

Exploring longitudinal academic trajectories of medical students with allergic rhinitis: Implications for early identification and support

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Research Article

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Abstract

Background

Allergic rhinitis (AR) is common among young adults and may impair sleep, concentration, and academic performance. However, little is known about longitudinal academic trajectories of medical students with AR. This study aimed to examine the longitudinal association between AR and academic performance during the early years of medical school. We further explored whether identifying AR at entry, as a common and potentially modifiable health condition, may provide an opportunity for early student support.

Methods

This prospective longitudinal observational study included 100 medical students who entered a Japanese medical school in 2023. AR status was assessed at entry using a questionnaire reviewed by an allergist and an otolaryngologist. Academic performance was assessed using grade point average (GPA) over the first four academic years. Students with allergic symptoms received routine health guidance, including recommendations for medical consultation, continued treatment, and management of their living environment. Longitudinal GPA trajectories were analyzed using a linear mixed-effects model. A sensitivity analysis included 95 students with GPA data through the first semester of the fourth year, immediately before clinical clerkships.

Results

Fifty-five students had AR and 45 did not. First-year GPA was significantly lower among students with AR than among those without AR. The between-group difference subsequently attenuated and was no longer statistically significant by the second year. Although academic year was significantly associated with GPA, the AR $\times$ academic year interaction was not significant.

Conclusions

AR was associated with lower academic performance during the earlier years of medical school, although longitudinal trajectories did not differ significantly by AR status. The attenuation of the GPA difference cannot be attributed to the support provided. Nevertheless, early identification of common, potentially modifiable health conditions such as AR may provide opportunities for individualized student support.

Background

Academic performance in medical school is influenced by a complex interplay of individual, educational, social, and health-related factors [1]. Early identification of students at risk of academic difficulty has therefore received considerable attention in medical education [2], because timely support may be more effective than remediation initiated only after substantial academic difficulties have become apparent [3]. However, prediction alone has limited educational value unless potentially relevant factors can be translated into timely and appropriate student support. From this perspective, identifying common, modifiable conditions that may interfere with learning may provide a practical opportunity to shift the focus from prediction of academic difficulty to support for learning.

Allergic rhinitis (AR) is one such condition. It is common among adolescents and young adults and may adversely affect daily functioning, quality of life, and academic productivity [4]. Previous studies have reported associations between allergic rhinitis and impaired academic performance, including among medical students [5–7]. Importantly, the relationship between allergic disease and academic demands may be bidirectional. In college students with mild allergic asthma, Busse's group demonstrated that allergen-induced eosinophilic airway inflammation was enhanced during final examinations compared with a low-stress academic period, suggesting that examination-related psychological stress may amplify allergic inflammatory responses [8]. Thus, allergic disease may not only interfere with learning but may itself be influenced by the learning environment. However, previous studies examining allergic rhinitis and academic outcomes, including those conducted among medical students, have predominantly used cross-sectional designs [5–7]. Less is known about how academic performance among students with AR changes longitudinally during medical school or whether identifying this condition at entry may provide an opportunity for early support.

The potential educational relevance of allergic rhinitis extends beyond the disease itself. Symptoms may be influenced by treatment and environmental exposures [9]. The transition to university may also involve changes in living arrangements, with students living alone assuming greater responsibility for medication management and control of their indoor environment. Thus, the academic implications of allergic rhinitis may reflect an interaction between a common health condition and the circumstances in which students live and learn. Importantly, both disease management and aspects of the living environment are potentially modifiable and may therefore represent actionable targets for student support.

At our medical school, information regarding allergic diseases was collected from students at entry as part of preparation for an early clinical exposure program that included home visits with physicians and nurses. This provided an opportunity to examine prospectively collected health information in relation to subsequent academic performance. Students were subsequently followed over four academic years, during which those reporting allergic symptoms were encouraged, where appropriate, to seek medical care, continue treatment, and improve their living environment.

This study therefore aimed to examine the longitudinal association between AR and academic performance during the early years of medical school. Rather than seeking to predict academic failure,

we explored whether a common, readily identifiable, and potentially modifiable health condition could help identify opportunities for early student support. We hypothesized that AR would be associated with lower academic performance during the earlier years of medical school.

