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POSSIBILITY OF IMPROVING DISEASE PREDICTION USING MATHEMATICAL MODELS

Ilenko-Lobach N.V[1], Boychenko O.M[1], IlenkoN.M[1], Salomatina S.O[2], Nikolishyna E.V[1], Karnauh M.M[3], Voloshyna A.V[3], Zaitsev A.V[1].

[1]*Associate Professor of the Department of Therapeutic Stomatology, Poltava State Medical University, Poltava, Ukraine.*

[2]*Associate Professor of the Department of Therapeutic Stomatology, Dnipro State Medical University, Ukraine.*

[3]*Associate Professor of the Department of Therapeutic Stomatology, Zaporizhia State Medical and Pharmaceutical University, Ukraine.*

Abstract.

Throughout their existence, people have sought to know what tomorrow holds for them. It was especially important to learn about a full life, illness or death. Science is the essence of human knowledge, which is organized according to certain principles, a real connection of judgments, predictions and problems of reality and its individual spheres or aspects.

Various indexes are used in modern periodontology. Index assessment allows you to succinctly and conveniently display the static state of periodontal tissues in quantitative terms. With their help, you can get an idea of the prevalence, degree of severity, the course of the inflammatory-destructive or dystrophic process, evaluate the effectiveness of the treatment and the quality of dispensary work in a specific patient or dispensary group. Among the indices, clinical ones are especially defined. They are the main group of indices that allows the clinician to assess the state of the periodontal tissues in a variety of ways. With their help, you can get a general idea of the nature of the course of the disease, plan the amount of medical interventions, evaluate the effectiveness of the treatment and dispensation.

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Key words. Forecasting, mathematical modeling, periodontal disease.

Introduction.

Throughout their existence, people have sought to know what tomorrow holds for them. It was especially important to learn about a full life, illness or death. Science is the essence of human knowledge, which is organized according to certain principles, a real connection of judgments, predictions and problems of reality and its individual spheres or aspects. The growth of human experience is ensured through scientific works. Scientific forecasting is a type of theoretical activity that consists in defining and describing certain phenomena of nature, social life, mental states that are absent or not known now, but may arise or be studied and discovered in the future. The problem of scientific forecasting is relevant for many spheres of life, including medicine. [1]. Currently, in the time of evidence-based medicine and the information and legal space, patients have high demands on the results of treatment, which forces doctors to clearly predict these results. Unfortunately, the existing forecasting methods and tools do not always sufficiently predict the course of the disease, remain complex and not integrated into practical activities [2.].

Mathematical modeling as a method of scientific knowledge began to be used by mankind many centuries ago, from the moment when the foundations of differential and integral calculus were laid. But its use in biomedical fields began only in the 80s of the 19th century. Modeling in medicine allows establishing deeper and more complex relationships between theory and experiment. A whole series of studies is impossible without it. In addition, some experiments are harmful to health. With the help of modeling, a number of different models can be developed on one set of information. You can also make your additions to the model. Thanks to modeling in the second half of the 20th century. immunology began to develop rapidly [3].

Many calculations are performed on computers using programs designed for this purpose. One of them is Microsoft Office Excel. With its help, you can simplify many tasks of any specialist who uses a computer in his work. This mathematical processor has been used in the field of data analysis for decades and has become an indispensable component of every computer. Excel provides users with the following capabilities:

1. Allows you to create dynamic and easy-to-manage tables.
2. Allows you to perform various calculations and operations on data. Formulas can include arithmetic operations, functions, conditional expressions, and more. It allows you to automate calculations and perform complex analytical tasks.
3. Provides ample opportunities to create various types of graphs and charts, facilitating effective analysis.
4. Allows you to filter and sort large amounts of information.
5. Excel has built-in analytical features that help you perform various types of analysis, including regression analysis, correlations, trends, and more.
6. Allows you to use predictive models to determine future trends.

To work with this program, the Statsoft company also developed the "STATISTICA" system, which is one of the most popular statistical programs for finding patterns, forecasting, classification, and visualization of material. It is used in various spheres of human activity, in particular in medicine [4].

