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INFORMATION TECHNOLOGY IN PEDIATRICS

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ՏԵՂԵԿԱՏՎԱԿԱՆ ՏԵԽՆՈԼՈԳԻԱՆԵՐԸ ՄԱՆԿԱԿԱՆ ԲԺՇԿՈՒԹՅԱՆ ՄԵՋ

Անեմիայի ուսումնասիրության մաթեմատիկական մեթոդները դեռ պետք է մշակվեն: Գերիշխող տեսակետը կենտրոնացած է հիվանդ երեխայի հիմնական ցուցանիշների վրա: Մենք ձգտում ենք հասկանալ մաթեմատիկական մեթոդների տեղն այս հետազոտության մեջ և ինչպես ներդաշնակեցնել մոտեցումները՝ ավելի լավ հասկանալու հիվանդությունը: Հոդվածում ներկայացնում ենք անամնեստական և կլինիկական լաբորատոր տվյալների վերլուծության մեթոդաբանություն, որը նախատեսված է տարբեր տեսական հիմքերի միջոցով գնահատելու հիմնական մաթեմատիկական մեթոդները (հավանականությունների տեսություն և մաթեմատիկական վիճակագրություն, օպտիմալացման մեթոդներ, ՏՏ դերն ախտորոշման մեջ):

Ընդգծենք ԱՀ-ում երեխաների անեմիայի ախտորոշման որոշ առանձնահատկություններ:

Հարկ է ընդգծել, որ մանկաբուժության մեջ ամենամեծ հրատապությունն են ԵԴՍԱ Երկաթ դեֆիցիտի սակավարյունության ժամանակին ախտորոշման և համարժեք բուժման խնդիրները: Մանկաբուժության մեջ ԵԴՍԱ-ի խնդրի արդիականությունը պայմանավորված է ոչ միայն դրա տարածվածությամբ, այլ նաև երեխաների առողջական վիճակի վրա երկաթի անբավարարության զգալի անբարենպաստ ազդեցությամբ: Ապացուցված է, որ ԵԴՍԱ-ը

հանդիսանում է մարմնի բազմաթիվ օրգանների և համակարգերի դիսֆունկցիայի պատճառ: Դա պայմանավորված է նրանով, որ երկաթը շատ սպիտակուցների մաս է (հեմոգլոբին, միոգլոբին, ցիտոքրոմներ, երկաթի սերոպրոտեիններ, օքսիդազներ, հիդրօքսիլազներ, սուպերօքսիդ դիսմուտազներ և այլն), որոնք ապահովում են համակարգային և բջջային աերոբ նյութափոխանակությունը և մարմնի ռեդոքս հոմեոստազը որպես ամբողջ: Հաստատվել է, որ օրգանիզմում երկաթի անբավարար պարունակությունը բացասաբար է անդրադառնում նյութափոխանակության գործընթացների վրա, ինչը հանգեցնում է տարբեր օրգանների և համակարգերի աշխատանքի խաթարմանը:

***Բանալի բառեր*`** *մաթեմատիկական մեթոդներ, էնտրոպիա, հավանականությունների տեսություն և մաթեմատիկական վիճակագրություն, β-տալասեմիա, ռեգրեսիոն մոդելներ, որոշման գործակից, Գաուսի բաշխման ֆունկցիա, տեղեկատվական տեխնոլոգիաներ:*

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ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ ИТ В ПЕДИАТРИИ

Математические методы изучения анемии еще не до конца разработаны. Доминирующая точка зрения сосредоточена на основных показателях больного ребенка. Мы стремимся понять место математических методов, составляющих основу в специализированных информационных технологиях в этих исследованиях и то, как согласовать подходы для лучшего понимания болезни. Мы представляем здесь методику анализа анамнестических и клинико-лабораторных данных, которые предназначены для оценки основных математических методов с использованием различных теоретических основ (теория вероятностей и математическая статистика, методы оптимизации, ИТ в диагностике).

Подчеркнем некоторые особенности диагностики анемии у детей при РА.

