Alina Vysochyna,
Ph.D., Sumy State University, Ukraine
ORCID ID 0000-0001-9490-1026
email : a.vysochyna@uabs.sumdu.edu.ua
Agnieszka Jakubowska,
Koszalin University of Technology, Poland
ORCID ID, 0000-0002-3610-8713
email: agnieszka.jakubowska@tu.koszalin.pl

Correspondence author: a.vysochyna@uabs.sumdu.edu.ua

INFLUENCE OF HEALTH EXPENDITURE ON COVID-19 CONTRACTION: THEORETICAL AND EMPIRICAL ANALYSIS

Abstract. *Intensive economic development leads to the inevitable consequences of anthropogenic impact on the environment. Air pollution, soil degradation, water pollution and lack of clean drinking water lead to deteriorating human health and increasing the burden on the health care system. Globalization and integration have also become important drivers of the rapid spread of the COVID-19 pandemic. All this leads to the need to transform the health care system and the model of its financing, and adapt it to these challenges. The aim of this work is to identify theoretical (based on bibliometric analysis) and empirical (based on panel data regression modelling) patterns of the impact of health care expenditure on the effectiveness of the COVID-19 combating. The theoretical part of the work involves the implementation of bibliometric analysis based on 262 Scopus publications, in the title, keywords or annotations of which both concepts such as «health expenditure» and «COVID-19» are mentioned. The practical implementation of this task is carried out using VOSviewer v.1.6.17. According to the results of the bibliometric analysis, contextual, geographical and temporal patterns of publishing activity of scientists on certain issues were revealed. The empirical part of the work involves a statistical analysis to identify the relationship between morbidity and mortality due to COVID-19 and the volatility of the share of current health expenditure in GDP and its structure. The task of this stage is to determine the benchmarking model of financial support of the health care system, which demonstrates the greatest resistance to COVID-19. The analysis was conducted on the basis of data for 13 countries in Europe and Asia (Azerbaijan, Belarus, Armenia, Georgia, Estonia, Latvia, Lithuania, Moldova, Poland, Romania, Slovakia, Hungary and Ukraine). According to statistical analysis, the most resistant to COVID-19 is the health care system of Estonia, which is characterized by the volume of health care expenditure at 4-6% of GDP. At the same time, in the structure of the current health care expenditure, 25% is private expenditure and 75% is government expenditure, and external financing is almost non-existent. However, similar proportions of public and private expenditure in other countries do not ensure similar resistance to coronavirus, so this ratio is not a benchmark. A more in-depth analysis using panel regression modelling in Stata 12/SE revealed the positive impact of public, private and external health expenditures on reducing mortality, as well as the positive impact of increasing current health expenditures on life expectancy. The obtained theoretical and practical results can be useful for scientists and government officials in the context of optimizing the financial support of the health care system, taking into account its effectiveness in resisting national and global threats (COVID-19).*

Keywords: *COVID-19, government health expenditure, panel data regression analysis, private health expenditure.*

Introduction. Changes in the paradigm of economic systems, exacerbation of environmental problems and intensification of technological development necessitate a qualitative and quantitative

