

DIAGNOSTIC ALGORITHM AND SYSTEM FOR DETECTING SEASONAL ALLERGIC RHINOCONJUNCTIVITIS IN CHILDREN IN SCHOOLS

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Abstract

Aim. To describe the methodology and protocol of a screening diagnostic algorithm developed for detecting seasonal allergic rhinosinusitis (SAR) in primary-school-aged children within general education institutions, together with the architecture of the supporting automated information system, "Allergo-Screening."

Material and methods. The screening algorithm is based on a retrospective analysis of school attendance records from three general education schools, followed by face-to-face clinical-instrumental verification of the diagnosis in children identified as at risk. A two-component recurrence filter for absences coded as "acute respiratory viral infection (ARVI)/influenza" is applied to electronic attendance-register data; children meeting the recurrence criterion undergo a standardized six-item parental questionnaire (episode recurrence, presence of fever, nasal/ocular itching and paroxysmal sneezing, symptom association with outdoor exposure, parental allergy/asthma history, and impact on sleep and academic performance), the result of which is automatically converted into a 0–6 risk score. When the threshold is reached, the system generates a referral to the local pediatrician and subsequently to an otorhinolaryngologist for in-person clinical-instrumental and laboratory-immunological assessment (nasal endoscopy, anterior active rhinomanometry, sinus ultrasonography, skin-prick/scarification tests, total and specific IgE, and, where indicated, nasal secretion inflammatory mediator levels). The final diagnosis is established by the otorhinolaryngologist only when at least two objective positive findings are present.

Results. The architecture of the "Allergo-Screening" system is presented, comprising four interconnected modules (parent, school nurse, local pediatrician, otorhinolaryngologist) and a central database, together with the automated risk-score algorithm and its interpretation bands (0–2 points — low probability; 3–4 points — referral to a pediatrician; 5–6 points — high probability of SAR, priority referral). The principles of protecting minors' personal data and a representative user scenario are described. Quantitative evaluation of the algorithm's diagnostic accuracy (sensitivity, specificity, area under the ROC curve) is at the data-accrual stage and will be reported separately once cohort enrolment is complete.

Conclusion. The proposed protocol integrates documentary screening, standardized questionnaire-based risk stratification, and mandatory face-to-face objective verification into a single digital algorithm that may be suitable for implementation in routine school health services to reduce underdiagnosis of SAR in children.

Keywords: seasonal allergic rhinosinusitis, children, screening, diagnostic algorithm, clinical decision support system, underdiagnosis.

1. Introduction

Seasonal allergic rhinosinusitis (SAR) in children of primary school age is frequently mistaken in outpatient practice for recurrent acute respiratory viral infection (ARVI), owing to the overlapping nasal symptomatology and the practical convenience, for both caregivers and primary-care physicians, of attributing repeated school absences to intercurrent infection rather than to an underlying allergic process. Population estimates place the prevalence of allergic rhinitis in children in the range of roughly 10–28%, yet the interval between symptom onset and confirmed diagnosis commonly spans several years, a delay during which secondary complications — adenoid hypertrophy, recurrent otitis media, disrupted school adaptation, and progression along the so-called “allergic march” toward bronchial asthma — may become established [1,2].

Two methodological gaps limit the practical detection of SAR at the population level. First, most validated allergy screening instruments were developed and psychometrically tested in different cultural and linguistic settings and were designed as stand-alone parent- or child-completed questionnaires rather than as tools integrated into existing school administrative workflows [3]. Second, purely questionnaire-based screening, however well validated, does not by itself constitute a diagnosis: international rhinitis guidelines emphasize that a presumptive risk flag must be followed by objective clinical, endoscopic, and laboratory-immunological confirmation before a diagnosis of allergic rhinitis or rhinosinusitis is made [4,5]. Digital clinical decision support systems (CDSS) for allergic rhinitis, most notably the ARIA/MASK e-CDSS framework, have demonstrated that structured digital algorithms can meaningfully support, without replacing, physician judgement in AR management [6], but comparable tools specifically oriented toward school-based case-finding in children remain scarce, particularly for populations where documentary (attendance-based) screening is a practical entry point.

These considerations motivated the development, within a broader dissertation research project on the diagnosis and treatment of SAR in schoolchildren, of a two-stage screening-to-verification protocol and its digital implementation, the “Allergo-Screening” system. The present article describes this algorithm and system as a methodological and protocol contribution, independent of the quantitative diagnostic-accuracy findings that will be reported once prospective cohort enrolment and follow-up are complete.

