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THE APPLICATION OF THE THEORY OF FRACTALS FOR STUDYING THE REGULARITIES OF FORMING THE INFOSPHERE OF TRAINING APPLICANTS FOR NURSING SPECIALITIES

O. V. Voznyuk[*], E. F. Malinovsky[**], V. V. Svyrydiuk[***]

The research stems from challenges which are characteristic of contemporary post-industrial, information and technological stage of development of human civilization. With respect to the initiation of training Masters of nursing in Ukraine a great importance is attributed to the research component of the professional competence of nurses with higher education, i.e. Masters of nursing. Taking into account the insufficient theoretical and methodical status of the problem, the researchers aim their study at developing a new approach to forming the infosphere of nursing as a research speciality on the basis of the theory of fractals. To achieve the goal the authors have used the content analysis of Master's theses of 150 Masters in accordance with 112 indices, Hurst index calculation included. The calculated Hurst index values testify to a high level of structural organization of Master's theses, as well as to certain regularities in using information sources in contrast with chaos and the absence of prevailing tendencies. The use of information sources which were referred to by the students of Master's course for conducting research and writing Master's theses, as well as the application of the techniques of content-analysis and scientific prognostication have made it possible to determine a number of tendencies in forming the infosphere of nursing as a research speciality. One can observe a pronounced tendency to decreasing the use of paper media as information sources, as well as the tendency to increasing the part of electronic media and the part of information sources in foreign languages. Among the information sources in foreign languages, in comparison with Russian English sources, prevail considerably. The study does not cover all aspects of the mentioned pedagogical problem since the further prospects for studying relates to the analysis of the quantity and quality of intellectual property objects created by the

[*] Doctor of Sciences (Pedagogy), Professor
(Zhytomyr Ivan Franko State University)
alexvoz@ukr.net
ORCID: 0000-0002-4458-2386

[**] Candidate of Philological Sciences (PhD in Philology), Assistant Professor
(S.P. Korolyov Zhytomyr Military Institute)
emalinovsky7@gmail.com
ORCID: 0000-0001-7262-5585

[***] Candidate of Pedagogical Sciences (PhD in Pedagogy), Assistant Professor
(S.P. Korolyov Zhytomyr Military Institute)
sviridyuk.vasil@gmail.com
ORCID: 0000-0003-4453-5974

Masters enabling to formulate scientometric criteria for assessing the significance of scientific research of the Masters, thus revealing their ability to create the objects of intellectual property.

Key words: *information sources, electronic media, nursing, Master of nursing, scientometrics technologies, Hurst indext, infosphere, fractality (self-similarity).*

ВИКОРИСТАННЯ ТЕОРІЇ ФРАКТАЛІВ ДЛЯ ВИВЧЕННЯ ЗАКОНОМІРНОСТЕЙ ФОРМУВАННЯ ІНФОРМАЦІЙНОГО ПРОСТОРУ ПІДГОТОВКИ ЗДОБУВАЧІВ МЕДСЕСТРИНСЬКИХ СПЕЦІАЛЬНОСТЕЙ

О. В. Вознюк, Е. Ф. Маліновський, В. В. Свиридюк

Дослідження випливає із викликів, характерних для сучасного постіндустріального, інформаційно-технологічного етапу розвитку людської цивілізації. Щодо започаткування підготовки магістрів сестринської справи в Україні велике значення надається дослідницькій складовій професійної компетентності медичних сестер з вищою освітою, тобто магістрів сестринської справи. Враховуючи недостатній теоретико-методичний статус проблеми, дослідження спрямоване на розробку нового підходу до формування інфосфери медсестринства як наукової спеціальності на основі теорії фракталів. Для досягнення поставленої мети автори використали контент-аналіз магістерських дисертацій 150 магістрів за 112 індексами, включаючи розрахунок індексу Херста. Розраховані значення індексу Херста свідчать про високий рівень структурної організації магістерських дисертацій, а також про певні закономірності використання джерел інформації на відміну від хаосу та відсутності переважаючих тенденцій. Використання інформаційних джерел, на які посилалися студенти магістратури для проведення досліджень та написання магістерських дисертацій, а також застосування прийомів змістовного аналізу та наукового прогнозування дозволили визначити низку тенденцій формування інфосфери медсестринства як наукової спеціальності. Спостерігається яскраво виражена тенденція до зменшення використання паперових носіїв інформації як джерела інформації, а також тенденція до збільшення частки електронних ЗМІ та частини джерел інформації іноземними мовами. Серед інформаційних джерел іноземними мовами в порівнянні з російською значно переважають англійські джерела. Дослідження не охоплює всіх аспектів зазначеної педагогічної проблеми, оскільки подальші перспективи вивчення пов'язані з аналізом кількості та якості створених магістрами об'єктів інтелектуальної власності, що дає змогу сформулювати наукометричні критерії оцінки значущості наукових досліджень наукової галузі студентів магістратури, виявляючи тим самим свою здатність створювати об'єкти інтелектуальної власності.

