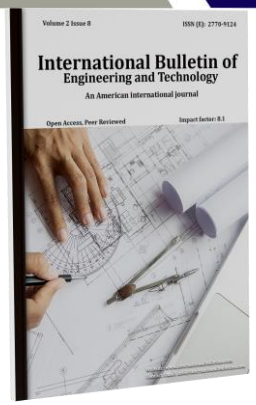

MATHEMATICAL MODELING IN IMMUNOLOGY

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Abstract: This article will consider the topic of mathematical modeling in immunology, presented to students by traditional and non-traditional methods, indicating the effectiveness of methods and positive results obtained in groups.

Keywords: Zig-zag method, disease dynamics, organ transplantation, cancer, allergy, immunodeficiency, antibody, immunoglobulin, immunity, plasma cells of the system, pathogen, virus, cell, protein poisons, plasma, globular proteins.

From the subject of mathematical modeling in biology and medicine, the subject of mathematical modeling in immunology was conducted as an experiment and test in groups 301 and 303 of the faculty of medical biology of Samarkand State Medical University.

- The number of students in the first group was 12, and the lesson was conducted in a traditional way.

- In the second group, the number of students was 14, and the lesson was conducted using the "Zig-zag" method of interactive education.

Briefly inform the participants about the "Zig-zag" method

We started our lesson by being 2.

"zig-zag" method

Zig-zag is a broken line, meaning a snake, a curve.

The essence of the zig-zag method in education is to present the educational material learned by one group to another group that has not yet learned it. The zig-zag method has several advantages. In particular, by using this method, students develop the ability to work as a team, and the time spent on mastering the subject is saved, and a large amount of material is mastered in a short time. The sequence of this method is as follows:

- as usual, students are divided into several groups;
- one question on the topic is distributed to each group (one question should be given to each participant in the group);
- group members learn this distributed question at the specified time;
- a leader is chosen for each group and they lead this group in studying the distributed text, in understanding their essence in depth;
- the opinion of the leader can be completed by the group members, additions and changes can be made;
- after the texts are fully studied in the group, they are exchanged between groups;
- now new questions are studied in these groups;
- after studying these questions, they will be changed again;
- these processes are repeated until all questions are studied in groups;

- in order to evaluate each other's knowledge and determine the level of mastery, the groups ask each other questions one after the other;

- to which group the question was asked, members of the first group can answer, members of other groups have the right to go additionally. The difference between this method and the "Brainstorming" method is that students' knowledge is evaluated here. To learn this method, students are divided into 2 groups or 3 groups. Because questions are asked depending on the number of subject groups.

The modeling method is widely used in medicine and related sciences. In medicine, the modeling method is a means of establishing increasingly deeper and more complex relationships between theory and experience. In the last century, the experimental method in medicine began to face certain limits, and it was found that it was impossible to carry out a number of studies without modeling. If we dwell on some examples of limitations in the field of application of experiments in medicine, then they are mainly as follows:

a) interference with biological systems is sometimes of such a nature that it is impossible to determine the causes of the changes that have occurred (due to interference or other reasons);

b) due to the low level of development of experimental technologies, some theoretically possible experiments are not carried out;

c) a large group of experiments related to human experience should be rejected for moral and ethical reasons. But modeling is widely used in medicine not only because it replaces experience. This is of great independent importance, expressed in a number of advantages:

1. Using the modeling method in one data set, it is possible to develop a number of different models, to choose the most effective one for different interpretations of the studied phenomenon and theoretical interpretation.

2. In the process of creating a model, you can make various additions to the studied hypothesis and simplify it.

3. In complex mathematical models, you can use a computer.

4. Modeling opens up the possibility of conducting modeling experiments (modeling experiments on test animals).

All this clearly shows that modeling performs independent functions in medicine and becomes an increasingly necessary stage in the process of theory creation. In the second half of the 20th century, a science related to medicine, such as immunology, developed widely.

Immunology is a medical-biological science; are the body's reactions aimed at maintaining its unique antigenic unity in relation to the effects of genetically alien signs (living bodies and substances with antigenic properties). studies the chemical structure and properties of antibodies and antigens, the laws of their interaction, methods of prevention and treatment of immunological diseases. study - theoretical directions of immunology.

Advances in immunology have a direct impact on treatment methods and all clinical practices in medicine. In immunology, treatment is closely related to problems (allergy and immunodeficiency). Until now, immunologists have collected a lot of data to monitor the progress of various infectious diseases, and based on the analysis of this data, fundamental results were obtained on various levels of detail about the mechanisms of interaction between antigens and antibodies: from the macroscopic to the intracellular genetic. These results made it possible to create mathematical models of immune processes.

The simplest mathematical model is based on the equilibrium ratio for each component involved in the immune response. It is because of this concept that the specific features of the immune system are not important for the analysis of the dynamics of the disease, and the main laws of the body's protective reaction come to the fore. Therefore, when constructing a mathematical model, the cellular and humoral components of immunity, which are involved in the fight against antigens entering the body, do not differ. Let's say that the body has such components. They are called antibodies, regardless of whether we are dealing with the cellular-lymphoid immune system or the humoral immunoglobulin.

