# MATHEMATICAL MODELING OF IMMUNE RESPONSE IN INFECTIOUS DISEASE (SUBCLINICAL FORM)

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**Introduction**. The studies in theoretical immunology on the basis of mathematical models are considered nowadays as a priority direction in the investigations of complex systems in biological sciences which is supported by the European Science Foundation and the European Society of Mathematical and Theoretical Biology. Aspects of an organism's defense against viral and bacterial infections and the reaction of immune system to infection are the main problems in practical immunology. Understanding of regularities in immune response provides the researchers and clinicians new powerful tools for the stimulation of the immune system and for increasing its efficiency in the struggle against antigen invasion. In this connection the construction of mathematical models of immune response to an antigen irritant is considered as the only right tactics in the cognition of the above regularities.

The **aim** of the work is to develop the simple mathematical model of subclinical form of infectious disease on the basis of an equilibrium relation for each component that participates in an immune response (antigen, antibody, plasma cell, and degree of damage of an organ subjected to antigen attack).

**Materials and methods**. The mathematical model must adequate represent the immunological models based on theoretical and experimental conceptions on the defense system of organism. Indeed, in designing the simplest model of immune defense we have used the main conception of immunology: an antibody binds an antigen and forms antibody-antigen complexes. In proportion to the quantity of these complexes, plasma cells are formed in an organism in a time t which carry out the mass production of antibodies. The quantity of plasma cells forming in response to antigenic stimulation depends on the viability of the affected organ: the more severe is the damage to this organ the less is the quantity of plasma cells because of the deficiency arising that affects the immune defense activity. It is seen that many details are missing in this model; however, all the essential components of the immune defense mechanism are taken into account.

The basic acting factors of an infectious disease are: 1) concentration of pathogenic multiplying antigens, $V(t)$; 2) concentration of antibodies, $F(t)$; 3) concentration of plasma cells, $C(t)$; 4) relative characteristic of affected organ, $m(t)$. So, the simple mathematical model of infectious disease is represented as the system of nonlinear differential equations:

$$
\begin{cases}
\dfrac{dV}{dt} = (\beta - \gamma F)V \\
\dfrac{dC}{dt} = \xi(m)\alpha V(t-\tau)F(t-\tau) - \mu_C(C - C^*) \\
\dfrac{dF}{dt} = \rho C - (\mu_f + \eta\gamma V)F \\
\dfrac{dm}{dt} = \sigma V - \mu_m m
\end{cases}
.
$$

This system of equations describes the dynamics of pathologic infection development during immune response.

**Results and discussion**. Subclinical form of infectious disease is usually latent and is not connected with physiological disorder of an organism. It is usual contact of an organism with a familiar antigen, and the organism has the resources sufficient to suppress the antigen: specific immunoglobulin, lymphocytes, interferon, macrophages, and other components of the immune system. In this case the proliferating population of viruses or bacteria is suppressed by available resources and the antigen is destroyed before it reaches the concentration level that provokes noticeable immune and physiological reactions of the organism. The pathogen population dynamics in this case is shown in Fig. 1.

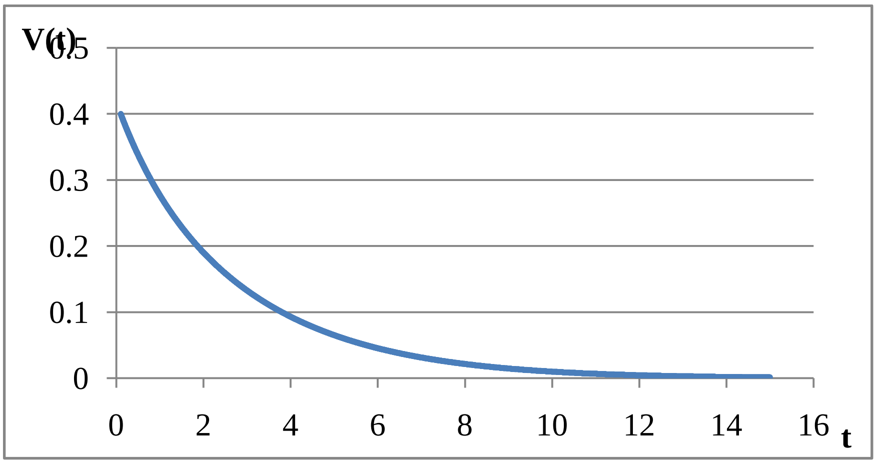


***Fig. 1.*** *Antigen concentration dynamics in case of subclinical form of disease*

The simple mathematical model of subclinical form of infectious disease, of course, is extremely approximate and requires further detailed elaboration. However, even in this form it allows one to include in the system various essential factors of infectious disease dynamics.

**Conclusions**. Realization of simple mathematical model of subclinical form of infectious disease with the help of spreadsheet LibreOffice Calc allows computing the main parameters of disease and representing them graphically. This model is useful for exploration of general picture of a disease course and for explanation of some results of observations. Some theoretical results may be used in searching for effective methods of treatment.