Ключові слова: *джерела інформації, електронні засоби масової інформації, сестринська справа, магістр медсестринства, наукометричні технології, індекс Херста, інфосфера, фрактальність (самоподібність).*

Introduction of the issue. At the beginning of the 21st century, Ukraine found itself in the period of trial. A rapid advance in science and engineering, the introduction of newest computer technologies into production, education and everyday life, as well as urbanization, economic cataclysms, international terrorism, geopolitical instability, manifestations of regional separatism, a high level of population migration – this is just a brief list of challenges which are characteristic of contemporary post-industrial, information and technological stage of development of human civilization. The above challenges are very hard to cope with in a separate country. Hence, as an answer to these global challenges, the progressive part of the Ukrainian society proclaimed the mainstreaming policy towards the European integration. Hence the researchers' attention is to be focused on fundamental universal

human values which are based on competence, intellectual property, research potentials of the country and training of a competitive personality [10].

Current state of the issue. Beginning from 2008, and as far as the training of masters of nursing in Ukraine is concerned, a great importance is attached to substantiating the process of forming the information environment of Nursing as a scientific speciality. The entire process is based on the information and communicative competence of Masters which is closely connected with the information and computer technologies and scientometrics that deal with studying the communicativeness of researchers and the quantitative evaluation of validity of research results according to citation indices.

At large, the scientific research while dealing with various aspects of communication in science and technology, deals also with the quantitative measurement of scientific results thus developing new approaches to quantitative assessment of the value of a scientific component, specifically in higher professional education. In this respect, Derek John de Solla Price believes, that evaluating scientific productivity, one cannot measure what one would like, but only that which is probable and possible [5; 6].

So, one of the main problems of the Masters' professional training in the higher educational establishments is connected with forming the scientific communicative competence in the Masters due to the quality of their scientific research. And this can be achieved by means of innovative scientometrics technologies [1; 2; 9; 5-7], particularly in the sphere of quantitative measurement [6] made on the basis of the theory of fractals [2].

Outline of unresolved issues brought up in the article. Taking into account the insufficient theoretical and methodical status of the problem, we can state that some questions concerning the quantitative measurement by means of scientometrics of the results of the conducted research presented in the Master's theses still remain unsolved. Specifically, we aim our study at developing a new approach to forming the infosphere of nursing as a research speciality on the basis of the theory of fractals being the newest perspective of scientific research.

Aim of the research. The analysis of the research and practical activities of higher educational establishments where Masters of nursing are trained testifies to the insufficient investigation into training Masters in this speciality. Hence, the research under study is aimed at elaborating new approaches to studying the regularities of shaping Nursing as a research speciality.

Results and discussion. In order to succeed, we use the method of content-analysis of Master's theses of 150 Zhytomyr medical institute graduates that were written and defended within 10 years beginning with 2010. With this in view, 150 theses were formalized (digitalized) according to 112 indices.

The formalized indices were put into the table of Excel for Windows Professional table which made them available for the correlation and content-analysis using the Excel and statisticl programs of statistical data processing.

At present, the majority of researchers consider the information infosphere to be a stochastic one possessing all characteristic features of fractality [3; 4; 8].

The fractality (self-similarity) of the infosphere lies in the fact that under the avalanche-like increase in the information amount, the distribution of its media according to such characteristics as sources, authors, subjects do not practically change its form. The application of the theory of fractals for analyzing the infosphere of research publications makes it possible to reveal some regularities.