What is an antibody? Immunoglobulins are large globular proteins of the blood plasma that are released by the plasma cells of the immune system and serve to neutralize the cells of pathogens and viruses, as well as protein toxins and some other foreign substances.

In this model, it is also assumed that the body has sufficient resources of macrophages that use the products of the immune response, as well as other non-specific factors necessary for the normal functioning of the immune system. In this regard, we will limit ourselves to the consideration of three components: the antigen, the antibody, and the antibody-producing plasma cell. Pathogenic bacteria or viruses act as antigens. It should also be noted that the degree of damage to the organ that is susceptible to antigen attack with the disease is of great importance, because it ultimately leads to a decrease in the activity of the immune system. This should naturally be reflected in mathematical models. Thus, we assume that the main active factors of mathematical modeling in immunology are the following values:

1) the concentration of pathogenic breeding antigens V (t);

2) concentration of antibodies F(t);

3) C(t) concentration of plasma cells;

4) relative properties of the affected organ m(t).

Let's move on to building the model equations. The first equation describes the change in the number of antigens in the body:

What is an antigen - any substance that the body considers foreign or potentially dangerous, and the body usually begins to produce its own antibodies.

$$dV = \beta V dt - \gamma FV dt . \quad (1)$$

By multiplying the first term on the left side of Eq

Dt - describes the increase in DV antigens over time. Naturally, v is proportional to a certain amount of β, which we call the multiplication factor of antigens.

The term FVDT γ describes the number of antigens neutralized by the factor f in the time interval Dt. In fact, it is clear that the number of such viruses is proportional to both the number of antibodies and the number of antigens in the body; γ - coefficient.

Antigens are associated with the possibility of neutralization when they meet antibodies. (1) with respect to dt, we have the following:

$$dV / dt = (\beta - \gamma F)V .$$

The second equation describes the growth of plasma cells:

$$dC = aF(t - \tau)V(t - \tau)dt - u(C - C^*)dt. \quad (2)$$

The appearance of plasma cells in the first member of the right side,

τ- is the formation time of the plasma cell cascade,

α- is the coefficient of probability of antigen-antibody meeting, activation of cascade reaction and number of new cells formed. The second term in the second formula describes the decrease in the number of plasma cells due to aging,

u- is a coefficient equal to the inverse value of their residence time,

C* is a constant level of plasma cells in a healthy body.

By dividing the equation (9.2) by dt, we obtain the following equation:

$dF=pCdt-h\gamma FVdt-u_1Fdt$, (3)

here

pCdt, Dt - formation of antibodies by plasma cells during the time interval;

p is the production rate of antibodies by one plasma cell;

hγFVdt - by binding to antibodies;

Dt - describes the decrease in the number of antigens over time;

u_1Fdt is a decrease in the population of antibodies, where

u_1 is a coefficient inversely proportional to the time of antibody decay. Dividing the equation (9.3) by dt, we get:

$dF / dt = pC - (u_1 + h\gamma V)F$.

Let us consider the equation for the relative characterization of target organ damage.

M - defines the characteristics of a healthy body part,

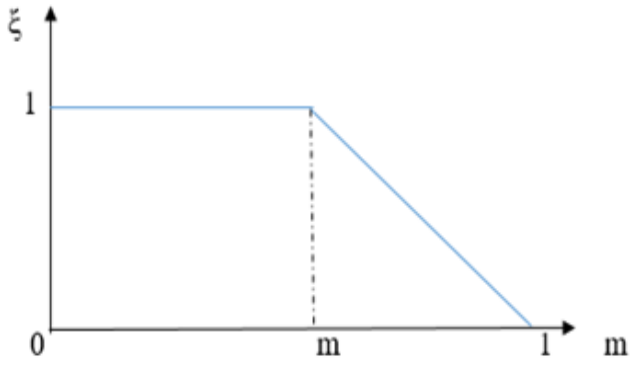
M* - defines the characteristics of the unhealthy part of a healthy body part.

If we consider the value of M according to the formula

$m = 1 - M^*/M$.

This is a relative feature of injury to a healthy body part. It is equal to 0 for an unaffected organ and 1 for completely damaged ones. Consider the following equation for this property:

$dm/dt=sV - u_2\, m$.



Pic-1

In this figure, the curve in the interval 0 < m < m* is equal to 1. This means that the functioning of immunological organs in this interval does not depend on the severity of the disease. But then their performance quickly declines. Thus, we arrive at the following system of nonlinear ordinary differential equations:

$dV / dt = (\beta - \gamma F)V$,

$dC / dt = aF(t - \tau)V(t-\tau) - u(C - C^*)$,

$dF / dt = pC - (u_1 + h\gamma V)F$,

$dm/dt=sV - u_2\, m$.

We attach initial data to the system of equations

t = t(0) (V(t(0), F(t(0), C(t(0), m(t(0)).

