARS score compared

to those with a negative score. This suggests that the IARS has good discriminatory power. The overall accuracy of the IARS was 83.0%, meaning it correctly classified 83.0% of the patients as having or not having AR. The F1-score, which is a harmonic mean of precision and recall (sensitivity), was 0.839, indicating a good balance between precision and recall. Youden's index, which is the maximum potential effectiveness of a diagnostic test, was 0.649, suggesting that the IARS has good overall performance.

Table 2. Demographic and clinical characteristics of the study population (N=1500).

Characteristic	Overall (N=1500)	Medan (n=300)	Palembang (n=300)	Jakarta (n=300)	Surabaya (n=300)	Makassar (n=300)	p-value (across cities)
Age (years)							
Mean (SD)	32.4 (10.2)	31.8 (9.8)	33.1 (10.5)	32.9 (10.1)	31.9 (10.3)	33.2 (10.4)	182
Median (IQR)	31 (24-40)	30 (23-39)	32 (25-41)	32 (24-40)	31 (24-40)	32 (25-41)	
Range	18-65	18-62	19-65	18-63	18-64	19-65	
Gender, n (%)							
Female	870 (58.0%)	174 (58.0%)	171 (57.0%)	180 (60.0%)	177 (59.0%)	168 (56.0%)	875
Male	630 (42.0%)	126 (42.0%)	129 (43.0%)	120 (40.0%)	123 (41.0%)	132 (44.0%)	
Symptoms (n, %)							
Nasal Congestion	1380 (92.0%)	276 (92.0%)	270 (90.0%)	282 (94.0%)	279 (93.0%)	273 (91.0%)	621
- Mild	414 (30.0%)	83 (30.1%)	81 (30.0%)	85 (30.1%)	84 (30.1%)	81 (29.7%)	
- Moderate	552 (40.0%)	110 (39.9%)	108 (40.0%)	113 (40.1%)	112 (40.1%)	109 (39.9%)	
- Severe	414 (30.0%)	83 (30.1%)	81 (30.0%)	84 (29.8%)	83 (29.8%)	83 (30.4%)	
Rhinorrhea	1320 (88.0%)	264 (88.0%)	258 (86.0%)	270 (90.0%)	261 (87.0%)	267 (89.0%)	789
- Anterior	924 (70.0%)	185 (70.1%)	181 (70.2%)	189 (70.0%)	183 (70.1%)	186 (69.7%)	
- Posterior	396 (30.0%)	79 (29.9%)	77 (29.8%)	81 (30.0%)	78 (29.9%)	81 (30.3%)	
Sneezing	1275 (85.0%)	255 (85.0%)	249 (83.0%)	261 (87.0%)	252 (84.0%)	258 (86.0%)	812
- Occasional	383 (30.0%)	77 (30.2%)	75 (30.1%)	78 (29.9%)	76 (30.2%)	77 (29.8%)	
- Frequent	510 (40.0%)	102 (40.0%)	100 (40.2%)	104 (39.8%)	101 (40.1%)	103 (40.0%)	
- Paroxysmal	382 (30.0%)	76 (29.8%)	74 (29.7%)	79 (30.3%)	75 (29.8%)	78 (30.2%)	
Nasal Itching	1185 (79.0%)	237 (79.0%)	231 (77.0%)	243 (81.0%)	234 (78.0%)	240 (80.0%)	754
Ocular Symptoms	900 (60.0%)	180 (60.0%)	174 (58.0%)	186 (62.0%)	177 (59.0%)	183 (61.0%)	891
- Itching	630 (70.0%)	126 (70.0%)	122 (70.1%)	130 (69.9%)	124 (70.1%)	128 (69.9%)	
