INTERNATIONAL MULTI DISCIPLINARY JOURNAL FOR RESEARCH & DEVELOPMENT
eISSN 2394-6334 Impact factor: 8.854 Volume 13, issue 01 (2026)

UDC: 616.9-022.7:612.017.1-07

PROGNOSIS OF AIRBORNE INFECTIONS THROUGH EVALUATION OF IMMUNOLOGICAL INDICATORS

Bayxanova Nasiba Tursunbayevna
Department of infectious diseases Andijan State Medical Institute Uzbekistan, Andijan

Abstract

Background: Airborne infections, including influenza, ARVI, and emerging coronaviruses, constitute a major public health burden globally and in Uzbekistan. While exposure to these pathogens is universal, susceptibility and disease severity vary significantly among individuals. This clinical variability is largely determined by the host's immune status prior to infection. This study aims to develop a comprehensive prognostic model for the susceptibility to and severity of airborne infections based on the evaluation of specific immunological indicators, focusing on the interplay between mucosal barriers and systemic immune responses. Methods: A prospective longitudinal study was conducted involving 200 healthcare workers (a high-risk group due to occupational exposure) at the Andijan Regional Infectious Diseases Hospital. Baseline immunological profiling included quantitative analysis of secretory IgA (sIgA) in saliva, serum Immunoglobulins (IgG, IgM, IgE), cytokine profile (IL-6, TNF-α, IFN-γ), and lymphocyte subsets (CD3+, CD4+, CD8+, CD16/56+). Participants were closely monitored for symptoms of airborne infections over a 6-month autumn-winter epidemic season. Results: Individuals who developed frequent or severe infections had significantly lower baseline levels of salivary sIgA (mean 45 mg/L vs 120 mg/L in the healthy group, $p<0.001$) and a suppressed Th1 response characterized by low IFN-γ levels. A prognostic index combining sIgA levels and Phagocytic Activity showed a sensitivity of 85% and specificity of 90% in predicting infection susceptibility. Furthermore, elevated total IgE was identified as a risk factor for prolonged recovery. Conclusion: Immunological screening, particularly the assessment of mucosal immunity (sIgA) and cytokine balance, serves as a reliable, non-invasive tool for forecasting the risk of airborne infections. Identifying immunocompromised individuals allows for targeted immunoprophylaxis and personalized preventive strategies.

Keywords

Airborne infections, immunology, prognosis, secretory IgA, cytokines, susceptibility, prevention, mucosal immunity.

IMMUNOLOGIK KO‘RSATKICHLARNI BAHOLASH ORQALI HAVO-TOMCHI INFEKSIYALARINI PROGNOZLASH

Annotatsiya

Kirish: Havo-tomchi infeksiyalari, jumladan gripp, O‘RVI va yangi koronaviruslar, jamoat salomatligiga jiddiy xavf tug‘diradi. Kasallik qo‘zg‘atuvchisi bilan to‘qnashuv hammada yuz bersa-da, kasallikka moyillik va uning og‘irlik darajasi individlar orasida keskin farq qiladi. Bu o‘zgaruvchanlik asosan organizmning immun statusiga bog‘liq. Ushbu tadqiqot shilliq qavat va tizimli immunitetning o‘ziga xos ko‘rsatkichlarini baholash asosida havo-tomchi infeksiyalariga moyillik va kasallik kechishini prognozlash modelini ishlab chiqishga qaratilgan. Usullar: Andijon viloyat yuqumli kasalliklar shifoxonasida 200 nafar tibbiyot xodimi (yuqori xavf guruhi) ishtirokida prospektiv uzunlamasi (longitudinal) tadqiqot o‘tkazildi. Boshlang‘ich immunologik profilga so‘lakdagi sekretor IgA (sIgA), qon zardobidagi immunoglobulinlar (IgG, IgM, IgE),

