DOI: 10.29141/2218-5003-2022-13-4-5 **EDN:** MOLSIV
JEL Classification: C00, I10

The role of socio-economic and scientometric indicators in the cancer mortality rate

Shushanik A. Sargsyan[1], Parandzem M. Hakobyan[1], Ruzanna A. Shushanyan[1], Aram R. Mirzoyan[1], Viktor A. Blaginin[2]

[1] Institute for Informatics and Automation Problems, National Academy of Sciences of the Republic of Armenia, Yerevan, Republic of Armenia
[2] Ural State University of Economics, Ekaterinburg, Russia

Abstract. Scientific research in the field of healthcare contributes to solving not only medical, but also economic and social issues. One of the latest trends is the growing interest in evaluating the effectiveness of research conducted. In the current study, we have hypothesized that science contributes to the reduction of the Cancer Mortality Rate (CMR) by making awareness about and bringing attention to this disease. The purpose of our investigation is to study the possible correlation between five scientometric indicators (Web of Science Documents, International Collaborations, etc.) and CMR changes for 14 countries. Furthermore, the expenditures of GDP in both science and healthcare for each of the studied countries have been considered within the framework of cancer-science relations in order to find out the possible socio-economic impact on cancer incidence. Methodologically, the study relies on the principles of scientometric management. The research data were retrieved from Web of Science and the World Health Organization for the period from 1997 to 2017. To investigate the correlation between scientific research and the CMR, we have used bibliometric data and nonparametric statistical methods (the Kruskal-Wallis test, Spearman's correlation coefficient) as well as the Dunn test of multiple group checks and the Shapiro-Wilk test. R language, Tidyverse package R and VOSviewer were used for data processing. The research results showed that during the period in question there was an increase in the CMR in Armenia and Georgia, while in Iran and Azerbaijan it remained almost consistent. For the rest of the countries from Asia and Europe, as well as Canada and the USA, the CMR experienced a downward trend. We have found close links between scientometric data, the CMR and economic costs for Europe and the USA. At the same time, for Armenia and neighbouring countries the correlation between the CMR and GDP was weak. Moreover, GDP costs incurred in healthcare and science did not have a positive effect on the CMR in Armenia, Azerbaijan and Georgia. This indicates that scientific and socio-economic factors are highly correlated with each other and, therefore, have a positive impact on the CMR, mainly in Europe and the USA. However, the science-health relationship in Armenia is still weak and requires efforts to prevent the continued rise in CMR levels. The findings of this study can also be applied to other fields of science and help to establish close links between scientometrics and various branches of medicine.

Keywords: scientometrics; socio-economic indicators; bibliometric indicators; oncology; oncopolicy; international collaboration.

Funding: The work was supported by the Science Committee of MESCS RA, in the frames of the research project № 20TTCG-5I013.

Article info: received May 5, 2022; received in revised form June 9, 2022; accepted June 29, 2022

For citation: Sargsyan Sh.A., Hakobyan P.M., Shushanyan R.A., Mirzoyan A.R., BlagininV.A. (2022). The role of socio-economic and scientometric indicators in the cancer mortality rate. *Upravlenets / The Manager*, vol. 13, no. 4, pp. 54–68. DOI: 10.29141/2218-5003-2022-13-4-5. EDN: MOLSIV.

Оценка смертности от онкологических заболеваний: роль социально-экономических и наукометрических показателей

Ш.А. Саргсян[1], П.М. Акопян[1], Р.А. Шушанян[1], А.Р. Мирзоян[1], В.А. Благинин[2]

[1] Институт проблем информатики и автоматизации Национальной академии наук Республики Армения, г. Ереван, Республика Армения
[2] Уральский государственный экономический университет, г. Екатеринбург, РФ

Аннотация. Научные исследования в сфере здравоохранения способствуют решению не только медицинских, но и экономико-социальных вопросов. Одной из современных тенденций является растущий интерес к оценке эффективности указанных исследований. Статья посвящена проверке гипотезы о значимости наукометрических показателей в снижении уровня смертности от онкологических заболеваний (CMR) за счет повышения осведомленности и привлечения внимания к данной проблеме. Изучена корреляция между пятью наукометрическими показателями публикационной активности в области онкологии (число документов в МНБД Web of Science, доля публикаций в международном соавторстве и др.) и изменениями индикатора CMR в 14 странах, а также взаимосвязь расходов ВВП на НИОКР и здравоохранение и их влияния на статистику онкологических заболеваний в этих странах. Методология исследования базируется на принципах наукометрического менеджмента. Использовались непараметрические методы (критерий Краскела – Уоллиса, коэффициент корреляции Спирмена), тесты Данна и Шапиро – Уилка, язык программирования R, пакеты Tidyverse package R и VOSviewer. Информационной базой работы послужили данные МНБД Web of Science и Всемирной организации здравоохранения за период 1991–2017 гг. Результаты исследования показали, что в изучаемый период CMR повышался в Армении и Грузии, оставался неизменным в Иране и Азербайджане и снижался в европейских и азиатских странах, а также в Канаде и США. В странах Европы и США выявлены тесные связи между наукометрическими данными, CMR и экономическими затратами. В то же время в Армении и соседних государствах взаимосвязь между CMR и ВВП оказалась довольно слабой. Более того, расходы ВВП как на здравоохранение, так и на НИОКР не способствовали снижению CMR в Армении, Азербайджане и Грузии. Это свидетельствует о том, что научные и социально-экономические факторы сильно коррелируют между собой и, следовательно, положительно влияют на CMR преимущественно в странах Европы и США. Вместе с тем в Армении связь между наукой и здравоохранением всё еще слаба, и ее необходимо укреплять для предотвращения продолжающегося роста уровня CMR. Полученные результаты могут быть полезны при установлении зависимости между наукометрическими показателями и различными областями медицины.

Ключевые слова: наукометрия; социально-экономические индикаторы; библиометрические индикаторы; онкология; онкополитика; международная коллаборация.

Финансирование: Работа выполнена при поддержке Комитета по науке Министерства образования, науки, культуры и спорта Республики Армения в рамках научного проекта № 20TTCG-5I013.

Информация о статье: поступила 5 мая 2022 г.; доработана 9 июня 2022 г.; одобрена 29 июня 2022 г.

Ссылка для цитирования: Sargsyan Sh.A., Hakobyan P.M., Shushanyan R.A., Mirzoyan A.R., Blaginin V.A. (2022). The role of socio-economic and scientometric indicators in the cancer mortality rate // Управленец. Т. 13, № 4. С. 54–68. DOI: 10.29141/2218-5003-2022-13-4-5. EDN: MOLSIV.

INTRODUCTION

The increased scientific and technological activities in recent years make their assessment necessary both in developed and developing countries. Moreover, it is an important point for nations' future from the periphery of scientific engagement [Lascurain-Sánchez et al., 2008]. It is generally known that scientometrics is used to evaluate the research performance of the academic community [Lee, 2003], research groups, departments, universities [Fakhree, Jouyban, 2011; Gureyev et al., 2020] and for developing benchmarks to evaluate the quality of information productivity [Velmurugan, Radhakrishnan, 2015] and publication activity. Research of diseases, especially those with high mortality rate, is a multidisciplinary and extremely dynamic field for researchers. The World Health Organization's (WHO) Report on knowledge for better health aims to demonstrate that health research is an investment.

Health research can lead directly to cost savings in the healthcare system through new therapies that reduce either the number of patients needing treatment or the overall cost of treatment per patient [Buxton, Hanney, Jones, 2004]. Recent reviews in the health field have identified the growing interest in expanding the scope of research evaluation. In addition to assessing knowledge production, it also covers economic / societal (i.e. wider, non-academic) impact of research in terms of informing health policies and clinical practice, and generating health and economic gains [Jones, Hanney, 2016]. In this respect, the analysis of medical research output and its impact is very important to detect public health quality [Lascurain-Sánchez et al., 2008], in which the statistical methods play a significant role [Nieminen et al., 2006, Jung et al., 2015]. Meanwhile, differences exist in the mortality rate of diseases mainly due to the differences in population risk factors caused by non-identical stages of social and economic changes. Healthcare financing is also critical for reaching universal health coverage (UHC), which is defined as ability of all people to obtain the quality health services they need without suffering financial hardship.

Despite the survival rate of cancer patients has been remarkably improved, cancer remains one of the most worrisome health problems worldwide [Lin et al., 2019]. Hence, the research in this field has a crucial part in further improvement of cancer treatment. Scientometric indicators are the main criterion for the allocation of resources for research in this field. Rigorous evaluation of scientific activity is especially essential when resources are limited and the costs of healthcare are high, as in the case of cancer [Ruiz-Coronel et al., 2020]. Identifying research indicators provide progress and insight into the research. It may also help in re-designing and developing national policies to control the problem in an improved manner [Munnolli, Shamprasad, 2017]. Therefore, it is important to understand the impact of cancer research policies (oncopolicy) to develop strategies (such as national cancer control programmes – NCCP), which can help to identify the causes of cancer rate incidence [Lewison et al., 2010].

