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INTEGRAL METHOD FOR ASSESSING THE EFFICIENCY OF DENTAL CARIES PREVENTION

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Abstract.

This is a part of research work of the Therapeutic Dentistry Department of the Poltava State Medical University (PSMU). The name of this research work is "Development of pathogenetic prevention of pathological changes in the oral cavity in patients with internal diseases" (state registration No. 0121U108263).

Key words. Adolescents, aggressive, behavior, bullying, emotional status, prevention.

Introduction.

Different microbiological methods have appeared in the access of a modern dentists. Some of these methods allow assessing the content of cariogenic microorganisms - Streptococcus mutans and Lactobacillus. Kits for conducting such rapid tests are produced in different countries all over the world. These are Dentocult SM Strip mutans (Orion Diagnostica, Finland; Vivadent, Liechtenstein), CRT-bacteria (Vivadent, Liechtenstein), Saliva-check mutans (GC Asia Dental Pte Ltd, Japan) and Dentocult LB (Orion Diagnostica, Finland; Vivadent, Liechtenstein). According to these tests, individual caries prevention programs have been created [1,2]. Prophylactic measures refer to primary prevention. It leads to some difficulties in using such tests for secondary and tertiary prevention.

In addition to primary prevention, there are rehabilitation programs that relate to secondary and tertiary prevention. In secondary prevention, it is used an indicator of changes in the intensity of caries growth over a certain period, which is considered sufficiently informative to assess the preventive effect of secondary prevention set measures. This indicator is based on the DMF index. This index has many varieties and can be used at the individual, group, and population levels [3,4]. After all, this indicator and its modifications also have negative aspects. The DMF index does not take into account the initial manifestations of caries and its etiology. This circumstance causes difficulties in the application of this index in primary prevention.

We have set several following tasks:

1. To develop a method for evaluating the dental caries prevention effectiveness using mathematical analysis.
2. On the basis of DMF index and microbiological studies, create an indicator that takes into account the etiological marker of caries and the severity of carious lesions.
3. This new indicator should take into account the interactions between cariogenic microorganisms and the host organism.
4. This new indicator should take into account the effectiveness of secondary prevention measures and their correction during implementation.

This direction is not fully developed. So, the study of this direction is relevant.

The purpose of the study is to create an objective indicator based on microbiological studies and the DMF index, which gives an idea of the effectiveness of preventive measures in a group of people at the secondary prevention level.

Materials and Methods.

As materials, we used research data of the therapeutic dentistry department, as well as microbiological, virological, and immunological data of the PSMU (Poltava). It was used mathematical methods of data analysis - approximation of graphs using the Excel 2010 program, as well as online methods for finding definite integrals.

Main part.

Microorganisms are causative agents of various diseases. This attitude to them lead to searching different methods of microorganisms destruction. However, in recent years, more and more attention has been paid to the study of the human microbiome, as well as the interactions of human microbiocenoses with each other and with the person himself.

Modern dentistry considers the microflora of the oral cavity as the cause of the carious process. Streptococci and lactobacilli are considered the most active in carious progress [4-6].

Rapid tests for the determination of Streptococcus mutans and Lactobacillus obviously have some disadvantages. According to the Saliva-check mutans test, the patient is considered to be at risk of caries when the amount of S. mutans in the oral fluid is 5x105 CFU/ml. The Dentocult LB test for revealing the presence of lactobacilli is considered positive at 105 CFU/ml. The exact number of microorganisms in these tests is not taken into account. This circumstance allows us to make only a supposition about the risk zone in which the subject is located.

New research methods have become more accurate and informative. In 2007, a large-scale international Human Microbiome Project was launched. Its first phase was focused on determining the human microflora and its characteristics [7]. To systematize the bacteria of the human oral cavity, the Human Oral Microbiome Database (HOMD) was created. The microbiota of the oral cavity is the most accessible for study. In particular, oral fluid can be used as a non-invasive, easily reproducible, and low-cost method for diagnosing and monitoring the body's physiological homeostasis and its destabilization [8].

Researchers of the Therapeutic Dentistry Department and the Department of Microbiology, Virology, and Immunology of the PSMU (Poltava, Ukraine) in 2013 studied the microbiocenosis of the oral cavity in young people aged 19-25 years with different intensity of the carious process. It was observed the percentage of carriers of the studied representatives of microflora and the quantitative content of microflora in carriers. In particular, in this study, indicators were determined regarding lactobacilli, streptococci (including γ-hemolytic streptococci, which include

S. mutans). The results of the study showed that an increase in the intensity of dental caries is accompanied by changes in the balance of the oral microflora composition. Statistical analysis of the obtained results was carried out using a standard program software "Microsoft Excel 2003". The probability of differences in the results obtained for different groups was determined using Student's t-test of reliability [9].

As it had been mentioned before the DMF index does not take into account the initial manifestations of caries and its etiology. Also, the DMF index has another negative aspect.