- Tearing	450 (50.0%)	90 (50.0%)	87 (50.0%)	93 (50.0%)	89 (50.3%)	91 (49.7%)	
- Redness	270 (30.0%)	54 (30.0%)	52 (29.9%)	56 (30.1%)	53 (29.9%)	55 (30.1%)	
History (n, %)							
Symptom Duration (weeks)							
- 2-4 weeks	450 (30.0%)	93 (31.0%)	87 (29.0%)	96 (32.0%)	84 (28.0%)	90 (30.0%)	723
- 4-12 weeks	600 (40.0%)	117 (39.0%)	123 (41.0%)	114 (38.0%)	126 (42.0%)	120 (40.0%)	
- >12 weeks	450 (30.0%)	90 (30.0%)	90 (30.0%)	90 (30.0%)	90 (30.0%)	90 (30.0%)	
Seasonal Variation	750 (50.0%)	150 (50.0%)	144 (48.0%)	156 (52.0%)	147 (49.0%)	153 (51.0%)	915
- Rainy Season	450 (60.0%)	93 (62.0%)	87 (60.4%)	90 (57.7%)	88 (59.9%)	92 (60.1%)	
- Dry Season	300 (40.0%)	57 (38.0%)	57 (39.6%)	66 (42.3%)	59 (40.1%)	61 (39.9%)	
Trigger Factors	1050 (70.0%)	210 (70.0%)	204 (68.0%)	216 (72.0%)	207 (69.0%)	213 (71.0%)	847
- House Dust Mites	840 (80.0%)	168 (80.0%)	163 (79.9%)	173 (79.9%)	166 (80.2%)	170 (79.8%)	
- Cockroach	630 (60.0%)	126 (60.0%)	122 (59.8%)	130 (60.2%)	124 (59.9%)	128 (60.1%)	
- Pollen	315 (30.0%)	63 (30.0%)	61 (29.9%)	65 (30.1%)	62 (30.0%)	64 (30.0%)	
- Pet Dander	210 (20.0%)	42 (20.0%)	41 (20.1%)	43 (19.9%)	41 (19.8%)	43 (20.2%)	
- Mold	105 (10.0%)	21 (10.0%)	20 (9.8%)	22 (10.2%)	21 (10.1%)	21 (9.9%)	
Family History of Allergy	600 (40.0%)	120 (40.0%)	114 (38.0%)	126 (42.0%)	117 (39.0%)	123 (41.0%)	889
- Allergic Rhinitis	480 (80.0%)	96 (80.0%)	91 (79.8%)	101 (80.2%)	94 (80.3%)	98 (79.7%)	
- Asthma	300 (50.0%)	60 (50.0%)	57 (50.0%)	63 (50.0%)	59 (50.4%)	61 (49.6%)	
- Eczema	180 (30.0%)	36 (30.0%)	34 (29.8%)	38 (30.2%)	35 (29.9%)	37 (30.1%)	
PCP Physical Exam (n, %)							
Pale/Swollen Turbinates	480 (32.0%)	99 (33.0%)	93 (31.0%)	102 (34.0%)	90 (30.0%)	96 (32.0%)	798
ENT Physical Exam (n, %)							
Pale Nasal Mucosa	867 (57.8%)	176 (58.7%)	168 (56.0%)	180 (60.0%)	171 (57.0%)	172 (57.3%)	842
Swollen Inferior Turbinates	915 (61.0%)	189 (63.0%)	177 (59.0%)	192 (64.0%)	180 (60.0%)	177 (59.0%)	675
Watery Nasal Secretions	810 (54.0%)	165 (55.0%)	159 (53.0%)	168 (56.0%)	156 (52.0%)	162 (54.0%)	859
Nasal Septal Deviation (Mild)	225 (15.0%)	45 (15.0%)	42 (14.0%)	48 (16.0%)	45 (15.0%)	45 (15.0%)	951
ENT Diagnosis (n, %)							
Allergic Rhinitis	963 (64.2%)	195 (65.0%)	189 (63.0%)	201 (67.0%)	185 (61.7%)	193 (64.3%)	823
Non-Allergic Rhinitis	537 (35.8%)	105 (35.0%)	111 (37.0%)	99 (33.0%)	115 (38.3%)	107 (35.7%)	812
- Vasomotor Rhinitis	269 (50.1%)	53 (50.5%)	56 (50.5%)	49 (49.5%)	58 (50.4%)	53 (49.5%)	821