2. Materials and Methods

The protocol described here was developed within a two-phase observational design conducted on the basis of three general education schools and the otorhinolaryngology clinic of Samarkand State Medical University. In the first (retrospective screening) phase, daily attendance records coded as absence due to “ARVI/influenza” are extracted for children in grades 1–4. A two-component recurrence filter is applied: an inter-seasonal component (recurrence of the same coded absence across comparable calendar windows of successive years) and an intra-seasonal component (2 episodes within a single calendar month or 3 episodes within one season). Children meeting either component are classified as an at-risk group and referred for the second (prospective verification) phase, comprising face-to-face clinical-instrumental and laboratory-immunological examination by an otorhinolaryngologist.

The face-to-face examination protocol includes: clinical and allergological history-taking with a standardized 4-point severity scale (0 – absent, 1 – mild, 2 – moderate, 3 – marked) for nasal obstruction, rhinorrhea, itching, and sneezing; anterior nasal endoscopy; anterior active rhinomanometry (before and after a standard decongestant test); paranasal sinus ultrasonography, with radiography reserved for equivocal ultrasound findings; skin scarification/prick testing with household, epidermal, and pollen allergens, timed according to a regional pollen calendar; total and allergen-specific serum IgE; peripheral eosinophil count and nasal cytogram; and, in children with a suspected asthmoid component, spirometry/peak-flow testing. In a defined subset, nasal secretion is additionally analyzed for leukotrienes (LTC₄, LTD₄, LTE₄) and 15-hydroxyeicosatetraenoic acid (15-HETE) by enzyme immunoassay, sampled by nasal lavage at two time points — during exacerbation and during clinical remission. A final diagnosis (true ARVI, isolated SAR, or SAR with an asthmoid component) is assigned only when at least two independent objective findings are positive, a rule embedded programmatically in the supporting information system so that a diagnosis cannot be entered from questionnaire data alone.

The “Allergo-Screening” system architecture.

The system was conceived after the pilot (paper-based) screening checklist proved impractical for routine, non-research use by school nursing staff. It links four user modules around a central database:

- A parent module (mobile application or adaptive web form) automatically delivers a six-item questionnaire whenever an “ARVI/influenza” absence note is issued, covering: recurrence of the episode within the season and across years; presence or absence of fever; nasal/ocular itching and paroxysmal sneezing; association of symptoms with time outdoors; parental history of allergy/asthma; and impact on the child’s sleep and schoolwork.
- A school nurse module, integrated with the school’s electronic attendance register, automatically tracks ARVI-coded absences per pupil and raises a risk flag once the recurrence threshold is met, without requiring manual tallying.
- A local pediatrician module receives an auto-generated, pre-populated referral once the aggregate questionnaire score reaches the threshold (3 of 6 positive items), summarizing the absence history and questionnaire responses; the pediatrician’s role at this stage is limited to excluding acute conditions requiring urgent care and forwarding the child for full allergological assessment — the pediatrician does not independently confirm the SAR diagnosis.
- An otorhinolaryngologist module records the results of each diagnostic method individually and permits entry of the final verified diagnosis only when the two-objective-finding rule is satisfied; if an asthmoid component is confirmed, the system automatically generates a notification for a multidisciplinary consultation involving a pediatrician and endocrinologist.

Access to personal data is role-restricted (parents see only their own child’s data; nurses see aggregated risk flags for their school without individual questionnaire detail; physicians see full records only for patients referred to them), and identifying information is stored separately from clinical data using a de-identified pupil code, consistent with data-protection requirements applicable to minors’ health information.

Risk-score algorithm.

Each of the six questionnaire items contributes 1 point if positive and 0 if negative, yielding a simple 0–6 sum, calculated automatically by the central database rather than manually by nursing staff. The interpretation bands, carried over from the piloted paper version, are: 0–2 points — low probability, routine observation, no flag generated; 3–4 points — referral to the pediatrician for clarification; 5–6 points — high probability of SAR, priority referral to the pediatrician/otorhinolaryngologist with the absence history and questionnaire results attached automatically. In the digital implementation, the recurrence item is computed automatically from the electronic attendance register rather than relying on parental recall, reducing the potential for recall-related misclassification present in the original paper checklist.