sitokin profili (IL-6, TNF-α, IFN-γ) va T-hujayra subpopulyatsiyalari (CD4+, CD8+) tahlili kiritildi. Ishtirokchilar 6 oylik epidemik mavsum davomida havo-tomchi infeksiyalari belgilari bo‘yicha kuzatildi. Natijalar: Tez-tez yoki og‘ir kasallangan shaxslarda boshlang‘ich sIgA darajasi (o‘rtacha 45 mg/l ga nisbatan sog‘lom guruhda 120 mg/l, p<0.001) va Th1/Th2 sitokin nisbati sezilarli darajada past ekanligi aniqlandi. sIgA va IFN-γ darajalariga asoslangan prognoz indeksi kasallikka moyillikni bashorat qilishda 85% sezuvchanlik va 90% spesifiklikni ko‘rsatdi. Xulosa: Immunologik skrining, xususan shilliq qavat immunitetini (sIgA) baholash, havo-tomchi infeksiyalari xavfini prognozlash uchun ishonchli noinvaziv vosita bo‘lib xizmat qiladi. Immuniteti zaiflashgan shaxslarni aniqlash maqsadli immunoprofilaktika o‘tkazish imkonini beradi.

Kalit so‘zlar

Havo-tomchi infeksiyalari, immunologiya, prognoz, sekretor IgA, sitokinlar, moyillik, profilaktika.

ПРОГНОЗИРОВАНИЕ ВОЗДУШНО-КАПЕЛЬНЫХ ИНФЕКЦИЙ ПУТЕМ ОЦЕНКИ ИММУНОЛОГИЧЕСКИХ ПОКАЗАТЕЛЕЙ

Аннотация

Введение: Воздушно-капельные инфекции, включая грипп, ОРВИ и новые коронавирусы, представляют собой серьезное бремя для общественного здравоохранения. Хотя контакт с возбудителями происходит повсеместно, восприимчивость и тяжесть заболевания значительно варьируют. Эта вариабельность во многом определяется иммунным статусом хозяина. Целью данного исследования является разработка прогностической модели восприимчивости и тяжести воздушно-капельных инфекций на основе оценки специфических иммунологических показателей с акцентом на мукозальный и системный иммунитет. Методы: В Андижанской областной инфекционной больнице было проведено проспективное лонгитюдное исследование с участием 200 медицинских работников (группа высокого риска). Исходное иммунологическое профилирование включало количественный анализ секреторного IgA (sIgA) в слюне, сывороточных иммуноглобулинов (IgG, IgM, IgE), цитокинового профиля (IL-6, TNF-α, IFN-γ) и субпопуляций Т-клеток (CD4+, CD8+). Участники находились под наблюдением на предмет симптомов воздушно-капельных инфекций в течение 6-месячного эпидемического сезона. Результаты: У лиц, которые часто или тяжело болели, наблюдались значительно более низкие исходные уровни sIgA в слюне (в среднем 45 мг/л против 120 мг/л в здоровой группе, p<0.001) и более низкое соотношение цитокинов Th1/Th2. Прогностический индекс, основанный на уровнях sIgA и IFN-γ, показал чувствительность 85% и специфичность 90% в прогнозировании восприимчивости к инфекции. Заключение: Иммунологический скрининг, в частности оценка мукозального иммунитета (sIgA), служит надежным неинвазивным инструментом для прогнозирования риска воздушно-капельных инфекций. Выявление лиц с ослабленным иммунитетом позволяет проводить таргетную иммунопрофилактику.

Ключевые слова

Воздушно-капельные инфекции, иммунология, прогноз, секреторный IgA, цитокины, восприимчивость, профилактика.

INTRODUCTION

Airborne infections, encompassing a broad spectrum from seasonal influenza and common cold viruses (ARVI) to more severe pathogens like measles, tuberculosis, and novel

coronaviruses, represent the single most common cause of morbidity globally. In Uzbekistan, the seasonal burden of these diseases during the autumn-winter period leads to significant economic losses due to workforce absenteeism, disrupts the educational process, and places a substantial strain on the primary and secondary healthcare systems.

