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## FINANCIAL, SOCIO-ECONOMIC, ENVIRONMENTAL AND PUBLIC HEALTH PATTERNS OF CREATING REGIONAL ROADMAPS TO PREVENT THE SPREAD OF THE COVID-19 EPIDEMIC

**Abstract.** The paper summarised arguments and counterarguments within the scientific discussions on the financial, socio-economic, environmental, and public health patterns of creating regional roadmaps to prevent the spread of the COVID-19 epidemic. The main goals of the paper were to develop the regional anti-epidemiological road map with markers using the instruments of differential calculus. The results of the analysis of the core health care (financial, social, economic, and ecological) determinants which justified the regional differentiation on vulnerabilities of the population of Ukraine from COVID-19 showed that they were based on the findings of other countries and did not consider the national and regional specifics. Methodological instruments were differential calculus of nonlinear equations, which allowed determining the critical values (markers) for each factor, which formalise the «weaknesses» and «bottleneck» of the region in terms of responding to future epidemiological threats. All regions of Ukraine and the city of Kyiv were selected as the object of research. The authors developed the roadmaps for future anti-epidemiological measures for each region of Ukraine. The results of the analysis could be useful for local governments to make informed decisions under existing powers and differentiated decisions to reduce social distancing, quarantine, suspension of economic facilities, changes in financial budgets, etc., considering the differences of each region on public health factors, social, ecological, and economic determinants.

**Keywords:** local budget, pandemic, reform, road map, the state budget.

**JEL Classification** H51, H75, I15, I18, K32, P36

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## ФІНАНСОВІ, СОЦІО-ЕКОНОМІЧНІ, ЕКОЛОГІЧНІ ПАТЕРНИ І ФАКТОРИ ГРОМАДСЬКОГО ЗДОРОВ'Я ПРИ ФОРМУВАННІ ДОРОЖНІХ КАРТ ОБМЕЖЕННЯ ПОШИРЕННЯ ПАНДЕМІЇ COVID-19

**Анотація.** Узагальнено аргументи і контраргументи в межах наукової дискусії з питання визначення та емпіричного обґрунтування фінансових, соціо-економічних, екологічних патернів та факторів громадського здоров'я для формування дорожніх карт з метою обмеження поширення епідемії COVID-19. Основною метою проведеного дослідження є розроблення регіональних протиепідеміологічних карт, що містять емпірично обґрунтовані маркери. Систематизація літературних джерел і підходів до розв'язання проблеми щодо встановлення основних факторів громадського здоров'я та фінансових, соціальних, економічних, екологічних детермінант, які обумовили регіональну диференціацію вразливості населення України від COVID-19, засвідчила, що вони ґрунтуються здебільшого на емпіричному досвіді інших країн і не повною мірою враховують національну і регіональну специфіку. Методичним інструментарієм проведеного дослідження стали методи диференціального числення нелінійних рівнянь, що дозволяє визначити критичні значення (маркери) для кожного фактору, які формалізують «слабкі місця» та «критичні точки» регіону щодо реагування на майбутні епідеміологічні загрози. Об'єктом дослідження обрано всі регіони України і м. Київ. Представлено дорожні карти майбутніх протиепідеміологічних заходів для кожного регіону України. Результати проведеного дослідження можуть бути корисними для органів місцевого самоврядування для ухвалення виважених рішень відповідно до існуючих повноважень і диференційовані рішення щодо послаблення заходів соціального дистанціювання, карантину, призупинення роботи економічних об'єктів, зміни фінансових бюджетів тощо, урахувавши відмінності кожного регіону за факторами громадського здоров'я, соціо-еколого-економічними детермінантами.

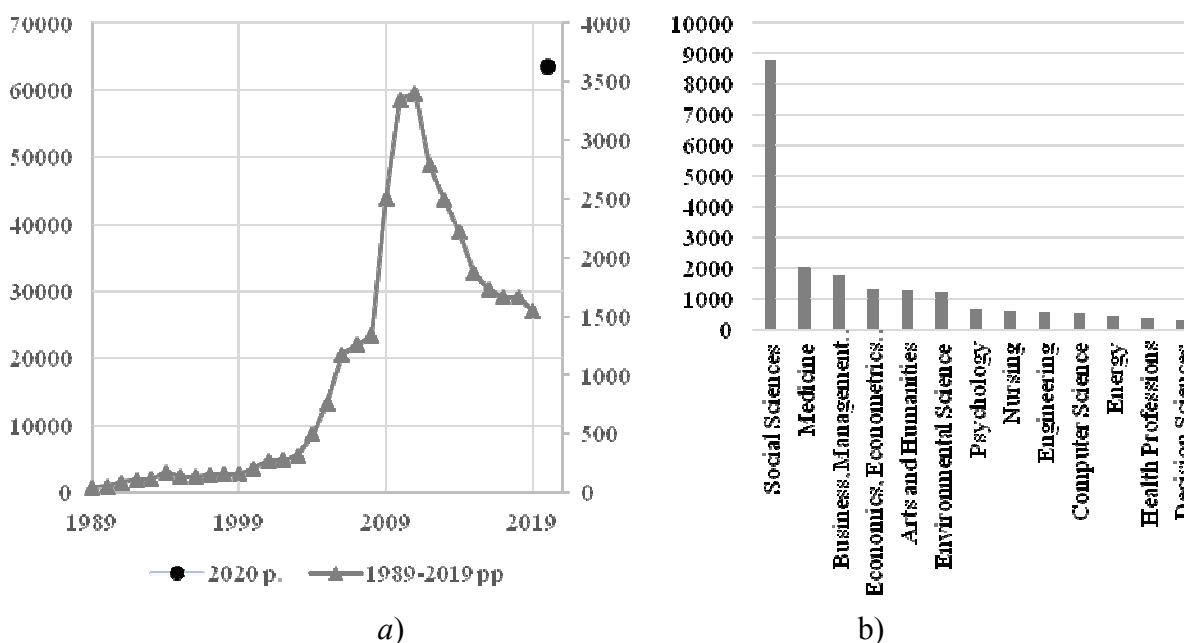
**Ключові слова:** державний бюджет, дорожня карта, місцевий бюджет, пандемія, реформи.