At present, the issue-related information volumes are actually

considered as self-similar formations capable of self-development. They are typical stochastic fractals, since their self-similarity, for instance the distribution of information clusters by their dimensions, coincides with the mathematically calculated expectations and is used for revealing the regularities from among the multiplicity of empirical data. Chaos postulation as an integral creative dynamic moment of the reality which can be self-organized (order and disorder are inseparable from each other) can be manifested at the present stage of the theory of fractals for analyzing chaos with the aim of looking for regularities, and Hurst index is used for calculating the probability of various trends which describe and prognosticate the dynamics of processes in time [9].

We suggest using the research strategy of the content-analysis of fractality of the dynamics rows through equalizing them according to the least square method with the aim of assessing the extrapolation indices for the next 2 or 3 years.

Table 1 suggests the list and specific weight of the information sources used by Masters of Nursing of Zhytomyr Medical institute for writing their Master's theses.

Table1

The structure of information sources which were used by Masters of Nursing when writing their Master's theses

Sequence No.	Name of Source	Absol.	M±m, %
1	Electronic internet resources	3611	21,5±0,3
2	Periodical research publications (journals)	3044	18,1±0,3
3	Collections of writings(abstracts and articles) of scientific and practical conferences, congresses, meetings, symposia and other scientific forums	2690	16,0±0,3
4	Monographs	1310	7,8±0,2
5	Reference books, encyclopedias, defining dictionaries	956	5,7±0,2
6	Regulatory acts of legislation (Laws of Ukraine, Resolutions of the Cabinet of Ministers, Orders of sectoral ministries	743	4,4±0,2
7	Master's theses	566	3,4±0,1
8	Standards (sectoral educational and industrial standards in rendering services	531	3,2±0,1
9	Dissertations	431	2,6±0,1
10	Textbooks	425	2,5±0,1
11	Dissertation extended abstracts	390	2,3±0,1
12	Reports on research practice	389	2,3±0,1
13	Instructional guidelines with visas of sectoral ministries	354	2,1±0,1
14	Domestic and foreign statistic publications	319	1,9±0,1
15	Manuals	248	1,5±0,1
16	Archival records	177	1,1±0,1
17	Patents for inventions and utility models and other patent and information documents and publications	142	0,8±0,1
18	Diploma papers	110	0,7±0,1
19	Abstract periodicals	107	0,6±0,1
20	Government reports	106	0,6±0,1
21	Mass media (newspapers, magazines, brochures etc.)	71	0,5±0,1
22	Commercial and business information (sale sheets etc.)	70	0,5±0,1
23	Resolutions of scientific and practical conferences, congresses, symposia, and other scientific forums.	35	0,2±0,1
24	Total	16825	100,0±0,0

In total, when writing their Master's theses 150 Masters of nursing have referred to 16825 various information sources which in average amounts to

112,1±1,8 sources per Master's paper. Most often Masters have referred to internet resources, articles in scientific journals, abstracts and articles in the proceedings of scientific and practical conferences, meetings, congresses, symposia and other scientific forums. The part of these three basic information sources totals 55,6±0,4% as compared to all sources used. Along with it, the prospective Masters have used 12147 (72,2±0,3%) of references in the Ukrainian language and 4678 (27,8±0,3%) in foreign languages. In its turn, among 4678 foreign language sources, those written in Cyrillic script (mostly Russian) amounted to 2540 (15,1±0,5%) and 2138 (12,7±0,5%) – in Latin (mostly English).

Table 2 presents the main indices of using information sources by Masters.

Table 2

The dynamics of using information sources by Masters

Index title	Years								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Quantity of Master's theses defended	19	14	24	13	14	23	12	16	15
Average quantity of information sources used	115,1	102,4	116,2	98,5	110,6	112,3	115,9	103,4	117,6
Share of sources in Ukrainian, %	90,4	73,9	76,7	80,4	75,9	87,5	71,6	80,3	70,6
Share of sources in foreign language, %	9,6	26,1	23,3	19,6	24,1	12,5	28,4	19,7	29,4
Share of foreign sources in Cyrillic script, %	5,6	15,9	11,0	9,5	9,8	5,3	8,2	6,4	5,8
Share of foreign sources in Latin, %	4,0	10,2	13,3	10,1	14,3	17,2	20,2	13,3	23,6
Share of electronic information sources, %	15, 4	18, 6	16,8	22,6	20,3	23,1	19,9	26,7	22,2

According to the data of table 2 it appears difficult to determine the regularity of using various research information sources by Masters of nursing.