Methods

Study design and participants

This was a prospective longitudinal observational study conducted at Tohoku Medical and Pharmaceutical University, Japan. The study population comprised 100 students who entered the Faculty of Medicine in April 2023. Students were followed from their first through fourth academic years for the primary longitudinal analysis, with fourth-year GPA assessed during the first semester, immediately before the start of clinical clerkships. In addition, a sensitivity analysis was conducted among 95 students with GPA data available across all four academic years. Information regarding allergic diseases had been collected at entry as part of routine preparation for an early clinical exposure program for first-year medical students. During this program, students accompanied physicians and nurses on home visits to patients. Because students could potentially encounter allergens in patients' homes, information regarding pre-existing allergic conditions was obtained before participation.

Allergy assessment

At entry, students were asked about the presence of allergic diseases, including AR, using a questionnaire. An English-language version of the questionnaire is provided in the Supplementary Material as the Supplementary Questionnaire. The completed questionnaires were reviewed by an allergist and an otolaryngologist, who determined the presence or absence of AR based on the information provided by the students. When classification based on the questionnaire responses was uncertain, additional clinical information obtained through medical interviews conducted as part of routine educational and health-related support was used to clarify AR status. For the present analysis, students were classified according to the presence or absence of AR at entry.

Living arrangements

Students' living arrangements were recorded and classified as living alone or living with family or others. Because moving away from home may alter both treatment adherence and control of the indoor environment, living arrangement was examined as a potential contextual factor modifying the association between AR and academic performance.

Academic performance

Academic performance was assessed using grade point average (GPA). GPA was calculated as the credit-weighted mean of grade points obtained across all courses during the relevant academic period, using the standard 4-point grading scale adopted by the university. The first-year GPA used for the baseline analysis was calculated from courses completed during the first semester of the first academic year.

The primary outcome was the longitudinal trajectory of GPA over the first four academic years.

Student support and follow-up

Students reporting allergic symptoms were provided with health-related advice as appropriate during follow-up. Students with inadequately controlled symptoms or interrupted treatment were encouraged to seek medical evaluation and to continue appropriate treatment. Where relevant, attention was also drawn to management of the living environment, including regular cleaning and reduction of potential indoor allergen exposure.

These measures constituted routine health guidance and student support rather than a standardized experimental intervention. No students were randomly assigned to receive or not receive support, and the study was not designed to establish a causal effect of the support measures on subsequent academic performance.

Statistical analysis

Student characteristics were summarized using appropriate descriptive statistics. GPA was compared between students with and without AR for each academic year using Student's *t* test. Standardized between-group effect sizes were expressed as Hedges' *g*. For the exploratory analysis of living arrangement, students were further stratified according to AR status and whether they lived alone or with others.

Because GPA measurements were repeatedly obtained from the same students over the first four academic years, longitudinal changes were analyzed using a linear mixed-effects model with student-level random effects. Academic year and AR status were included as fixed effects, and the AR × academic year interaction was examined to determine whether GPA trajectories differed according to AR status. The association between AR and first-year GPA according to living arrangement was examined in an exploratory analysis.

Effect estimates with 95% confidence intervals (CI) were reported in addition to *P* values. Statistical significance was defined as a two-sided *P* value < .05. No a priori sample size or power calculation was performed because the study included the entire cohort of eligible students. JMP version 19 (SAS Institute Inc., Cary, NC, USA) was used for all analyses.

Ethical considerations

The study was approved by the Institutional Review Board of Tohoku Medical and Pharmaceutical University (Approval No. 2024-A-005-0000). The study analyzed routinely collected educational and health-related data. Informed consent for participation was obtained through an institutional review board-approved opt-out procedure in accordance with institutional ethical standards.

Results

Participant characteristics

A total of 100 medical students were included in the analysis. Of these, 55 students had AR and 45 did not. Baseline demographic and clinical characteristics according to AR status are summarized in **Table 1**. The two groups were generally comparable with respect to sex and living status. Among students with AR, concomitant allergic conditions, including atopic dermatitis, food allergy, asthma, and urticaria, were also observed.

Academic performance according to allergic rhinitis status

Entrance examination scores did not differ significantly between students with and without AR ($P = 0.753$, data not shown). The mean GPA was lower among students with AR than among those without AR during the first academic year (**Table 2**). In the first year, the mean GPA was 2.518 in students with AR and 2.700 in those without AR [mean difference, -0.182 ; 95% CI, -0.355 to -0.009 ; $P = 0.039$]. The between-group difference was not statistically significant in the second, third, or fourth academic year. Figure 1 illustrates the longitudinal trajectories of GPA according to AR status across the four academic years. The difference in GPA between students with and without allergic rhinitis was greatest in the first academic year and gradually diminished over subsequent years.