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**Introduction.** Considering the official data, on November 14, Ukraine has 525 176 laboratory confirmed cases of the COVID-19 and 9508 deaths of people infected with the coronavirus. At the same time, 3876966 tests were done [8]. At the same time, the Ukrainian regions differ significantly in the level of vulnerability of the population to this infection. Thus, the

number of patients/deaths per 100 thousand population was the highest in Chernivtsi (362/15), Ivano-Frankivsk (100/6), Rivne (141/3), Ternopil (110/3) regions. However, in Dnipropetrovsk (29/1), Zaporizhia (26/1), Mykolaiv (25/1), Poltava (19/1), Kherson (17/1) regions, the penetration of COVID-19 was less [25]. Such tendency actualised the analysis of the reasons for such significant regional differentiation of the scale of population vulnerability.

**Analysis of the recent research and problem setting.** The scientific community had already had a powerful background on the identification of social and economic drivers or inhibitors of extending the epidemics of infectious diseases similar in characteristics to COVID-19. Thus, for 1986—2020 years, more than 96,648 were published by the researchers in the papers indexed by Scopus (*Fig. 1a*). Moreover, 10 266 documents published in the papers in the scientific journals from the following subjects' areas: social sciences, business, management and accounting, economics, econometrics, and finance (*Fig. 1b*). The pic of publications was in 2020 — 7522 documents which focused on the actions to overcome the consequences from COVID 19. The scientist Koonin Lisa had the most significant number of publications (12) with CDC COVID-19 Emergency Response Team, United States. The publications focused on the necessity to modernise the health care system under the pandemic conditions with the purpose to eliminate the negative consequences [17; 18; 26].



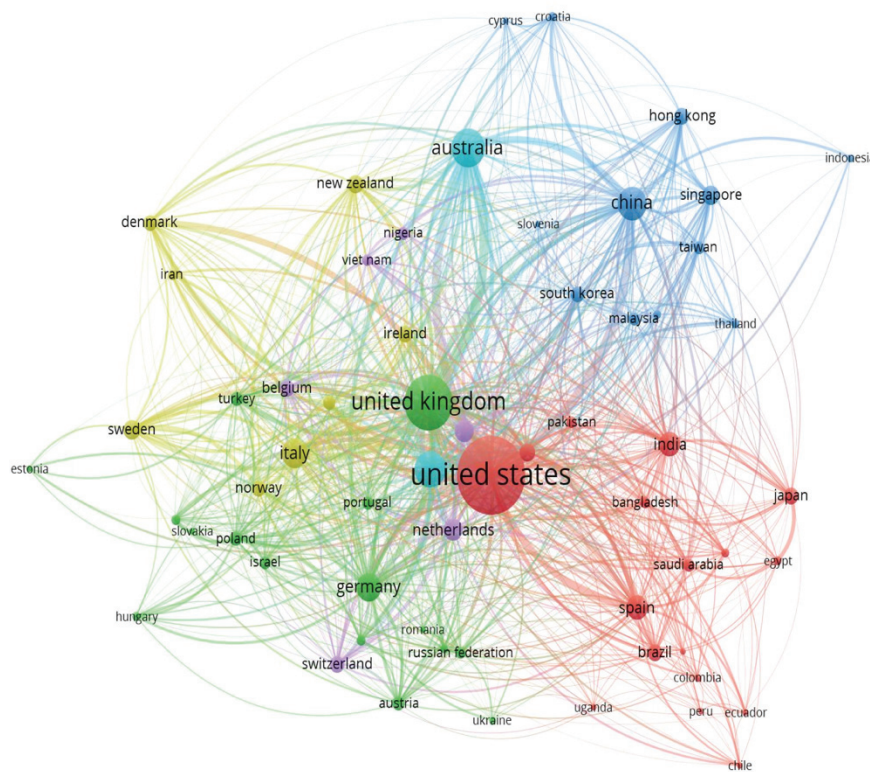
**Fig. 1. Evolution of scientific literature in the field of pandemic (a) and its subject areas (b)**

*Note.* Compiled by the authors based on Scopus data.

For the bibliometric analysis, the methodology which emphasised in the papers [11; 16; 24; 28; 29; 31; 39] was used. The bibliometric analysis of the investigations on pandemic confirmed that the most scientific papers were published by the scientists with affiliation from the USA, UK, China, and Australia (*Fig. 2*). Besides, the scientists from the USA had a joint investigation with scientists from China, the UK, Italy, and Spain. Noted, the highest speed of extending COVID-19 was registered in China, Italy, and Spain.

The results of national and regional sensitives to COVID-19 were researched by the scientists in the paper A. Farseev et al. [12]. The scientists confirmed the statistically significant relationships between the dynamic of COVID-19 spreading, economic determinants and indicators of public health. In the paper, Y. Ji et al. [15] analysed the relationships between death rate due to COVID and available recourses in the health care system. The similar investigation was provided in the paper P. Tahmasebi et al. [30] on the cases of 14 countries; in paper Z. Wu and J. M. McGoogan [36] — based on 72 314 confirmed cases in China. The number of the papers empirical confirmed that the level of international and regional migration was the catalysator of COVID-19 extending: in paper Z. Chen et al. [6] proved the statistically significant relationships

between emigration from Wuhan and infection's penetration to other Chinese cities; in the paper, Y. Bai et al. [2] — identified, that asymptomatic migrants could transmit COVID-19; the scientists in the paper [7] concluded that movement of unidentified infected persons was the argument to provide the stringent epidemiological restrictions.



