The dispersion complexes and prognostic tables of allergic triggers "Tree dust" construction

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Abstract. Allergy is one of the most widespread diseases in the world and its epidemic growth over the past 30-40 years is obvious. The results of numerous Russian and foreign epidemiological studies objectively reflect the steady increase in allergic pathology, including pollen allergens being one of the most common allergic triggers. About 15% of the population has the pollen affects allergy, this is one of the most common allergic diseases. Hence, it is important to construct dispersion complexes and prognostic tables to assess the impact of an allergic triggers "birch pollen + alder pollen" combination on the category of observed symptoms ("nasal congestion", "rash", "choking", "itching"). To determine the effect strength on the allergic triggers combination "birch pollen + alder pollen" on symptoms, dispersion complexes were constructed. The calculations were carried out using the STIR computer system with the implementation of a computational algorithm for constructing dispersion complexes and predictive probability tables.

1. Introduction

Allergy is a state of altered immunological organism reactivity in the form of its sensitivity increase to exo- and endogenous antigens. The cause of allergies can be a variety of substances (allergens) that cause an immune response of the humoral or cellular type in the body which is accompanied by damage to the body's own tissues [1]. In clinical practice, allergic reactions are understood as manifestations based on an immunological conflict. In the diagnosis of allergic reactions, it is important to identify the allergen, its causal relationship with clinical manifestations and the type of immunological reaction [2].

The allergies development is a complex and multifactorial process that depends not only on a genetic predisposition but also on exposure to food and aeroallergens in the environment as well as on a number of non-specific factors (smoking, air pollution, infections) [3].

Obviously, there is the various environmental factors complex effect on the human body, their interweaving and potentiation. The study of these mechanisms is extremely important for basic and applied allergology, as it can provide the key to effective prevention.

The main purpose of this work is to construct dispersion complexes and prognostic tables (using the example of allergic triggers combination "birch pollen + alder pollen" and the symptom of nasal congestion.) allowing to assess the impact of a combination of allergic triggers "birch pollen + alder pollen" on the category of observed symptoms diagnosed in the order scale.

The objectives of this work are:

- calculation of joint distributions of allergic triggers combination "birch pollen + alder pollen" and symptoms necessary for the formation of prognostic tables;
• dispersion complexes construction of the allergic triggers combination "birch pollen + alder pollen" and symptoms;
• the obtained results processing and analysis.

2. The dispersion complex construction.

A dispersion complex is a gradations set with discrete variables or characteristics involved for the research, averages for each gradation (partial means) and for the entire complex (general average).

The main dispersion complex values are: $C_\xi$ – general variation measure of the effective trait, $C_x$ – factorial measure variations of the effective trait, $C_z$ – random variation measure of the effective trait [4].

To calculate the dispersion complex, the following auxiliary quantities are introduced:

$$S_1 = \sum_{j=0}^{g} \sum_{i=0}^{k} f_{ij} \xi_i,$$  \hspace{1cm} (1)

$$S_2 = \sum_{j=0}^{g} \sum_{i=0}^{k} f_{ij} \xi_i^2,$$ \hspace{1cm} (2)

$$S_3 = \sum_{j=0}^{g} \left( \frac{\sum_{i=0}^{k} f_{ij} \xi_i}{n_j} \right)^2,$$ \hspace{1cm} (3)

where $\xi_i$ — значение результативного признака, изменяющегося в результате статистического влияния организованных и неорганизованных факторов, the effective feature value that changes as a result of organized and unorganized factors statistical influence, $i = 0, \ldots, k$, $k$ – the number of the effective sign possible outcomes, and $f_{ij}$ –the frequency value of the effective feature $\xi_i$ at $j$ gradation, $g$ – the number of organized factors various gradations;

$$H = \frac{S_1^2}{n}.$$ \hspace{1cm} (4)

The variation measures calculation is carried out according to the following formulas:

$$C_\xi = C_x + C_z,$$ \hspace{1cm} (5)

$$C_x = S_2 - H,$$ \hspace{1cm} (6)

$$C_z = S_2 - S_3,$$ \hspace{1cm} (7)

$$C_x = S_3 - H.$$ \hspace{1cm} (8)

If any variation measure is divided into a common variation measure, then it gets the influence coefficient of factor or factors combination:

$$\eta_\xi^2 = \frac{C_z}{C_\xi}, \eta_x^2 = \frac{C_x}{C_\xi},$$ \hspace{1cm} (9)