transformation of international and national standards of health care. Thus, in the list of the negative consequences of the intensification of economic activity there are air pollution, water pollution and deficit of clean water, soil degradation, as well as deteriorating food habits and culture, and food quality (although food products have become more accessible due to innovative technologies in the food industry and related fields). All of the above-mentioned necessitates reforming the health care system in order to improve its capacity to absorb these shocks. Increasing the burden on the health care system leads to an increase in expenditure burden on both public authorities and insurance companies or households. In particular, according to (World Health Organization, 2021) over the last twenty years (2000-2019) total health care expenditures increased from 8.5% to 9.8% of world GDP (absolute base growth is 4.3 trillion USD and relative is 102.4%).
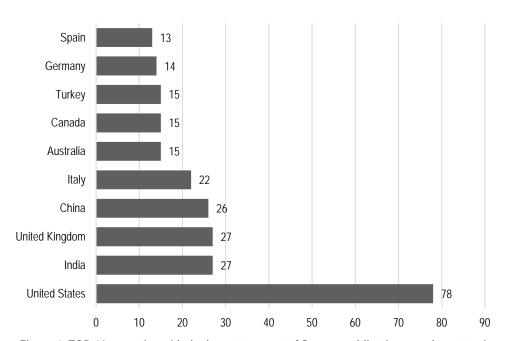
At the same time, globalization and integration in the economic and social spheres lead to the elimination of obstacles to large-scale labour mobility, which creates risks for faster dissemination of various diseases and the negative synergistic effect of their destructive effects. One of such threat that hit the world at the end of 2019 and is still relevant today is the COVID-19 pandemic. In total, 533 million coronavirus cases and almost 6 million deaths have been reported worldwide during the pandemic period (Worldometer, 2022). This situation has provoked significant crash-tests of the effectiveness of the health care system as a whole in the world and for each country individually. However, it should be noted that the effectiveness of counteracting the coronavirus pandemic in Ukraine and the world depended on various factors, including the overall level of institutional readiness of the health care system, the model of this system, the intensity of migration, economic conditions, the scale of health care funding, etc.

The aim of this work is to identify theoretical (based on bibliometric analysis) and empirical (based on regression modelling) patterns of the impact of health care expenditures on the effectiveness of the COVID-19 counteraction. The main hypothesis, which will be tested in this study, can be formulated as follows: volume of health care expenditures is a relevant and important factor in ensuring the effectiveness of the counteraction of COVID-19 pandemic and other similar threats.
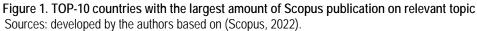
Literature Review. Thus, the first step in this study is to determine the theoretical basis for the relevance of the relationship between volume of health care expenditures and the effectiveness of the counteraction of COVID-19 pandemic and other similar threats. To achieve this task, a bibliometric analysis was conducted based on 262 publications in the scientometric database Scopus (Scopus, 2022) using VOSviewer v.1.6.17 tool (VOSviewer, 2022). Bibliometric analysis is based on publications that include in title, keywords or abstract both of such concepts as «health expenditure» and «COVID-19».

Given the fact that publications on the specifics of the coronavirus pandemic appeared not so long ago, the publications included in the sample cover the time horizon of 2020-2022. In particular, in 2020 73 documents on relevant topics were published, in 2021 – 138 papers, and during the first month of 2022 – 51 articles have already been published. List of TOP-10 countries with the largest number of Scopus articles (Scopus, 2022), in which contain both «health expenditure» and «COVID-19» key concepts, shown in Figure 1.

Thus, it can be noted that researchers from the United States, India, Great Britain, China, and Italy provide the largest number of publications on certain topics. It is interesting to note that the world leaders in the number of COVID -19 cases are the United States, India, Brazil, France, and Germany, and in terms of mortality – the United States, Brazil, India, Russia and Mexico (Worldometer , 2022). Thus, there is a coherence between COVID-19 morbidity and mortality rates and the publishing activity of scientists on the same topic in some countries.

Figure 1. TOP-10 countries with the largest amount of Scopus publication on relevant topic
Sources: developed by the authors based on (Scopus, 2022).

In turn, Figure 2 shows the contextual relationships within the Scopus publications (Scopus, 2022), in which in the title, keywords or abstracts it is mentioned both of such as concepts «health expenditure» and «COVID-19».

In particular, according to the results of the contextual block of bibliometric analysis performed by VOSviewer v.1.6.17 (VOSviewer, 2022), it can be noted that publications on relevant topics by the criterion of co-occurrence between keywords can be conditionally grouped into six content clusters, namely:

– red cluster - study of the impact of models and scales of health care expenditures on the quality of the system as a whole and the effectiveness of the COVID-19 pandemic counteraction (the largest cluster, characterized by the highest level of agreement with search parameters);
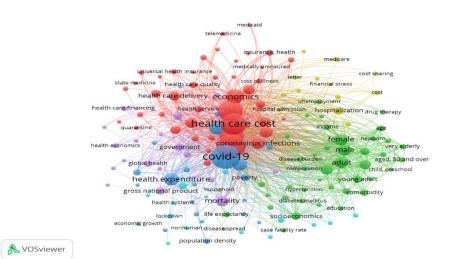
– green cluster - study of age, gender, social and medical (disease) preconditions and consequences of the spread of the COVID-19 pandemic;
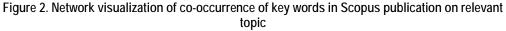
– yellow cluster - a study of the relationship between the cost of medical services and outpatient treatment (hospitalization) , including and through coronavirus ;