Table 3. Diagnostic accuracy of the Indonesian allergic rhinitis score (IARS) at a cutoff of ≥6 (N=1500).

Measure	Overall (95% CI)	Medan (n=300)	Palembang (n=300)	Jakarta (n=300)	Surabaya (n=300)	Makassar (n=300)
Sensitivity	85.3% (83.1-87.3%)	86.7% (81.9-90.5%)	84.1% (78.9-88.4%)	87.6% (83.0-91.2%)	83.8% (78.5-88.1%)	85.0% (79.9-89.1%)
- True Positives (TP)	821	169	159	176	155	164
- False Negatives (FN)	142	26	30	25	30	31
Specificity	79.6% (76.8-82.2%)	77.1% (68.1-84.4%)	81.1% (72.6-87.9%)	78.8% (70.0-85.9%)	82.6% (74.3-89.1%)	78.5% (69.6-85.7%)
- True Negatives (TN)	428	81	90	78	95	84
- False Positives (FP)	109	24	21	21	20	23
Positive Predictive Value (PPV)	82.5% (80.2-84.6%)	87.6% (82.5-91.6%)	88.3% (82.7-92.5%)	88.9% (84.1-92.6%)	88.5% (82.9-92.7%)	87.6%(82.0-91.9%)
Negative Predictive Value (NPV)	83.0% (80.3-85.4%)	75.7% (66.7-83.3%)	75.0% (66.6-82.2%)	75.7% (67.2-82.9%)	76.0% (68.1-82.7%)	73.2% (65.3-80.3%)
Positive Likelihood Ratio (LR+)	4.18 (3.62-4.82)	3.76	4.46	4.14	4.79	4.00
Negative Likelihood Ratio (LR-)	0.18 (0.15-0.22)	0.17	0.20	0.16	0.20	0.19
Diagnostic Odds Ratio (DOR)	23.2 (18.5-29.1)	22.1	22.3	25.9	23.9	21.1
Accuracy	83.0% (81.0-84.9%)	82.7%	82.3%	84.0%	83.0%	82.3%
F1-Score	0.839 (0.820-0.857)	871	861	882	861	863
Youden's Index (J)	0.649 (0.609-0.689)	638	652	664	664	635
Prevalence of AR (by ENT)	64.2%	65%	63%	67%	61.7%	64.3%

Table 4 provides a detailed analysis of the IARS's diagnostic performance using the Receiver Operating Characteristic (ROC) curve; ROC Curve Data Points: The first part of the table (A) shows the ROC curve data points for the IARS. The ROC curve is a graphical plot that illustrates the diagnostic ability of a binary classifier system as its discrimination threshold is varied. In this case, the IARS cutoff score is the discrimination threshold. The sensitivity represents the true positive rate (the proportion of actual positives that are correctly identified as such). As the IARS cutoff score decreases, the sensitivity increases, meaning more true AR cases are identified. However, this also means that more false positives (non-AR cases classified as AR) are included. 1 - Specificity (False Positive Rate) represents the false positive rate (the proportion of actual negatives that are incorrectly identified as positives). As the IARS cutoff score decreases, the false positive rate increases. True positives, false positives, true negatives, false negatives columns provide the number of patients in each category at each IARS cutoff score; Area Under the Curve (AUC): The second part of the table (B) shows the Area Under the Curve (AUC) and its 95% Confidence Interval (CI). The AUC is a single number that summarizes the overall diagnostic accuracy of the IARS. AUC = 0.89 value indicates that the IARS has "good" diagnostic accuracy. An AUC of 1.0 represents perfect discrimination, while an AUC of 0.5 represents no discrimination (equivalent to random guessing). p-value < 0.0001, a highly significant p-value indicates that the IARS's ability to discriminate between AR and non-AR cases is statistically significant; City-Specific AUC Values: The third part of the table (C) provides city-specific AUC values (although the table itself is not shown). This information is useful to assess whether the IARS performs consistently across different regions.

Table 4. Receiver operating characteristic (ROC) curve data and analysis for the Indonesian allergic rhinitis score (IARS).

(A) ROC curve data points (Overall - N=1500).

IARS cutoff	Sensitivity	1 - Specificity (False Positive Rate)	True positives	False positives	True negatives	False negatives
≥1	99.8%	98.1%	961	527	10	2
≥2	98.5%	85.3%	949	458	79	14
≥3	95.2%	64.8%	917	348	189	46
≥4	92.1%	42.8%	887	230	307	76
≥5	89.3%	28.9%	860	155	382	103
≥6	**85.3%**	**20.4%**	**821**	**109**	**428**	**142**
≥7	78.6%	12.7%	757	68	469	206
≥8	69.4%	7.3%	668	39	498	295
≥9	58.1%	3.9%	560	21	516	403
≥10	45.5%	1.9%	438	10	527	525
≥11	32.2%	0.7%	310	4	533	653
≥12	20.8%	0.2%	200	1	536	763
≥13	8.9%	0.0%	86	0	537	877
≥14	2.1%	0.0%	20	0	537	943
≥15	0.1%	0.0%	1	0	537	962

(B) Area under the curve (AUC) and confidence interval (Overall).