And if the variation measure is divided into the corresponding number of freedom degrees, we get the variance:

$$\sigma_\xi^2 = \frac{C_z}{n-1}, \sigma_x^2 = \frac{C_x}{n-g}, \sigma_z^2 = \frac{C_z}{g-1}.$$ \hspace{1cm} (10)

To check the reliability of the factor influence or the factors combination, it is used the Fisher criterion in the form of corresponding factorial variance ratio to the random variance:
\[ F_c = \frac{\sigma^2_x}{\sigma^2_z} \] (11)

The resulting value is compared with the table value of the Fisher test. If the calculated value of \( F \) criterion is greater than the critical value for a certain significance level \( (\alpha=0,05) \) and the corresponding numbers of freedom degrees for the numerator and denominator, then the variances are considered different [5].

3. The prognostic tables construction of allergic triggers «Tree dust».

The study included 119 patients of 18–35 years old with moderate bronchial asthma atopic form, comorbid with allergic rhinitis and atopic dermatitis. The patients who were under observation for 3 years.

The intensity of symptoms was recorded using a standard RTSS scale system which included an assessment of the severity of the most frequent symptoms. Each symptom is rated on a scale of 0 to 3, where 0 is no symptoms, 1 is mild, 2 is moderate and 3 is severe.

The study included patients with SCORAD index from 20 to 40 points, with exacerbation up to 3-4 times a year and remission duration less than 4 months, with insufficiently of the basic anti-inflammatory therapy pronounced effect.

As a measuring allergens scale, it is used the order point scale which corresponds to the allergen level in the body and symptoms are in the severity body's reaction form to the allergen.

The methodology for the distribution symptom calculating is as follows:
1) survey conducting among patients;
2) removing the reaction of their body to certain allergens;
3) formation of distribution tables;
4) interpretation of results

The calculations were carried out using the STIR computer system with the computational algorithm implementation for constructing dispersion complexes and predictive probability tables.

Table 1 shows the combination likelihood "birch pollen + alder pollen" allergic trigger levels and Nasal congestion symptom (severity) joint distribution and symptom joint distribution and allergens.

| symptom joint distribution and allergens | Nasal congestion symptom (severity) |
|----------------------------------------|-----------------------------------|
|                                        | 1       | 2       | 3       |
| Allergen level "birch" 00 | Allergen level "alder" 00 | 0,016807 | 0,084034 | 0,092437 |
| 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0,016807 | 0,084034 | 0,092437 |
| 0 1 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0,016807 |
| 0 2 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0,008403 |
| 0 3 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0,008403 |
| 1 0 0 | 0 0 0 | 0,016807 | 0 0 0 | 0,016807 | 0 0 0 | 0,033613 |
| 1 1 0 | 0 0 0 | 0 0 0 | 0,008403 | 0 0 0 | 0,008403 | 0 0 0 | 0,02521 |
| 1 2 0 | 0 0 0 | 0 0 0 | 0,008403 | 0 0 0 | 0,008403 | 0 0 0 | 0,016807 |
| 2 0 0 | 0 0 0 | 0 0 0 | 0,016807 | 0 0 0 | 0,016807 | 0 0 0 | 0,07563 |
| 2 1 0 | 0 0 0 | 0 0 0 | 0,008403 | 0 0 0 | 0,008403 | 0 0 0 | 0,02521 |
| 2 2 0,016807 | 0,008403 | 0,033613 | 0,084034 | 0,084034 |
| 2 3 0 0 | 0,008403 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 |
| 2 4 0,008403 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 |
| 3 0 0,008403 | 0,016807 | 0,042017 | 0,084034 | 0,084034 |
| 3 1 0 0 | 0,008403 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0 | 0 0 0
the severity symptom of a "nasal congestion". The most likely allergic triggers pair is "birch pollen + alder pollen" with levels (2; 2) and nasal congestion at a value of 3 and the least combination of allergen levels (2; 3) and nasal congestion at a value of 1.

A table graphical representation is shown in Figure 1. For the remaining symptoms, the following pairs of allergic triggers “birch pollen + alder pollen” are most likely to occur: with levels (2; 2) and the suffocation severity at a value of 3 (probability 0.092), 2 itching severity (0.067), 2 rash symptom severity (0.1).

Figure 1. Allergic triggers joint distribution "birch pollen + alder pollen" and nasal congestion symptom.