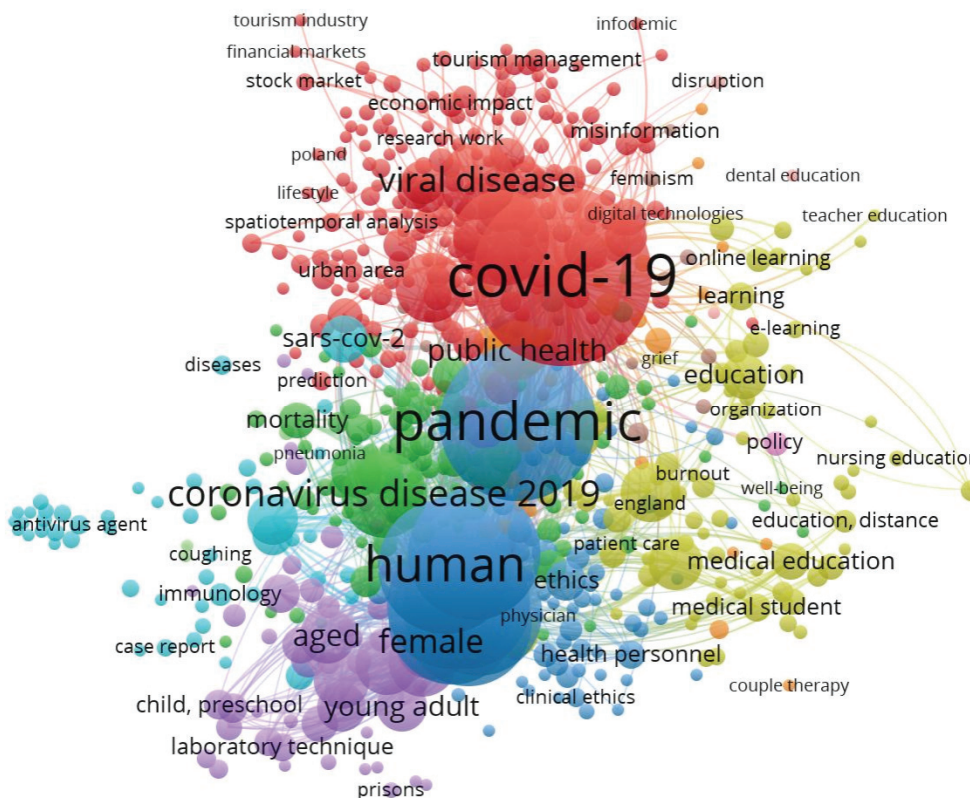
**Fig. 2. The visualisation map of investigations on the pandemic issues within the countries**

*Note.* Compiled by the authors based on the data from Scopus using the VOSviewer.

The results of the co-occurrence analysis allowed concluding that 10 clusters could cluster all publication. The most significant red cluster of publications focused on the analysing of linking among economic determinants and extending COVID-19. The second biggest cluster (green) connected with the analysis of the social patterns of pandemic. The blue cluster analysed the linking among the level of quality of the health care system and pandemic consequences. The yellow cluster merged the publications on the investigation of the relationship between COVID-19 and educations and medical readiness to overcome the consequences of the pandemic. The fifth cluster (purple) analysed issues with COVID-19 under the gender and age factors (*Fig. 3*).

The powerful scientific backgrounds were achieved in the forecasting of macroeconomic and social consequences due to implementation of lockdowns and identification of channels through which the pandemic influenced economic and social. In the paper [21] the authors allocated the channels as follows: consumption of goods and services reduction, increase of operating expenses of business and reassessment of macroeconomic risks; in the paper [19] the authors investigated the global trajectory of financial and economic shocks from pandemic outside the directly affected countries, the dependence of the dynamics of their spread on the morbidity in the virus origin countries and the degree of the population vulnerability of recipient countries of migration flows. In the papers, Meltzer et al. [23] and in [3; 4] explained the various models (including — Oxford) for forecasting the probability of economic consequences from the previous pandemic for economic. In the paper [35] showed the econometric models for developing four different scenarios of pandemic. The authors allocated the following core parameters: mortality and morbidity rates of diseases that hinder business continuity. Considering the World data Bank, the economic losses could be classified by three types: about 12% — related to mortality, 28% — from lack of workers, up to

60% — from changes in economic and social behaviour [32]. Besides, the latest paper and analytical reports focused on the COVID-19 consequences' forecasting. Thus, in the paper [13], the authors formalised the lockdown impact on the risk of medical system overload and mortality rate from COVID-19. At the same time, the mostly papers based on the empirical findings from the other countries and did not consider the national and regional features.



**Fig. 3. The visualisation of co-occurrence analysis of the paper which focused on the analysis of pandemic under the subject areas: social sciences, business, management and accounting, economics, econometrics, and finance**

*Note.* Compiled by the authors based on the data from Scopus using the VOSviewer.

**The paper aimed** to develop the regional anti-epidemiological road map with markers using the instruments of differential calculus.

**Methodology and methods.** The main directions in the modern investigation on developing of roadmaps are using the empirical justification of regional patterns which formalise the weakness and bottlenecks of each region considering the future epidemiological threats. In this case, the scientists used the vast number of economic and mathematical models [1; 5; 10; 14; 20; 22; 27; 33; 34; 37; 38]. Considering it, at the first stage, the nonlinear spatial model with stepwise exceptions by the Aitken method was used for defining the individual «retrospective portraits of the region's vulnerability to COVID-19» — patterns (set of combinations) of public health factors, social, economic, and environmental determinants, which, cumulatively, have determined the regional specifics of the rate of pandemic spreading. The target indicators were the level of morbidity and mortality of the region's population from COVID-19, and variables — indicators of financial, economic, social, and environmental development of the regions. At the second stage, using the Newton's methods, gradient, simplex methods, the critical values (markers) for each factor of constructed nonlinear models were determined. Thus, the functional dependencies «Number of confirmed cases of COVID-19» and «Number of confirmed cases of death from COVID-19» should be up to 0, and the variables should be non-negative. The list of partial intervals and corresponding frequencies or relevant frequencies at the third stage allowed establishing the priority of innervations within the framework of the implementation of anti-epidemiological road maps.

**Description of the main research material.** The empirical findings on the checking linking among the results indicators (morbidity/mortality rate in the region from COVID-19) and variables — public health factors (more than 20 major classes of diseases), and more than 20 determinants of environmental, social and economic specifics of the region allowed to establish in what combinations of that factors the impact would be the statistically significant and formalise in the form of linear multifactor regression equations to establish the dependence:

– for regress and «The number of confirmed cases of COVID-19» (y):

$$y = 7,5 \cdot 10^{-4} a_1^2 - 2,7 a_1 + 2,3 a_2^2 - 0,8 a_2 - 1,3 \cdot 10^{-10} \cdot a_3^2 + 4,4 \cdot 10^{-5} a_3 - 6,6 \cdot 10^{-4} a_4^2 + 6,7 a_4 + 2,2 \cdot 10^{-2} a_5^2 - 9,6 a_5 - 5,9 \cdot 10^{-6} a_6^2 + 11,2 a_6 + 1,4 a_7^2 - 18,5 a_7 - 670,2, \quad (1)$$

where  $a_1$  — the numbers of the international migrants (migration growth, declining), persons;  $a_2$  — carbon dioxide emissions into the atmosphere, thousands of tonnes;  $a_3$  — the amount of waste accumulated during operation, in specially designated places and facilities, thousands of tonnes;  $a_4$  — the number PCR tests on COVID-19;  $a_5$  — the number of contracts for medical care under the program of medical guarantees;  $a_6$  — the numbers of the infections beds in the hospitals;  $a_7$  — number of highly qualified medical workers (infectious disease specialists, therapists, paediatricians);