Longitudinal analysis of academic performance

To evaluate longitudinal changes in academic performance, a linear mixed-effects model was used with repeated GPA measurements across the four academic years. Academic year was significantly associated with GPA ($P < 0.0001$), indicating an overall change in academic performance over time. However, the interaction between AR status and academic year was not statistically significant ($P = 0.2405$), indicating that the longitudinal pattern of GPA change did not differ significantly between students with and without AR. Thus, although between-group comparisons showed lower GPA among students with AR in the first year and no statistically significant difference in the second, third, or fourth year, the mixed-effects model did not provide evidence of a differential longitudinal trajectory according to AR status (**Table 3**).

Exploratory interaction analyses

Exploratory analyses were conducted to examine the association between AR and first-year GPA according to living arrangement (**Supplementary Table 1**). Among students living alone, those with AR

had lower first-year GPA than those without AR, whereas no significant difference was observed among students living with family. However, the AR $\times$ living arrangement interaction was not statistically significant ($P = 0.342$), providing no evidence that living arrangement significantly modified the association between AR and GPA. To minimize the potential influence of attrition due to academic delay, a sensitivity analysis was conducted among the 95 students with GPA data available from the first through the fourth year. In this restricted cohort, the between-group difference was significant in the first year but not from the second year onward. The standardized between-group difference also decreased from the first to the fourth year (Hedges' g , -0.458 to -0.046 ; **Supplementary Table 2**).

Discussion

Several important findings emerged from this longitudinal study. First, students with AR had lower GPA than those without AR during the earlier years of medical school, whereas the between-group difference progressively attenuated through the first semester of the fourth academic year, immediately before the start of clinical clerkships. Second, despite this apparent convergence, the AR $\times$ academic year interaction was not statistically significant, indicating that the overall longitudinal trajectories did not differ significantly between the groups. Third, in the sensitivity analysis restricted to the same 95 students with available longitudinal data, the magnitude of the between-group difference progressively decreased, with Hedges' g declining from -0.458 in the first year to -0.046 in the fourth year. Taken together, these findings suggest an association between AR and academic performance during the earlier years of medical school but do not support attributing the subsequent convergence in GPA to AR-related support or intervention.

These findings nevertheless suggest that AR-related symptoms may represent clinically relevant and potentially modifiable factors [10] associated with academic performance, particularly during the earlier years of medical education. While AR is generally not considered a severe illness, symptoms such as nasal obstruction, rhinorrhea, sneezing, sleep disturbance, and impaired concentration may interfere with learning and daily functioning. Previous studies have reported negative effects of AR on cognitive function, quality of life, and academic performance [11], although findings regarding objective educational outcomes have not been entirely consistent [3, 12, 13]. For medical students facing substantial academic demands, even relatively mild but persistent symptoms could adversely affect sleep, concentration, study efficiency, and academic performance. The present findings therefore extend the potential educational relevance of AR beyond its conventional clinical consequences and suggest that common chronic conditions may warrant consideration in student support.

An important feature of the present study was the longitudinal follow-up after students with AR were advised to seek appropriate medical care. While the GPA difference between students with and without AR diminished over subsequent academic years, the absence of a significant AR $\times$ academic year interaction prevents attribution of this pattern to the intervention. Moreover, the intervention consisted primarily of recommendations to seek medical evaluation and treatment rather than a structured program that verified treatment initiation, adherence, or symptom control. Consequently, whether

students actually received appropriate treatment, continued treatment, or achieved adequate control of AR could not be determined. This represents an important limitation of the present study and suggests that simply recommending medical consultation may be insufficient as an educational support strategy. Future interventions may need to extend beyond recommendations for consultation to include appropriate follow-up, while respecting student autonomy and confidentiality.

The progressive attenuation of the between-group difference should also be interpreted in the context of student progression through medical school. Students with poorer academic performance may be more likely to experience delayed progression and therefore may not contribute GPA data in later academic years. Such changes in cohort composition could produce apparent convergence between groups even in the absence of differential improvement. Despite potential changes in cohort composition, the progressive attenuation observed even in the fixed cohort of 95 students suggests that selection alone may not fully explain this pattern. Other factors, including academic adaptation or changes in AR symptoms or treatment, may also have contributed.