Epidemiological observations consistently reveal a striking paradox: despite identical environmental exposure to a pathogen (e.g., within a household or hospital ward), clinical outcomes vary dramatically. Some individuals remain asymptomatic or experience only mild symptoms, while others develop severe, protracted illness or complications such as pneumonia. This disparity cannot be explained solely by viral load or virulence; it highlights the critical, determining role of the host's immune competence.

The ability to forecast or predict susceptibility to infection is the "Holy Grail" of preventive medicine. Currently, risk stratification is often rudimentary, relying on demographic parameters like age or the presence of obvious chronic comorbidities (diabetes, COPD). However, these markers do not account for the dynamic, functional state of the immune system in otherwise "healthy" individuals. Modern immunology offers a sophisticated toolkit to assess the body's readiness to defend itself against invasion.

The defense against airborne pathogens is multi-layered. It begins with the mucosal immune system of the upper respiratory tract, spearheaded by Secretory Immunoglobulin A (sIgA) and innate antimicrobial peptides. If this barrier is breached, the systemic immune response—orchestrated by T-lymphocytes, B-cells, and a complex cytokine network—engages to clear the infection. We hypothesize that quantitative deficiencies or dysregulation in these specific immunological markers exist *prior* to infection and can serve as reliable predictive biomarkers.

This study aims to move beyond reactive treatment by validating a panel of immunological tests to prognosis the risk of airborne infections. By studying a high-exposure cohort of healthcare workers in the Andijan region, we seek to develop a predictive model that allows for the early identification of "immunologically fragile" individuals, enabling personalized preventive interventions.

LITERATURE REVIEW

Mucosal Immunity: The Gatekeeper The mucosal surface of the respiratory tract is the primary battlefield. Secretory IgA (sIgA) is the dominant antibody in secretions (saliva, nasal fluid). It functions through "immune exclusion"—agglutinating pathogens, trapping them in the mucus layer, and preventing their adherence to the respiratory epithelium. Seminal work by *Brandtzaeg (2013)* established the correlation between low salivary sIgA and increased incidence of upper respiratory tract infections (URTI) in athletes and children. However, its predictive value in the general adult population in Central Asia, where environmental factors like dry climate and dust may affect mucosal integrity, remains understudied. Recent studies also highlight the role of the microbiome in regulating sIgA production, suggesting a "gut-lung axis" of immunity.

The Cytokine Network and Antiviral Defense The balance between pro-inflammatory and anti-inflammatory cytokines determines the outcome of an infection.

Interferons (Type I and II): IFN-alpha and IFN-gamma are critical for establishing an antiviral state in cells, halting viral replication. A delayed or suppressed interferon response is a hallmark of severe viral disease (as vividly demonstrated during the COVID-19 pandemic).

Pro-inflammatory Cytokines: Chronically elevated levels of IL-6 and TNF-alpha may indicate a state of "inflammaging" or metabolic stress. This chronic low-grade inflammation can impair the acute immune response, rendering the host more susceptible to symptomatic disease

and "cytokine storms." *Gleeson et al. (2011)* proposed that the ratio of pro- to anti-inflammatory cytokines could serve as a "readiness index" for the immune system.

T-Cell Subsets and Immunosenescence The ratio of Helper T-cells (CD4+) to Cytotoxic T-cells (CD8+) is a classic marker of immune regulation. While traditionally used in HIV monitoring, subtle inversions (ratio <1.0) or depressions in the CD4/CD8 ratio in HIV-negative individuals have been linked to "immunosenescence"—the premature aging of the immune system. This condition reduces the repertoire of T-cells available to recognize new viral antigens, increasing susceptibility to novel strains of influenza or coronaviruses.

Phagocytic Activity and Innate Immunity Neutrophils and macrophages form the first line of cellular defense. The Phagocytic Index (the percentage of cells actively engulfing bacteria) and the Phagocytic Number (average number of bacteria per cell) reflect the functional capacity of the innate immune system. Defects in phagocytosis, often secondary to stress or micronutrient deficiency (Zinc, Vitamin D), can lead to secondary bacterial superinfections following a viral illness.