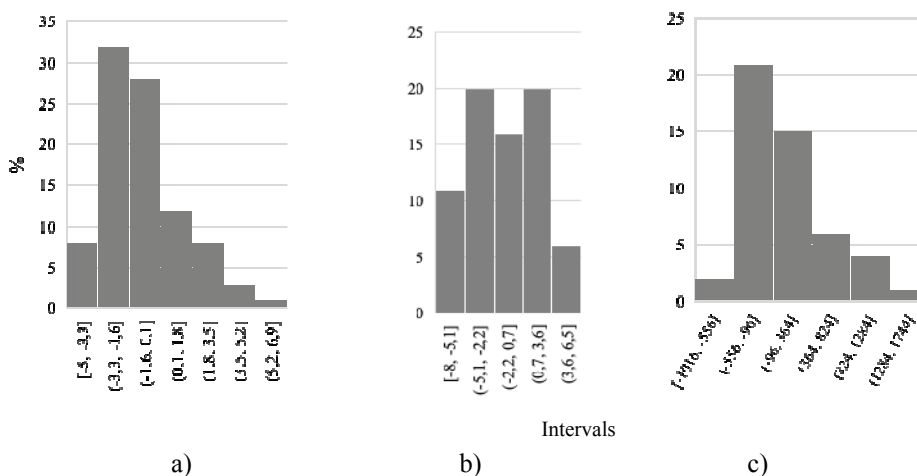
– for regress and «The number of confirmed deaths from COVID-19» (z):

$$z = 4,3 \cdot 10^{-1} b_1^2 - 22,7 b_1 - 1,5 b_2^2 + 10,5 b_2 - 7,2 \cdot 10^{-8} \cdot b_3^2 - 4,5 \cdot 10^{-3} b_3 - 8,4 \cdot 10^{-12} b_4^2 + 3,2 \cdot 10^{-5} b_4 + 1,3 \cdot 10^{-5} b_5^2 - 8,6 \cdot 10^{-2} b_5 + 8,4 \cdot 10^{-3} b_6^2 - 8,8 \cdot 10^{-1} b_6 - 2,2 \cdot 10^{-7} b_7^2 + 1,9 \cdot 10^{-2} b_7 + 1453,4 \quad (2)$$

where  $b_1$  — the average registered unemployment, thousands of persons;  $b_2$  — using of employees' labour hours and part-time employment per full-time employee, hours;  $b_3$  — carbon dioxide emissions into the atmosphere, thousands of tonnes;  $b_4$  — he amount of waste accumulated during operation, in specially designated places and facilities, thousands of tonnes;  $b_5$  — the volume of stocks of light petroleum products and gas at gas stations, gasoline, thousands of tonnes;  $b_6$  — numbers of artificial lung ventilation in hospitals;  $b_7$  — the incidence of the endocrine system diseases, eating disorders and metabolic disorders.

Considering the findings, the Ukrainian government should indicate the patterns in the social sector as follows as developing the effective mechanism for monitoring and limitation of migration's moving; mitigation of negative consequences on the unemployment which provoked by COVID-19; ensuring the efficient using of employees' labour hours.

The results of the analysis of the unemployment in all Ukrainian regions for the last five years showed that the maximum intervals of changes were [-5.1, -3.5] (Fig. 4a). At the same time, the declining of unemployment was less than in 10% cases, in particular in the following regions: Dnipropetrovsk (the decreasing by 5.0 points in 2017), Lviv (by 4.1 points in 2017), Zaporizhzhia (by 3.7 points in 2016), Poltava (by 3.6 points in 2016) and in Kyiv (by 3.7 points in 2017).



**Fig. 4. The histogram of the changes in the unemployment rate (a), using employees' labour hours and part-time employment per full-time employee (b) and international migration in Ukraine among all regions (c)**

Note. Compiled by the authors based on [9].

Considering the State Statistics Service of Ukraine, the positive changes in using of employees' labour hours and part-time employment per full-time employee in the interval [-8, -5] was in 17% cases, particularly in the regions: Vinnytsa (2018 year), Volyn (2019 year), Dnipropetrovsk (2019 year), Zakarpattia (2018 year), Ivano-Frankivsk (2018 year) (Fig. 4b). The changes in the unemployment rate in all Ukrainian regions showed in Fig. 4c.

The generalisation findings and Ukrainian features of development and spreading of COVID-19 allowed identifying the markers and relevant priorities for social sectors under the implementation of the Roadmaps to prevent the spreading of the COVID-19 epidemic (Table 1).

Table 1

**The markers and relevant priorities for social sectors under the implementation of the Roadmaps to prevent the spreading of the COVID-19 epidemic**

Region	M		Un		Lh	
	Level	Priority	Level	Priority	Level	Priority
Vinnytsa	↓ by 316	(3)	const, $\Delta \in [0;6]$	–	↓ by 2	(3)
Volyn	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;16,5]$	–	↓ by 12	(1)
Dnepropetrovsk	const, $\Delta \in [0;90]$	–	↓ by 2,7	(3)	↓ by 12	(1)
Donetsk	↓ by 69	(3)	const, $\Delta \in [0;12,7]$	–	const, $\Delta \in [0;1]$	–
Zhytomyr	↓ by 162	(3)	const, $\Delta \in [0;10,5]$	–	const, $\Delta \in [0;1]$	–
Zakarpattia	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;19,5]$	–	const, $\Delta \in [0;10]$	–
Zaporozhzhia	↓ by 415	(3)	const, $\Delta \in [0;2,5]$	–	↓ by 10	(1)
Ivano-Frankivsk	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;15,7]$	–	const, $\Delta \in [0;15]$	–
Kyiv	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;10,6]$	–	↓ by 9	(1)
Kirovograd	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;15,7]$	–	↓ by 11	(1)
Luhansk	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;16,5]$	–	const, $\Delta \in [0;8]$	–
Lviv	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;10,1]$	–	const, $\Delta \in [0;1]$	–
Mykolayiv	↓ by 358	(3)	const, $\Delta \in [0;6,2]$	–	↓ by 11	(1)
Odesa	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;10,8]$	–	↓ by 14	(1)
Poltava	↓ by 764	(1)	↓ by 0,5	(3)	↓ by 7	(2)
Rivny	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;11,4]$	–	const, $\Delta \in [0;7]$	–
Sumy	↓ by 477	(3)	const, $\Delta \in [0;9,6]$	–	↓ by 3	(2)
Ternopil	↓ by 613	(2)	const, $\Delta \in [0;15]$	–	const, $\Delta \in [0;9]$	–
Kharkiv	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;11,3]$	–	↓ by 12	(1)
Kherson	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;13]$	–	↓ by 11	(1)
Khmelnitsk	↓ by 246	(3)	const, $\Delta \in [0;11,4]$	–	↓ by 5	(2)
Cherkasy	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;5,2]$	–	↓ by 8	(2)
Chernivetsk	↓ by 160	(3)	const, $\Delta \in [0;18,2]$	–	const, $\Delta \in [0;9]$	–
Chernihiv	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;13,4]$	–	↓ by 9	(1)
City of Kyiv	const, $\Delta \in [0;90]$	–	const, $\Delta \in [0;15,6]$	–	↓ by 17	(1)