Следует подчеркнуть, что вопросы своевременной диагностики и адекватного лечения железодефицитных состояний являются наиболее актуальными в педиатрии. Актуальность проблемы железодефицитных состояний в педиатрии обус-ловлена не только его широкой распространенностью, но и значительным неблагоприятным влиянием дефицита железа на состояние здоровья детей. Доказано, что иммунодефицитное состояние является причиной дисфункции многих органов и систем организма. Это связано с тем, что железо входит в состав многих белков (гемоглобин, миоглобин, цитохромы, серопротеины железа, оксидазы, гидроксилазы, супероксиддисмутазы и др.), обеспечивающих системный и клеточный аэробный метаболизм и окислительно-восстановительный гомеостаз организма как весь. Установлено, что недостаточное содержание железа в организме отрицательно сказывается на обменных процессах, что приводит к нарушению функционирования различных органов и систем.

Ключевые слова: *информационные технологии, математические* *методы, энтропия, теория вероятностей и матема-тическая статистика, β-талассемия, регрессионные модели, коэффициент детерминации, функ-ция распределения Гаусса.*

Mathematical methods for the study of anemia have yet to be developed. The dominant point of view is focused on the main indicators of the sick child. We strive to understand the place of mathematical methods in this research and how to harmonize approaches to better understand disease. We present here a methodology for the analysis of anamnestic and clinical laboratory data, which are designed to evaluate basic mathematical methods using various theoretical foundations (probability theory and mathematical statistics, optimization methods, IT in diagnostics). We emphasize some of the features of the diagnosis of anemia among children in RA.

It should be emphasized that the issues of timely diagnosis and adequate treatment of IDS are of the greatest urgency in pediatrics. The urgency of the problem of IDS in pediatrics is due not only to its widespread occurrence, but also to the significant adverse effect of iron deficiency on the health status of children. It has been proven that IDS is the cause of dysfunction of many organs and systems of the body. This is due to the fact that iron is a part of many proteins (hemoglobin, myoglobin, cytochromes, iron seroproteins, oxidases, hydroxylases, superoxide dismutases, etc.), which provide systemic and cellular aerobic metabolism and redox homeostasis of the body as a whole. It has been established that insufficient iron content in the body adversely affects metabolic processes, which leads to disruption of the functioning of various organs and systems.

Key words: *mathematic methods, entropy, probability theory and mathematical statistics, β-talas-semiya, regression models, coefficient of determination, Gaussian distribution function.*

Introduction

Because of the distinction between the importance of the two diseases, anemia and β-thalassemia, and the cost-effective and labor-intensive tests to differentiate them, large-scale studies have proposed several distinguishing indicators for rapid and inexpensive differentiation between these two common hematological disorders since 1973. of the year. These indexes are based on blood parameters obtained using automatic blood cell counters, which traditionally measured the parameters of hemoglobin (HGB), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), red blood cell distribution width (RDW), mean corpuscular hemoglobin concentration (MCHC) and red blood cell count (RBC). In several studies the measures of diagnostic accuracy have been examined, which have reported varying results and none of these measures have shown a sensitivity or specificity of 100%. Thus, the aim of this study was to assess the diagnostic function of 40 different indexes among patients with anemia using precision measures [1].

Anemia is widespread among children in developing countries. This is related to the violation of physical growth and mental development. Pale palms are noticed at the primary level for diagnosis based on several studies. The aim of the study was to systematically assess the accuracy of clinical signs in the diagnosis of anemia among children. A systematic review of the accuracy of clinical signs of anemia in children. We searched various databases and tracking links. In the diagnosis of anemia, clinical studies should have been carried out using hemoglobin as the gold standard [2].

Anemia among children is a major public health problem worldwide. It is an often multifactorial disease, the most common cause of which is iron deficiency. The consequences are varied and largely underestimated.

MATERIALS AND METHODS

A brief excursion to Entropy

Having arisen in the depths of thermodynamics by solving a particular problem, the concept of entropy began to expand with amazing energy, quickly crossed the boundaries of physics and penetrated into the most intimate areas of human thought. Along with the Clausius entropy, statistical, informational, mathematical, linguistic, intellectual and other entropies appeared. Entropy became the basic concept of information theory and began to act as a measure of the uncertainty of a certain situation. In a sense, it is a measure of scattering, and in this sense, it is similar to dispersion. But if the dispersion is an adequate measure of scattering only for special probability distributions of random variables (for example, a normal Gaussian distribution), then the entropy does not depend on the type of distribution. The popularity of entropy is associated with its important properties: universality and additivity. For its part, the information turned out to be a characteristic of the degree of dependence of some variables. It can be compared with correlation, but if the correlation characterizes only a linear relationship of variables, information characterizes any connection. The type of connection can be any and unknown to the researcher.