The listed opportunities create incredible conditions for conducting various researches, which is very important for the advancement of human knowledge. Therefore, it is of interest to know how well modern scientists in medicine use the listed computer support for prediction. This is the relevance of our work.

The purpose of the work: Analysis of modern clinical research such as forecasting using the capabilities of the computer program Excel, in particular in dental theory and practice.

The task: To evaluate the peculiarities of the use of the Excel device in predicting treatment in modern dental research and to make further assumptions regarding the improvement of this practice.

Scientific novelty: The results of the assessment of the features of the use of the Excel device for predicting treatment in modern dental research were obtained, and further assumptions were made regarding the improvement of this practice.

Practical significance: The conducted analysis has theoretical and practical significance for therapeutic stomatology.

Materials and Methods.

The materials were the results of clinical studies conducted at the dental center of the National Medical University named after O.O. Bogomolets; the results of a scientific study conducted in the cardiology department of the Lviv Emergency Medical Care Hospital and the Dental Medical Center of Danylo Halytsky Lviv National Medical University; the results of a scientific study conducted in the rheumatology department of the ENT hospital "Lviv Regional Clinical Hospital" and at the Department of Therapeutic Stomatology, Periodontology and Stomatology of the Danylo Halytsky Lviv National Medical University.

Analysis of the aforementioned clinical studies. Mathematical analysis based on elements of regression analysis - approximation, which was carried out using the computer program Excel, which we used repeatedly [6], as well as other capabilities of this program [7].

Results.

Various indexes are used in modern periodontology. Index assessment allows you to succinctly and conveniently display the static state of periodontal tissues in quantitative terms. With their help, you can get an idea of the prevalence, degree of severity, the course of the inflammatory-destructive or dystrophic process, evaluate the effectiveness of the treatment and the quality of dispensary work in a specific patient or dispensary group. Among the indices, clinical ones are especially defined. They are the main group of indices that allows the clinician to assess the state of the periodontal tissues in a variety of ways. With their help, you can get a general idea of the nature of the course of the disease, plan the amount of medical interventions, evaluate the effectiveness of the treatment and dispensation.

The PMA (papillary-marginal-alveolar (cellular)) index belongs to the indices that determine the degree of inflammation of the gums. The index was proposed by I. Schour and M. Massler in 1948. It is one of the most common - the first basic indices of gingival inflammation, which was subsequently modified by various authors. The modification of C. Parma in 1960 was the most convenient [8-10]. The index allows you to objectively assess the degree of inflammation of the gums and is still used in the C. Parma modification [11,12]. Such long-term viability of this clinical method draws attention to it, makes it more closely familiar with the example of its use in the sense of forecasting the treatment of periodontal diseases, and possibly another embodiment.

It is interesting to see how well the treatment indicators will be displayed with the help of PMA when the mathematical apparatus of the Excel computer program is applied to it. This method was used by us regarding the relationship between representatives of the oral microbiome and proved good results [8]. The mathematical apparatus is a universal method of studying a real phenomenon or process. Therefore, we tried to involve this concept in identifying the possibilities of predicting the condition of periodontal tissues using an index assessment.

To find out the effectiveness of the application of different types of scaling at the first stage of treatment of periodontal diseases in 2017 at the dental center of the National Medical University of O.O. Bogomolets a study was conducted.

Patients with equivalent periodontal conditions (chronic generalized periodontitis, chronic catarrhal gingivitis of mild and moderate severity, chronic hypertrophic gingivitis of mild severity) were divided into groups according to the types of scaling:

Patients with equivalent periodontal conditions (chronic generalized periodontitis, chronic catarrhal gingivitis of mild and moderate severity, chronic hypertrophic gingivitis of mild severity) were divided into groups according to the type of scaling: using instrumental scaling (using hand tools), using electromechanical scaling (using an ultrasonic tool) and using combined scaling (using ultrasound and hand tools). They underwent a clinical examination, which included an index assessment of the level of periodontal inflammation using the PMA index (Table 1) [9].