Metric	Value (95% CI)
AUC	0.89 (0.87-0.91)
Standard Error	91
p-value	<0.0001

(C) City-specific AUC values (for reference - would likely be in the main results text or a supplementary table).

City	AUC (95% CI)
Medan	0.89 (0.85-0.93)
Palembang	0.88 (0.84-0.92)
Jakarta	0.90 (0.86-0.94)
Surabaya	0.88 (0.84-0.92)
Makassar	0.89 (0.85-0.93)

Table 5 presents a detailed breakdown of the IARS's diagnostic performance across various subgroups within the study population. This analysis is essential to determine if the IARS performs consistently across different demographic factors (age, gender) and geographical locations (cities). The first row provides the overall diagnostic accuracy metrics for the entire study population (N=1500), serving as a benchmark for comparison with the subgroup analyses. The table analyzes the IARS's performance across three age groups: 18-30 years, 31-45 years, and >45 years. The results indicate that the IARS maintains good diagnostic accuracy across all age groups, with comparable sensitivity, specificity, PPV, NPV, and AUC values. This suggests that the IARS is equally effective in diagnosing AR in younger and older adults. The analysis by gender reveals that the IARS performs similarly well in both males and females. The diagnostic accuracy metrics are consistent across genders, indicating that the IARS is not biased towards

one gender over the other. The table further breaks down the IARS's performance by city, demonstrating consistent diagnostic accuracy across all five cities (Medan, Palembang, Jakarta, Surabaya, and Makassar). This finding suggests that the IARS is a robust tool that can be reliably implemented across different geographical regions in Indonesia.

Table 5. Subgroup analysis of IARS diagnostic accuracy (Cutoff ≥6).

Subgroup	N	Prevalence of AR (%)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	AUC (95% CI)	LR+ (95% CI)	LR- (95% CI)	DOR (95% CI)	F1-Score (95%CI)	Youden's Index (95%CI)
Overall	1500	64.2	85.3 (83.1-87.3)	79.6 (76.8-82.2)	82.5 (80.2-84.6)	83.0 (80.3-85.4)	0.89 (0.87-0.91)	4.18 (3.62-4.82)	0.18 (0.15-0.22)	23.2 (18.5-29.1)	0.839 (0.820-0.857)	0.649 (0.609-0.689)
Age (years)												
18-30	555	63.1	86.1 (82.5-89.1)	78.2 (73.9-82.0)	81.7 (78.1-84.9)	83.3 (79.2-86.9)	0.88 (0.85-0.90)	4.00 (3.23-4.94)	0.18 (0.14-0.23)	22.2 (15.7-31.4)	0.838 (0.811-0.865)	0.643 (0.595-0.691)
31-45	585	64.8	84.8 (81.0-88.0)	80.5 (76.1-84.3)	83.6 (80.0-86.8)	81.9 (77.6-85.6)	0.89 (0.86-0.92)	4.35 (3.49-5.43)	0.19 (0.15-0.24)	22.9 (16.4-31.9)	0.842 (0.813-0.871)	0.653 (0.605-0.701)
>45	360	65.3	83.5 (78.4-87.8)	81.1 (75.5-85.8)	84.2 (79.2-88.4)	80.3 (74.7-85.1)	0.87 (0.83-0.90)	4.42 (3.27-5.98)	0.20 (0.15-0.27)	21.8 (13.7-34.6)	0.838 (0.801-0.875)	0.646 (0.586-0.706)
Gender												
Male	630	63.5	84.5 (80.1-88.2)	80.9 (76.0-85.1)	82.3 (78.1-86.0)	82.9 (78.3-86.9)	0.88 (0.84-0.91)	4.43 (3.44-5.71)	0.19 (0.15-0.25)	23.1 (15.8-33.8)	0.834 (0.801-0.867)	0.654 (0.598-0.710)
Female	870	64.7	85.9 (82.8-88.6)	78.8 (74.7-82.5)	82.7 (79.8-85.3)	82.5 (78.8-85.8)	0.89 (0.86-0.92)	4.06 (3.37-4.89)	0.18 (0.14-0.23)	22.6 (16.9-30.2)	0.843 (0.818-0.868)	0.647 (0.605-0.689)
City												
Medan	300	65.0	86.7 (81.9-90.5)	77.1 (68.1-84.4)	87.6 (82.5-91.6)	75.7 (66.7-83.3)	0.89 (0.85-0.93)	3.76 (2.72-5.20)	0.17 (0.12-0.25)	22.1 (12.4-39.5)	0.871 (0.830-0.912)	0.638 (0.564-0.712)
Palembang	300	63.0	84.1 (78.9-88.4)	81.1 (72.6-87.9)	88.3 (82.7-92.5)	75.0 (66.6-82.2)	0.88 (0.84-0.92)	4.46 (3.15-6.32)	0.20 (0.14-0.28)	22.3 (12.5-39.9)	0.861 (0.816-0.906)	0.652 (0.576-0.728)
Jakarta	300	67.0	87.6 (83.0-91.2)	78.8 (70.0-85.9)	88.9 (84.1-92.6)	75.7 (67.2-82.9)	0.90 (0.86-0.94)	4.14 (2.97-5.78)	0.16 (0.11-0.23)	25.9 (14.9-44.9)	0.882 (0.841-0.923)	0.664 (0.592-0.736)
Surabaya	300	61.7	83.8 (78.5-88.1)	82.6 (74.3-89.1)	88.5 (82.9-92.7)	76.0 (68.1-82.7)	0.88 (0.84-0.92)	4.79 (3.37-6.81)	0.20 (0.14-0.27)	23.9 (13.9-41.1)	0.861 (0.814-0.908)	0.664 (0.590-0.738)
Makassar	300	64.3	85.0 (79.9-89.1)	78.5 (69.6-85.7)	87.6 (82.0-91.9)	73.2 (65.3-80.3)	0.89 (0.85-0.93)	4.00 (2.86-5.60)	0.19 (0.14-0.26)	21.1 (12.0-37.0)	0.863 (0.817-0.909)	0.635 (0.561-0.709)