• DMF index reflects the past dynamics of caries and only increases with the age of the patient.

• DMF index and its modifications are unreliable with an increase in tooth lesions due to the formation of new cavities in the treated teeth, the occurrence of secondary caries and the loss of fillings.

Approximation is used in a number of different prognostication methods. Approximation helps researchers to make approximate calculations and calculate the planned indicators by replacing the original objects with simpler ones [10].

The definite integral is one of the basic concepts of mathematical analysis. The geometric meaning of a definite integral is the expression of the "curvilinear trapezoid" area bounded by the graph of a function [11].

In the study of oral microbiocenosis, indicators were determined regarding lactobacilli and streptococci (including γ-hemolytic streptococci, to which S. mutans belongs), as well as the number of Streptococcus γ-haemolyticus and Lactobacillus in the oral liquid in individuals with different caries intensity (Table 1).

The percentage of carriers of the above-mentioned oral microflora representatives among the examined people is shown in Table 2.

Table 1. *The amount of Streptococcus γ-haemolyticus and Lactobacillus in the oral liquid of people with different caries intensity, lg CFU/ml.*

Microflora	DMF=0	DMF≤6	DMF≥6
S. γ-haemolyticus	6,0±0,10	6,7±0,06	7,3±0,07
Lactobacillus	4,1±0,05	4,4±0,13	4,9±0,18

Table 2. *The number of carriers of Streptococcus γ-haemolyticus and Lactobacillus with different intensity of caries, %.*

Microflora	DMF=0	DMF ≤6	DMF ≥6
Carriers of *S. γ-haemolyticus*	100	100	100
Carriers of *Lactobacillus*	43	55	70

In explaining the causes of dental caries, it is really important that carries it occur due to a violation of the dynamic balance between the forces of opposing biological objects - macro- and microorganisms [12]. Based on this statement, we propose the most objective parameter taken into account in the prevention of dental caries, to position the interaction between the microorganism and its oral microbiocenosis representatives. This parameter can be determined when considering together the number of carriers of cariogenic microorganisms in the examined people and the number of cariogenic microorganisms representatives in their oral liquid.

For realizing this idea, we will summarize in one table the number of carriers of Streptococcus γ-haemolyticus with the number of Streptococcus γ-haemolyticus in the oral liquid of the examined people. For more convenient calculations, 100% carriage will be taken in account like 1 and the DMF index will be represented as rigidly fixed units (Table 3). Then we remake these data into graphs and approximate them using Excel 2010 (Figure 1).

We have done exactly the same manipulations with the number of Lactobacillus microorganisms and their carriers (Table 4 and Figure 2).

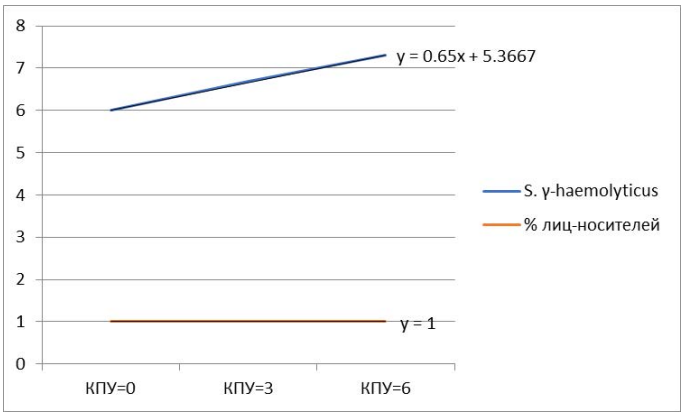
Table 3. *The number of carriers of Streptococcus γ-haemolyticus with different intensity of caries (%) and the content of Streptococcus γ-haemolyticus in the oral liquid of these individuals (Ig CFU / ml).*

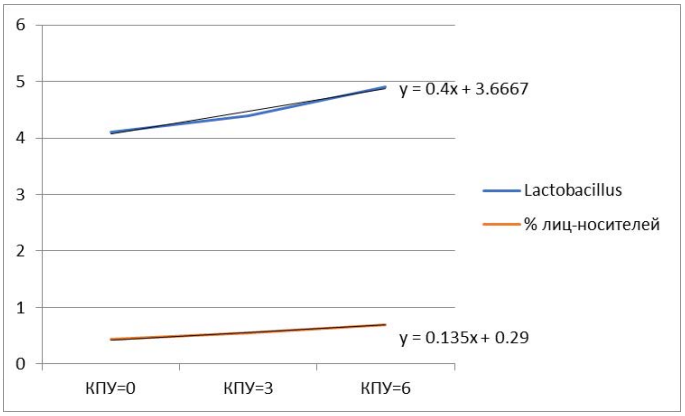
Indexes	DMF=0	DMF =3	DMF =6
S. γ-haemolyticus	6,0	6,7	7,3
% of carriers	1	1	1

Table 4. *The number of carriers of Lactobacillus with different caries intensity (%) and the content of Lactobacillus in the oral liquid of these individuals (Ig CFU / ml).*

Indexes	DMF=0	DMF =3	DMF =6
Lactobacillus	4,1	4,4	4,9
% of carriers	0,43	0,55	0,70

Figure 1. *Graph of the remaking of table 3 data into a visual form.*





conclusions based on them. In addition, these models can be used for further transformations in the mathematical analysis of the studied data.