Table 1. *Changes in indicators of the PMA index according to C. Parma (1960), % in patients using different types of scaling (M±m).*

Types of scaling	Research deadlines			
	1 day	2 day	14 day	after 3 months
Instrumental	24,30±1,14	26,01±1,15	18,33±1,15	20,30±1,14
Electromechanical	23,50±1,11	15,13±1,15	10,65±1,15	21,29±1,11
Combined	23,18±1,11	20,15±1,15	4,91±1,15	14,58±1,11

On the basis of the obtained results, conclusions were drawn regarding the advantage of the combined method of removing dental deposits - it combines the advantages of instrumental and ultrasonic types of scaling and allows you to avoid complications arising from the use of these methods separately.

We have created mathematical models of the dynamics of periodontal inflammation in the above-mentioned groups of patients - with the help of approximation, graphs of changes in the PMA index over 3 months have been created, graph trends and their mathematical formulas have been reproduced (Figure 1) [13].

Thus, for the group of patients who underwent instrumental scaling, a mathematical model with the best approximation reliability (R2) was created when determining the polynomial function according to the formula y = 0.0063 x2 - 0.6306 x + 26.032. R2 was 0.9277. For the group of patients who underwent electromechanical scaling, a mathematical model was created with the best approximation reliability (R2) when determining the polynomial function according to the formula y = 0.0099 x2 - 0.8887 x + 20.795. R2 was 0.7239. For the group of patients

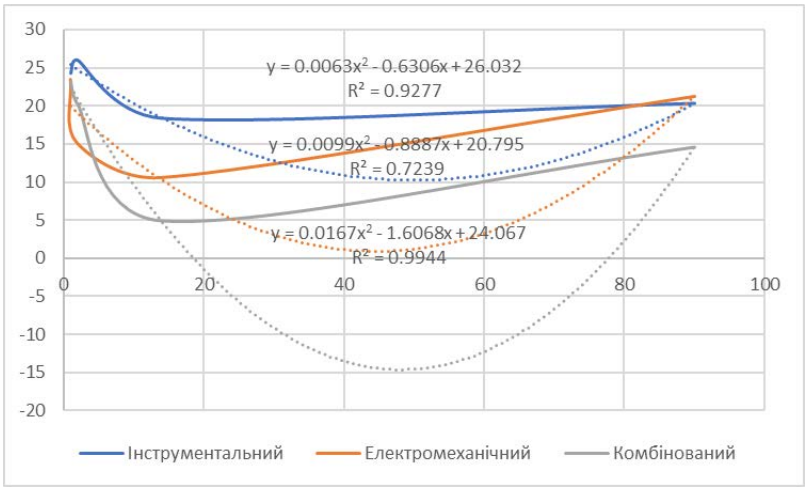

Figure 1. *Graphs, trends, and formulas for changes in PMA index indicators according to C. Parma (1960) (%) in patients using different types of scaling within 3 months.*

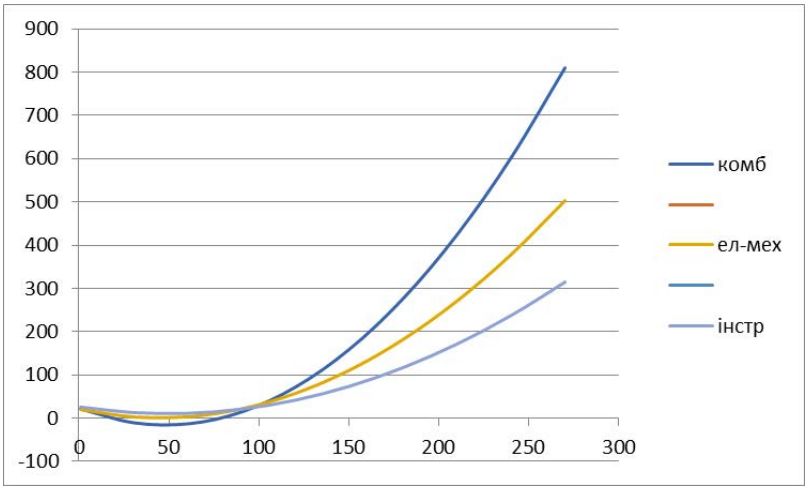

Figure 2. *Graphs of changes in indicators of the PMA index according to C. Parma (1960) (%) in patients using different types of scaling during 12 months.*

who underwent combined scaling, a mathematical model was created with the best approximation reliability (R2) when determining the polynomial function according to the formula y = 0.0167 x2 - 1.6068 x + 24.067. R2 was 0.9944.