Information can be considered as negative entropy. Then entropy and information look like concepts of the same level. However, this is not so: unlike entropy, information is a general scientific concept, approaching in its meaning to a philosophical category.

In this article, we will try to understand a difficult problem: if there is something in common between different types of information, or if they are completely different entities, misunderstood by the same name. Does technical information have anything to do with thermodynamic information, and if so, what kind of? Is there a connection between the Clausius-Kelvin thermodynamic entropy and the Boltzmann-Planck statistical entropy? In general, can entropy be a measure of chaos?

It is obvious that no one can answer these questions unambiguously. But once again it is useful to discuss.

The following stages of the formation of the entropy concept can be distinguished:

1865 - Rudolf Julius Clausius.

As part of the theory of thermal machines, the concept of entropy was introduced as a thermodynamic value. Entropy S is set by a dynamic equation through the speed of change of thermal energy Q and absolute temperature T.

$$d_t\, S = d_t Q \,/\, T, \tag{1}$$

1872 - Ludwig Boltzmann.

Entropy is introduced as a measure of a set W microstate of the thermodynamic system using a special constant K = $k=1.38x10^{-23}$ *J/g.K*.

$$S = -k \sum_i p_i (logp_i), \tag{2}$$

1902 - Josiah Willard Gibbs.

Entropy is introduced through the density distribution r (x), the probabilities of states over the phase space W of a statistic-physical system

$$S(X) = -\sum_{i=1}^{n} p(x_i)\, log_2(p(x_i)), \tag{3}$$

1948 - Claude Shannon.

The entropy of the discrete distribution of the PI probability is introduced on the set of alternative states and information, as a decrease in entropy upon receiving a message.

$$H = -\lambda \sum_{i=1}^{n} p_i lgp_i\,; \tag{4}$$

$$I = H_1 - H_2; \tag{5}$$

1953 - Alexander Yakovlevich Khinchin.

The Boltzmann's constant is introduced as mathematical normalization of the base of logarithms, regardless of the thermodynamic interpretation.

$$S = -k \sum_{i=1}^{n} P_i\, lnP_i, \tag{6}$$

1955 - Arthur Robert Mac.

Combinatorial interpretation of entropy, as a measure of a structured set of alternatives:$n = n_1 + n_2 + \cdots + n_m$

$$S = -k \sum_{i=1}^{m} (n_i/n)\, \text{In}\, (n_i/n), \tag{7}$$

1965 - Andrei Nikolayevich Kolmogorov.

Generalization of the entropy concept on ergodic random processes $u(t)$ through the limit probability distribution having a density $f(x)$.

$$S = -m_W f(x) logf(x) dx; f(x) = lim_{t\to I} Prob\{u(t) = x\}. \tag{8}$$

The work is taken in the partition algebra on W, as all possible intersections of the elements of the factors. Introducing the complexity measure of the symbolic sequence y = (y1, y2, ...), as the minimum specific (on the symbol) length of the program p, that generates it on the universal Turing machine.

$$S_\alpha(X) = \frac{1}{1-\alpha} log \sum_{i=1}^{n} p_i^\alpha = \frac{1}{1-\alpha} \langle p^{\alpha-1} \rangle \tag{9}$$

1970 - Henri de Régnier.

Introduction of entropy as b - moment of the partition measure.

$$S = (1-b)^{-1} \ln\left(\sum_{i=1}^{N} (n_i)\, b\right), \tag{10}$$

1999 - Alexander Moiseyevich Khazen.

The introduction of the entropy concept -information as a generalized action in mechanics with the energy function L on the phase space W. The Boltzmann constant depends on the level of the process. This is the generalization of R. Yu. Clausius's approach.

$$S = km_{[0;t]} L(W(t))dt, \tag{11}$$

2000 - Alexander Vladimirovich Koganov.