The traditional illustration method, i.e. the graphic presentation of the dynamics of indices, also makes it impossible to see a distinct regularity or tendency (Fig.1)

When using the content-analysis of fractality of dynamics rows, one can determine the prevailing tendency (trend), carry out the extrapolation; and applying Hurst index calculation one can assess the probability of using research information sources by Masters of nursing prognosticated for 2019, 2020 and 2021. Table 3 presents the distribution of Master's works according to the average quantity of information sources used depending on the year of defence.

According to table 3 data we have constructed a graph related to the dynamics of the average quantity of the information sources used in Master's theses depending on the defence year (fig.2).

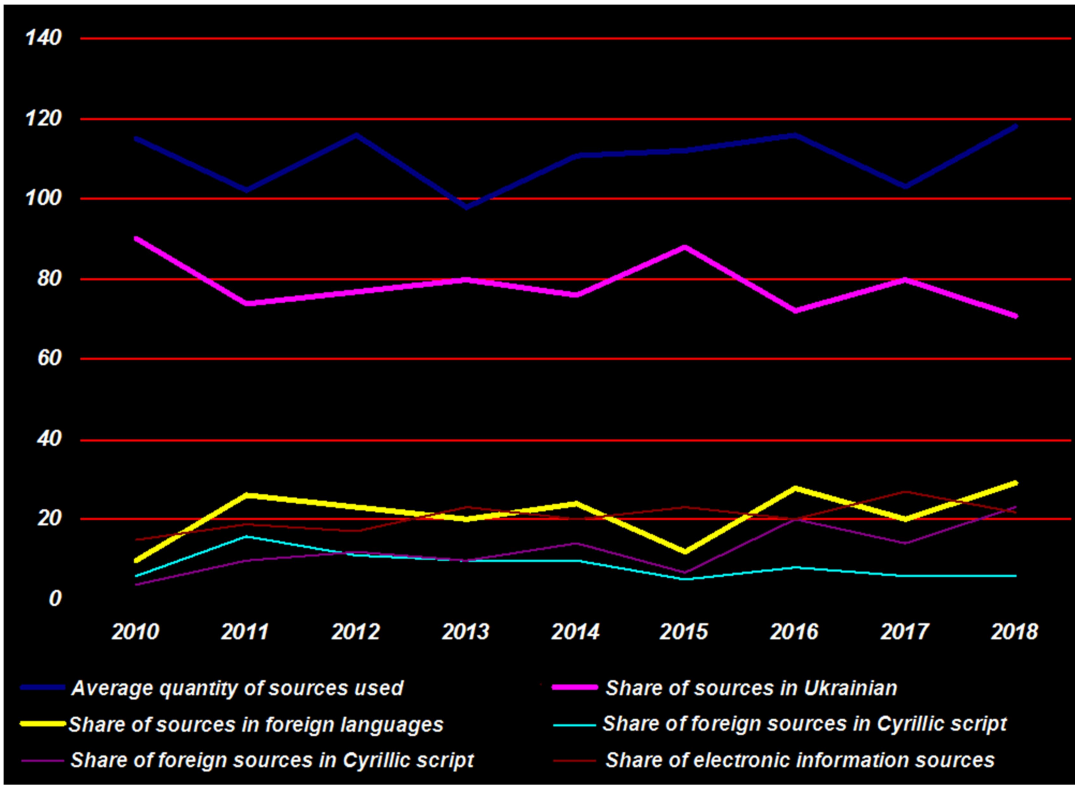

Fig. 1. The dynamics of using various research information sources by Masters of nursing

Table 3

The distribution of the quantity of the information sources used in Master's theses depending on the defence year

Defence year	Quantity of theses defended		Average quantity of the information sources used depending on the defence year, M±m
	Absolute quantity of master's theses defended	Part M±m, %	
2010	19	12,7±3,0	115,1
2011	14	9,3±2,6	102,4
2012	24	16,0±3,3	116,2
2013	13	8,7±2,5	98,5
2014	14	9,3±2,6	110,6
2015	23	15,3±3,2	112,3
2016	12	8,0±2,4	115,9
2017	16	10,7±2,9	103,4
2018	15	10,0±2,8	117,6

With the aim of determining the prevailing tendency we have used the technique of equalizing the rows of the dynamics according to the least square method. Table 4 presents the initial data for using the above technique. We have completed Table 4 with the initial data according to the algorithm presented below.