After that, with the help of Excel, we created graphs that reproduced the dynamics of periodontal inflammation (according to the PMA index) over 12 months (Figure 2).

The resulting graphic models visualize how inflammation can develop in the periodontal tissues if nothing is involved in reducing its progression.

In 2022, a dissertation was defended, devoted to the solution of measures to optimize the treatment and prevention of chronic generalized periodontitis in patients with ischemic heart disease through the use of statin-based drugs. Patients with ischemic heart disease who were undergoing inpatient treatment at the cardiology department of the Emergency Medical Care Hospital of the city of Lviv and patients with a diagnosis of chronic generalized periodontitis without somatic diseases who applied for treatment at the Danylo Halytskyi Dental Medical Center of LNMU.

Three groups were formed from them: the main group and comparison group 1 - patients with ischemic heart disease and chronic generalized periodontitis of the initial I and II degree of severity and comparison group 2 - patients with chronic generalized periodontitis, in which the presence of somatic pathology was not indicated in the anamnesis [14].

The results of determining the PMA index before treatment, after it and in the long term are shown in Table 2.

Table 2. *Results of treatment and prevention of chronic generalized periodontitis according to the PMA index in the studied groups (M±m,%).*

Research groups	**Terms of research**			
	Before treatment	**After treatment 7 days**	**After treatment 1 month**	**After treatment 6 months**
Main group	49,89	22,78	20,88	19,09
Comparison group 1	48,42	34,29	31,86	38,48
Comparison group 2	39,29	21,56	20,94	26,47

Based on the obtained results, the therapeutic effectiveness of the developed gel composition based on atorvastatin was proven

and it was recommended as an additional local medication in the complex treatment and prevention of inflammatory and dystrophic-inflammatory diseases of periodontal tissues in patients with ischemic heart disease.

We have created mathematical models of the dynamics of periodontal inflammation in the indicated groups of patients - by means of approximation, graphs of changes in the PMA index over 6 months were invented, graph trends and their mathematical formulas were reproduced (Figure 3).

The following indicators were invented:

1. For the main group, the best approximation reliability of R2=0.6045 was when determining the polynomial function with the following formula: y=0.0044x2-0.9108x+41.313.

2. For comparison group 1, the best approximation reliability of R2=0.6023 was when determining the polynomial function with the following formula: y=0.0029x2-0.5465x+44.196.

3. For comparison group 2, the best approximation reliability of R2=0.497 was when determining the polynomial function with the following formula: y=0.003x2-0.5768x+33.61.

After that, with the help of Excel, we created graphs that reproduced the dynamics of periodontal inflammation (according to the PMA index) over 12 months (Figure 4).

The resulting graphic models visualize how inflammation can develop in the periodontal tissues if nothing is involved in reducing its progression.

In Lviv, in 2023, a dissertation work was defended, which presented a theoretical generalization and a new solution to an urgent task of modern dentistry - clinical and laboratory substantiation of the effectiveness of the prevention and treatment of periodontal diseases in patients with gout based on the results of clinical, biochemical, immunological and physicochemical blood tests and oral fluid.

In order to achieve the goal, two groups of patients were created: the main group with chronic generalized periodontitis (initial-I and II degrees of severity) was treated according to the therapeutic and preventive scheme developed by the doctoral student: additionally prescribed the drugs "Monmorol" (ToV Nutrimed, Ukraine); "Biotrit-denta" (NPA Odesa Biotechnology, Ukraine); the drug "Acerola S-500" with bioflavonoids (ToV Nutrimed, Ukraine). In the control group, traditional methods were used for the treatment of periodontal diseases (gingivitis, chronic generalized periodontitis initial-I and II degrees of severity, periodontitis) in accordance with generally accepted protocols. The papillary-marginal-alveolar index (RMA, Parma, 1960) was used to assess the degree of inflammation of the gums. The proposed treatment and prevention complex made it possible to achieve remission of generalized periodontitis.