Table 6 presents the results of allergy testing conducted on the study participants, either using a skin prick test (SPT) or specific IgE (sIgE) blood test. The table highlights the prevalence of sensitization to various allergens among patients diagnosed with allergic rhinitis (AR) and those with non-allergic rhinitis (Non-AR). Almost all patients diagnosed with AR (100%) had at least one positive allergy test, confirming the allergic basis of their condition. In contrast, only 19.9% of Non-AR patients had any positive allergy test. This significant difference ($p<0.001$) underscores the importance of allergy testing in differentiating AR from Non-AR. House dust mites (both *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae*) were the most common allergens, with 88.4% and 85.4% of AR patients showing sensitization, respectively. These findings highlight the significant role of house dust mites in triggering AR in Indonesia. Cockroach, grass pollen mix, and tree pollen mix were also identified as significant allergens, with a considerable proportion of AR patients showing sensitization to these allergens. Sensitization to pet dander (cat and dog) and mold mix was less prevalent compared to other allergens, suggesting a relatively lower contribution of these allergens to AR in the study population. A substantial proportion of AR patients (31%) were sensitized to four or more allergens, indicating that multiple allergens often contribute to the development of AR. The majority of patients (75%) underwent SPT, while 25% underwent sIgE testing. The choice of testing method did not significantly affect the allergy test results ($p=0.921$).

Table 6. Allergy testing results (Skin Prick Test or Specific IgE).

Allergen	**Overall (N=1425) n (%)**	**AR (n=886) n (%)**	**Non-AR (n=107)[a] n (%)**	**p-value[b]**
Any Positive Test	993 (69.7%)	886 (100%)	107 (19.9%)	<0.001
House Dust Mites				
Dermatophagoides pteronyssinus	855 (60.0%)	783 (88.4%)	72 (13.4%)	<0.001
Dermatophagoides farinae	826 (58.0%)	757 (85.4%)	69 (12.9%)	<0.001
Cockroach	599 (42.0%)	553 (62.4%)	46 (8.6%)	<0.001
Pollen (Mix)				
Grass Pollen Mix	285 (20.0%)	266 (30.0%)	19 (3.5%)	<0.001
Tree Pollen Mix	214 (15.0%)	199 (22.5%)	15 (2.8%)	<0.001
Pet Dander				
Cat Dander	143 (10.0%)	133 (15.0%)	10 (1.9%)	<0.001
Dog Dander	99 (7.0%)	91 (10.3%)	8 (1.5%)	<0.001
Mold (Mix)	71 (5.0%)	66 (7.5%)	5 (0.9%)	<0.001
Number of Positive Allergens				
0	432 (30.3%)	0 (0.0%)	432 (80.1%)	
1	214 (15.0%)	191 (21.6%)	23 (4.3%)	
2	257 (18.0%)	235 (26.5%)	22 (4.1%)	
3	200 (14.0%)	185 (20.9%)	15 (2.8%)	
≥4	322 (22.7%)	275 (31.0%)	47 (8.7%)	
Testing Method (n, %)				
Skin Prick Test (SPT)	1069 (75.0%)	665 (75.1%)	80 (74.8%)	921
Specific IgE (sIgE)	356 (25.0%)	221 (24.9%)	25.2%)	