Introducing the complexity measure with a mathematical model A, as a set of numbers characterizing RI resources consumed in the implementation of the mathematical model on technical means. In case if the resource is the memory of computing means, we obtain variants of entropy formulas of A. R. Poppy and the complexity of A. N. Kolmogorov.

$$C = (R_1, \dots, R_M); R = R(A). \tag{12}$$

Entropy is entered as the complexity of a set of model states.

$$S = (R_1, \dots, R_M); R = R(stateA). \tag{13}$$

Information is measured by the complexity of the model restructuring, as a consequence of the received message.

$$I = (R_1, \dots, R_M); R = R(A|A'). \tag{14}$$

Statistical analysis

Correlation-regression analysis lies in the construction and analysis of a mathematical model in the form of a regression equation (correlation), which characterizes the dependence of a feature on the factors that determine it.

Correlation-regression analysis involves the following stages:

- preliminary analysis (here the main directions of the entire analysis are formulated, the methodology for assessing the effective indicator and the list of the most significant factors are determined);
- collection of information and its primary processing;
- building a model (one of the most important stages);
- evaluation and analysis of the model.

The tasks of correlation analysis are reduced to highlighting the most important factors that affect the effective sign, measuring the tightness of the relationship between the factors, identifying unknown reasons for the relationship and assessing the factors that have the maximum impact on the result.

The tasks of regression analysis are to establish the form of dependence, determine the regression equation and use it to estimate the unknown values of the dependent variable, predict the possible values of the effective attribute with the given values of the factor attributes.

Correlation analysis is a method of statistical research of experimental data, which allows to determine the degree of linear dependence between variables.

Pairwise linear correlation is the simplest correlation system, representing a linear relationship between two attributes. Its practical significance lies in the selection of one most important factor, which determines the variation of the effective feature.

To determine the degree of tightness of the paired linear relationship, the linear correlation coefficient, which was first introduced in the early 1890s, is used. Pearson, Edgeworth and Weldon. In theory, various versions of the formulas for calculating this coefficient have been developed and are applied in practice:

$$r = \frac{\overline{xy} - \bar{x} \cdot \bar{y}}{\sigma_x \sigma_y} = \frac{\sum (x - \overline{x})(y - \bar{y}}{n \sigma_x \sigma_y}; \quad (15)$$

$$\sigma_x = \sqrt{\frac{\sum (x - \bar{x})^2}{n}}; \qquad \sigma_y = \sqrt{\frac{(y - \bar{y})^2}{n}}, \quad (16)$$

where n is the number of observations.

With a small number of observations for practical calculations, it is more convenient to calculate the linear correlation coefficient using the following formula:

$$r = \frac{\sum XY - \frac{(\sum X) \cdot (\sum Y)}{n}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{n}\right) \cdot \left(\sum Y^2 - \frac{(\sum Y)^2}{n}\right)}}. \quad (17)$$

The term "regression" (derived from the Latin regression - retreat, return to something) was also introduced by Francis Galton in 1886.

If the resulting feature increases or decreases steadily with an increase in the factor feature, then such a relationship is linear and is expressed by the equation of a straight line.

Linear regression refers to finding an equation of the form:

$$y_x = a_0 + a_1 x + \varepsilon \quad (18)$$

This equation shows the average value of the change in the effective attribute x per one unit of its measurement. The parameter sign indicates the direction of this change. In practice, the construction of linear regression refers to estimating its parameters a_0, a_1.

RESULTS

The following software packages were used to analyze the data and develop regression models: Statistica, Minitab, MS Excel.

To define the criteria for our analysis, we identified informative signs that correlate with the main markers of anemia.

Table 1 shows the matrix of correlation coefficients. Figure 1. correlation coefficient diagram.

Research on iron deficiency anemia is mainly focused on anamnestic data and clinical laboratory examination, so we do not question the place of mathematical methods and the way of reconciling different points of view for a better understanding of anemia. We more accurately consider certain mathematical approaches through the creation of a mathematical tool for detecting difficulties in the diagnosis of anemia, which can be used by both pediatricians and IT specialists. These methods should facilitate exchanges between these two types of professionals by offering a general checklist of the difficulties in diagnosing anemia in children that each of them can use (for diagnosis and for therapeutic purposes). To develop this tool, we conducted a retrospective analysis of 130 anemic children. Anamnesis and clinical and laboratory parameters were reviewed. We have provided a variety of mathematical methods based on the type of the data being processed intended for the diagnosis of iron deficiency anemia.