The course of calculations (algorithm) for completing table 4:

1. Year 2014 is assumed as the median.

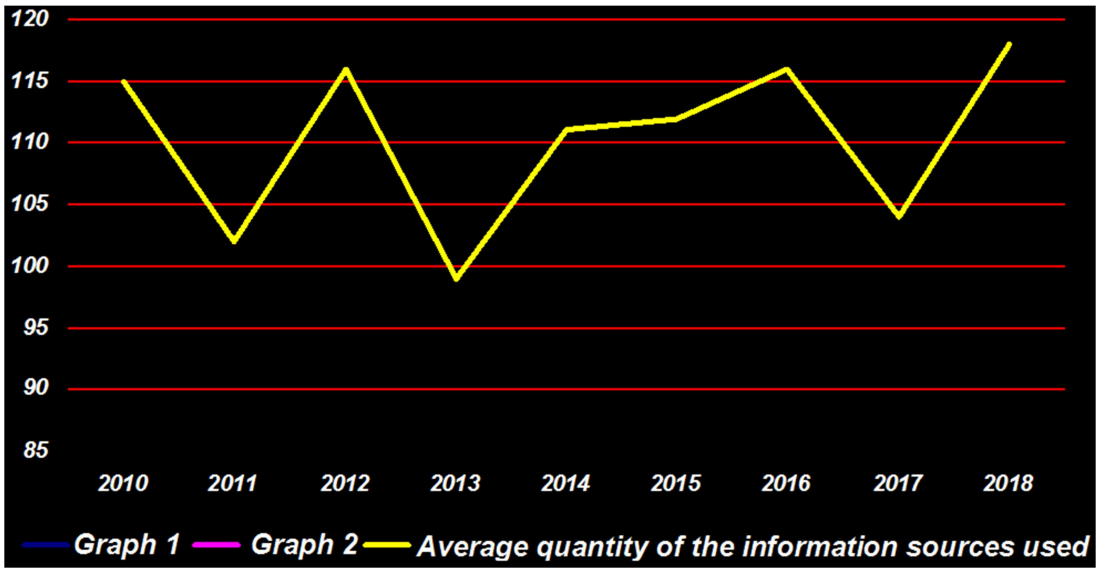

Fig. 2. The graph of the dynamics of the average quantity of the information sources used per thesis depending on the defence year

2. The constant value (A_0) is determined according to formula 1:

$$A_0 = \frac{\sum Y}{n} = \frac{991,8}{9} = 110,2 \quad \text{(Formula 1)}$$

3. The sum of values is determined in XУ column. The values of columns X and У are multiplied together and summarized. The sum $\Sigma_{yx} = 26,2$

4. The values in column X are raised to the square, thus obtaining the values of the data in column X^2. When summarizing the values in column X^2, we obtain the sum: $\Sigma X^2 = 60$.

5. We are calculating the second constant value (A_1) according to the formula 2:

$$A_1 = \frac{\sum YX}{\sum X^2} = \frac{26,2}{60} = 0,44 \quad \text{(Formula 2)}$$

Table 4

The initial data for trending with the average quantity of the information sources used in Master's theses with the interval of 9 years and the prediction for 3 consecutive years

Years	Average value of the number of pages, У	Conditional time, X	XУ	X^2	Equalized data, $У_x$
2010	115,1	-4	-460,4	16	108,4
2011	102,4	-3	-307,2	9	108,9
2012	116,2	-2	-232,4	4	109,3
2013	98,5	-1	-98,5	1	109,8
2014	110,6	0	0	0	110,2
2015	112,3	1	112,3	1	110,6
2016	115,9	2	231,8	4	111,1
2017	103,4	3	310,2	9	111,5
2018	117,6	4	470,4	16	112,0
n =9	**Σ_y = 991,8**		**Σ_{yx} = 26,2**	**ΣX^2 = 60**	
2019		5			112,4
2020		6			112,8
2021		7			113,3

6. We are calculating the equalized data of the dynamics row according to Formula 3:

$Y_x = A_0 + A_{1X}$ (Formula 3):