– dark blue cluster - analysis of socio-economic preconditions for the effectiveness of the fight against COVID-19 (economic growth rate, population density, poverty rate, etc.).

– violet cluster - study of the impact of financial and economic (capital allocation, GDP growth, quality of financial management, etc.) and institutional prerequisites (quality of public administration, relations between levels of government) on ensuring the quality of health care and its resistance to shocks caused by the COVID-19 pandemic;

– turquoise cluster - analysis of key determinants, tools and measures to combat the spread of COVID-19 (impact of vaccination, lockdown, compliance with sanitary requirements for the spread of coronavirus infection, mortality from COVID-19 and its complications).

Figure 2. Network visualization of co-occurrence of key words in Scopus publication on relevant topic
Sources: developed by the authors based on (Scopus, 2022; VOSviewer, 2022).

In turn, Figure 3 presents a visual map of the density of relationships between keywords in publications that meet the search criteria. In particular, among 262 publications in the scientometric database Scopus (Scopus, 2022), in the title, keywords or abstracts of which it is mentioned both such concepts as «health expenditure» and «COVID-19», such keywords as «health care cost», «coronavirus infection», «COVID-19», «economics», «health expenditure», «mortality», «male», «female», «adult» are the most widely used concepts that also characterized by the highest density of links with other concepts. This, in particular, allows us to conclude that in publications on relevant topics economic, age and gender aspects are the most commonly mentioned in terms of characteristics the relationship between health expenditure and COVID-19.

In order to better understanding the main theoretical and empirical findings in the context of studying the impact of health care spending on the effectiveness of the COVID-19 pandemic combating, it is necessary to analyse the TOP-10 most cited Scopus publications (Scopus, 2022) on relevant issues (Table 1).

Among the most cited publications on the relevant issues are the following research areas:

− research of population readiness for vaccination as one of the main tool of combating the spread of COVID-19 (Wong et al., 2020; Harapan et al., 2020) ;

− searching for mechanisms to reduce the burden on health care workers caused by the COVID-19 pandemic (Moazzami et al., 2020);

− description of testing new drugs against COVID-19 (Kirkland and Tchkonia, 2020);

− simulation of stress testing of health care system capacity caused by its overloading because of COVID-19 (Verelst et al., 2020);

− modelling the impact of lockdown duration on the effectiveness of counteracting the spread of COVID-19 (morbidity and mortality dynamics), as well as the economic consequences of such regulatory interventions (Coccia, 2021b);

− modelling the relationship between health care expenditures, air pollution levels and coronavirus mortality rates (Coccia, 2021a);

   – modelling the likelihood of different types of complications caused by COVID-19 (Shahjouei, 2020);

   – determining the social preconditions for the spread of coronavirus infection (Rollston and Galea, 2020);

   – research of «operating expenses and revenues of primary care practices» caused by the pandemic (Basu et al., 2020).
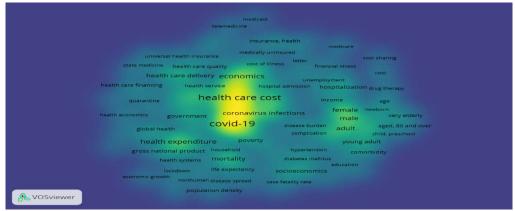

Figure 3. Density visualization of co-occurrence of key words in Scopus publication on relevant topic
Sources: developed by the authors based on (Scopus, 2022; VOSviewer, 2022).