We call the resulting system of equations the simplest mathematical model of the disease. It describes the dynamics of the development of pathogenic infection against the background of the immune response.

This mathematical model can be used to interpret clinical studies

Result: Mathematical modeling in Immunology in the first group

The positive results obtained by explaining the topic in the traditional way were as follows.

Proportion 12 - 100
1 - x ,

_____

X=100/12=8,33

8,33%*12=99,96% assimilation

(3 student 5- price, 4 student 4 - price, 6 student 3- price, 1 student 2- price) with the result.

8,33 % * 3 student =24.49 %

8,33% * 4 student =33.32 %

8,33% * 6 student =49,98 %

8,33% * 1 student =8,33%

We achieved a positive rate of 57.81% through 99.96% absorption

Unconventional method to students of the second group

The positive results obtained by explaining the educational methods with the "zig-zag" method were as follows.

Proportion 14 - 100
1 - x ,

_____

X=100/14=7,14

7,14%*14=99,96% assimilation

(7 student 5- price, 5 student 4 - price, 3 student 3- price, 1 student 2- price) with the result.

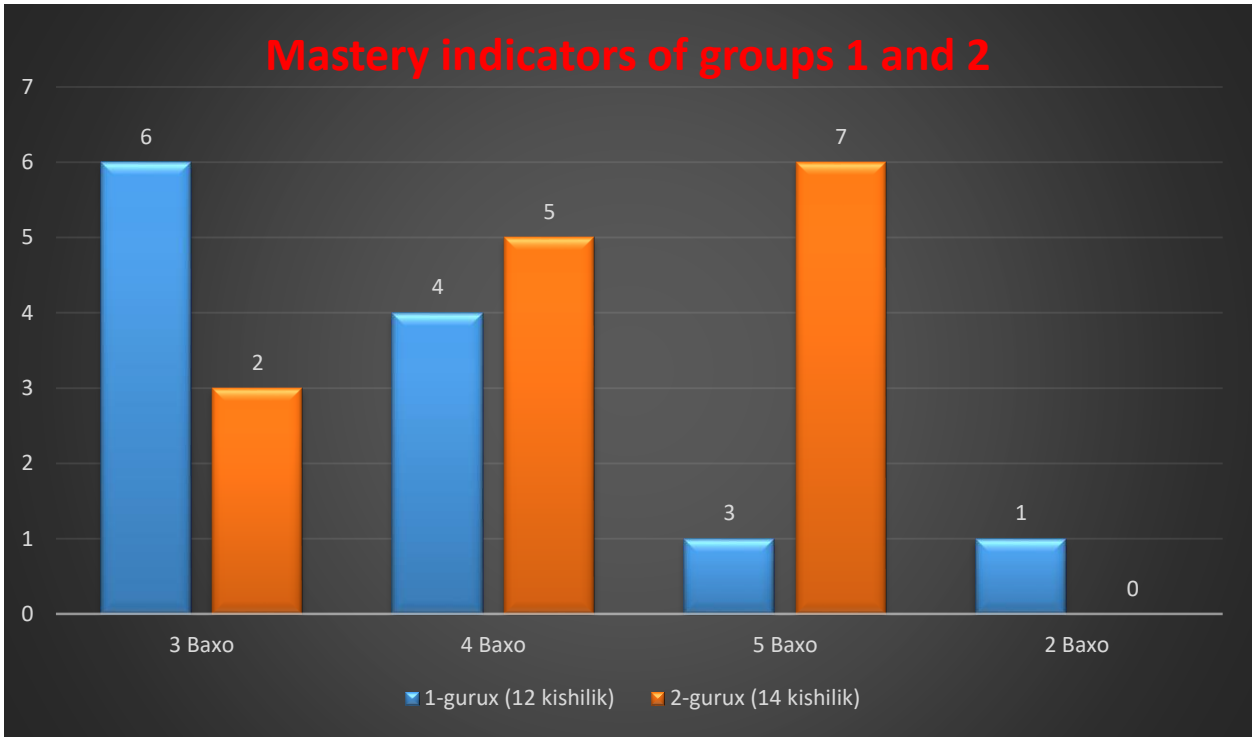
7,14 % * 7 student =49,98 %

7,14% * 5 student =35,70 %

7,14% * 2 student =14,28 %

We achieved a positive rate of 85.68% with 99.96% adoption

The teaching process using the "zig-zag" method gave a good result, because the topic of mathematical modeling in immunology is the root cause of the problem, the reasons for contracting the disease, the problem, where, with whom, how long ago the symptoms of the disease began to be felt, the symptoms of the disease and the We develop a mathematical model of an infectious disease by taking the data and achieve a quick and effective treatment of the disease.



In the process of using interactive educational methods, we will achieve positive results if we know which type of method is appropriate for the given topic and if we are ready for it. We inform you that the effectiveness of the lesson conducted using the "zig-zag" method was 27.78% higher than the traditional method when experimental tests were conducted in two groups of the Faculty of Medical Biology of Samarkand State Medical University.

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