Existing Prognostic Models vs. Needs Most existing prognostic models rely on clinical history (e.g., "frequency of colds last year"). While useful, this is a retrospective approach. There is a pressing need for objective, quantifiable biological markers that can guide personalized preventive strategies *before* the onset of the epidemic season. Such biomarkers would justify the use of immunomodulators or targeted vaccination in specific subgroups.

MATERIALS AND METHODS

Study Design A prospective longitudinal observational study was conducted at the Andijan Regional Infectious Diseases Hospital. The study period covered the high-risk autumn-winter epidemic season (October 2023 – March 2024).

Participants The cohort consisted of 200 healthcare workers (doctors, nurses, and orderlies) from departments with high occupational exposure to respiratory infections (Admission, ICU, Respiratory Wards).

Inclusion Criteria: Age 25-55 years, generally healthy at baseline, written informed consent. Exclusion Criteria: Known primary or secondary immunodeficiency (HIV, on chemotherapy), active autoimmune diseases, chronic use of systemic corticosteroids, pregnancy.

Immunological Assessment (Baseline) Before the start of the epidemic season (in September), all participants underwent comprehensive testing:

Mucosal Immunity: Collection of unstimulated whole saliva in the morning. Determination of sIgA concentration by enzyme-linked immunosorbent assay (ELISA). Systemic Immunity: Venous blood samples were analyzed for: Cellular Immunity: Lymphocyte phenotyping using flow cytometry (monoclonal antibodies to CD3, CD4, CD8, CD16, CD56, CD19). Humoral Immunity: Serum concentrations of IgG, IgM, IgA, and total IgE using turbidimetry. Cytokine Status: Serum levels of IFN-gamma, IL-4, IL-6 using ELISA kits. Phagocytosis: Neutrophil phagocytic activity using latex beads (Phagocytic Index and Number).

Monitoring and Grouping Participants kept a daily symptom diary and were monitored for 6 months. PCR confirmation was sought for symptomatic cases. Based on the clinical outcome at the end of the season, participants were retrospectively divided into: Group 1 (Resistant) - No ARVI/Flu episodes or mild asymptomatic course (0-1 mild episode). Group 2 (Susceptible) - Frequent illness or severe course (1 episode requiring sick leave >5 days, complications like bronchitis/pneumonia).

Statistical Analysis Differences in baseline markers between Group 1 and Group 2 were analyzed using the Mann-Whitney U test. Logistic regression analysis was used to identify

independent predictors. Receiver Operating Characteristic (ROC) curve analysis was used to determine cut-off values for predictive markers with optimal sensitivity and specificity.

RESULTS

Incidence of Infection Over the 6 months, 45% (90/200) of participants fell into the "Susceptible" group, suffering from frequent or severe infections, while 55% (110/200) remained "Resistant." Mucosal Immunity as a Predictor There was a highly significant difference in baseline salivary sIgA levels. Group 1 (Resistant) - Mean sIgA = 120 ± 25 mg/L. Group 2 (Susceptible) - Mean sIgA = 45 ± 12 mg/L ($p<0.001$). ROC analysis indicated that a threshold of sIgA < 60 mg/L predicted susceptibility with a Sensitivity of 82% and Specificity of 88%. This suggests that mucosal deficiency is a primary determinant of infection risk.

Systemic Markers and Cytokine Balance - Interferon-gamma: Significantly lower in the Susceptible group (15.4 pg/ml vs 42.8 pg/ml in Resistant), indicating a weak Th1 antiviral response.

T-Cell Subsets: While absolute lymphocyte counts were often normal, the Immunoregulatory Index (CD4/CD8) was lower in the Susceptible group (1.2 vs 1.8), suggesting subtle T-cell dysregulation.

IgE Levels: 30% of the Susceptible group had elevated total IgE (>100 IU/ml), despite no active allergy symptoms. This correlates with the concept that atopy skews the immune system towards Th2, suppressing antiviral defense.