Table 1

Correlation coefficient matrix

		C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
46	Fe	-0.04	-0.07	0.01	-0.23	-0.17	-0.15	0.14	-0.17	0.20	-0.03	-0.01	-0.12	-0.02	-0.07	0.18	0.22	0.13	0.04	-0.03	-0.14	-0.11	0.14	0.16	0.05	0.13	0.13	0.07	0.13	0.06	0.10	0.12	0.06	-0.01	0.27	0.3
47	Bilirubin	-0.11	-0.05	0.17	-0.12	0.00	-0.01	0.07	-0.02	-0.07	-0.06	-0.10	0.25	-0.05	0.02	0.12	0.15	-0.20	0.05	-0.04	0.26	0.28	0.21	0.01	0.21	0.06	0.09	0.12	0.05	0.11	0.05	0.13	0.02	0.11	0.22	0.2
48	Undirect	0.26	0.11	0.08	-0.02	0.04	0.16	-0.07	-0.03	0.11	-0.02	0.12	-0.14	0.00	-0.08	0.03	0.02	0.20	0.34	0.25	-0.09	-0.07	0.04	0.01	-0.01	-0.13	0.22	0.06	-0.10	0.02	0.39	-0.10	0.11	0.01	0.12	0.1
49	Direct	-0.13	-0.01	0.21	-0.03	0.05	-0.05	0.08	0.09	-0.17	-0.08	-0.20	0.17	-0.28	0.01	0.03	0.06	-0.13	0.10	0.05	0.22	0.23	0.16	-0.29	0.01	-0.03	-0.26	-0.27	-0.17	-0.08	-0.13	0.06	-0.09	0.02	0.28	0.2
50	LDG	0.04	-0.13	0.08	0.16	0.17	0.14	0.15	0.14	0.14	0.17	0.30	0.13	-0.05	0.10	0.11	0.17	-0.05	0.19	0.15	0.18	0.23	0.30	-0.09	-0.02	0.11	0.11	0.17	0.00	0.07	0.02	0.24	0.32	0.18	0.28	0.3
51	CRP	-0.15	-0.23	0.23	0.01	0.05	0.03	0.10	0.07	-0.03	0.12	0.03	0.03	-0.27	0.18	0.13	0.05	-0.03	-0.07	-0.08	0.01	0.00	0.04	0.02	0.46	0.32	0.10	0.12	0.14	0.25	0.09	0.28	0.20	-0.01	0.23	0.3
52	Total protein	-0.05	0.12	0.02	-0.02	0.00	-0.12	0.17	0.02	-0.04	0.23	-0.05	-0.05	-0.10	0.16	-0.05	0.04	0.04	0.03	0.01	-0.04	-0.01	0.14	-0.05	-0.05	0.06	0.13	0.06	0.06	0.17	0.14	-0.02	-0.03	-0.12	-0.06	-0.0