Table 1. TOP-10 the most citied Scopus publications on relevant topic

№	Document title	Authors	Year	Source	Cited by
1	The use of the health belief model to assess predictors of intent to receive the COVID-19 vaccine and willingness to pay	Wong, L.P., Alias, H., Wong, P.-F., Lee, H.Y., AbuBakar, S.	2020	Human Vaccines and Immunotherapeutics 16(9), pp. 2204-2214	270
2	COVID-19 and telemedicine: Immediate action required for maintaining healthcare providers well-being	Moazzami, B., Razavi-Khorasani, N., Dooghaie Moghadam, A., Farokhi, E., Rezaei, N.	2020	Journal of Clinical Virology 126,104345	192
3	Senolytic drugs: from discovery to translation	Kirkland, J.L., Tchkonia, T.	2020	Journal of Internal Medicine 288(5), pp. 518-536	158
4	Indications for healthcare surge capacity in European countries facing an exponential increase in coronavirus disease (COVID-19) cases, March 2020	Verelst, F., Kuylen, E., Beutels, P.	2020	Eurosurveillance 25(13)	97
5	The relation between length of lockdown, numbers of infected people and deaths of Covid-19, and economic growth of countries: Lessons learned to cope with future pandemics similar to Covid-19 and to constrain the deterioration of economic system	Coccia, M.	2021	Science of the Total Environment 775,145801	72

Continued Table 1

6	Willingness-to-pay for a COVID-19 vaccine and its associated determinants in Indonesia	Harapan, H., Wagner, A.L., Yufika, A., (...), Groneberg, D.A., Mudatsir, M.	2020	Human Vaccines and Immunotherapeutics 16(12), pp. 3074-3080	55
7	Risk of stroke in hospitalized SARS-CoV-2 infected patients: A multinational study	Shahjouei, S., Naderi, S., Li, J., (...), Abedi, V., Zand, R.	2020	EBioMedicine 59,102939	54
8	COVID-19 and the Social Determinants of Health	Rollston, R., Galea, S.	2020	American Journal of Health Promotion 34(6), pp. 687-689	50
9	Primary care practice finances in the United States amid the COVID-19 pandemic	Basu, S., Phillips, R.S., Phillips, R., Peterson, L.E., Landon, B.E.	2020	Health Affairs 39(9), pp. 1605-1614	46
10	High health expenditures and low exposure of population to air pollution as critical factors that can reduce fatality rate in COVID-19 pandemic crisis: a global analysis	Coccia, M.	2021	Environmental Research 199,111339	45

Sources: developed by the authors (Scopus, 2022).

Thus, it can be noted that in general the topic of the most cited relevant publications is quite closely correlated with the contextual blocks identified using bibliometric analysis. However, it is fair to note that earlier publications focused on the dissemination trends of COVID-19 and its determinants, while later work focused on identifying the effects of a pandemic on various areas of human life and identifying the most effective tools of combating the intensity of the spread of coronavirus infection.

According to the literature review, it is noted that there is a lack of scientific publications aimed at identifying the relationship between indicators of the spread of COVID-19 (morbidity, mortality, vaccination rates) and the peculiarities of financing the health care system. This determines the expediency of a deeper scientific search in this direction.

Methodology and research methods. The empirical part of this study aims to test the following hypothesis: volume of health care expenditures is a relevant and important factor in ensuring the effectiveness of the counteraction of COVID-19 pandemic and other similar threats. To test this hypothesis, it will be used panel data regression modelling using the Stata 12/SE software. The sample of countries includes a bloc of Eastern Partnership countries and neighbour to Ukraine EU member states – 13 countries in total, including Armenia, Azerbaijan, Belarus, Estonia, Georgia, Hungary, Latvia, Lithuania, Poland, Moldova, Romania, Slovakia, and Ukraine. The time range of the study is 2000-2019 (due to the lack of newer statistics for the entire sample). Considering that the coronavirus pandemic is expanded the world in 2019 - 2022, and statistics for this period are not yet available, it makes it impossible to obtain reliable simulation results using it as an effective variable indicator of the spread of coronavirus infection. In this regard, as the dependent variables it is selected more general indicators – Death rate, crude (per 1,000 people) and Life expectancy at birth, total (years). Instead, the block of independent variables is represented by the following indicators that characterize the financing of health care:

– Domestic General Government Health Expenditure (GGHE-D);
– Domestic Private Health Expenditure (PVT-D);
– External Health Expenditure (EXT);

    – Current Health Expenditure as % Gross Domestic Product (CHE);

    – Capital health expenditure as % Gross Domestic Product (CapHE).