Table 2 presents the combination probability prediction of allergic triggers levels "birch pollen + alder pollen" with a known symptom severity "nasal congestion". So, with nasal congestion at level 1, it is most likely that a person has a combination of allergens levels (2; 2), at level 2 is allergens combination (2,2), the same combination at level 3. This can be seen in Figure 2, where the combination meeting likelihood (2.2) is maximal for all 3 degrees of severity symptom compared to other combinations.

Probability prediction of allergic triggers levels combination "birch pollen + alder pollen" with known symptoms severity:

1) Choking:
   a) 2 severity degree with a probability of 0.11 – level (2.2);
   b) 3 severity degree with a probability of 0.14 – level (2.2),

2) Itching:
   a) 1 severity degree with a probability of 0.17 – level (2.2);
   b) 2 severity degree with a probability of 0.13 – level (2.2);
   c) 3 severity degree with a probability of 0.2 – level (0.2),

3) Rash:
a) 1 severity degree with a probability of 0,18 – level (3,2),
b) 2 severity degree with a probability of 0,15 – level (2,2),
c) 3 severity degree with a probability of 0,09 – level (2,0).

Table 2. Predictive combination table of the allergic triggers levels "birch pollen + alder pollen" with a known severity of symptom "nasal congestion".

| The combination likelihood of allergens with known symptom severity | Nasal congestion symptom (severity) |
|--------------------------------------------------------------------|-------------------------------------|
| | 1 | 2 | 3 |
| Allergen level "birch" | Allergen level "alder" | | | |
| 0 | 0 | 0,2 | 0,277778 | 0,150685 |
| 0 | 1 | 0 | 0 | 0,027397 |
| 0 | 2 | 0 | 0,027778 | 0 |
| 0 | 3 | 0 | 0,027778 | 0 |
| 1 | 0 | 0 | 0,055556 | 0,054795 |
| 1 | 1 | 0 | 0,027778 | 0,041096 |
| 1 | 2 | 0 | 0,027778 | 0,027397 |
| 2 | 0 | 0 | 0,055556 | 0,123288 |
| 2 | 1 | 0 | 0,027778 | 0,041096 |
| 2 | 2 | 0,2 | 0,111111 | 0,136986 |
| 2 | 3 | 0 | 0,027778 | 0 |
| 2 | 4 | 0,1 | 0 | 0 |
| 3 | 0 | 0,1 | 0,055556 | 0,068493 |
| 3 | 1 | 0 | 0,027778 | 0,013699 |
| 3 | 2 | 0,1 | 0,055556 | 0,041096 |
| 3 | 3 | 0 | 0,083333 | 0,09589 |
| 3 | 4 | 0 | 0,055556 | 0 |
| 4 | 1 | 0,1 | 0,027778 | 0,027397 |
| 4 | 2 | 0,1 | 0 | 0,068493 |
| 4 | 3 | 0,1 | 0 | 0,027397 |
| 4 | 4 | 0 | 0,027778 | 0,054795 |
Figure 2. The different combinations meeting likelihood of allergic triggers levels "birch pollen + alder pollen" with known symptom severity "nasal congestion"

Table 3 shows the different degrees probabilistic prognosis of symptom severity "nasal congestion" according to known data of allergic triggers levels combination "birch pollen + alder pollen". For example, if we know that a person has of allergen levels combination (2; 3), then according to the table we can determine that the most likely to occur is 2 nasal congestion degree and with the allergens levels combination (2.4) - 1 degree.

The different degrees meeting probabilistic prognosis of symptom severity "nasal congestion" with known combination data of allergic triggers levels "birch pollen + alder pollen" showed that the most common is 3 degree of the symptom severity.

For the "rash" symptom, the most common is the 2nd degree of symptom severity, for the "suffocation" symptom - the 3rd degree and for the "itch" symptom – the 2nd degree. The obtained data analysis showed that the most pronounced effect is possessed by allergens combination "birch pollen + alder pollen" at levels 2 and 3. They are manifested to a greater extent in the symptom "rash" and least of all in the symptom "nasal congestion".