Phagocytic Activity The Phagocytic Index was significantly reduced in the Susceptible group (40% vs 65% in Resistant), implying a compromised first line of cellular defense against secondary bacterial invaders.

Prognostic Index We developed a "Susceptibility Score" combining sIgA, IFN-gamma, and Phagocytic Index. Participants with a low composite score had a 9-fold higher risk (Odds Ratio 9.2) of developing severe ARVI compared to those with a high score.

DISCUSSION

This study validates the concept that immune status *before* exposure determines the clinical outcome. The most powerful single predictor was salivary sIgA. This is a highly practical finding because saliva collection is non-invasive, cheap, pain-free, and easy to perform in mass screenings (e.g., in schools or factories). A low sIgA level essentially leaves the "gates open" for airborne viruses to attach and invade.

The correlation with low IFN-gamma suggests a defect in the early antiviral response. Patients with low baseline interferon levels allow the virus to replicate to higher titers before the adaptive immune system catches up, leading to more severe systemic symptoms and tissue damage.

The link with elevated IgE in the susceptible group supports the "Th2 shift" hypothesis. Individuals with an atopic (allergic) constitution often have a Th2-skewed immune response, which suppresses the Th1 (antiviral) response required to clear respiratory viruses efficiently. This explains why "allergic" children often suffer from frequent colds.

CONCLUSION

Forecasting airborne infections is not only theoretically possible but practically feasible through targeted immunological profiling.

Salivary sIgA is a robust, non-invasive, and cost-effective biomarker for predicting susceptibility to airborne pathogens. It reflects the integrity of the primary barrier defense.

The combination of low mucosal immunity (sIgA) and low systemic antiviral potential (IFN-gamma) creates a specific "high-risk" phenotype prone to frequent and severe infections.

Individuals identified as "high risk" by this model are prime candidates for preventive measures. The "wait and see" approach should be replaced by "predict and protect."

RECOMMENDATIONS

1. Clinical Implementation:

Screening Algorithm - Introduce voluntary sIgA screening for high-risk groups (medical staff, teachers, kindergarten workers) in September, before the onset of the epidemic season. A simple ELISA test can identify those needing protection.

Risk Stratification - Use the CD4/CD8 ratio and IFN-gamma levels as secondary markers for patients with recurrent infections to rule out secondary immunodeficiencies.

2. Targeted Prophylaxis:

Immunomodulation - For individuals identified as "Susceptible" (Low sIgA/IFN-gamma), prescribe a prophylactic course of bacterial lysates (e.g., Broncho-Vaxom, Ribomunyl) or interferon inducers. These agents are proven to boost mucosal sIgA production and macrophage activity.

Vitamin D Supplementation - Given its role in inducing antimicrobial peptides (cathelicidins), aggressive correction of Vitamin D deficiency is mandatory for the high-risk group.

3. Lifestyle Interventions:

Stress Management - Chronic stress lowers sIgA. Counseling high-risk individuals on sleep hygiene and stress reduction is a valid immunological intervention.

Probiotics - Encourage the consumption of probiotics, which can stimulate the gut-lung axis to produce more IgA.

REFERENCES

1. Brandtzaeg, P. (2013). Secretory IgA: Designed for Anti-Microbial Defense. *Frontiers in Immunology*, 4, 222.
2. Gleeson, M., et al. (2011). Daily probiotic's (Lactobacillus casei Shirota) reduction of infection incidence in athletes. *International Journal of Sport Nutrition and Exercise Metabolism*, 21(1), 55-64.
3. World Health Organization. (2020). *Immunology of SARS-CoV-2*. Scientific Brief.
4. Khaitov, R. M. (2018). *Immunology*. GEOTAR-Media.
5. Azimov, R. K., et al. (2019). Seasonal variations in immune status among the population of the Fergana Valley. *Central Asian Journal of Medicine*.
6. Calder, P. C. (2013). Feeding the immune system. *Proceedings of the Nutrition Society*, 72(3), 299-309.