The relationship between dependent and explanatory variables will be determined based on a set of simple regression models.

All statistics are generated from open sources, including the collection "Health Nutrition and Population Statistics" (World Bank DataBank, 2022) and (World Health Organization, 2021).

Results. Given the impossibility of obtaining empirical results of modelling on the impact of health care expenditures on the prevalence of COVID-19, it is advisable to conduct a preliminary statistical analysis with these parameters to identify common patterns.

First of all, it is advisable to analyse the dynamics of the case fatality rate (ratio of the number of deaths to the number of COVID-19 cases) from April 1, 2020 to February 1, 2022 (Our World in Data, 2022) in terms of 13 sample countries (Table 2, Figure 4).

According to the analysis of the presented statistics, it can be noted that the highest mortality rates were recorded in Romania, Hungary, Moldova and Ukraine, while the benchmark country can be considered Estonia. It is fair to note that the largest reduction in mortality during the analysed period was achieved in such countries as Belarus (-34%), Hungary (-30%), and Romania (-29%). In Estonia, Azerbaijan, Lithuania and Ukraine, there has also been a reduction in mortality, but not as large.
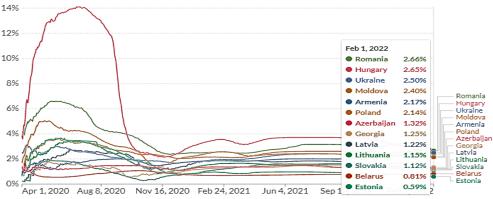

Figure 4. Case fatality rate (CFR) of COVID -19 from April 1, 2020 to February 1, 2022
Sources: developed by the authors based on (Our World in Data, 2022).

Table 4. Absolute and relative change of case fatality rate (CFR) of COVID-19 from April 1, 2020 to February 1, 2022

Country	CFR (April 1, 2020)	CRF (February 1, 2022)	Absolute change	Relative change
Armenia	0.70%	2.17%	+ 1.47%	+ 210%
Azerbaijan	1.39%	1.32%	-0.07%	-5%
Belarus	1.23%	0.81%	-0.41%	-34%
Estonia	0.64%	0.59%	-0.05%	-8%
Georgia	0.62%	1.25%	+ 0.63%	+ 103%
Hungary	3.81%	2.65%	-1.16%	-30%
Latvia	0.20%	1.22%	+ 1.01%	+ 500%
Lithuania	1.17%	1.15%	-0.02%	-2%
Moldova	1.18%	2.40%	+ 1.21%	+ 103%
Poland	1.68%	2.14%	+ 0.46%	+ 27%

Continued Table 4

Romania	3.74%	2.66%	-1.08%	-29%
Slovakia	0.25%	1.12%	+ 0.87%	+ 348%
Ukraine	2.52%	2.50%	-0.02%	-1%
EUROPE	**7.17%**	**1.25%**	**-5.92%**	**-83%**

Sources: developed by the authors based on (Our World in Data, 2022).

The next step is to compare the effective indicators of pandemic control with the indicators of public spending on health care (Figures 5 and 6). Thus, it can be noted that in most of the studied countries the volume of health care expenditures ranges from 4-9% of GDP. Azerbaijan has the lowest amount of expenditures on health care - no more than 4% of GDP, and the largest - Armenia (10-12%). It is worth noting that the country-benchmark in the fight against coronavirus is characterized by the volume of health care expenditures at the level of 4-6%. Thus, it can be noted that significant health care expenditures are not a guarantee of high effectiveness in combating COVID-19.

Figure 5. Current Health Expenditure as% Gross Domestic Product in 2000-2019
Sources: developed by the authors based on (World Health Organization, 2021).