	A	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
1		Age	Sex	Sots.status	weight	height	breastfeeding	complementary foods	Abgar	S1	S2	UZI	Index Mentzera	Neu	Lym	Mon	Eos	RBC	HGB	HCT	MCV	MCH	MCHC	RDW-CV	RDW-SD	PLT	MPV	PDW	PCT	P-LCC	P-LCR	ALY%	LIC%	ESR	AlAt	
2	Age	1.00	0.14	-0.01	0.19	0.21	0.19	-0.07	0.11	0.35	0.28	0.22	-0.41	0.49	-0.43	0.03	-0.02	0.53	0.53	0.52	-0.34	-0.32	-0.14	0.13	-0.11	-0.29	-0.04	-0.20	-0.30	-0.13	0.21	-0.23	0.07	0.13	-0.19	-0.1
3	Sex	0.14	1.00	0.07	0.00	-0.02	0.07	-0.11	0.04	-0.05	0.04	0.04	0.14	-0.08	0.15	-0.45	-0.09	-0.10	0.17	0.16	0.17	0.17	0.06	0.00	-0.10	-0.01	0.04	-0.05	0.15	-0.01	0.09	-0.13	-0.30	0.10	-0.29	-0.3
4	Sots.status	-0.01	0.07	1.00	0.21	0.27	0.27	0.13	0.25	0.13	0.06	0.14	-0.01	-0.06	-0.04	0.03	-0.14	-0.01	-0.03	0.04	0.02	-0.03	-0.20	-0.08	0.16	0.29	-0.04	-0.03	0.10	0.21	0.01	0.00	0.15	0.23	0.06	0.1
5	weight	0.19	0.00	0.21	1.00	0.94	0.34	0.42	0.86	0.02	0.14	0.25	-0.05	-0.03	0.00	-0.13	0.02	0.06	0.14	0.18	0.02	-0.01	-0.16	-0.03	-0.04	-0.08	0.05	-0.05	-0.05	-0.01	0.13	-0.01	0.27	0.12	-0.04	-0.1
6	Hight	0.21	-0.02	0.27	0.94	1.00	0.41	0.38	0.91	0.06	0.14	0.31	-0.03	-0.07	0.04	-0.04	0.03	0.05	0.15	0.20	0.04	0.01	-0.17	-0.01	0.04	-0.11	0.06	-0.05	-0.06	-0.01	0.16	-0.04	0.28	0.15	0.00	-0.0
7	breastfeeding	0.19	0.07	0.27	0.34	0.41	1.00	-0.51	0.32	0.13	0.22	0.26	-0.01	-0.05	0.15	0.01	-0.09	0.01	0.15	0.19	0.06	0.01	-0.16	-0.01	0.18	-0.01	0.16	0.14	-0.04	0.18	0.20	0.02	0.10	0.12	0.02	-0.0
8	complementary foods	-0.07	-0.11	0.13	0.42	0.38	-0.51	1.00	0.32	0.00	-0.07	0.15	0.01	-0.07	-0.05	0.09	0.09	0.02	0.01	-0.02	-0.01	0.02	0.09	-0.08	-0.10	0.11	-0.11	-0.15	0.13	-0.08	-0.12	-0.07	0.12	-0.03	0.11	0.1
9	Abgar	0.11	0.04	0.25	0.86	0.91	0.32	0.32	1.00	-0.01	0.01	0.16	-0.03	-0.11	0.02	-0.10	0.05	0.04	0.07	0.14	0.03	0.00	-0.19	0.05	0.03	-0.12	0.03	-0.10	-0.10	-0.05	0.16	0.02	0.28	0.15	-0.05	-0.0
10	S1	0.35	-0.05	0.13	0.02	0.06	0.13	0.00	-0.01	1.00	0.07	0.20	-0.31	0.11	-0.10	0.09	0.14	0.38	0.09	0.16	-0.34	-0.31	-0.01	0.29	-0.13	-0.06	0.10	-0.02	0.07	-0.02	0.16	-0.20	0.01	0.10	0.18	0.2
11	S2	0.28	0.04	0.06	0.14	0.14	0.22	-0.07	0.01	0.07	1.00	0.27	-0.10	0.15	0.02	0.04	-0.17	0.13	0.31	0.29	0.00	0.02	0.08	-0.01	0.13	-0.03	0.14	0.14	-0.09	0.05	0.08	-0.12	0.02	0.14	0.08	-0.1
12	UZI	0.22	0.04	0.14	0.25	0.31	0.26	0.15	0.16	0.20	0.27	1.00	-0.08	0.00	0.13	-0.10	0.09	0.12	0.22	0.19	-0.03	-0.03	0.02	0.00	0.10	0.01	0.11	0.11	0.19	0.09	0.11	-0.20	0.00	-0.08	-0.03	0.0
13	Index Mentzera	-0.41	0.14	-0.01	-0.05	-0.03	-0.01	0.01	-0.03	-0.31	-0.10	-0.08	1.00	-0.28	0.34	0.00	-0.13	-0.95	-0.14	-0.35	0.94	0.92	0.57	-0.38	0.18	0.22	0.10	0.19	0.17	0.29	-0.04	0.14	0.04	-0.03	-0.02	-0.0
14	Neu	0.49	-0.08	-0.06	-0.03	-0.07	-0.05	-0.07	-0.11	0.11	0.15	0.00	-0.28	1.00	-0.76	0.09	-0.01	0.23	-0.04	-0.07	-0.34	-0.33	-0.17	0.35	0.00	-0.06	0.10	0.13	-0.07	-0.07	0.02	0.00	0.31	0.22	-0.31	-0.3
15	Lym	-0.43	0.15	-0.04	0.00	0.04	0.15	-0.05	0.02	-0.10	0.02	0.13	0.34	-0.76	1.00	-0.19	-0.08	-0.32	-0.03	0.01	0.39	0.36	0.17	-0.28	0.09	0.05	0.11	0.21	0.13	0.22	0.00	0.12	-0.23	-0.31	0.13	0.2
16	Mon	0.03	-0.45	0.03	-0.13	-0.04	0.01	0.09	-0.10	0.09	0.04	-0.10	0.00	0.09	-0.19	1.00	0.08	0.00	-0.06	-0.09	-0.04	-0.04	-0.08	0.16	0.16	0.24	0.05	0.03	0.14	0.16	0.06	-0.02	0.05	0.09	0.26	0.1
17	Eos	-0.02	-0.09	-0.14	0.02	0.03	-0.09	0.09	0.05	0.14	-0.17	0.09	-0.13	-0.01	-0.08	0.08	1.00	0.12	-0.15	-0.15	-0.21	-0.18	-0.04	0.23	0.01	0.07	0.02	0.01	0.12	-0.07	0.00	-0.16	-0.16	-0.02	0.11	0.1
18	RBC	0.53	-0.10	-0.01	0.06	0.05	0.01	0.02	0.04	0.38	0.13	0.12	-0.95	0.23	-0.32	0.00	0.12	1.00	0.35	0.53	-0.84	-0.81	-0.42	0.30	-0.22	-0.27	-0.01	-0.14	-0.17	-0.26	0.16	-0.16	-0.03	0.06	0.03	0.1
19	HGB	0.53	0.17	-0.03	0.14	0.15	0.15	0.01	0.07	0.09	0.31	0.22	-0.14	-0.04	-0.03	-0.06	-0.15	0.35	1.00	0.90	0.15	0.20	0.33	-0.23	-0.15	-0.32	0.06	-0.03	-0.24	-0.23	0.13	-0.02	-0.01	0.20	0.04	0.0
20	HCT	0.52	0.16	0.04	0.18	0.20	0.19	-0.02	0.14	0.16	0.29	0.19	-0.35	-0.07	0.01	-0.09	-0.15	0.53	0.90	1.00	-0.05	-0.02	0.06	-0.15	-0.20	-0.38	-0.08	-0.15	-0.34	-0.31	0.05	0.00	-0.02	0.17	-0.01	0.0
21	MCV	-0.34	0.17	0.02	0.02	0.04	0.06	-0.01	0.03	-0.34	0.00	-0.03	0.94	-0.34	0.39	-0.04	-0.21	-0.84	0.15	-0.05	1.00	0.99	0.62	-0.45	0.15	0.12	0.10	0.20	0.09	0.20	-0.05	0.19	0.02	0.07	-0.02	-0.0