Exploratory subgroup analysis according to living arrangement showed that, among students living alone, those with AR had lower first-year GPA than those without AR, whereas little difference was observed among students living with family. However, the AR $\times$ living arrangement interaction was not statistically significant. These findings should therefore be regarded as hypothesis-generating rather than evidence that living arrangement modifies the association between AR and academic performance. The possible relevance of living arrangements nevertheless deserves further investigation. Students living alone may have greater responsibility for managing their living environment, medication use, sleep habits, and healthcare access without day-to-day family support. For students with AR, environmental allergen exposure and inadequate symptom management could potentially contribute to persistent symptoms. However, the present study did not objectively assess environmental exposures, adherence to treatment, or symptom severity, and these mechanisms remain speculative. Future studies should incorporate direct assessments of symptom control, healthcare utilization, treatment adherence, and relevant environmental factors.

From an educational perspective, these findings may have implications for early identification and student support [14, 15]. Academic difficulties are often approached primarily through educational factors such as study habits, learning strategies, or prior academic achievement. The present study suggests that common health conditions may also merit consideration, particularly when they are treatable and potentially affect sleep, concentration, and daily functioning. Importantly, identification of a health condition should not be used to predict academic failure or stigmatize students. Rather, such information may help institutions recognize opportunities for timely and individualized support. The stronger association observed during the earlier years of medical school may be particularly relevant because this period represents a potential opportunity for early support before academic difficulties become established.

Several limitations should be acknowledged. First, this was a single-institution study involving a relatively small cohort of 100 medical students, which limits statistical power, particularly for interaction and subgroup analyses, and may limit generalizability. Second, AR status was based on information obtained from students, and detailed measures of disease severity, symptom burden, allergen sensitization, and treatment status were not systematically collected. Third, students were advised to seek medical care; however, subsequent treatment initiation, adherence, and clinical response were not confirmed. Fourth, progression through medical school resulted in changes in the students contributing GPA data at later time points, introducing the possibility of selection effects. Although the sensitivity analysis using a fixed cohort of 95 students addressed this issue in part, it cannot determine whether the observed attenuation resulted from changes in AR symptoms, treatment, academic adaptation, or other unmeasured factors. Fifth, residual confounding by factors associated with both health status and academic performance cannot be excluded. Finally, despite differences in GPA observed at individual academic years, the absence of a significant AR $\times$ academic year interaction means that the longitudinal trajectories of students with and without AR cannot be considered statistically different.

Future follow-up should therefore move beyond identifying AR status alone and examine whether actual treatment and symptom control are associated with subsequent academic trajectories. Individual interviews assessing healthcare consultation, treatment continuation, symptom control, sleep, and possible barriers to care may help clarify the mechanisms underlying the observed associations. Such an approach could also determine whether more active support—extending from recommendation for consultation to confirmation of appropriate clinical management—has educational value. Prospective assessment of these factors would be particularly valuable for distinguishing the effects of clinical improvement from academic adaptation and selection associated with progression through medical school.

In conclusion, AR was associated with lower GPA particularly during the earlier years of medical school in this cohort, whereas the magnitude of the between-group difference attenuated over subsequent years. However, the absence of a significant AR $\times$ academic year interaction, together with the progressive attenuation of the effect size in the fixed-cohort sensitivity analysis, precludes attributing this pattern to the support provided during follow-up. From a medical education perspective, early academic difficulty remains an important challenge, highlighting the need to identify potentially modifiable factors and provide appropriate support during the early years of medical school. The present findings suggest that common health conditions such as AR may warrant consideration as part of this broader approach. Early recognition and appropriate management of AR may represent one practical component of comprehensive student support. Further studies incorporating symptom severity, treatment status, and subsequent academic trajectories are needed to determine whether such health-oriented support can contribute to improved academic outcomes.

Declarations

Ethics approval and consent to participate

Full ethical approval for the study was obtained from the Ethical Review Committee of Tohoku Medical and Pharmaceutical University (approval no. 2024-A-005-0000). All methods were performed in accordance with relevant research guidelines and regulations, including the Declaration of Helsinki. Informed consent for participation was obtained through an institutional review board-approved opt-out procedure.

Consent for publication

Not applicable

Availability of data and materials

The datasets that support the findings of this study are not publicly available to protect participant confidentiality. The data may be made available from the corresponding author upon reasonable request and with approval from the institutional ethics committee.

Competing interests

The authors declare that they have no competing interests as defined by BMC, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

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Authors' contributions

Yutaka Nakamura: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Supervision, Project administration.

Kaoru Toshima-Niitsuma and Masashi Sasaki: Data curation, Formal analysis, Writing – original draft.