$У_1$ = 110,2 + (0,44) · (-4) = 108,4
$У_2$ = 110,2 + (0,44) · (-3) = 108,9
$У_3$ = 110,2 + (0,44) · (-2) = 109,3
$У_4$ = 110,2 + (0,44) · (-1) = 109,8
$У_5$ = 110,2 + (0,44) · 0 = 110,2
$У_6$ = 110,2 + (0,44) · 1 = 110,6
$У_7$ = 110,2 + (0,44) · 2 = 111,1
$У_8$ = 110,2 + (0,44) · 3 = 111,5
$У_9$ = 110,2 + (0,44) · 4 = 112,0

On this stage we have got 9 values for constructing the equalized row of the dynamics, i. e. of the trend. The consecutive 3 values will be obtained by means of extrapolating the trend for the subsequent years: 2019. 2020 and 2021.

$У_{10}$ = 110,2 + (0,44) · 5 = 112,4
$У_{11}$ = 110,2 + (0,44) · 6 = 112,8
$У_{12}$ = 110,2 + (0,44) · 7 = 113,3

Using the values of Table 4 we are constructing two graphs: the empirical and the equalized one (trend-oriented, prognosticating), Fig. 3.

In figure 3 one can precisely observe the prevailing tendency (trend) towards increasing the average quantity of the information sources in Master's theses. With respect to a certain likelihood ratio we can prognosticate that the mean value of the quantity of the information sources in Master's theses to be defended in 2019, 2020, 2021 will amount, in average, to 112.4, 112.8, 113.3 information sources per master's thesis respectively.

To prove the prognostication probability we will use the Hurst index calculation.

Hurst index is a measure of persistency, i.e. the process tendency to trends as distinct from the chaotic movement. Hurst index is the degree index in formula 4.

$$\frac{\Re}{\sigma} = \left(\frac{N}{2}\right)^H \qquad \text{(Formula 4)}$$

where: H – Hurst index; R – variation range (interval), in our case the range of variation of the quantity of the information sources amounts to 19,1; σ – mean square deviation (sigma), in our case sigma amounts to 7,0; N – number of years taken as a basis when equalizing the row of the dynamics; in our case – 9 years.

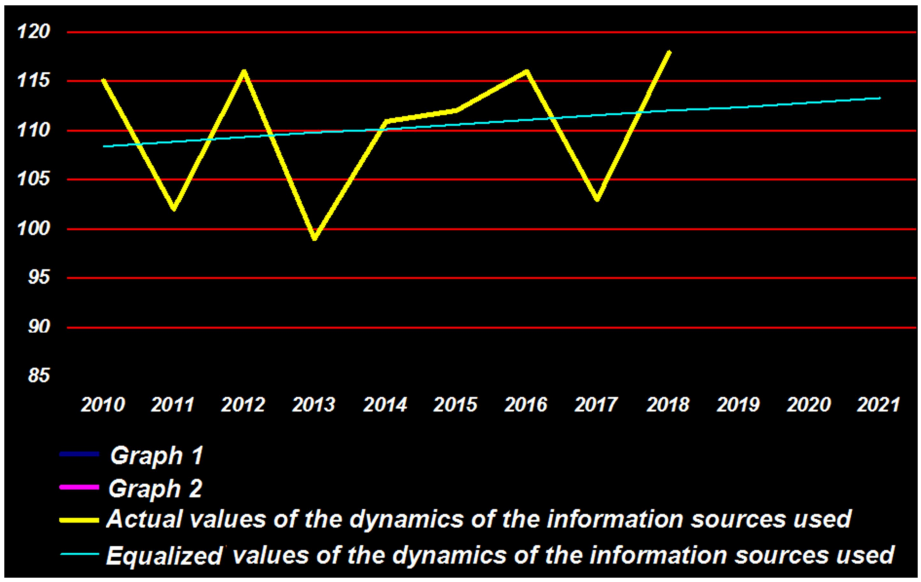

Fig. 3. Actual and equalized dynamics of the average quantity of the information sources within 9 years

Having solved the equation, we obtain the value of Hurst index which equals 0,670.

$$\frac{\Re}{\sigma} = \left(\frac{N}{2}\right)^{H} \frac{19,1}{7,0} = 2,73$$

$$2,73 = 4,5^{H}$$

$$H = \log_{4,5} 2,73 = 0,670$$

The value of Hurst index which equals ½ proves marginal. All values which are less than ½ testify to the low prognostication probability. Hurst index which is approaching to zero testifies to the absence of the prevailing tendency (trend), and the quantities analyzed take on random values. The values of H which are bigger than ½ are focused on a certain direction of the dynamics of the process in the past and have a high probability of extending the dynamics in the same direction in future. The larger the value of Hurst index exceeding ½ is, the higher the prognosticating probability.