Discussion

After the procedure of correlation analysis and identification of informative signs, in addition to the main markers of anemia, a regression analysis has been carried out to determine the type of relation between these signs and entropia of the main diseases: iron deficiency anemia and β-thalassemia. Hemoglobin, erythrocytes, hematocrit and Mentzer index have been considered as the main markers. The Mentzer index is the main marker in the differential diagnosis of iron deficiency anemia and β-thalassemia. Therefore, the attention has been paid to obtaining a reliable and adequate regression model reflecting the relation between entropia and the main markers of anemia.

Below are the results of the performed regression analysis. Thus, we try based on experimental data, to establish a connection between Shannon's entropy and Boltzmann's entropy.

The regression analysis procedure has been carried out with the Statgraphics software package.

Multiple Regression - S1

Dependent variable: S1

Independent variables:

MCH

Index Mentzera

Parameter	*Estimate*	*Standard Error*	*T Statistic*	*P-Value*
MCH	0.256	0.0241	10.61	0.0000
Index Mentzera	-0.189	0.034	-5.6	0.0000

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	641.261	2	320.63	723.75	0.0000
Residual	29.682	67	0.44301		
Total	670.942	69			

R-squared = 95.58 percent

R-squared (adjusted for d.f.) = 95.5 percent

Standard Error of Est. = 0.67

Mean absolute error = 0.54

The StatAdvisor

The output shows the results of fitting a multiple linear regression model to describe the relationship between S1 and 2 independent variables. The equation of the fitted model is

S1 = 0.256185*MCH - 0.189914*Index Mentzera

Further ANOVA for Variables in the Order Fitted

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
MCH	627.371	1	627.371	1416.15	0.0000
Index Mentzera	13.89	1	13.89	31.35	0.0000
Model	641.26	2			