In addition to the general dynamics of current health care expenditures, their structure should also be investigated. Thus, Estonia has a ratio of 25% of private expenditures to 75% of government expenditures in the structure of current health care expenditures, while external funding is almost non-existent. For example, Armenia has almost the same ratio, but in favour of private spending, but the death rate from coronavirus in Armenia is quite high, which indicates the lower efficiency of such a model of building a health care financing. It is fair to note that in Ukraine government and private health care expenditures is distributed approximately equally, but the death rate from COVID-19 in our country is stable and has not changed significantly compared to April 2020.

Taking into account the above-mentioned statistical analysis results, it can be concluded that for the selected 13 countries it is not possible to establish a clear correlation between the current expenditures on health care and its structure with the effectiveness of combating the spread of coronavirus infection. In this regard, it is advisable to analyse the relationship between indicators of health care financing with life expectancy and death rates in the country. The simulation results are presented in table 5.

Based on the simulation results, the following conclusions can be drawn:
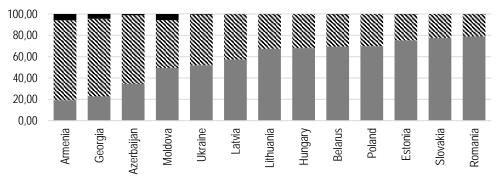
– an increase of 1% in general government health care expenditure is accompanied by a decrease in mortality in the analysed countries by 0.021 cases per 1000 people;

–   an increase of 1% in private health care expenditure is accompanied by a decrease in mortality in the analysed countries by 0.011 cases per 1000 people with a 90% probability;

–   an increase of 1% in external health care expenditure is accompanied by a decrease in mortality in the analysed countries by 0.069 cases per 1000 people with a 90% probability;

–   the increase in the share of both current and capital expenditures on health care in GDP does not have a statistically significant impact on the mortality rate;

–   an increase in the current health expenditures to GDP ratio in 1% leads to an increase in life expectancy of 0.536 years with 99% probability, while an increase of 1% in external health expenditures leads to a reduction of 0.138 year life expectancy with a probability of 95%.

Figure 6. Structure of Current Health Expenditure, averaged for 2000-2019
Sources: developed by the authors based on (World Health Organization, 2021).

Table 5. Regression results (author calculation)

Variable	Coefficient	Standard deviation	p-value	Significance	Prob > chi2
Dependent variable - Death rate, crude (per 1,000 people)					
GGHE-D	- 0.021	0.007	0 .002	***	0.0019
PVT-D	- 0 .011	0.007	0.096	*	0.0957
EXT	-0.069	0.010	0.000	***	0.0002
CHE	0.054	0.035	0.125		0.1248
CapHE	-0.041	0.171	0.810		0.8100
Dependent variable - Life expectancy at birth, total (years)					
GGHE-D	0.012	0.018	0.490		0.4896
PVT-D	-0.001	0.018	0.958		0.9584
EXT	-0.138	0.061	0.023	**	0.0233
CHE	0.536	0.107	0.000	***	0.0000
CapHE	-0.087	0.557	0.875		0.8753

Notes: *** - significance at 1% level; ** - significance at 5% level; * - significance at 10% level.
Sources: developed by the authors.

Conclusions. Thus, the results of the analysis aimed at identifying theoretical (based on bibliometric analysis) and empirical (based on regression modelling) patterns of the impact of health care expenditure on the effectiveness of pandemic control partially confirmed the basic hypothesis of this study. In particular, in the context of the theoretical block of the research (bibliometric analysis of 262 Scopus publications, in the title, keywords or abstracts of which there are both mentioned such concepts as «health expenditure» and «COVID-19»), it is identified six contextual clusters of research in this specific subject area. «health care cost», «coronavirus infection», «COVID-19», «economics», «health expenditure», «mortality», «male», «female», «adult» are the most often used keywords in these publications. Scientists from the United States, India, Brazil, France, and Germany have published the largest number of relevant research papers. It should be noted that there is a direct link between the countries with the highest mortality and morbidity rates of COVID-19 and the countries with the highest number of publications.