For creating an objective indicator based on microbiological studies and the DMF index, we made further transformations

based on the use of a definite integral. The geometric idea of a definite integral is the area. Therefore, it is used to find the area of figures enclosed within the specified limits of functions [13,14].

Because of the microbiological study converted into mathematical formulas, we made further transformations. We imagined that during the first examination of the group of respondents, their DMF index was equal to zero, the number of carriers of these microorganisms in percentages and the content of the microorganisms themselves in CFU / ml corresponded to those given in tables 1 and 2 with DMF = 0. During the second examination of the group of respondents, the average DMF index was less than or equal to 6, the number of carriers of these microorganisms in percentages and the content of the microorganisms themselves in CFU / ml corresponded to those given in tables 1 and 2 with DMF = 3. After some time, during the third examination of the group of respondents, their average DMF index was already more than or equal to 6, the number of carriers of these microorganisms in percent and the content of the microorganisms themselves in CFU / ml corresponded to those given in tables 1 and 2 with DMF =6. The obtained data were approximated to those which specified in tables 3 and 4. Then, using the Excel 2010 program, trend graphs were built, and the trend functions were approximated, as shown in figures 1 and 2. As a result, the numerical values of the areas enclosed between the found functions at certain intervals of DMF values were determined. For realizing this, we used the method of calculating the areas of flat figures using a definite integral (formula 1).

$$S = \int_a^b f(x)dx - \int_a^b \varphi(x)dx \qquad (1)$$

where: S is the area of the desired figure; a, b - limits of the DMF, in which it is necessary to find the area of the desired figure; f(x) is the upstream function; φ(x) is the underlying function; dx is the differential of the function.

To find the required area, we used the help of an online calculator, which greatly simplified the task.

Results.

We used an online calculator to find the area with the help of a definite integral for the interactions between Streptococcus γ-haemolyticus and the examined contingent in the range of DMF index from 0 to 3, we obtained a value of 16.025 conventional square units [15]. For the interval DMF index from 3 to 6, a numerical value of 21.8751 conventional square units was obtained [16].

We have done the same operations with using an online calculator to find the area with the help of a definite integral for the interactions between Lactobacillus and the examined contingent in the range of DMF from 0 to 3, we obtained a value of 11.3235 conventional square units [17]. For the interval DMF from 3 to 6, a numerical value of 13.7083 conventional square units was obtained [18].

After analyzing the situation of interactions between Streptococcus γ-haemolyticus and the examined contingent, we saw that the area of interaction increases by 5.8501 conventional square units. This circumstance led to the assumption that ineffective preventive measures were chosen, or the diet and lifestyle of the examined contingent led to an increase of the carious in the group. This increase is associated with the vital activity of Streptococcus γ-haemolyticus.

After analyzing the interactions between Lactobacillus and the examined contingent, we saw that the interaction area increased by 2.3848 conventional square units. This circumstance led to the assumption that either ineffective preventive measures were chosen, or the diet and lifestyle of the examined contingent led to an increase in the intensity of the carious process in the group. Again, this increase is due to the activity of Lactobacillus. However, in numerical terms, the activity of Lactobacillus is inferior to the activity of Streptococcus γ-haemolyticus, which could indicate the auxiliary role of lactobacilli in the caries-forming process.

After that work, we noted the positive aspects of the proposed integral method for assessing the prevention of dental caries:

- when the studying area tends to decrease due to the reduction of the gaps along the abscissa, we have an idea about the reducing of tertiary preventive measures.
- when the studying area tends to decrease due to the reduction of gaps along the ordinate from above, we have an idea about the pathogen focused prevention.
- when the studying area tends to decrease due to the reduction of gaps along the ordinate from below, we have an idea about the carrier's focused prevention.
- when the studying area tends to decrease due to the reduction of gaps along the ordinate and abscissa, we have an idea about the prevention focused on both - carriers of the pathogen and the pathogen.

Conclusion.

Based on DMF index and microbiological studies, an integral method for evaluating the effectiveness of caries prevention has been developed. The method is based on the use of an integral indicator that takes into account the etiological marker of dental caries and the severity of the carious lesion. During calculating the indicator, interactions between cariogenic microorganisms and the host organism are also taken into account. The integrated method for evaluating the effectiveness of caries prevention allows you to adjust preventive measures in groups.

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16. ∫ (0.65x+5.3667)-1 dx Решение определённых интегралов - Калькулятор Онлайн.
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18. ∫ (0.4x+3.667)-(0.135x+0.29) dx Решение определённых интегралов - Калькулятор Онлайн.