Note. Const — the indicator is in the acceptable levels under the achievement the goal; ↓ — declining; M — the numbers of the international migrants (migration growth, declining), persons; Un — the average registered unemployment, thousands of persons; Lh — using of employees' labour hours and part-time employment per full-time employee, hours;  $\Delta \in [ \dots ]$  — the interval for indicators' changes; (1) — urgent; (2) — immediate; (3) — important.

Considering the empirical results, it is necessary to implement the actions for achievement of the target indicators of the numbers of the international migrants, the average registered unemployment, using of employees' labour hours and part-time employment per full-time employee in the short-term in the following region: (M) — Poltava region (urgent), Ternopil region (urgent), Vinnytsa region, Donetsk region, Zhytomyr region, Zaporizhzhia region, Mykolaiv region, Sumy region, Khmelnytsk region, Chernihiv region (immediate); (Un) — Dnipropetrovsk region, Poltava region (important); (Lh) — Volyn region, Dnipropetrovsk region, Zaporizhzhia region, Kyiv region, Kirovohrad region, Mykolaiv region, Odesa region, Kharkiv region, Kherson region, Chernihiv region, Kyiv (urgent), Poltava region, Sumy region, Khmelnytsk region, Cherkasy region (immediate), Vinnytsa region (important).

The generalisation of the EU experience, findings and Ukrainian features of development and spreading of COVID-19 allowed developing the actions in the social sector under the implementation of the Roadmaps to prevent the spreading of the COVID-19 epidemic (Table 2).

Table 2

**The actions in the social sector under the implementation of the Roadmaps  
to prevent the spreading of the COVID-19 epidemic**

<b>Actions</b>	<b>Responsible</b>	<b>Sources</b>	<b>Risks</b>
To develop the organisational and legal actions on limitation of internal movement of the region's residents and foreign citizens	State Migration Service of Ukraine, Government, Regional State Administrations	Local budget	Lack of political will, lack of public support, lack of consensus in society
Providing additional financing for supporting the labour migrant and those who lost their jobs because of COVID-19	Bodies of social protection of the population of local state administrations, the Ministry of Finance of Ukraine, Regional State Administrations	The joint financing of State and local budgets	Limitation of the financial recourses, institutional failure
Changing the Government program on social protection of workers, paid leave and unemployment benefits	Social protection bodies of the population of local state administrations Regional State Administrations, Ministry of Social Policy of Ukraine	The joint financing of State and local budgets	Limitation of the financial recourses, institutional failure
Providing the regulatory framework for virtual jobs	Ministry of Social Policy of Ukraine, Ministry and Committee for Digital Transformation of Ukraine	State budget	Institutional failure, lack of political will, lack of public support
Developing of bylaws, regulations and mechanisms for reintegration into society of labour migrant, their family members	Ministry of Social Policy of Ukraine, Bodies of social protection of the population of local state administrations	The joint financing of State and local budgets	Institutional failure, lack of political will, lack of public support
Developing state target programs and financial support to increase self-employment	Ministry of Social Policy of Ukraine, Regional State Administrations	State budget	Limitation of the financial recourses, institutional failure

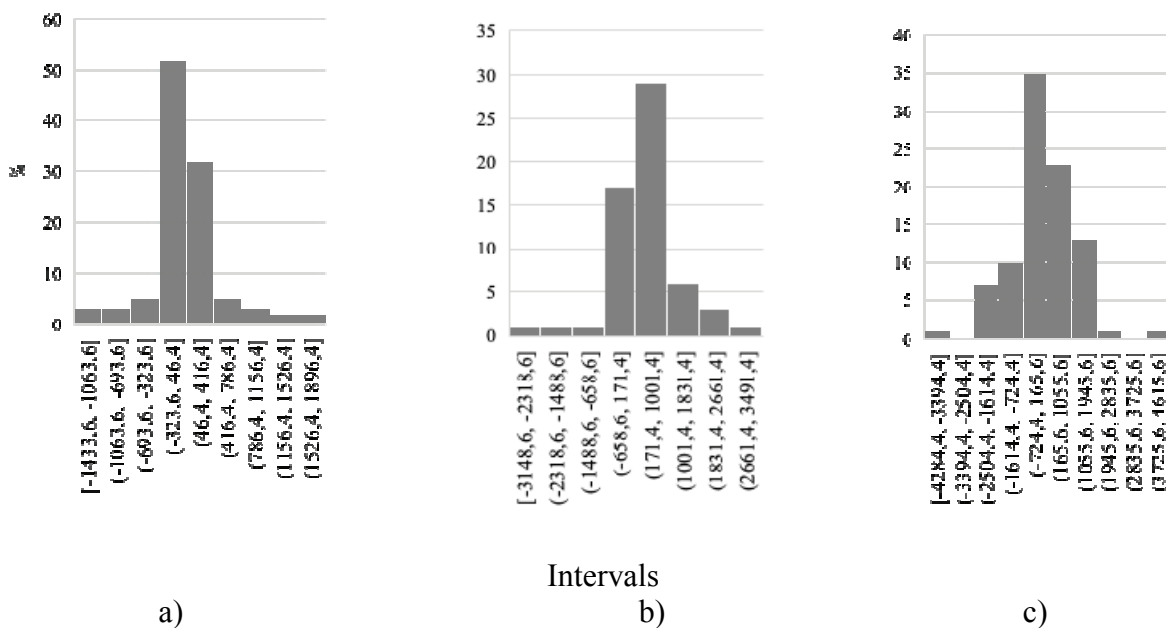
*Note.* Developed by the authors.