In many important areas of biological research, the scientific process increasingly involves catalysing collaborative efforts that bring together investigators with different scientific background and perspectives to solve complex problems on interdisciplinary or multidisciplinary approach [Cheng et al., 2020; Kremer, Werner, 2009; Lee, Bozeman, 2005; Shehatta, Mahmood, 2017]. Scientific publications that emerged from collaborations usually have more impact [Fell, König, 2016; Glänzel, 2001; Parish, Boyack, Ioannidis, 2018]. Starting from the 2000s, science in Armenia has entered a rapid development stage, due to several reforms in the economic, educational, and scientific sectors.

Consequently, the publication activity of Armenian researchers progressively rose. This was the result of development in science and technology and encouraging of scientific productivity, thanks to its visibility and impact on scientific collaborations [Sargsyan et al., 2020]. Despite all of these benefits Armenia is in particular need of targeted efforts to reduce its cancer burden. Currently, it is the second most common cause of death and premature death in Armenia. Moreover, Armenia has the second highest rate of cancer-related deaths in the world, while its closest neighbours rank far better (Turkey 41st, Georgia 82nd, Azerbaijan 93rd, Iran 120th) [Berg et al., 2021].

This article aims to study the correlation between the cancer-related scientific research and the CMR for the countries under study. Ultimately, Armenia is the main subject of interest within the framework of this research.

DATA AND METHODS

For interpretation of the aforementioned goals, 14 countries were selected. They can be divided into two groups:

1) the top 10 countries with the highest number of publications dedicated to oncology: Canada (CAN), China (CHN), the United Kingdom (UK), France (FRA), Germany (DEU), Italy (ITA), Japan (JPN), the Netherlands (NLD), and the United States of America (USA);

2) Armenia (ARM) – the main target country of this study – and its neighbouring countries: Iran (IRN), Turkey (TUR), Georgia (GEO), and Azerbaijan (AZE). The data were gathered from the Web of Science InCites[1] dataset by subject category of "oncology". The publications from the mentioned countries have been identified and separated to make quantitative analyses. The following scientometric indicators were used to correlate with the CMR: Web of Science Documents, % International Collaborations, % Industry Collaborations, Impact Relative to the World, and the Category Normalized Citation Impact. All types of documents have been taken for conducting the research. We consider that international collaboration and science–industry convergence can promote cancer research, therefore having a correlation with mortality incidence.

The data about the CMR were retrieved from the official website of the World Health Organization[2], which is the most recognized organization dealing with the issues of international public health, therefore covering the official database regarded the CMR. Whereas the overall data about the CMR in the WHO website were found since 2017 for the countries in question, we have analysed the most recent and available data. Hence, the scientometric and the other indicators were also implemented for the corresponding time period. The CMR is normalized for both sexes and ages from 1991 to 2017.

According to most studies, economic growth boosts public health. Health expenditure is often used as a measure of public health, therefore, with the increase in the economy, various medical policies have been constantly implemented with the main focus on the public health [Niu et al., 2021]. Consequently, we analysed the expenditure of GDP [Sprent, Smeeton, 2000] both for health and science to make a correlation with scientometric indicators and the CMR from the perspective of the economy.

It is intended to use several statistical tools to assess the socio-economic profile and its potential influence on publications, i.e. cancer mortality correlation. Furthermore, non-parametric methods [Bonnini et al., 2014] were used for statistical analysis, as normal distribution conditions are not substantiated for the data provided. R language[3] has been used for the statistical analysis, calculations and graphical visualization. To conduct statistical analysis, it was necessary to filter data, and pre-processing required some actions, for which the modern tidyverse package R[4] was also applied.

RESEARCH RESULTS

The diagrams (box plot) of the CMR by year observed for each country are given in Fig. 1 (see Appendix, Table 1 for statistical characteristics). According to this diagram Armenia is leading in terms of average CMR compared to its neighbouring countries – Georgia, Azerbaijan, Iran, Turkey – and Japan. In the framework of other listed countries, Armenia possibly has the same CMR on average.

To verify this impression, the selected countries were divided into two groups. The first group includes Georgia, Azerbaijan, Iran, Turkey, and Japan, while the second group comprises the US, European countries, Canada, and China.

[1] InCites - Clarivate. https://incites.clarivate.com/
[2] The World Health Organization. https://www.who.int/
[3] The Comprehensive R Archive Network. https://cran.r-project.org.
[4] Tidyverse. R packages for data science. https://www.tidyverse.org.

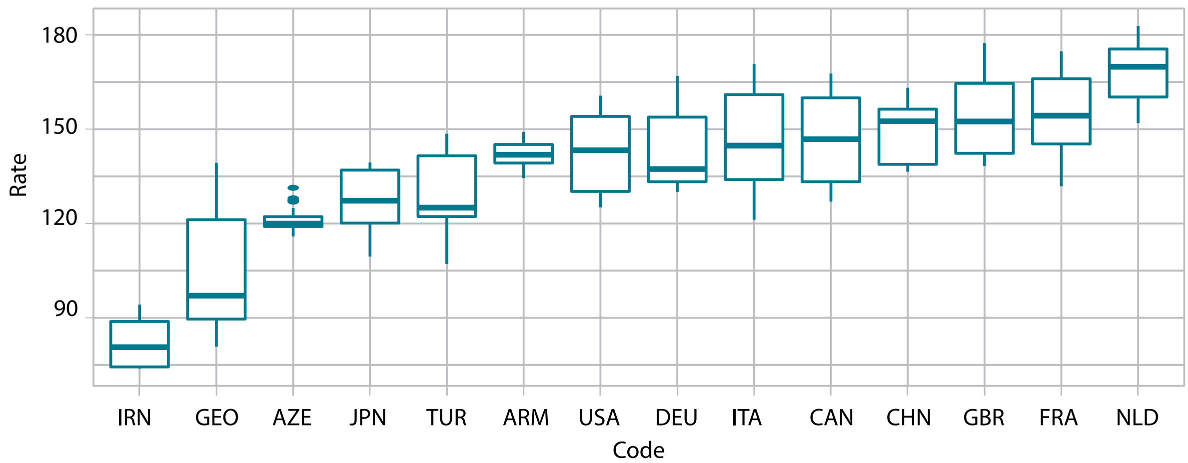

Fig. 1. Average CMR by country in 1991–2017

Рис. 1. Средний CMR в исследуемых странах, 1991–2017

Statistically, comparison of the average CMR for each country from both groups (including Armenia) can reveal interesting details. With that in mind, the Kruskal-Wallis nonparametric test [Kruskal, Wallis, 1952] was used in each group (including Armenia) to reveal a statistically significant difference in the average CMR among the countries. The parametric method One-Way Analysis of Variance (One-way ANOVA) has not been used, since the conditions for its application was not met concerning the normal distribution of the data grouped by countries. In case of normality testing of grouped data, the Shapiro-Wilk test was used.

According to the results of the Kruskal-Wallis test, there is a statistically significant difference between the CMR of the countries included in the aforementioned groups. The Dunn test of multiple group checks [Dinno, 2015] was also used in order to find out between which countries the statistically significant differences were mainly observed. The results suggest that Armenia is predominant in terms of the CMR compared to the countries of the first group.

For the countries from the second group there was no such significant statistical difference in the mortality rate in comparison to Armenia, except for the Netherlands. The same result was found among the possible pairs of other countries in this group, except for the Netherlands. Moreover, the Netherlands is a significant leader in its CMR.

As the next step of the investigation, the CMR dynamics was considered for each country by year, which is presented in Fig. 2.