The results of determining the PMA index before treatment, after it and in the long term are shown in Table 3.

Table 3. *Results of treatment and prevention of chronic generalized periodontitis according to the PMA index in the studied groups (M±m,%).*

Terms of observation	**Main group**	**Control group**
	PMA, %	**PMA, %**
Before treatment	58,30±10,31	56,89±10,14
1 month after treatment	33,21±3,16	42,88±6,32
6 months after treatment	31,09±3,14	44,19±6,53
12 months after treatment	40,83±5,55	58,02±10,74

We have created mathematical models of the dynamics of periodontal inflammation in the indicated groups of patients - by means of approximation, graphs of changes in the PMA index over 12 months were invented, graph trends and their mathematical formulas were reproduced (Figure 5).

For the main group, the best approximation reliability (R2=0.6216) was when defining the logarithmic function

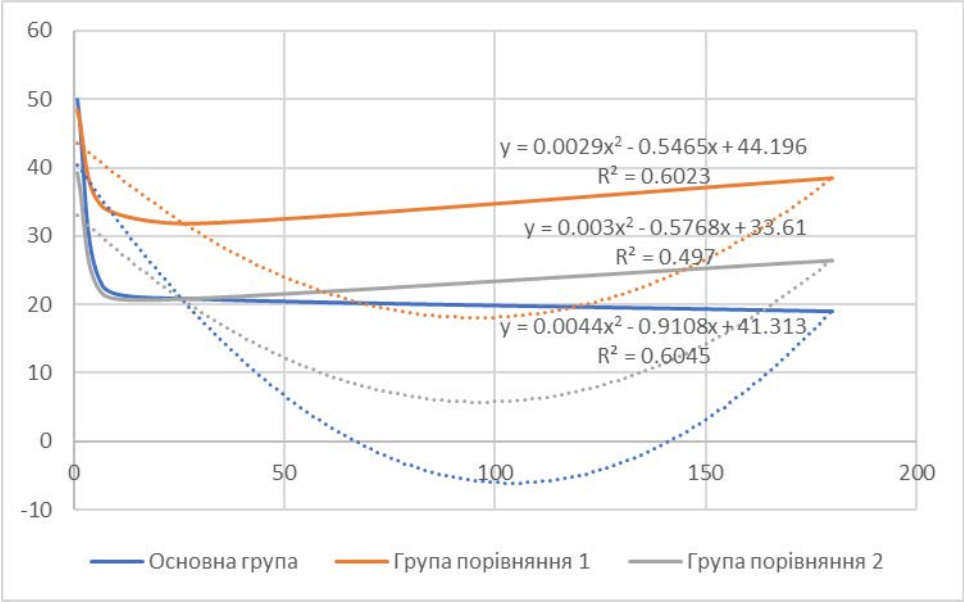

Figure 3. *Graphs, trends and formulas of changes in PMA index indicators according to C. Parma (1960) (%) in patients with chronic generalized periodontitis on the background of ischemic heart disease and without somatic pathology during 6 months.*