For improvement the environmental governance and effective using of the natural recourses the Ukrainian government should be focused on the following goals: declining carbon dioxide emissions in the atmosphere; reduction the waste accumulated during operation in specially designated places and facilities; implementing the mechanisms for increasing of light oil and gas stocks.

The analysis of the ecological indicators' fluctuations confirmed that for the last five years the maximum decreasing of carbon dioxide emissions in the atmosphere was in Dnipropetrovsk region by 7276,4 thousand tones and accumulated waste — by 22544,6 thousand tonnes in 2015 and 2019 years corresponding (*Fig. 5*). Besides, in 2019 compare the last time the convergent process on declining carbon dioxide emissions in the atmosphere and reduction the waste accumulated during operation in specially designated places and facilities were in two regions: Dnipropetrovsk region and Lviv region.

The Energy Strategy of Ukraine «Security, energy efficiency, competitiveness» for the 2035 year and Concept «Green energy transition» defined, that one of the core targets was the minimisation of carbon dioxide emissions in the atmosphere. Thus, before the 2050 year, Ukraine should decline the carbon dioxide emissions in the atmosphere by 60% of the emission in the 1990 year, in 2035 — not more than 50%. The findings confirmed that the developing of the emission trade system, creating relevant regulatory and legal support, defining the indicated specific indicators allowed reaching the abovementioned goals.





**Fig. 5. The histogram of changes of carbon dioxide emissions into the atmosphere (a), the amount of waste accumulated during operation, in specially designated places and facilities (b) and the volume of stocks of light petroleum products and gas at gas stations, gasoline (c) in Ukraine for all regions**

Note. Compiled by the authors based on [9].

In accordance with the Cabinet of Ministers of Ukraine «National Waste Management Strategy until 2030» (from November 8, 2017, № 820-p), the primary target indicator is to reduce the total amount of waste disposed of by 60% in 2019—2023. At the same time, the above dynamics of waste management, in particular in the Dnipropetrovsk region, indicates the lack of a systematic approach to addressing this issue. Thus, inefficient regulations on environmental consumption of products, low level of recycling, no initiatives of local government have become key issues in the implementation of the abovementioned Strategy. Noted, that the Concept «Creating minimum reserves of oil and oil products in Ukraine by 2020» provided for the storage and renewal of minimum reserves at level 3.57 million tons.

Considering the findings (Table 3), the changes on environmental governance should be done in the following regions: (CO<sub>2</sub>) — Vinnytsia, Dnipropetrovsk, Donetsk, Zaporizhia, Ivano-Frankivsk, Kharkiv, Kyiv (urgent), Kyiv, Luhansk, Lviv, Mykolaiv, Poltava, Rivne, Sumy, Khmelnytsky, Cherkasy, Chernihiv (immediate), Volyn, Zhytomyr, Zakarpattia, Kirovohrad, Odesa, Ternopil, Kherson, Chernivtsi (important); (W) — Vinnytsia, Dnipropetrovsk, Donetsk, Zaporizhia, Ivano-Frankivsk, Kharkiv, Kyiv, Luhansk, Lviv, Mykolaiv, Poltava, Rivne, Sumy, Khmelnytsky, Cherkasy, Chernihiv, Volyn, Zhytomyr, Kirovohrad, Odesa, Chernivtsi (urgent), Transcarpathian, Ternopil, Kherson (important); (Nr) — Vinnytsia, Donetsk, Ivano-Frankivsk, Luhansk, Mykolaiv, Poltava, Rivne, Sumy, Khmelnytsky, Cherkasy, Chernihiv Volyn, Zhytomyr, Kirovohrad, Chernivtsi, Zakarpattia, Ternopil, Kherson (important).

Table 3

**The indicators for environmental governance and effective using of the natural recourses  
under the implementation of the Roadmaps to prevent the spreading  
of the COVID-19 epidemic**

Region	CO <sub>2</sub> <sup>*</sup>		W <sup>**</sup>		Nr	
	Level	Priority	Level	Priority	Level	Priority
Vinnytsia	↓ by 2142,12	(1)	↓ by 7418,51	(1)	↓ by 1628,5	(3)
Volyn	↓ by 186,96	(3)	↓ by 1947,18	(1)	↓ by 1790,3	(3)
Dnepropetrovsk	↓ by 9398,64	(1)	↓ by 2458675,16	(1)	const, Δ ∈ [0;4445]	–
Donetsk	↓ by 9411,24	(1)	↓ by 207836,12	(1)	↓ by 2572,5	(3)
Zhytomyr	↓ by 276,92	(3)	↓ by 1248,39	(1)	↓ by 2225,8	(3)
Zakarpattia	↓ by 105,12	(3)	↓ by 519,82	(3)	↓ by 1281,5	(3)
Zaporozhzhia	↓ by 5465,32	(1)	↓ by 40270,59	(1)	const, Δ ∈ [0;413,6]	–
Ivano-Frankivsk	↓ by 5159,56	(1)	↓ by 10579,03	(1)	↓ by 2443,2	(3)
Kyiv	↓ by 1913,72	(2)	↓ by 10741,62	(1)	const, Δ ∈ [0;382,5]	–
Kirovograd	↓ by 370,08	(3)	↓ by 125586,56	(1)	↓ by 2401,8	(3)
Luhansk	↓ by 961,44	(2)	↓ by 14894,34	(1)	↓ by 3614,9	(3)
Lviv	↓ by 1361,04	(2)	↓ by 51214,47	(1)	const, Δ ∈ [0;1958]	–
Mykolayiv	↓ by 859,92	(2)	↓ by 12987,78	(1)	↓ by 1380,4	(3)
Odesa	↓ by 475,64	(3)	↓ by 2825,94	(1)	const, Δ ∈ [0;1742]	–
Poltava	↓ by 788,20	(2)	↓ by 560230,8	(1)	↓ by 1177,3	(3)
Rivny	↓ by 834,72	(2)	↓ by 5759,84	(1)	↓ by 1676,9	(3)
Sumy	↓ by 634,84	(2)	↓ by 8232,74	(1)	↓ by 3055	(3)
Ternopil	↓ by 269	(3)	↓ by 133,15	(3)	↓ by 2207,4	(3)
Kharkiv	↓ by 3038,32	(1)	↓ by 10155,67	(1)	const, Δ ∈ [0;958,4]	–
Kherson	↓ by 124,48	(3)	↓ by 313,67	(3)	↓ by 1745,5	(3)
Khmelnyskyi	↓ by 896,88	(2)	↓ by 2043,64	(1)	↓ by 1633,9	(3)
Cherkasy	↓ by 1046,72	(2)	↓ by 1540,89	(1)	↓ by 871,5	(3)
Chernivetsk	↓ by 56,92	(3)	↓ by 822,87	(1)	↓ by 2412,9	(3)
Chernihiv	↓ by 617,12	(2)	↓ by 2771,18	(1)	↓ by 2102,8	(3)
City of Kyiv	↓ by 2118,24	(1)	↓ by 2939,40	(1)	const, Δ ∈ [0;308,9]	–