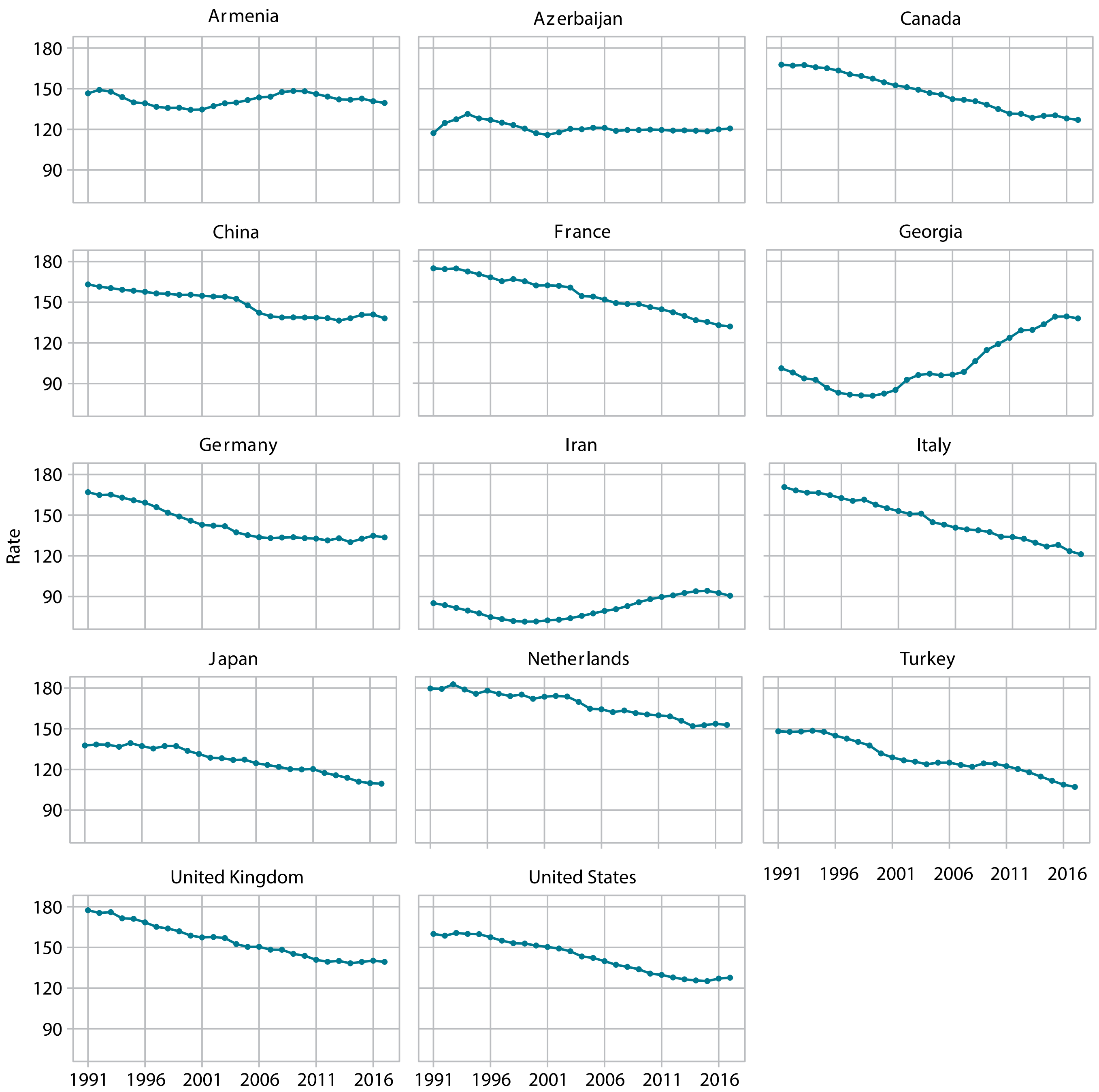

Fig. 2. Dynamics of CMR in the selected countries in 1991–2017

Рис. 2. Динамика CMR в исследуемых странах, 1991–2017

It is clear that in some countries from the first groups, such as Iran, Armenia, and Azerbaijan, there has been no dynamic change in the CMR over the years. It should also be mentioned that Georgia, a country with a relatively low average mortality rate, has shown a steady increase in the CMR over the years.

In other countries, such as Japan, Turkey, the United States, Germany, Italy, Canada, China, the United Kingdom, France, and the Netherlands, the mortality rate have considerably decreased during the period in question. It should be noted that Japan and Turkey, which are from the first group, detect a dynamic decrease in the mortality rate, having a relatively low average CMR towards Armenia. The countries from the second group show the highest average CMR but have a dynamic decrease in the CMR by year. Thus, Armenia is observing worrisome results in terms of cancer incidence by these two indicators: the highest average CMR and almost stable CMR over the years. Based on the above, it is expedient to establish the factors that contribute to the reduction of the CMR for the second group of countries. We have preferred to consider the scientific publications as factor to interpret this issue. It is able to become a possible guideline and forecast in terms of improvement of the grim statistics of cancer, especially for Armenia. In this regard, our research aims to discover whether science has an impact on the decline in mortality for each selected country. To understand the above-mentioned pattern, we calculated a correlation between the CMR and scientometric indicators for each country.

It is widely known that correlation coefficient presents the strength and direction of a relationship between variables. The correlation coefficient belongs to the range [–1, 1]. The sign of the coefficient alludes to the direction of the connection, and the accepted absolute value presents the strength of the connection. The correlation is strong when the absolute value of the correlation coefficient is greater than 0.75. And it is moderate when the absolute value is between 0.25 and 0.75. There is no correlation when the absolute value of the correlation coefficient is less than 0.25.

The Spearman nonparametric correlation coefficient has been used because the available data were not normally distributed, and that fact did not allow the use of the Pearson correlation coefficient for computations. The results of the calculation are presented in Table 1.

As part of our research, we are interested in detecting a strong correlation to find out the most influential factors on the CMR. As shown in Table 1, there were no correlations between scientometric indicators and the CMR for both Armenia and Azerbaijan, in comparison to Iran and Georgia, which observed a strong and moderate positive correlation between the CMR and Web of Science Documents, respectively. There has been an increase in the CMR over the years for both Georgia and Iran. It can be a reason for gradual increase in studies in academic circles. According to Appendix Table 2, these two countries did not show publication activity between 1991 and 2017. And it has been gradually increasing in the following years. The visualization of this result is presented in Fig. 3, which shows that in the case of Iran the relationship is non-linear, and in the case of Georgia, there is a strong linear relationship between the CMR and Web of Science Documents. In the cases of both Armenia and Azerbaijan, there is no relationship between these two indicators.

In all of the countries with the rapidly declining CMR, a strong negative correlation was observed only between the indicator of Web of Science Documents and the CMR. The visualization of this result is presented in Fig. 4.

Additionally, there was also observed a strong negative correlation between Category Normalized Citation

Table 1 – Correlation coefficients between the CMR and bibliometric indicators for each country
Таблица 1 – Коэффициенты корреляции между CMR и библиометрическими показателями в исследуемых странах

Indicators	Countries												
	First group						Second group						
	Azerbaijan	Georgia	Iran	Turkey	Japan	Armenia	Canada	China	France	Germany	Italy	Netherlands	United Kingdom	United States
WOSdoc	–0.14	0.8	0.65	–0.97	–0.97	0.0	–0.99	–0.94	–0.96	–0.91	–0.97	–0.96	–0.96	–0.98
CNCI	–0.19	0.56	–0.01	–0.44	–0.65	–0.25	–0.88	0.02	–0.95	–0.82	–0.87	–0.85	–0.84	–0.81
IntColl	–0.17	0.6	–0.01	–0.33	–0.87	–0.1	–0.96	0.77	–0.92	–0.85	–0.94	–0.94	–0.98	–0.98
IndColl	NA	0.29	0.44	–0.83	–0.12	0.0	–0.92	0.12	–0.95	–0.85	–0.95	–0.95	–0.96	–0.88
IRWorld	–0.21	0.59	0.36	–0.56	0.49	–0.2	0.53	0.18	–0.63	–0.01	–0.64	–0.15	–0.45	–0.93

Note: WOSdoc is Web of Science Documents; CNCI is Citation impact (citation per paper) normalized for the subject, year, and document type; IntColl is Percentage of publications that have international co-authors; IndColl is Percentage of publications that have co-authors from industry; IRWorld is Citation impact of the set of publications as a ratio of the world average.

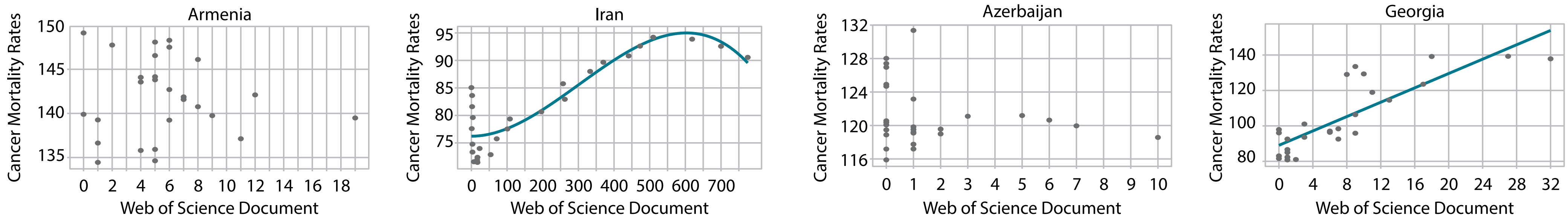

Fig. 3. The scatter plot of Web of Science Documents and CMR in the countries with the growing CMR
Рис. 3. Соотношение документов Web of Science и CMR в странах с растущим CMR