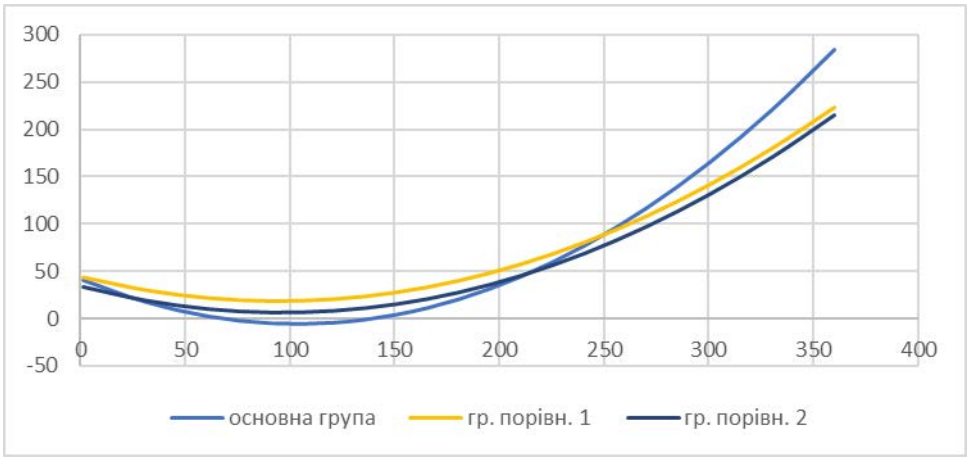

Figure 4. *Graphs of changes in PMA index according to C. Parma (1960) (%) in patients with chronic generalized periodontitis on the background of ischemic heart disease and without somatic pathology during 12 months.*

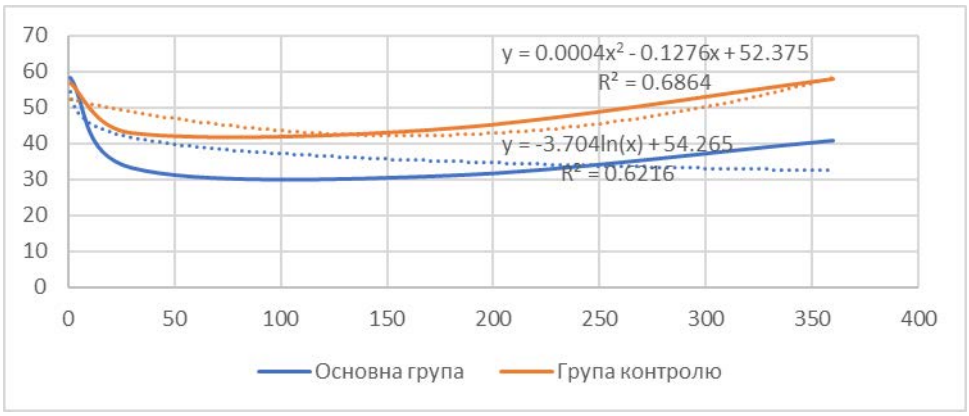

Figure 5. *Graphs, trends, and formulas for changes in PMA index indicators according to C. Parma (1960) (%) in patients with chronic generalized periodontitis on the background of gout within 12 months.*

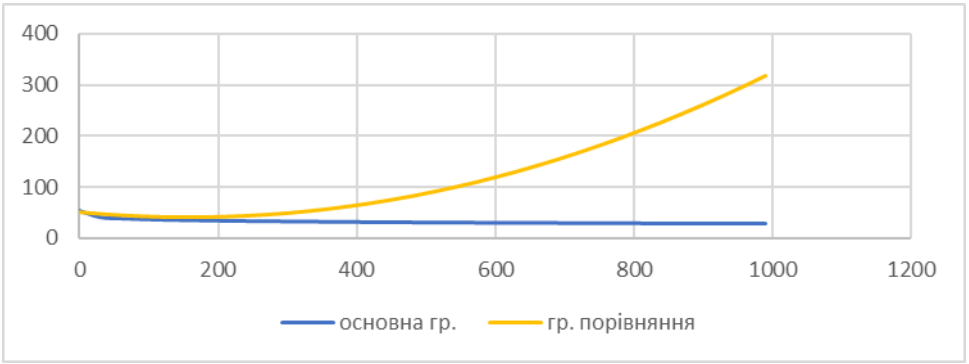

Figure 6. *Graphs of changes in indicators of the PMA index according to C. Parma (1960) (%) in patients with gout during 36 months.*

according to the following formula: y=-3.704ln(x)+54.265. For the control group, the best approximation reliability (R2=0.6864) was when determining the polynomial function according to the following formula: y=0.0004x2-0.1276x+52.375. We have created mathematical models of the dynamics of periodontal inflammation in the indicated groups of patients - by means of approximation, graphs of changes in the PMA index over 36 months were invented, graph trends and their mathematical formulas were reproduced (Figure 6).

Discussion.

With the help of the Excel computer program, we obtained prognostic mathematical models of the disease when applying various treatment measures to its stabilization.