*Note.* Const — the indicator is in the acceptable levels under the achievement the goal; ↓ — declining; CO<sub>2</sub> — carbon dioxide emissions into the atmosphere, thousands of tonnes; W — the amount of waste accumulated during operation, in specially designated places and facilities, thousands of tonnes; Nr — the volume of stocks of light petroleum products and gas at gas stations, gasoline, thousands of tonnes; Δ ∈ [ ... ] — the interval for indicators' changes; (1) — urgent; (2) — immediate; (3) — important; \* — considering the targets under the Concept «Green energy transition»; \*\* — considering the targets of the national waste management strategy in Ukraine until 2030.

The empirical results, a compilation of the Ukrainian and international experience on improving environmental governance and using of the natural recourses allowed developing of actions under the implementation of the Roadmaps to prevent the spreading of the COVID-19 epidemic (*Table 4*).

The empirical findings confirmed that for improving the Ukrainian health care system, the government should focus policy considering the following: introduction of mechanisms aimed at increasing the number of contracts for medical care under the program of medical guarantees; providing the required number of beds for patients in infectious diseases wards; availability of highly qualified medical workers (infectious disease specialists, therapists and paediatricians); providing a sufficient number of artificial lung ventilation in hospitals; reducing the incidence of diseases of the endocrine system, eating disorders and metabolic disorders.

Table 4

**Interventions for improving the environmental governance and using of the natural recourses under the implementation of the Roadmaps to prevent the spreading of the COVID-19 epidemic**

<b>Actions</b>	<b>Responsible</b>	<b>Sources</b>	<b>Risks</b>
To transform of state executive bodies functions from ineffective control to timely monitoring of environmental pollution and efficient use of natural resources	Bodies of local state administrations on the environmental protection and rational use of natural resources	Local budget	Institutional failure, lack of political will
To develop a state program for launching a system of greenhouse gas emissions trading and its integration with sectoral and local policies for the transition to low-carbon development	Ministry of Environmental Protection and Natural Resources, Ministry of Economic Development, Trade and Agriculture of Ukraine, Bodies of local state administrations on the environmental protection and rational use of natural resources	The joint financing of State and local budgets, grants from international institutions	Institutional failure, lack of political will
To develop local digital environmental management systems to ensure control, monitoring and verification of environmental data and their integration into a single national system	Bodies of local state administrations on the environmental protection and rational use of natural resources, Ministry of Environmental Protection and Natural Resources, Ministry and Committee for Digital Transformation of Ukraine	The joint financing of State and local budgets, grants from international institutions	Limitation of the financial recourses, institutional failure, lack of political will
To develop the organisational and legal basis for improving the system of environmental taxation for environmental pollution	Ministry of Environmental Protection and Natural Resources, Ministry of Finance of Ukraine	State budget	Institutional failure, lack of political will, lack of public support
Updating the targets of the national waste management strategy in Ukraine to the 2030 level, considering the needs and constraints of each region	Bodies of local state administrations on the environmental protection and rational use of natural resources, Ministry of Environmental Protection and Natural Resources	The joint financing of State and local budgets, grants from international institutions	Institutional failure, lack of political will, lack of public support, lack of consensus in society
Establish an effective system of environmental communication, awareness, education and environmental awareness of all stakeholders through educational campaigns, consultations, clarifications on available grant opportunities to implement measures to minimise the negative impact on the environment, etc.	Local public authorities, Bodies of local state administrations on the environmental protection and rational use of natural resources	Local budget, grants from international institutions	Institutional failure, lack of political will, lack of public support, lack of consensus in society
Improving the efficiency of oil and oil products storage infrastructure and building an extensive system of storage facilities in each region of the country	Ministry of Environmental Protection and Natural Resources, Ministry of Energy of Ukraine, Bodies of local state administrations on the environmental protection and rational use of natural resources	Local budget, grants from international institutions	Limitation of the financial recourses, institutional failure, lack of political will

*Note.* Developed by the authors.

Considering the data on November 30 in Ukraine, the officials registered cases of coronavirus was 732 625 and 12 327 death from coronavirus [25]. It allowed concluding that national health system could not stop extending the new coronavirus in time. Besides, the negative

effect of these trends was exacerbated by the absence of sufficient numbers of medical staff who were ready and made decisions on the restrictive measures for the coronavirus extending.

The lack of an integrated national digital system of secondary and tertiary care does not allow to minimise the negative impact on limited human resources during a pandemic. At the same time, according to official statistics in the country, only 10% of the available potential of ventilators is used. It allowed the available financial resources to direct to other needs of the fight against COVID-19, including the purchase of medical equipment and PCR tests, as well as the training of medical staff.

The generalisation of the EU experience, findings and Ukrainian features of development and spreading of COVID-19 allowed developing the actions in the health sector under the implementation of the Roadmaps to prevent the spreading of the COVID-19 epidemic (*Table 5*).