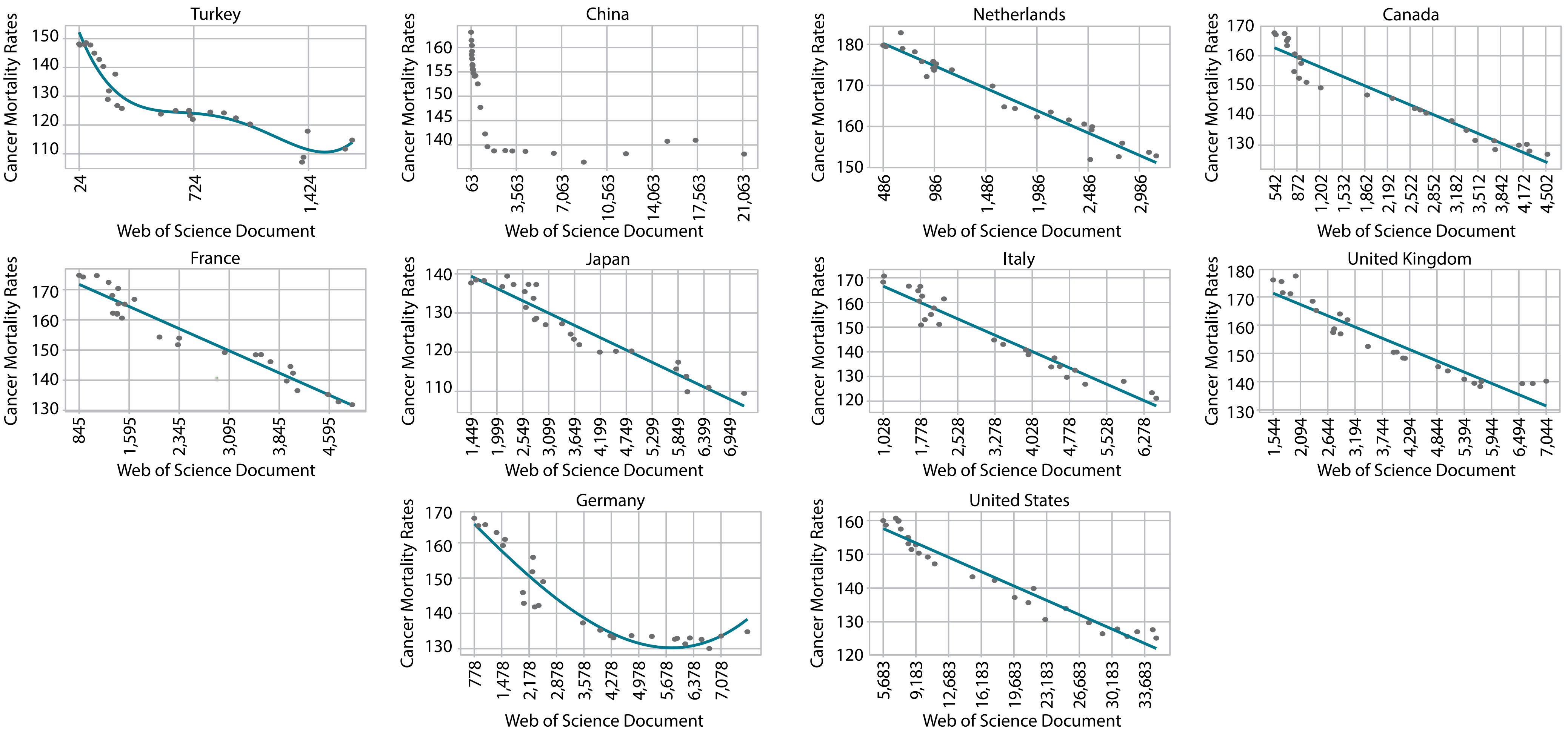

Fig. 4. The scatter plot of Web of Science Documents and the CMR of the countries with the declining CMR
Рис. 4. Соотношение числа документов Web of Science и CMR в странах со снижающимся CMR

Impact (CNCI) as normalized scientific data, and the CMR in the case of European countries, Canada, and the US. The overall picture was the same in terms of both international and science-industry collaboration (Table 1).

For the Impact Relative to World Average, a strong correlation was observed *only for the United States*. Hence, this indicator has an exceedingly slight impact on decreasing of the CMR (Table 1).

To find out whether the other scientometric indicators[1] promote this strong correlation between Web of Science Documents and the CMR, we calculated the correlation coefficient between Web of Science Documents and the CMR, without the effect of other scientometric indicators. That is the partial correlation coefficient was calculated.

As represented in Table 2, these partial correlations are significantly smaller, which means that other scientometric indicators contribute to this connection, i.e. their absence would lead to a decrease in correlation.

In addition to the scientometric data, the correlation coefficients between GDP and the CMR have been evaluated (Table 3).

For the case of Armenia, there is no correlation for both cases of GDP. There is a very week negative correlation for Azerbaijan and Georgia. From the results, it can be considered that there is a strong negative correlation in GDP spending on research and development for Turkey, China, and Italy. A moderate negative correlation was observed for Japan, Germany, the Netherlands, the United Kingdom, and the United States.

As for the expenditure on healthcare, there are strong negative correlations in the case of Japan, Canada, France, Italy, the Netherlands, the United Kingdom, and the United States. A moderate negative correlation was observed for China and Germany. Thus, it can be said that, in general, investments in healthcare contribute to the fight against cancer.

Above, we have found a strong correlation between the CMR and Web of Science Documents in countries with the declining mortality rate (Table 1). To determine the possible impact of GDP on this strong correlation, the partial correlation coefficient has been calculated. The results are shown in Table 4.

According to Table 4, in the case of the countries with a dynamic decline in cancer other than France and the United States, we can consider that the impact of GDP contributes to a strong negative correlation between the CMR and Web of Science Documents.

Thus, together with scientometric data, GDP helps to strengthen the impact of Web of Science Documents on the declining mortality rate process.

[1] The results of the calculations of the main statistical characteristics of the observed scientometric data are presented in relevant tables in Appendix.

Table 2 – Partial correlation between the number Web of Science Documents and the CMR
Таблица 2 – Частичная корреляция между числом документов Web of Science и CMR

Canada	China	France	Germany	Italy	Japan	Turkey	Netherlands	United Kingdom	United States
–.77	–0.15	–0.59	–0.12	–0.77	–0.7	–0.4	–0.5	–0.2	–0.2

Table 3 – Correlation coefficients between GDP spending and the CMR for each country
Таблица 3 – Коэффициенты корреляции между расходами ВВП и CMR в исследуемых странах

GDP	Countries													
	First group						Second group							
	Azerbaijan	Georgia	Turkey	Iran	Japan	Armenia	Canada	China	France	Germany	Italy	Netherlands	United Kingdom	United States
GDP spending on R&D	–0.3	0.16	–0.9	–0.45	–0.56	–0.04	0.89	–0.82	–0.70	–0.71	–0.97	–0.59	–0.55	–0.6
GDP spending on healthcare	–0.26	0.38	0.59	0.87	–0.98	0.24	–0.90	–0.29	–0.96	–0.51	–0.78	–0.88	–0.81	–0.92

Table 4 – Partial correlation between Web of Science Documents and the CMR (excluding the impact of GDP in countries with declining cancer mortality)
Таблица 4 – Частичная корреляция между числом документов Web of Science и CMR (исключая влияние ВВП в странах со снижающейся смертностью от онкологических заболеваний)

Canada	China	France	Germany	Italy	Japan	Turkey	Netherlands	United Kingdom	United States
0.01	–0.15	–0.92	–0.4	–0.63	–0.56	–0.45	–0.66	–0.83	–0.97

DISCUSSION AND CONCLUSION

Certain basic facts about cancer remain unknown around the globe. Considering the cultural, socio-economic, and environmental factors which can influence cancer outcomes, it is unclear whether and to what extent national economic and health system characteristics are associated with cancer outcomes, and whether a country's wealth mediates these effects. Finally, the accuracy of a country's cancer statistics has itself been shown to be a measure of health system organization. Lower-income countries with the least access to healthcare likely had the greatest underestimation of cancer death. This may also have explained the underlying reason for the paradoxical finding of the increased CMR [Batouli, 2014].

The increase of the cancer burden, especially in the low- and middle-income countries, is being driven by factors including population growth, aging, and lifestyle, as well as social and economic development. To respond to the increasing cancer burden, it is extremely preferable to make monitoring and enforce a national prevention programme [Puspitaningtyas et al., 2021], especially for low-income countries. Armenia also compares poorly with the countries of the region and globally. It has been among the top five countries with the highest incidence and CMR in the region of Western Asia, which is due to the high prevalence of risk factors, incomplete screening strategies, as well as issues with diagnostic and treatment modalities.

Based on the current study, it can be argued that the CMR was higher for Armenia (both for two indicators – the mortality rate on average and the same rate over the years) and Georgia. For Iran and Azerbaijan, the mortality rate over the years remain almost consistent. In the case of Japan, Turkey, the United States, Germany, Italy, Canada, China, the United Kingdom, France, and the Netherlands, the CMR has decreased, which is possibly due to active scientific productivity, which is observed via the correlation with some scientometric indicators. Moreover, there was observed a strong link between Category Normalized Citation Impact as normalized scientometric data, and the mortality rate in the case of European countries, Canada, and the US.

In other words, the greater the scientific activity, the lower the CMR, and the science remarkably promotes the reduction of the latter for these countries. For Armenia and Azerbaijan, the scientometric indicators have not observed any positive impact on the CMR. In a comparison of these countries, Iran and Georgia showed a rapid increase in the mortality rate regardless of scientometric indicators. Possibly, there are other factors: social, political and / or environmental which are responsible for the continuous growth of the CMR in the mentioned countries.

Additionally, the GDP expenditures for both healthcare and R&D have shown an obvious impact in terms of fighting against cancer mortality for European countries, the US, and Turkey. In the case of Armenia, Azerbaijan, and Georgia, they play a negligible role. Interestingly, Turkey as a neighbouring country with Armenia indicates a good behaviour in regards to the CMR, where the active scientific productivity and high GDP expenditures for both science and healthcare help in the fight against cancer, which is not typical for other neighbouring countries – Azerbaijan, Georgia, and Iran.

As an emerging market economy and a candidate country for EU membership, Turkey has engaged in large-scale international science and research programmes and organizations in Europe since the 1950s, and even more intensely after its candidacy status commenced at the end of 1999. These engagements, which can be framed as Science Diplomacy efforts, were motivated by the Turkish government's perception that Turkey needs to become more integrated with the European countries, and must stay abreast of the science and technology developments even when there are tensions between the two parties [Karacan, 2021]. Generally said, the Europeanization of Turkey probably made a positive impact on healthcare and science policy, which is also referred in this study.