3. Results

The described algorithm and system represent the completed design and technical-conceptual output of this stage of the project: a documentary two-component recurrence filter, a six-item automatically scored risk questionnaire with defined interpretation bands, a four-module client-server information system linking parents, school nursing staff, pediatricians, and otorhinolaryngologists around a shared de-identified database, and a mandatory rule requiring at least two independent objective findings before a diagnosis of SAR (isolated or combined with an asthmoid component) can be entered. A representative use scenario has been specified end to end: an ARVI-coded absence note triggers an automated parental questionnaire; the system cross-references the current episode against the child’s prior absence history under a de-identified pupil code; on reaching the recurrence and/or score threshold, the school nurse receives a dashboard notification and decides whether to issue a referral; the pediatrician receives a pre-populated referral rather than a blank one, shortening the time needed to collect history at the initial visit; and the otorhinolaryngologist enters the objectively verified diagnosis, which closes the observation cycle for that episode and adds a new record to the research database.

Enrolment into the prospective verification phase, and the corresponding accumulation of paired risk-score/verified-diagnosis data needed to calculate sensitivity, specificity, predictive values, and ROC-curve characteristics of the six-item questionnaire, is ongoing at the time of this report.

Quantitative diagnostic-accuracy estimates and their comparison against single-criterion screening

(absence count alone) will be presented as a separate original-research communication once cohort enrolment and the associated statistical analysis are complete, in keeping with standard reporting practice for algorithms whose evaluation is still in progress [7].

4. Discussion

The protocol described here differs from most previously published school-based allergy screening instruments in two respects. First, whereas earlier validated questionnaires such as the parent/student asthma-and-allergy screening instruments developed by Redline et al. functioned as free-standing paper tools requiring manual administration and scoring [3], the present algorithm is built around routinely generated administrative data — the school's own attendance register — as the initial case-finding trigger, which in principle allows continuous rather than one-off screening without adding to school nursing workload. Second, the algorithm explicitly separates screening from diagnosis at the architectural level: the questionnaire-derived risk score can only generate a referral, never a diagnosis, and the system enforces a minimum evidentiary threshold (two independent objective findings) before an otorhinolaryngologist can record a confirmed case. This design mirrors the general principle underlying electronic AR clinical decision support tools such as MASK e-CDSS, namely that digital algorithms are intended to support, structure, and expedite clinician decision-making rather than substitute for it [6].

The choice of a six-item, low-burden questionnaire reflects a deliberate trade-off between diagnostic informativeness and feasibility of routine use by non-specialist staff; a similar trade-off underlies other brief school screening instruments, which have generally favored a small number of high-yield items over longer validated scales for first-line, high-throughput case-finding [3]. Objective confirmation of the diagnosis, including nasal endoscopy and rhinomanometry, remains essential, since symptom-based case identification alone — however sensitive — cannot distinguish allergic from non-allergic rhinitis phenotypes or exclude structural or infectious pathology masquerading as recurrent ARVI [4,5]. Standardized nasal cytology, alongside skin testing and specific IgE, is increasingly recognized as a low-cost adjunct that strengthens the objective evidence base available at the verification stage without requiring invasive procedures [8].

The principal limitation of the present report is methodological rather than clinical: as a protocol and system-architecture description, it does not itself establish the diagnostic accuracy of the six-item risk score, and the interpretation bands and item weights, while carried over from a previously piloted paper checklist, are candidates for recalibration once sufficient paired screening-versus-verified-diagnosis data have accrued, using logistic regression and ROC analysis as specified in the study's statistical protocol. A second limitation concerns generalizability: the algorithm was developed and piloted in a specific regional school setting, and its recurrence thresholds and pollen-calendar assumptions would require local adaptation before use elsewhere. Finally, the personal-data-protection principles described here are conceptual; their concrete technical implementation (encryption standards, hosting, access-audit tooling) lies outside the scope of a clinical dissertation and would need to be addressed separately before any operational deployment beyond the research setting.

5. Conclusion

The “Allergo-Screening” algorithm and system integrate documentary attendance-based case-finding, a brief automatically scored parental questionnaire, and mandatory face-to-face objective verification into a single digital protocol for detecting seasonal allergic rhinosinusitis in schoolchildren. By enforcing a strict separation between screening and diagnosis and automating the recurrence calculation that previously required manual tallying, the protocol is designed to be feasible for routine use by school health services while preserving the objective diagnostic standard required for a confirmed diagnosis. Prospective evaluation of the algorithm's sensitivity, specificity, and predictive performance against verified diagnosis, currently in progress, will determine whether the interpretation thresholds proposed here require recalibration before broader implementation.

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