Table 5

**The patterns to increase the efficiency of health care under the implementation of the Roadmaps to prevent the spreading of the COVID-19 epidemic**

Region	ALV		H		D	
	Level	Priority	Level	Priority	Level	Priority
Vinnitsa	const	–	↓ by 2118,03	(1)	- by 192	(2)
Volyn	const	–	↓ by 902,62	(2)	- by 173	(2)
Dnepropetrovsk	const	–	↓ by 2773,89	(1)	- by 220	(1)
Donetsk	const	–	↓ by 1145,29	(2)	- by 282	(1)
Zhytomyr	const	–	↓ by 983,28	(2)	- by 204	(1)
Zakarpattia	const	–	↓ by 1634	(1)	- by 118	(2)
Zaporozhzhia	const	–	↓ by 1097,44	(2)	- by 104	(2)
Ivano-Frankivsk	const	–	↓ by 1964,95	(1)	- by 98	(2)
Kyiv	const	–	↓ by 1782,62	(1)	- by 261	(1)
Kirovograd	const	–	↓ by 935,34	(2)	- by 336	(1)
Luhansk	const	–	↓ by 370	(3)	- by 327	(1)
Lviv	const	–	↓ by 1921	(1)	- by 52	(3)
Mykolayiv	const	–	↓ by 993,74	(2)	- by 311	(1)
Odesa	const	–	↓ by 1268,46	(2)	- by 188	(2)
Poltava	const	–	↓ by 913,16	(2)	- by 296	(1)
Rivny	const	–	↓ by 1537,99	(1)	- by 292	(1)
Sumy	const	–	↓ by 856,97	(2)	- by 260	(1)
Ternopil	const	–	↓ by 1379,47	(2)	- by 28	(3)
Kharkiv	const	–	↓ by 1906,38	(1)	- by 109	(2)
Kherson	const	–	↓ by 681,7	(3)	- by 259	(1)
Khmelnysk	const	–	↓ by 1357,54	(2)	- by 286	(1)
Cherkasy	const	–	↓ by 1035,73	(2)	- by 322	(1)
Chernivetsk	const	–	↓ by 867,85	(2)	- by 182	(2)
Chernihiv	const	–	↓ by 602,4	(2)	- by 293	(1)
City of Kyiv	const	–	↓ by 2333,08	(1)	- by 144	(2)

*Note.* Const — the indicator is in the acceptable levels under the achievement the goal; ↓ — declining; ALV — numbers of artificial lung ventilation in hospitals; H — the incidence of the endocrine system diseases, eating disorders and metabolic disorders; D — number of highly qualified medical workers (infectious disease specialists, therapists and paediatricians);  $\Delta \in [ \dots ]$  — the interval for indicators' changes; (1) — urgent; (2) — immediate; (3) — important.

Considering the findings in *Table 5*, the interventions in long-term should be done in the following regions: (H) — Vinnitsa, Dnipropetrovsk, Zakarpattia, Ivano-Frankivsk, Kyiv, Lviv, Rivne, Kharkiv, Kyiv (urgent), Volyn, Donetsk, Zhytomyr, Zaporizhia, Kirovohrad, Mykolaiv, Odesa, Poltava, Sumy, Ternopil, Khmelnytsky, Cherkasy, Chernivtsi, Chernihiv (immediate), Luhansk, Kherson (important); (D) — Kyiv, Kirovohrad, Luhansk, Dnipropetrovsk, Donetsk, Zhytomyr, Mykolaiv, Poltava, Rivne, Sumy, Kherson, Khmelnytsky, Cherkasy, Chernihiv (urgent), Vinnitsa, Volyn, Zakarpattia, Zaporizhia, Ivano-Frankivsk, Chernivtsi, city of Kyiv (immediate), Lviv, Ternopil (important).

The generalised of interventions for increasing efficiency of the health care system under the implementation of the Roadmaps to prevent the spreading of the COVID-19 epidemic showed in *Table 6*.

Table 6

**The interventions for increasing efficiency of the health care system  
under the implementation of the Roadmaps to prevent the spreading  
of the COVID-19 epidemic**

Actions	Responsible	Sources	Risks
Development of an integrated national digital eHealth system with the possibility of providing secondary and tertiary care	Ministry and Committee for Digital Transformation of Ukraine, Department of Health of the Regional State Administration, Ministry of Health of Ukraine	The joint financing of State and local budgets	Limitation of the financial resources, institutional failure
The direction of state financial aid for training and retraining of medical staff	Ministry of Finance of Ukraine, Department of Health of the Regional State Administration, Ministry of Health of Ukraine	The joint financing of State and local budgets	Limitation of the financial resources, institutional failure
Regulate the legal framework for determining the guaranteed level of free care and ensure its integration into all local health care facilities	The Verkhovna Rada of Ukraine, the Cabinet of Ministers of Ukraine, Department of Health of the Regional State Administration, Ministry of Health of Ukraine	State budget	Limitation of the financial resources, institutional failure, lack of political will
Development of a state program for the development of medical care infrastructure at the primary and secondary levels	The Verkhovna Rada of Ukraine, the Cabinet of Ministers of Ukraine, Ministry of Health of Ukraine	State budget	Limitation of the financial resources, institutional failure, lack of political will
Introduction of effective mechanisms to ensure free competition in the market of medical services and medicines	The Verkhovna Rada of Ukraine, the Cabinet of Ministers of Ukraine, Ministry of Health of Ukraine	State budget	Institutional failure, lack of political will

**Conclusions.** The Ukrainian health system was not ready to overcome the issues which provoked by the new virus COVID-19. Thus, the limitation of financing of pharmaceutical research, lack of knowledge and qualified medical specialists, their lowest salary were the core reasons which provoked the implementation of lockdown. It allowed the government to restrict the spreading of COVID-19. However, the lockdown had a significant impact on social and economic development of the country and regions. Besides, it led to a substantial economic losses in the business sector. Based on the regression analysis, the statistical significant factors which provoked the regional difference of the incidence and mortality of the population from coronavirus were identified: the numbers of the international migrants (migration growth, declining), persons; carbon dioxide emissions into the atmosphere, thousands tonnes; the amount of waste accumulated during operation, in specially designated places and facilities, thousands tonnes; the number PCR tests on COVID-19, the number of contracts for medical care under the program of medical guarantees; the numbers of the infectious beds in the hospitals; number of highly qualified medical workers (infectious disease specialists, therapists and paediatricians); the average registered unemployment, thousands of persons; using of employees' labour hours and part-time employment per full-time employee, hours; carbon dioxide emissions into the atmosphere, thousands tonnes; the amount of waste accumulated during operation, in specially designated places and facilities, thousands tonnes; the volume of stocks of light petroleum products and gas at gas stations, gasoline, thousands tonnes; numbers of artificial lung ventilation in hospitals; the incidence of the endocrine system diseases, eating disorders and metabolic disorders. The findings allowed identifying the determinants for the declining of the economic losses and social risks from large-scale lockdown of economic. That determinants were the basis for developing the roadmaps to prevent the spreading of the COVID-19 epidemic for Ukrainian regions. The roadmaps could help to the local government (considering to their duties) accept the justified and differentiated decisions to reduce measures of social distancing, quarantine, suspension of economic facilities, etc. considering the features of each region depend on public health, socio-environmental and economic determinants.

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