Considering the results, it could be concluded that enforcing scientific productivity and enhancing collaborative networks with countries which have successful profile in cancer fighting will be a right and useful step, especially for Armenia. Moreover, Armenia needs a National Cancer Registry to accurately collect and process data associated with the CMR for promoting and enlarging treatment modalities in the framework of national guidelines, which is the next problem that should be taken into consideration. Besides, there is at least a shortage of financial support and / or unreasonable distribution of financial resources for cancer research at the national level. Moreover, the cooperation with oncologists, biologists as well as with healthcare policymakers is urgently needed. Straightening science-industry relationships as in the case of countries discussed in this study will also promote the accessibility and usability for sharing good practices.

Furthermore, one cannot neglect the content-related aspect of cancer studies. Numerous medical research domains are at the forefront of science [Blaginin, Matveeva, 2016] as the cited half-life is extremely short. From the position of management and decision-making on enhancing research activity, endogenous topics within the cancer research block are worth special attention.

We have selected 5,000 most highly cited publications in the Web of Science database on Oncology to map the research field. Most of the articles in the sample were published by US researchers (Fig. 5). The models of neural connections based on textual and bibliographic data are built using the VosViewer software [Van Eck, Waltman, 2014]. We can also observe some countries in the green and blue collaboration groups by topic.

Mapping of the pool of publication allowed categorizing the topics into three groups: genomic and cellular studies, gender and age studies of mortality, as well as the cyclicity of diseases, assessment and practical research (Fig. 6). Publications on the topic in question within the

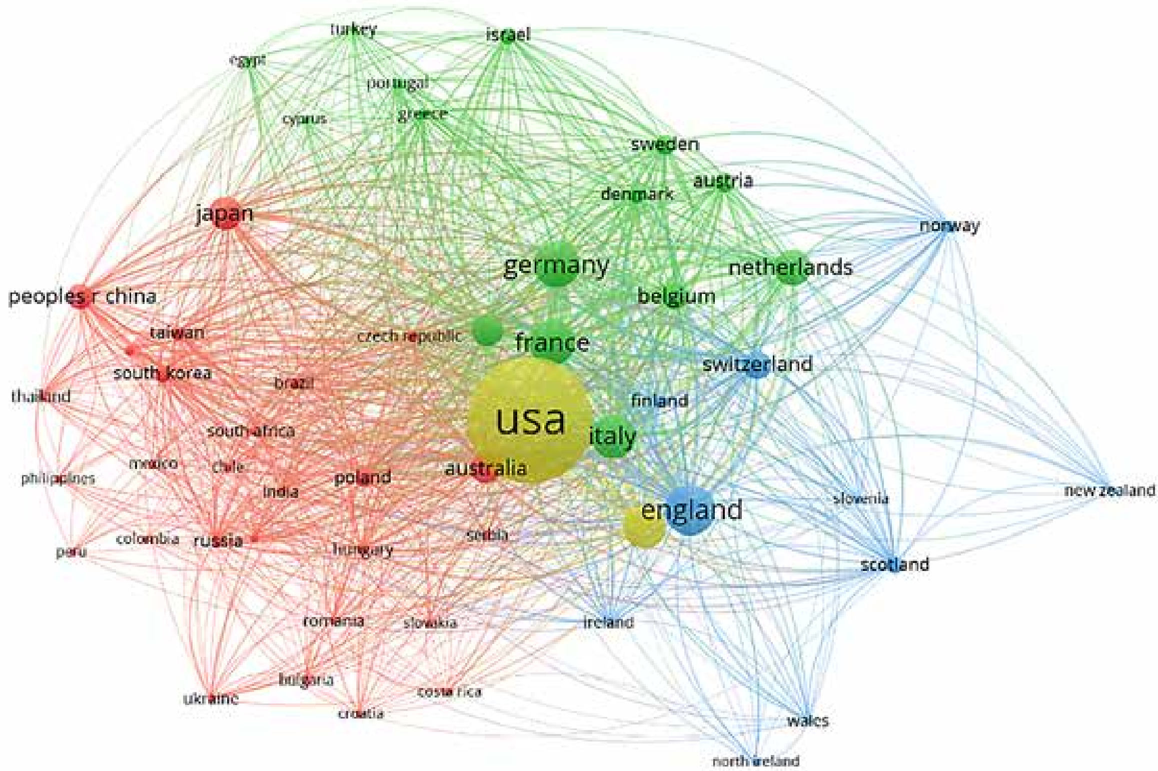

Fig. 5. Publication impact on the oncology research field by country

Рис. 5. Публикационное влияние на тематику онкологии в исследуемых странах

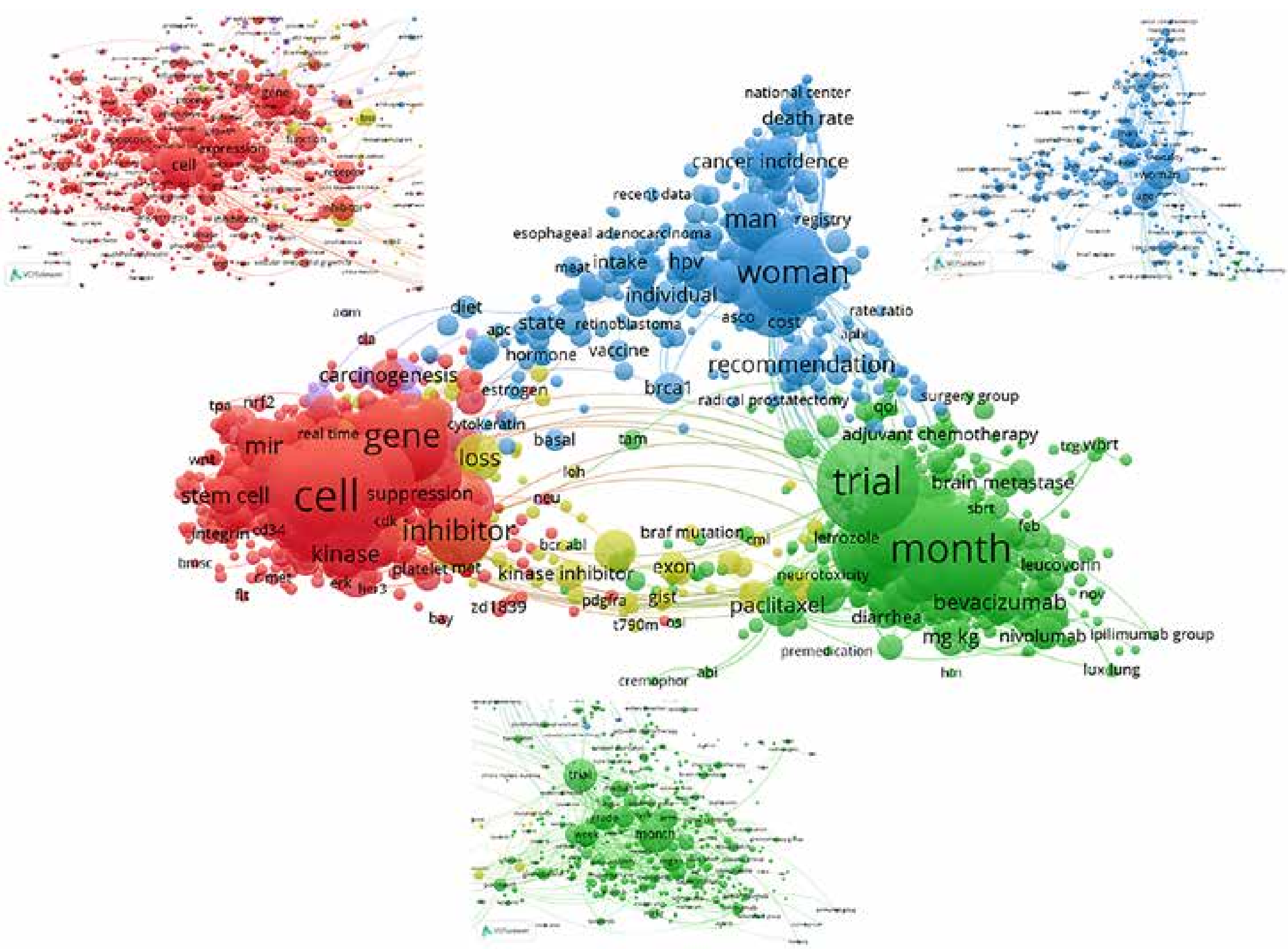

Fig. 6. Mapping of the "Oncology" research field according to Web of Science

Рис. 6. Картографирование публикаций в области онкологии по данным Web of Science specified enlarged groups increase the likelihood of being cited, which, within the framework of our findings, means a decrease in the incidence rate.

However, boosting the potential partnership between scientists and clinicians within cancer research will be a tangible step for making good management and guides in a way of new approaches and challenges in oncology that Armenia faces nowadays [Papikyan, Connor, Amiryan, 2018]. Additionally, the symbiotic enterprise with local and international healthcare organizations and governmental sectors which deals with policymaking in oncology (oncopolicy) will support the decreasing of the CMR in Armenia.

It is worth mentioning that Armenia made its first steps since 2017 with the "ArMed" national digital health system[1]. The platform enables the collection and synchronization of clinical, administrative, and financial data linked with the provision of standard healthcare services, and aims to facilitate patient's engagement. Furthermore, "ArMed" has played an important role in the management of the Covid-19 pandemics in Armenia. "ArMed" also aims to enhance its capabilities and opportunities for other diseases such as cancer to enable relevant departments to obtain accurate statistics on the overall health picture in Armenia with the active negotiation of the WHO Regional Office.