However, according to statistical analysis of Case indicators fatality rate (CFR) of COVID-19 and Current Health Expenditure as % Gross Domestic Product it has not been found that for the 13 countries studied there is a clear relationship between these parameters. However, in-depth analysis using panel data regression modelling revealed the positive impact of public, private and external health expenditures on reducing mortality, as well as the positive impact of increasing current health expenditures on life expectancy.

Thus, the main hypothesis of this study was partially confirmed. Among the prospects for further research is expanding the geographical structure of the sample, as well as the implementation of time lags (is a particularly promising vector of research, given that this study did not find a statistically significant relationship between mortality / life expectancy and capital health care expenditure). The obtained theoretical and practical results can be useful for scientists and government officials in the context of optimizing the health care system financing, taking into account its effectiveness in terms of resistance to national and global threats (COVID-19).

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Аліна Височина, *к.е.н., доцент, Сумський державний університет, Україна*
Агнєшка Якубовська, Кошалінський технологічний університет, Польща

Вплив видатків на охорону здоров'я на боротьбу з COVID-19: теоретичний та емпіричний аналіз

Інтенсивний розвиток економіки призводить до неминучих наслідків антропогенного впливу на навколишнє природнє середовище. Погіршення стану атмосферного повітря, виснаження ґрунтів, забруднення водойм та недостача чистої питної води призводять до погіршення стану здоров'я людей та зростання навантаження на систему охорони здоров'я. Глобалізація та інтеграція також стали одним із важливих драйверів стрімкого поширення пандемії COVID-19. Усе це призводить до необхідності трансформації та адаптації до таких викликів системи охорони здоров'я та моделі її фінансування. Метою даної роботи є виявлення теоретичних (на основі бібліометричного аналізу) та емпіричних (на основі регресійного моделювання) закономірностей впливу видатків на охорону здоров'я на ефективність боротьби з пандемією. Теоретичний блок роботи передбачає здійснення бібліометричного аналізу на основі 262 Scopus публікацій, у назві, ключових словах чи анотації яких згадуються обидва такі поняття як «health expenditure» та «COVID-19». Практична реалізація цього завдання здійснена з використанням VOSviewer v.1.6.17. За результатами бібліометричного аналізу було виявлено контекстуальні, географічні та часові закономірності публікаційної активності вчених з визначеної проблематики. Емпіричний блок роботи передбачає проведення статистичного аналізу з метою виявлення взаємозв'язків між захворюваністю та смертністю унаслідок COVID-19 та волатильністю частки поточних видатків на охорону здоров'я у ВВП і їх структурою. Завданням даного етапу є визначення бенчмаркінг-моделі фінансового забезпечення системи охорони здоров'я, що демонструє найбільшу резистентність до впливу COVID-19. Аналіз проведено на основі даних для 13 країн Європи та Азії (Азербайджан, Білорусь, Вірменія, Грузія, Естонія, Латвія, Литва, Молдова, Польща, Румунія, Словаччина, Угорщина та Україна). За результатами статистичного аналізу визначено, що найбільш резистентною до COVID-19 є система охорони здоров'я Естонія, для якої характерним є притаманними є обсяг фінансування системи охорони здоров'я на рівні 4-6% ВВП. При цьому у структурі поточних видатків на охорону здоров'я 25% припадає на приватні видатки на 75% – на державні, зовнішнє фінансування майже відсутнє. Однак, подібні пропорції державних і приватних видатків в інших країнах не дозволяють забезпечити аналогічну резистентність до коронавірусу, тому це співвідношення не є еталонним. Більш глибокий аналіз з використанням панельного регресійного моделювання засобами Stata 12/SE дозволив виявити позитивний вплив державних, приватних та зовнішніх видатків на охорону здоров'я на зниження рівня смертності населення, а також встановити позитивний вплив зростання поточних видатків на охорону здоров'я на тривалість життя населення. Отримані теоретичні та практичні результати можуть бути корисними для науковців та представників органів державної влади у контексті оптимізації фінансового забезпечення системи охорони здоров'я з урахуванням її ефективності щодо резистентності національним та глобальним загрозам (COVID-19).

Ключові слова: COVID-19, державні видатки на охорону здоров'я, приватні видатки на охорону здоров'я, регресійний аналіз на панельних даних.