95.0% confidence intervals for coefficient estimates

Parameter	*Estimate*	*Standard Error*	*Lower Limit*	*Upper Limit*
MCH	0.257	0.0242	0.208	0.3044
Index Mentzera	-0.189	0.0339	-0.258	-0.122

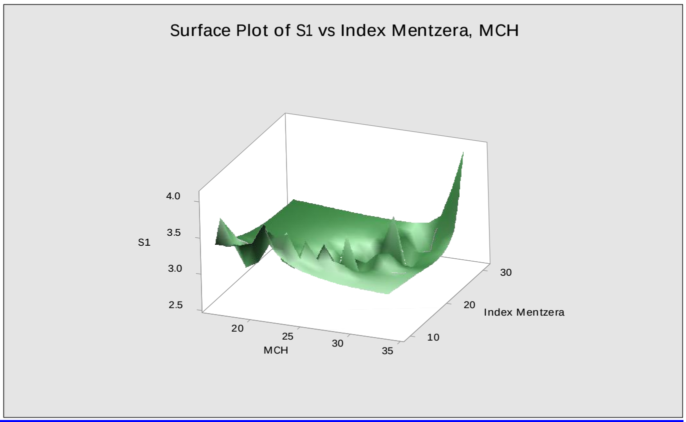

Fig.1. Surface of S1vs Index Mentzera, MCH

Or

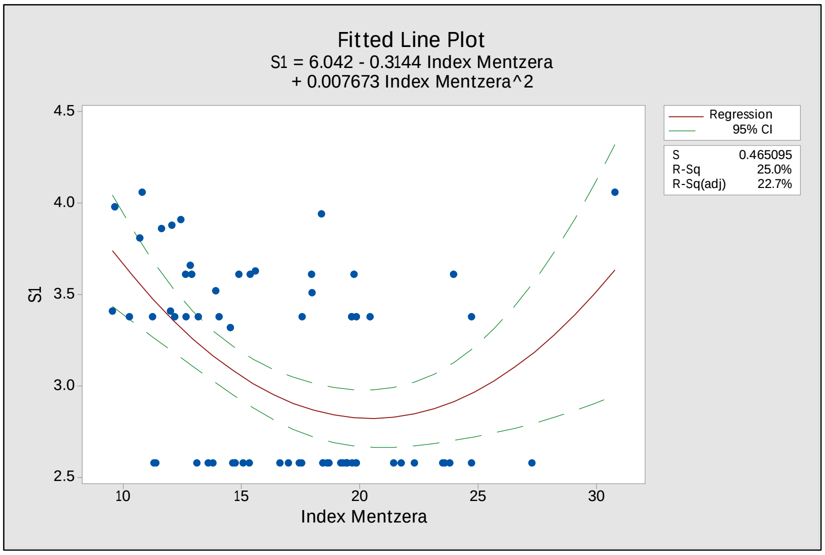

Fig.2. Polynomial dependence of entropy on the mentzer index

Polynomial Regression Analysis: S1 versus Index Mentzera

The regression equation is
S1 = 6.042 - 0.3144 Index Mentzera + 0.007673 Index Mentzera^2
S = 0.465095   R-Sq = 25.0%   R-Sq(adj) = 22.7%
Analysis of Variance

Source	SS	MS	F	P
Regression	4.75	2.375	10.98	0.000
Error	14.28	0.216		
Total	19.03			

Sequential Analysis of Variance

Source	SS	F	P
Linear	1.88	7.35	0.009
Quadratic	2.87	13.27	0.001

Fitted Line: S1 versus Index Mentzera

The higher the value of the Mentzer index, the lower the value of Shannon's entropy.

Conclusions

There is no single optimal marker or combination of tests for the differential diagnosis of anemia. The knowledge and experience of the physician requiring appropriate hematological and biochemical analysis related to the preliminary diagnosis play an important role in the diagnosis of anemia. It is recommended to use algorithms as a tool for detecting anemia to reduce the number of laboratory tests and accurately diagnose the underlying cause (s) in patients.

Over the past decade, significant progress has been made in the procedures and algorithms for the differential diagnosis of anemia. A complete blood count is the main procedure for examining anemia. At the first stage, the percentage of microcytic erythrocytes is taken into account. The second step is to check the number of MCVs, RDWs and RBCs.

The main goal of this research was to study the effectiveness of the implementation of the anemia diagnosis strategy by mathematical methods.

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