In conclusion, it should be mentioned, that the investigation model used in our research can become a guide for assessing the input of science on the various problems in medicine, especially for Covid-19. Hence, scientometrics is one of the successful tools that promotes the evaluation of scientific potential output in healthcare to make profitable strategies for devastating diseases on the national, as well as on the global level. ■

[1] The electronic healthcare system ArMed. https://www.armed.am/en/auth/loginnew

Appendix – Key statistical characteristics of the CMR and bibliometric indicators: data for the countries under study [1]
Приложение – Ключевые статистические показатели CMR и библиометрические индикаторы: данные по исследуемым странам

Table 1 – Statistical characteristics of the CMR data by country
Таблица 1 – Статистические характеристики данных CMR

Code	Min	Q_1	Mean	Median	Q_2	SD	Max
IRN	71.5	74.4	81.6	80.7	88.8	7.8	94.2
GEO	80.8	89.6	104.2	97.0	121.2	19.9	139.3
AZE	115.9	119.0	121.2	120.0	122.2	3.7	131.4
TUR	107.1	122.2	129.3	125.0	141.5	12.9	148.6
JPN	109.5	120.1	126.7	127.2	137.0	9.8	139.4
DEU	130.1	133.3	143.6	137.3	153.9	12.6	167.0
ARM	134.4	139.2	141.9	141.9	145.1	4.5	149.1
USA	125.2	130.2	143.3	143.3	154.1	12.8	160.7
ITA	121.2	134.0	146.8	144.8	161.0	15.3	170.7
CAN	127.0	133.3	147.4	146.8	160.0	14.2	167.7
GBR	138.3	142.3	154.7	152.5	164.6	12.9	177.4
CHN	136.5	138.8	148.8	152.5	156.4	9.3	163.2
FRA	131.9	145.3	155.3	154.3	166.1	13.7	174.8
NLD	151.9	160.3	167.7	169.8	175.5	9.7	182.8

[1] Calculated values:
- maximum and minimum values (max, min);
- mean and median values;
- lower-upper quadrants (Q_1, Q_2);
- standard deviation (SD).

Table 2 – Statistical characteristics Web of Science Document data by country
Таблица 2 – Статистические характеристики данных документов Web of Science

Code	Min	Q_1	Mean	Median	Q_2	SD	Max
AZE	0.0	0.0	1.6	1.0	1.5	2.5	10.0
ARM	0.0	4.0	5.6	5.0	7.0	4.0	19.0
GEO	0.0	1.0	7.5	6.0	9.5	8.2	32.0
IRN	0.0	5.5	198.7	71.0	351.5	243.2	775.0
TUR	24.0	159.5	609.8	523.0	944.5	538.0	1,691.0
CHN	63.0	174.5	3,682.7	581.0	3,759.5	5,965.9	21,172.0
NLD	486.0	942.0	1,637.4	1,553.0	2,477.5	867.4	3,151.0
CAN	542.0	835.0	2,126.1	1,896.0	3,408.5	1,413.3	4,527.0
FRA	845.0	1,414.5	2,523.7	2,050.0	3,835.5	1351.0	4,939.0
JPN	1,449.0	2,601.0	3,665.1	3,033.0	4,694.5	1,640.6	7,253.0
ITA	1,028.0	1,801.5	3,270.6	3,261.0	4,529.0	1,673.7	6,525.0
GBR	1,544.0	2,583.0	3,826.7	3,453.0	5,228.0	1,681.4	7,045.0
DEU	778.0	2,032.0	3,768.6	3,552.0	5,928.5	2,198.8	7,751.0
USA	5,683.0	8,362.0	17,493.5	15,241.0	26,470.0	10,264.7	34,923.0

Table 3 – Statistical characteristics of Category Normalized Citation Impact by country
Таблица 3 – Статистические характеристики нормализованного по категориям влияния цитирования

Code	Min	Q_1	Median	Q_2	SD	Max
AZE	0.0	0.0	0.0	0.0	0.1	0.4
GEO	0.0	0.0	0.1	0.6	1.3	5.8
ARM	0.0	0.0	0.1	0.5	0.6	3.1
TUR	0.2	0.4	0.5	0.6	0.2	1.2
IRN	0.0	0.3	0.5	0.7	0.2	0.9
JPN	0.7	0.8	0.9	1.0	0.2	1.4
CHN	0.7	0.9	0.9	1.0	0.2	1.5
ITA	0.6	0.9	1.0	1.5	0.4	1.9
DEU	0.8	1.0	1.2	1.5	0.3	1.9
GBR	1.1	1.2	1.4	1.9	0.3	2.2
USA	1.3	1.4	1.5	1.6	0.1	1.8
NLD	1.1	1.4	1.5	1.7	0.3	2.1
FRA	0.9	1.1	1.6	2.2	0.6	2.9
CAN	1.2	1.5	1.8	2.1	0.4	2.6

Table 4 – Statistical characteristics of International Collaboration data by country
Таблица 4 – Статистические характеристики данных международного сотрудничества

Code	Min	Q_1	Median	Q_2	SD	Max
AZE	0.0	0.0	0.0	0.0	19.1	70.0
TUR	3.5	9.8	12.0	13.4	3.4	17.5
GEO	0.0	0.0	16.7	35.4	28.5	100.0
JPN	10.4	14.2	16.9	17.4	3.0	21.1
IRN	0.0	15.7	19.7	28.7	19.8	100.0
USA	12.3	18.5	20.9	25.2	5.5	32.5
ITA	16.2	22.5	27.4	35.0	8.4	43.5
GBR	18.4	23.9	31.8	43.3	11.9	57.0
ARM	0.0	7.1	33.3	45.0	28.3	100.0
DEU	23.7	28.5	36.0	41.0	8.1	50.0
FRA	24.3	29.0	38.0	43.5	9.6	55.0
NLD	26.7	34.5	39.9	44.4	8.9	57.0
CHN	16.8	27.7	40.6	49.0	13.1	58.1
CAN	25.5	36.5	40.7	47.4	8.6	56.8

Table 5 – Statistical characteristics of Industry Collaboration data by country
Таблица 5 – Статистические характеристики данных сотрудничества с промышленностью

Code	Min	Q_1	Median	Q_2	SD	Max
IRN	0.0	0.0	0.0	0.2	0.2	0.9
GEO	0.0	0.0	0.0	0.0	4.5	14.3
AZE	0.0	0.0	0.0	0.0	0.0	0.0
ARM	0.0	0.0	0.0	0.0	2.4	12.5
TUR	0.0	0.0	0.6	1.3	0.8	2.5
CHN	0.0	1.2	1.6	2.1	0.9	4.9
ITA	0.9	2.2	2.8	6.0	2.5	8.1
JPN	3.6	4.2	4.6	5.2	0.7	6.2
CAN	1.5	3.5	4.8	6.1	2.1	8.9
DEU	2.0	2.9	5.1	7.8	2.9	11.0
GBR	1.5	2.4	5.2	8.2	3.1	11.0
USA	2.9	4.3	5.3	6.0	1.2	6.7
NLD	1.2	4.2	5.7	6.5	2.0	8.8
FRA	2.6	5.5	7.2	9.2	3.1	14.0

Table 6 – Statistical characteristics of Impact relative to World data by country
Таблица 6 – Статистические характеристики воздействия относительно мировых данных

Code	Min	Q_1	Mean	Median	Q_2	SD	Max
AZE	0.0	0.0	0.1	0.0	0.0	0.2	0.6
GEO	0.0	0.0	0.6	0.1	0.3	1.7	8.8
ARM	0.0	0.0	0.5	0.1	0.3	1.5	7.9
TUR	0.3	0.4	0.6	0.6	0.7	0.2	1.4
IRN	0.0	0.4	0.7	0.7	1.0	0.4	1.7
JPN	1.1	1.4	1.5	1.5	1.6	0.2	1.9
ITA	1.2	1.4	1.6	1.6	1.7	0.3	2.2
DEU	1.2	1.5	1.6	1.6	1.8	0.3	2.3
CHN	1.3	1.6	1.7	1.6	1.8	0.3	3.0
GBR	1.3	1.7	1.9	1.9	2.0	0.3	2.5
FRA	1.5	1.8	2.0	2.0	2.2	0.4	3.2
USA	1.6	1.8	2.1	2.1	2.4	0.3	2.7
NLD	1.9	2.0	2.3	2.2	2.5	0.3	2.9
CAN	1.6	2.1	2.4	2.3	2.7	0.4	3.3

References

Batouli A., Jahanshahi P., Gross C.P., Makarov D.V., Yu J.B. (2014). The global cancer divide: Relationships between national healthcare resources and cancer outcomes in high-income vs. middle- and low-income countries. *Journal of Epidemiology and Global Health*, vol. 4, no. 2, pp. 115–124. DOI: 10.1016/j.jegh.2013.10.004

Berg C.J., Harutyunyan A., Paichadze N., Hyder A.A., Petrosyan V. (2021). Addressing cancer prevention and control in Armenia: Tobacco control and mHealth as key strategies. *International Journal for Equity in Health*, vol. 20, Article number: 4. https://doi.org/10.1186/s12939-020-01344-8

Blaginin V., Matveeva A. (2016). Research fronts: A strategic imperative for the development of Russian science. *Moscow Economic Journal,* no. 4.