Table 3. Different degrees meetings probabilistic prognosis of the symptom severity "nasal congestion" with known data on the combination of allergic triggers levels "birch pollen + alder pollen".

| Allergen level "birch" | Nasal congestion symptom (severity) |
|------------------------|----------------------------------|
| Allergen level "alder" | 1                  | 2                   | 3                   |
| 0                      | 0,086957 | 0,434783 | 0,478261 |
| 1                      | 0       | 1       | 0       |
| 2                      | 0       | 1       | 0       |
| 3                      | 0       | 1       | 0       |
| 0                      | 0,333333 | 0,666667 | 0,666667 |
| 1                      | 0,25    | 0       | 0,75    |
| 2                      | 0,333333 | 0,666667 | 0,666667 |
| 3                      | 0,181818 | 0,818182 | 0,818182 |
| 4                      | 0,25    | 0       | 0,75    |
Figure 3. Different degrees meetings probabilistic prognosis of the symptom severity "nasal congestion" with known data on the combination of allergic triggers levels "birch pollen + alder pollen".

4. Dispersion complex when studying allergic triggers combinations "Birch dust + Alder dust" and the symptom "Nose connected".

On the example of allergic triggers combination "birch pollen + alder pollen" and the symptom "nasal congestion", the dispersion complex was calculated according to the constructing dispersion complexes algorithm (1) - (11) (Table 4).

Table 4. The effect strength of the allergic triggers combination "birch pollen + alder pollen" on the symptom "nasal congestion".

| Stage 1 | Stage 2 | Stage 3 |
|---------|---------|---------|
| 0.125   | 0       | 0.625   |
| 0       | 1       | 0       |
| 0.125   | 0.25    | 0       |
| 1       | 0.5     | 0.5     |
| 0.166667| 0.333333| 0.5     |
| 0       | 0.3     | 0.7     |
| 0.25    | 0.25    | 0.5     |
| 0.166667| 0.83333| 0.666667|
| 0.333333| 0       | 0.8     |

| 2 | 2 | 0.125 | 0.25 | 0.625 |
|---|---|-------|------|-------|
| 2 | 3 | 0     | 1    | 0     |
| 2 | 4 | 1     | 0    | 0     |
| 3 | 0 | 0.125 | 0.25 | 0.625 |
| 3 | 1 | 0     | 0.5  | 0.5   |
| 3 | 2 | 0.16667 | 0.333333 | 0.5 |
| 3 | 3 | 0     | 0.3  | 0.7   |
| 3 | 4 | 0     | 1    | 0     |
| 4 | 1 | 0.25  | 0.25 | 0.5   |
| 4 | 2 | 0.16667 | 0   | 0.833333|
| 4 | 3 | 0.333333 | 0  | 0.666667|
| 4 | 4 | 0     | 0.2  | 0.8   |

| $S_1$ | $S_2$ | $S_3$ | $H$   |
|-------|-------|-------|-------|
| 301   | 811   | 768.902042 | 761.352941 |
| $\zeta C$ | $\xi C$ | $\zeta C$ | $\eta_x$ |
| 49.647059 | 7.549101 | 42.097958 | 0.389943 |
| $\sigma^2 \zeta$ | $\sigma^2 \xi$ | $\sigma^2 \zeta$ | $\eta^2_x$ |
| 0.420738 | 0.377455 | 0.429571 | **0.152055** |
| $F_\zeta$ | $\alpha$ | $g - 1$ | $n - g$ |
Analyzing the resulting table by parameter $\eta^2$ it can be seen that the effect of allergic triggers combination "birch pollen + alder pollen" on the symptom "nasal congestion" is 15.2%.

Dispersion complexes were also calculated for other combinations of indicators. It was found that when analyzing the complexes of allergic triggers combination "birch pollen + alder pollen", the greatest effect on the "suffocation" symptom is about 18.3% and the least effect on the symptom "rash" and is about 11.4%. The influence on the symptom "itching" is 15.2%.

5. Conclusion.

In this work it was presented the joint distribution tables of allergic triggers combination "birch pollen + alder pollen" with symptoms of nasal congestion, rash, suffocation, itching. It was calculated the prognostic tables for the allergic triggers levels combination "birch pollen + alder pollen" with known symptoms severity, also calculated a probabilistic forecast of different degrees of symptoms severity occurrence with known data of allergic triggers levels combination "birch pollen + alder pollen". The obtained data analysis showed that the most pronounced effect is possessed by the allergens combination “birch pollen + alder pollen” at levels 2 and 3.

They appear to a greater extent in the "rash" symptom, least of all – in the "nasal congestion" symptom. Dispersion complexes of allergic triggers combination "birch pollen + alder pollen" and symptoms were constructed. The dispersion complexes analysis of allergic triggers combination "birch pollen + alder pollen" showed that the greatest effect is on the "suffocation" symptom (18.3%) and the least is on the "rash" symptom (11.4%).

References

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