In the study of Dikova I.H. for the group of patients who underwent instrumental scaling, a mathematical model was created with the best approximation reliability (R2=0.9277) when determining the polynomial function according to the formula y = 0.0063 x2 - 0.6306 x + 26.032. For the group

of patients who underwent electromechanical scaling, a mathematical model was created with the best approximation reliability (R2=0.7239) when determining the polynomial function according to the formula y = 0.0099 x2 - 0.8887 x + 20.795.

For the group of patients who underwent combined scaling, a mathematical model with the best approximation reliability (R2=0.9944) was created when determining the polynomial function according to the formula y = 0.0167 x2 - 1.6068 x + 24.067.

In the study of O.V. Skibchyk. The following indicators were invented:

1. For the main group, the best approximation reliability (R2=0.6045) was when determining the polynomial function according to the formula y=0.0044x2-0.9108x+41.313.

2. For comparison group 1, the best approximation reliability (R2=0.6023) was when determining the polynomial function according to the formula y=0.0029x2-0.5465x+44.196.

3. For comparison group 2, the best approximation reliability (R2=0.497) was when determining the polynomial function according to the formula y=0.003x2-0.5768x+33.61.

In the study Gnid M.R. for the main group, the best approximation reliability (R2=0.6216) was when defining the logarithmic function according to the following formula: y=-3.704ln(x)+54.265. For the control group, the best approximation reliability (R2=0.6864) is based on the following formula: y=0.0004x2-0.1276x+52.375.

The reliability index can vary from 0 to 1. The higher it is, the more reliable the approximation.

It is believed that when the value of this indicator is 0.85 and above, the correspondence of the simulated function to reality can be considered the most reliable.

In essence, all invented mathematical models, except for one, are formulas of a function of the second degree (quadratic). But in the case of research Hnid M.R. for the main group, the best approximation reliability was found when defining the logarithmic function.

In the study of Dikova I.G. according to the mathematical models created by us, a stable remission is achieved within three months. After 100 days, the progression of the disease begins. In addition, the combined method of scaling after the end of remission gives the fastest further progression of the disease.

In the study of O.V. Skibchyk. according to the mathematical models created by us, a stable remission is also achieved within three months. Then there is a slow progression of the disease, in which the main group is the first to reach one hundred percent.

In the study Hnid M.R. according to the mathematical models created by us, a stable remission is observed for 200 days. After that, the progression of the disease begins in the comparison group. And in the main group, on the contrary, remission goes to the stabilization phase.

From July 1, 2018, the Procedure for the provision of primary medical care entered into force, and the dispensary became a thing of the past. In its place, scheduled screenings have been introduced, the conduct of which is determined by the order of the Ministry of Health of Ukraine dated March 19, 2018 No. 504 "On approval of the Procedure for providing primary medical care".

Conclusion.

Modelling of the disease process is possible using the tools of the mathematical processor Microsoft Office Excel. But in our case, the obtained mathematical models do not always have the appropriate degree of reliability. This indicates the need to refine the mathematical apparatus due to the databases used in medical research. Reproduction of mathematical models with different formulas can indicate not only the imperfection of the used approach. It can also be a manifestation of the intervention of therapeutic agents, which were used to eliminate or stabilize the disease, in the work of other body systems besides the dental and jaw system. Or something else, which can also be caused by the vital activity of the human body or the influence of the surrounding environment on it. In our study, the case of inconsistency of one mathematical model with others has positive consequences.

The different period of remission also attracts attention. In connection with the introduction of the screening assessment, the modelling of the further development of the disease is gaining relevance. This indicates that doctors in their research should use the construction of mathematical models both in the sense of predicting the consequences of treatment and the progress of the disease, as well as to determine the date of a repeat visit to the doctor and to study the essence of the pathology itself. This can be beneficial in understanding the studied disease state, as well as in creating new approaches to its elimination and disease prevention (correction).

Prospects for further research: are to clarify the possibility of improving the quality of forecasting the consequences of treatment and the progress of the disease using mathematical modeling in dental practice.

Conflict of interest. The authors declare no conflict of interest.

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