Tomomitsu Miyasaka: Data curation, Writing – original draft, Writing – review & editing.

Fumi Shishido: Data curation, Writing – review & editing.

Tomohiro Arikawa, Naomi Hino-Fukuyo, Junichi Kameoka, and Michiko Yuki: Writing – review & editing.

Fumi Shoji, Teruyuki Sato, Nobuo Ohta, Yuichi Ohkawara, Tsutomu Tamada, and Isao Ohno: Investigation, Data curation.

All authors reviewed and approved the final manuscript.

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Tables

Tables 1 to 3 are available in the supplementary files section.

Figures

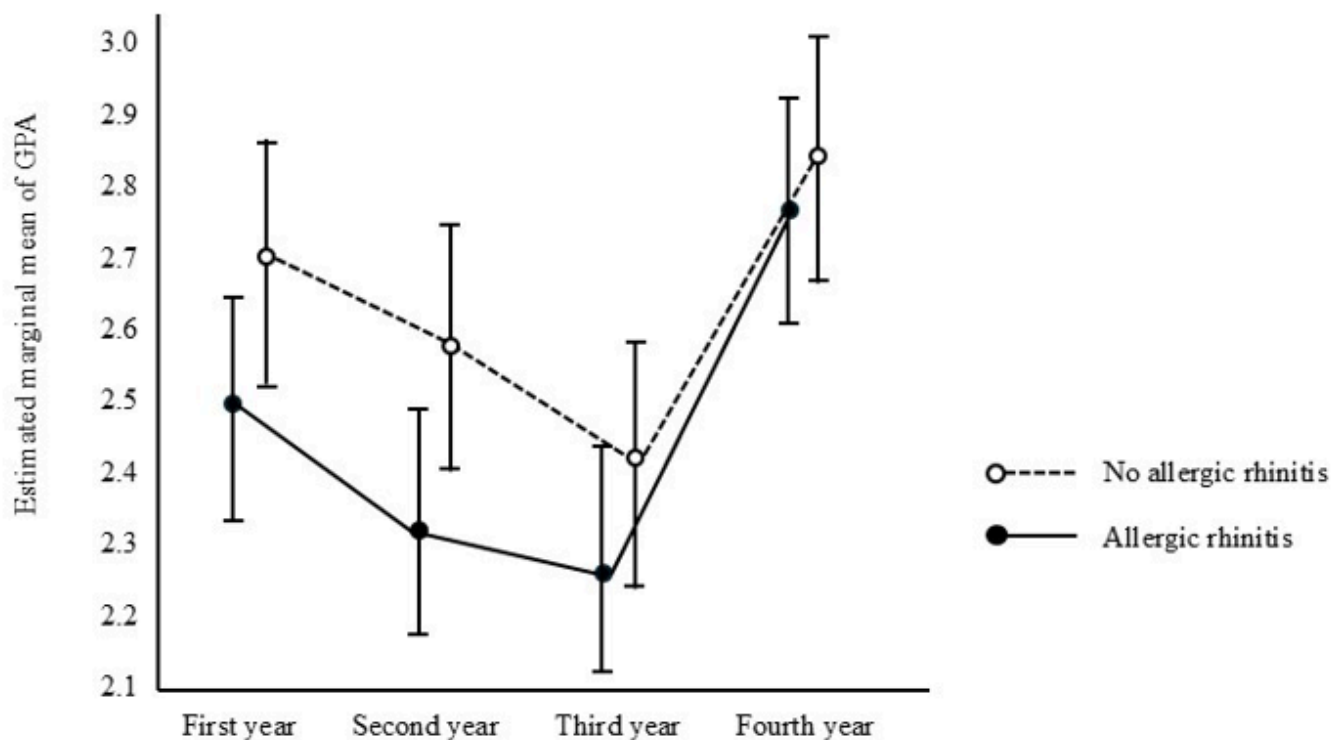


Figure 1

Longitudinal changes in estimated marginal mean grade point average (GPA) according to allergic rhinitis status. Fourth-year GPA represents first-semester GPA before clinical clerkships. Error bars indicate 95% confidence intervals. The between-group difference in GPA gradually diminished over subsequent academic years.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table1.xlsx](#)
- [Table2.xlsx](#)
- [Table3.xlsx](#)
- [SupplementaryTable1.xlsx](#)
- [SupplementaryTable2.xlsx](#)
- [SupplementaryQuestionnaire.xlsx](#)