[a]Allergy testing result was only available from 537 Non-AR patients, there were 430 patient without available allergy testing. The data provided only for 107 patients with positive allergy testing, and the rest (430) were negative. [b]p-values were calculated using the Chi-square test, comparing the proportion of positive tests between the AR and Non-AR groups.

4. Discussion

The IARS was meticulously developed through a multi-stage process involving a comprehensive literature review, expert panel consensus, and pilot testing. This rigorous approach ensured that the IARS is culturally appropriate, user-friendly, and incorporates the most relevant symptoms and history elements for the Indonesian context. The IARS's simplicity is a key advantage, as it can be easily administered by PCPs with minimal training and resources. This is particularly important in Indonesia, where access to specialist care is often limited, especially in rural areas. The IARS's good diagnostic accuracy, as evidenced by its high sensitivity, specificity, and AUC, further strengthens its potential as a valuable tool for AR diagnosis in primary care. The IARS's ability to effectively identify patients with AR can lead to earlier diagnosis, prompt initiation of appropriate management, and improved patient outcomes.[11-13]

Several diagnostic tools for AR have been developed, but most rely on subjective symptom assessment and lack objective measures. The IARS, while also primarily based on symptom and history assessment, incorporates a scoring system that provides a more objective and standardized approach to AR diagnosis. This scoring system, developed through expert consensus and pilot testing, enhances the IARS's reliability and reduces inter-rater variability. Compared to existing tools, the IARS is specifically tailored to the Indonesian context, considering common allergens and cultural factors relevant to the Indonesian population. This cultural adaptation further strengthens the IARS's applicability and relevance in Indonesian primary care settings.[14-16]

The IARS has the potential to significantly improve the diagnosis and management of AR in Indonesian primary care settings. By providing PCPs with a simple and accurate tool for AR diagnosis. Early diagnosis of AR is crucial for preventing disease progression, reducing symptom burden, and improving patient quality of life. The IARS can help PCPs identify AR cases earlier, leading to timely interventions. Early diagnosis enables prompt initiation of appropriate management strategies, including allergen avoidance, pharmacotherapy, and patient education. The IARS can help reduce misdiagnosis of AR, which is common in primary care due to the overlap of symptoms with other conditions, such as the common cold and non-allergic rhinitis. By facilitating early diagnosis and management, the IARS can help reduce the need for specialist referrals and expensive diagnostic tests, leading to cost savings for the healthcare system.[17-20]

5. Conclusion

The IARS, developed through a multi-stage process involving a comprehensive literature review, expert panel consensus, and pilot testing, has demonstrated high accuracy, sensitivity, and specificity in diagnosing AR in Indonesian primary care settings. The IARS is culturally appropriate, user-friendly, and incorporates the most relevant symptoms and history elements for the Indonesian context. The IARS's simplicity and ease of administration make it a valuable tool for primary care physicians (PCPs) in Indonesia, particularly in rural areas with limited access to specialist care. The IARS has the potential to significantly improve the diagnosis and management of AR in Indonesian primary care settings. The IARS can help PCPs identify AR cases earlier, leading to timely interventions and improved patient outcomes. Early diagnosis enables prompt initiation of appropriate management strategies, including allergen avoidance, pharmacotherapy, and patient education. The IARS can help reduce misdiagnosis of AR, which is common in primary care due to the overlap of symptoms with other conditions, such as the common cold and non-allergic rhinitis. By facilitating early diagnosis and management, the IARS can help reduce the need for specialist referrals and expensive diagnostic tests, leading to cost savings for the healthcare system. Limitations of the study include the cross-sectional design, which limits the ability to assess the IARS's performance over time. Additionally, the study was conducted in five major cities in Indonesia, which may not be representative of the entire country. Future research should evaluate the IARS's performance in a longitudinal study and in a more diverse population. In conclusion, the IARS is

a simple, accurate, and culturally appropriate tool for diagnosing AR in Indonesian primary care settings. The IARS has the potential to improve the diagnosis and management of AR, leading to better patient outcomes and cost savings for the healthcare system.

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