Bonnini S., Corain L., Marozzi M., Salmaso L. (2014). *Nonparametric hypothesis testing: Rank and permutation methods with applications in R*. John Wiley & Sons.

Buxton M., Hanney S., Jones T. (2004). Estimating the economic value to societies of the impact of health research: A critical review. *Bulletin of the World Health Organization*, vol. 82, no. 10, pp. 733–739.

Cheng F., Ma Y., Uzzi B., Loscalzo J. (2020). Importance of scientific collaboration in contemporary drug discovery and development: A detailed network analysis. *BMC Biology*, vol. 18, Article number: 138. https://doi.org/10.1186/s12915-020-00868-3

Dinno A. (2015). Nonparametric pairwise multiple comparisons in independent groups using Dunn's test. *The Stata Journal*, vol. 15, no. 1, pp. 292–300. https://doi.org/10.1177/1536867X1501500117

Eck N.J. van, Waltman L. (2014). Visualizing bibliometric networks. In: Y. Ding, R. Rousseau, D. Wolfram. (Eds.). *Measuring scholarly impact: Methods and practice* (pp. 285–320). Springer.

Fakhree M.A.A., Jouyban A. (2011). Scientometric analysis of the major Iranian medical universities. *Scientometrics*, vol. 87, issue 1, pp. 205–206. https://doi.org/10.1007/s11192-010-0336-z

Fell C.B., König C.J. (2016). Is there a gender difference in scientific collaboration? A scientometric examination of co-authorships among industrial-organizational psychologists. *Scientometrics*, vol. 108, issue 1, no. 6, pp. 113–141. DOI: 10.1007/s11192-016-1967-5

Glänzel W. (2001). National characteristics in international scientific co-authorship relations. *Scientometrics*, vol. 51, pp. 69–115. https://doi.org/10.1023/A:1010512628145

Gureyev N.V., Mazov A.N., Kosyakov D.V., Guskov A.E. (2020). Review and analysis of publications on scientific mobility: Assessment of influence, motivation, and trends. *Scientometrics*, vol. 124, no. 2, pp. 1599–1630. DOI: 10.1007/s11192-020-03515-4

Jones T., Hanney S. (2016). Tracing the indirect societal impacts of biomedical research: Development and piloting of a technique based on citations. *Scientometrics*, vol. 107, pp. 975–1003. DOI: 10.1007/s11192-016-1895-4

Jung Y., Kim J., So M., Kim H. (2015). Statistical relationships between journal use and research output at academic institutions in South Korea. *Scientometrics*, vol. 103, pp. 751–777. https://doi.org/10.1007/s11192-015-1563-0

Karacan B.D. (2021). Science diplomacy as a foreign policy tool for Turkey and the ramifications of collaboration with the EU. *Humanities and Social Sciences Communications*, vol. 8, Article number: 49, pp. 1–12. https://doi.org/10.1057/s41599-021-00722-z

Kremer R.K., Werner M. (2009). Aspects of the scientific cooperation of Estonia and Germany in view of bibliometry. *Scientometrics*, vol. 58, no. 4, pp. 255–262. DOI: 10.3176/proc.2009.4.07

Kruskal W.H., Wallis W.A. (1952). Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association*, vol. 47, no. 260, pp. 583–621. https://doi.org/10.2307/2280779

Lascurain-Sánchez L.M., García-Zorita C., Martin-Moreno C., Suárez-Balseiro C., Sanz-Casado E. (2008). Impact of health science research on the Spanish health system, based on bibliometric and healthcare indicators. *Scientometrics*, vol. 77, no. 1, pp. 131–146. DOI: 10.1007/s11192-007-1922-6

Lee C.K. (2003). A scientometric study of the research performance of the Institute of Molecular and Cell Biology in Singapore. *Scientometrics*, vol. 56, pp. 95–110. https://doi.org/10.1023/A:1021902724734

Lee S., Bozeman B. (2005). The impact of research collaboration on scientific productivity. *Social Studies of Science*, vol. 35, issue 5, pp. 673–702. https://doi.org/10.1177/0306312705052359

Lewison G., Purushotham A., Mason M., McVie G., Sullivan R. (2010). Understanding the impact of public policy on cancer research: A bibliometric approach. *European Journal of Cancer*, vol. 46, pp. 912–919. DOI: 10.1016/j.ejca.2009.12.020

Lin L., Yan L., Liu Y., Yuan F., Li H., Ni J. (2019). Incidence and death in 29 cancer groups in 2017 and trend analysis from 1990 to 2017 from the Global Burden of Disease Study. *Journal of Hematology & Oncology*, vol. 12, Article number: 96. https://doi.org/10.1186/s13045-019-0783-9

Munnolli S.S., Shamprasad P.M. (2017). Scientometric study of Indian cancer research based on Scopus database. *COLLNET Journal of Scientometrics and Information Management*, vol. 11, issue 2, pp. 201–214. https://doi.org/10.1080/09737766.2017.1284729

Nieminen P., Carpenter J., Rucker G., Schumacher M. (2006). The relationship between quality of research and citation frequency. *BMC Medical Research Methodology,* vol. 6, Article number: 42. https://doi.org/10.1186/1471-2288-6-42

Niu X.-T., Yang Y.-C., Wang Y.-C. (2021). Does the economic growth improve public health? A cross-regional heterogeneous study in China. *Frontiers in Public Health*, vol. 9, 704155. https://doi.org/10.3389/fpubh.2021.704155

Papikyan A., Connor S.R., Amiryan D. (2018). Development of palliative care in Armenia. *Journal of Pain and Symptom Management*, vol. 55, issue 2, pp. S19–S24. https://doi.org/10.1016/j.jpainsymman.2017.02.023

Parish A.J., Boyack K.W., Ioannidis J.P.A. (2018). Dynamics of co-authorship and productivity across different fields of scientific research. *PLoS ONE,* vol. 13, no. 1, e0189742. https://doi.org/10.1371/journal.pone.0189742

Puspitaningtyas H., Espressivo A., Hutajulu S.H., Fuad A., Allsop M.J. (2021). Mapping and visualization of cancer research in Indonesia: A scientometric analysis. *Cancer Control*, vol. 28. https://doi.org/10.1177/10732748211053464

Ruiz-Coronel A., Andrade J.L.J., Carrillo-Calvet H. (2020). National Cancer Institute scientific production scientometric analysis. *Gaceta Medica de Mexico*, vol. 156, no. 1, pp. 4–10. DOI: 10.24875/GMM.19005103

Sargsyan A.Sh., Maisano D.A., Mirzoyan A.R., Manukyan A.A., Gzoyan E.G. (2020). EU-EAEU dilemma of Armenia: Does science support politics? *Scientometrics*, vol. 122, pp. 1491–1507. https://doi.org/10.1007/s11192-019-03337-z

Shehatta I., Mahmood K. (2017). Bibliometric patterns and indicators of research collaboration of Egyptian health scientists: 1980–2014. *Malaysian Journal of Library & Information Science*, vol. 22, no. 2, pp. 45–65. DOI: 10.22452/mjlis.vol22no2.4

Sprent P., Smeeton N.C. (2000). *Applied nonparametric statistical methods* (3rd ed.). Chapman and Hall/CRC.

Velmurugan C., Radhakrishnan N. (2015). A scientometric analysis research papers published on pharmacognosy as reflected in the Web of Science. *Advances in Pharmacognosy and Phytomedicine*, 1(1): 27–40.

Источники

Batouli A., Jahanshahi P., Gross C.P., Makarov D.V., Yu J.B. (2014). The global cancer divide: Relationships between national healthcare resources and cancer outcomes in high-income vs. middle- and low-income countries. *Journal of Epidemiology and Global Health*, vol. 4, no. 2, pp. 115–124. DOI: 10.1016/j.jegh.2013.10.004

Berg C.J., Harutyunyan A., Paichadze N., Hyder A.A., Petrosyan V. (2021). Addressing cancer prevention and control in Armenia: Tobacco control and mHealth as key strategies. *International Journal for Equity in Health*, vol. 20, Article number: 4. https://doi.org/10.1186/s12939-020-01344-8

Blaginin V., Matveeva A. (2016). Research fronts: A strategic imperative for the development of Russian science. *Moscow Economic Journal,* no. 4.

Bonnini S., Corain L., Marozzi M., Salmaso L. (2014). *Nonparametric hypothesis testing: Rank and permutation methods with applications in R*. John Wiley & Sons.

Buxton M., Hanney S., Jones T. (2004). Estimating the economic value to societies of the impact of health research: A critical review. *Bulletin of the World Health Organization*, vol. 82, no. 10, pp. 733–739.

Cheng F., Ma Y., Uzzi B., Loscalzo J. (2020). Importance of scientific collaboration in contemporary drug discovery and development: A detailed network analysis. *BMC Biology*, vol. 18, Article number: 138. https://doi.org/10.1186/s12915-020-00868-3

Dinno A. (2015). Nonparametric pairwise multiple comparisons in independent groups using Dunn's test. *The Stata Journal*, vol. 15, no. 1, pp. 292–300. https://doi.org/10.1177/1536867X1501500117

Eck N.J. van, Waltman L. (2014). Visualizing bibliometric networks. In: Y. Ding, R. Rousseau, D. Wolfram. (Eds.). *Measuring scholarly impact: Methods and practice* (pp. 285–320). Springer.