The technique of equalizing the dynamics graphs makes it possible to use other time intervals as well. Table 5 presents the value of Hurst index and prognosticated values of the quantity of the information sources used depending on the duration of the interval (3, 5, 7 and 9 years), according to which the equalizing of the dynamics rows and the calculations of the prognostication probability were made. Among the four intervals analyzed the value of Hurst index for the 3-year-long interval proves most probable. Consequently, in 2019, 2020 and 2021 the average quantity of the information sources per Master's thesis will amount to 113,6, 114,3, and 114,9 respectively.

Table 5

The value of Hurst index and prognosticated values of the average quantity of the information sources depending on the interval according to which the equalizing of the rows of the dynamics and the prognostications were made

Name of index	Intervals according to which the equalizing of the rows of the dynamics were made, years			
	3	5	7	9
Hurst index	1,490	1,026	0,800	0,670
Prognosticated values of the average quantity of the information sources used				
2019	113,6	113,5	113,4	112,4
2020	114,3	114,0	114,1	112,8
2021	114,9	114,5	114,7	113,3

Similar calculations were made for other indices concerning using the information sources by Masters of nursing: part of the sources were in foreign languages, part of the sources – in electronic information media, etc.

One can observe a pronounced tendency towards the rapid increase in the part of the information sources in foreign languages used by Masters of nursing. Among the information sources used in English there exists a more pronounced tendency towards the increase in the specific weight (part) of English references. Instead, the part of references written in the Cyrillic script (Russian) is decreasing. One can also observe a regular tendency towards the increase in the use of publications in paper media and the increase of the part of electronic media by masters of nursing.

These are the most characteristic regularities of forming the infosphere of nursing as a research specialty by young researchers of Zhytomyr medical institute.

Conclusions and research perspectives.

1. By large, working at the Master's theses 150 Masters of nursing referred to 16825 different information sources which at average amounts to 112,1±1,8 sources per Master's thesis. Most cited

were internet-resources, papers in research journals, as well as abstracts and articles in the proceedings of scientific and practical conferences, congresses, meetings, symposia, and other scientific forums. In total, the part of these three information sources amounts to 55,6±0,4% of all sources cited. Besides, future Masters used 12147 (72,2±0,3%) research sources in Ukrainian and 4678 (27,8±0,3%) – in foreign languages. In its turn, among 4678 foreign sources, 2540 (15,1±0,5%) were written in Cyrillic script (mostly in the Russian language) and 2138 (12,7±0,5%) – in Roman letters (mostly in English).

2. The use of the information sources referred to by students of the Master's course, when writing Master's theses, the technique of the content-analysis have made it possible to determine a series of tendencies in forming the infosphere of the research speciality of "Nursing".

3. It has been established that the calculated Hurst index values testify to a high level of structuredness of Master's theses, as well as to the availability of certain regularities of using the information sources by Masters of nursing as opposed to chaos and the absence of prevailing tendencies.

4. In particular, there exists a regular tendency towards the decrease in the use of paper media as information sources by Masters of nursing, as well as the corresponding increase in the part of electronic information sources.

5. One can also observe the tendency towards increasing the part of information sources in foreign languages used by Masters of nursing. Among the information sources used in foreign languages the part of references in English is increasing rapidly, whereas the part of Russian references used is decreasing.

The study does not highlight all aspects of forming the infosphere of nursing as a research speciality. The further aspect for studying relates to the analysis of the quantity and quality of intellectual property objects created by the Masters that enables to formulate scientometric criteria for assessing the significance of scientific research of the Masters, thus revealing their ability not only to create the objects of intellectual property, but also to present these objects to the international scientific community by means of scientometric web-network, to promote them on the market of intellectual property.

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