Fakhree M.A.A., Jouyban A. (2011). Scientometric analysis of the major Iranian medical universities. *Scientometrics*, vol. 87, issue 1, pp. 205–206. https://doi.org/10.1007/s11192-010-0336-z

Fell C.B., König C.J. (2016). Is there a gender difference in scientific collaboration? A scientometric examination of co-authorships among industrial-organizational psychologists. *Scientometrics*, vol. 108, issue 1, no. 6, pp. 113–141. DOI: 10.1007/s11192-016-1967-5

Glänzel W. (2001). National characteristics in international scientific co-authorship relations. *Scientometrics*, vol. 51, pp. 69–115. https://doi.org/10.1023/A:1010512628145

Gureyev N.V., Mazov A.N., Kosyakov D.V., Guskov A.E. (2020). Review and analysis of publications on scientific mobility: Assessment of influence, motivation, and trends. *Scientometrics*, vol. 124, no. 2, pp. 1599–1630. DOI: 10.1007/s11192-020-03515-4

Jones T., Hanney S. (2016). Tracing the indirect societal impacts of biomedical research: Development and piloting of a technique based on citations. *Scientometrics*, vol. 107, pp. 975–1003. DOI: 10.1007/s11192-016-1895-4

Jung Y., Kim J., So M., Kim H. (2015). Statistical relationships between journal use and research output at academic institutions in South Korea. *Scientometrics*, vol. 103, pp. 751–777. https://doi.org/10.1007/s11192-015-1563-0

Karacan B.D. (2021). Science diplomacy as a foreign policy tool for Turkey and the ramifications of collaboration with the EU. *Humanities and Social Sciences Communications*, vol. 8, Article number: 49, pp. 1–12. https://doi.org/10.1057/s41599-021-00722-z

Kremer R.K., Werner M. (2009). Aspects of the scientific cooperation of Estonia and Germany in view of bibliometry. *Scientometrics*, vol. 58, no. 4, pp. 255–262. DOI: 10.3176/proc.2009.4.07

Kruskal W.H., Wallis W.A. (1952). Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association*, vol. 47, no. 260, pp. 583–621. https://doi.org/10.2307/2280779

Lascurain-Sánchez L.M., García-Zorita C., Martin-Moreno C., Suárez-Balseiro C., Sanz-Casado E. (2008). Impact of health science research on the Spanish health system, based on bibliometric and healthcare indicators. *Scientometrics*, vol. 77, no. 1, pp. 131–146. DOI: 10.1007/s11192-007-1922-6

Lee C.K. (2003). A scientometric study of the research performance of the Institute of Molecular and Cell Biology in Singapore. *Scientometrics*, vol. 56, pp. 95–110. https://doi.org/10.1023/A:1021902724734

Lee S., Bozeman B. (2005). The impact of research collaboration on scientific productivity. *Social Studies of Science*, vol. 35, issue 5, pp. 673–702. https://doi.org/10.1177/0306312705052359

Lewison G., Purushotham A., Mason M., McVie G., Sullivan R. (2010). Understanding the impact of public policy on cancer research: A bibliometric approach. *European Journal of Cancer*, vol. 46, pp. 912–919. DOI: 10.1016/j.ejca.2009.12.020

Lin L., Yan L., Liu Y., Yuan F., Li H., Ni J. (2019). Incidence and death in 29 cancer groups in 2017 and trend analysis from 1990 to 2017 from the Global Burden of Disease Study. *Journal of Hematology & Oncology*, vol. 12, Article number: 96. https://doi.org/10.1186/s13045-019-0783-9

Munnolli S.S., Shamprasad P.M. (2017). Scientometric study of Indian cancer research based on Scopus database. *COLLNET Journal of Scientometrics and Information Management*, vol. 11, issue 2, pp. 201–214. https://doi.org/10.1080/09737766.2017.1284729

Nieminen P., Carpenter J., Rucker G., Schumacher M. (2006). The relationship between quality of research and citation frequency. *BMC Medical Research Methodology,* vol. 6, Article number: 42. https://doi.org/10.1186/1471-2288-6-42

Niu X.-T., Yang Y.-C., Wang Y.-C. (2021). Does the economic growth improve public health? A cross-regional heterogeneous study in China. *Frontiers in Public Health*, vol. 9, 704155. https://doi.org/10.3389/fpubh.2021.704155

Papikyan A., Connor S.R., Amiryan D. (2018). Development of palliative care in Armenia. *Journal of Pain and Symptom Management*, vol. 55, issue 2, pp. S19–S24. https://doi.org/10.1016/j.jpainsymman.2017.02.023

Parish A.J., Boyack K.W., Ioannidis J.P.A. (2018). Dynamics of co-authorship and productivity across different fields of scientific research. *PLoS ONE,* vol. 13, no. 1, e0189742. https://doi.org/10.1371/journal.pone.0189742

Puspitaningtyas H., Espressivo A., Hutajulu S.H., Fuad A., Allsop M.J. (2021). Mapping and visualization of cancer research in Indonesia: A scientometric analysis. *Cancer Control*, vol. 28. https://doi.org/10.1177/10732748211053464

Ruiz-Coronel A., Andrade J.L.J., Carrillo-Calvet H. (2020). National Cancer Institute scientific production scientometric analysis. *Gaceta Medica de Mexico*, vol. 156, no. 1, pp. 4–10. DOI: 10.24875/GMM.19005103

Sargsyan A.Sh., Maisano D.A., Mirzoyan A.R., Manukyan A.A., Gzoyan E.G. (2020). EU-EAEU dilemma of Armenia: Does science support politics? *Scientometrics*, vol. 122, pp. 1491–1507. https://doi.org/10.1007/s11192-019-03337-z

Shehatta I., Mahmood K. (2017). Bibliometric patterns and indicators of research collaboration of Egyptian health scientists: 1980–2014. *Malaysian Journal of Library & Information Science*, vol. 22, no. 2, pp. 45–65. DOI: 10.22452/mjlis.vol22no2.4

Sprent P., Smeeton N.C. (2000). *Applied nonparametric statistical methods* (3rd ed.). Chapman and Hall/CRC.

Velmurugan C., Radhakrishnan N. (2015). A scientometric analysis research papers published on pharmacognosy as reflected in the Web of Science. *Advances in Pharmacognosy and Phytomedicine*, 1(1): 27–40.

Information about the authors

Shushanik A. Sargsyan

Cand. Sc. (Biology), Head of the Center for Scientific Information Analysis and Monitoring (CSIAM). **Institute for Informatics and Automation Problems of the National Academy of Sciences of the Republic of Armenia (IIAP NAS RA)**, Yerevan, Armenia. E-mail: shushanik@iiap.sci.am

Parandzem M. Hakobyan

Cand. Sc. (Physics and Mathematics), Senior Research Fellow of the Department of Information Theory and Statistical Models. **Institute for Informatics and Automation Problems of the National Academy of Sciences of the Republic of Armenia (IIAP NAS RA)**. E-mail: par_h@iiap.sci.am

Ruzanna A. Shushanyan

Junior Research Fellow of the Center for Scientific Information Analysis and Monitoring (CSIAM). **Institute for Informatics and Automation Problems of the National Academy of Sciences of the Republic of Armenia (IIAP NAS RA)**, Yerevan, Armenia. E-mail: shushanyanruzan@mail.ru

Aram R. Mirzoyan

Cand. Sc. (History), Senior Research Fellow of the Center for Scientific Information Analysis and Monitoring (CSIAM). **Institute for Informatics and Automation Problems of the National Academy of Sciences of the Republic of Armenia (IIAP NAS RA)**, Yerevan, Armenia. E-mail: mirzoyan.aram@gmail.com

Viktor A. Blaginin

Head of Scientometrics, R&D and Rankings Dept. **Ural State University of Economics**, Ekaterinburg. Russia. E-mail: v.a.blaginin@usue.ru

Информация об авторах

Саргсян Шушаник Артуровна

Кандидат биологических наук, руководитель Центра анализа и мониторинга научной информации. **Институт проблем информатики и автоматизации Национальной академии наук Республики Армения (НАН РА)**, г. Ереван, Республика Армения. E-mail: shushanik@iiap.sci.am

Акопян Парандзем Мкртычевна

Кандидат физико-математических наук, старший научный сотрудник Департамента теории информации и статистических моделей. **Институт проблем информатики и автоматизации Национальной академии наук Республики Армения (НАН РА)**, г. Ереван, Республика Армения. E-mail: par_h@iiap.sci.am

Шушанян Рузанна Арсеновна

Младший научный сотрудник Центра анализа и мониторинга научной информации. **Институт проблем информатики и автоматизации Национальной академии наук Республики Армения (НАН РА),** г. Ереван, Республика Армения. E-mail: shushanyanruzan@mail.ru

Мирзоян Арам Робертович

Кандидат исторических наук, старший научный сотрудник Центра анализа и мониторинга научной информации. **Институт проблем информатики и автоматизации Национальной академии наук Республики Армения (НАН РА)**, г. Ереван, Республика Армения. E-mail: mirzoyan.aram@gmail.com

Благинин Виктор Андреевич

Начальник Управления наукометрии, НИР и рейтингов. **Уральский государственный экономический университет**, г. Екатеринбург, РФ. E-mail: v.a.blaginin@usue.ru