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Original Article

Risk assessment of sports activity and the impact of economic and demographic indicators during the COVID-19 pandemic

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Abstract:
There are a lot countries which use measures to prevent spread of coronavivus infection COVID 19 coused by SARS-CoV-2. But despite of this pandemic continues. Particularities of sports activities include systematic contact with significant numbers of people, regular visits to other countries and cities for participation in competitions. It means sportsmen are in group of increased risk of infection and spread of COVID 19. For safe partisipation it is important to know measures which are implemented by countries for epidemic control, to study dynamics of indicators, that charachterise epidemic process, to investigate effectivness used preventive measures and posibility to assess potential risks being sportsmen in particular country. **Purpose of research.** To assess risks of infection COVID 19 in process of sport activities and to study influence of economics and demographic indicators and level of vaccination spread on area and speed of COVID-19. **Background.** To overcome the epidemic of COVID-19, it is important to study the dynamics of indicators that characterize the epidemiological process. **Material and methods.** We analyzed the indicators of 100 countries of the world, which on 03/25/2020 topped the rating by the number of infected people in the country. There were analysis and synthesis of literature, Internet resources, statistical methods among research methods. **Results.** It was found that the economic and demographic indicators of the country do not affect the incidence of COVID-19 however affect on the proportion of population coverage with vaccinations. At the beginning of the study (03/25/2020), in countries with higher economic and demographic indicators, the spread of coronavirus occurred at a slower pace, but now (11/14/2021) the economic and demographic indicators do not affect the country's place in the ranking by the number of infected. The increase in the number of infected and the death rate from coronavirus in the world leads to an increase in the amount of vaccine used. **Conclusions.** It has been proven that an increase in the number of used vaccines leads to a decrease in the country's place in the ranking in terms of the number of infected. Vaccination is an effective measure to stop the spread of infection in the world.
Keywords. **Sportsmen, risk, pandemic, epidemiological analysis, indicators, vaccination, COVID-19.**

Introduction.

The spread of coronavirus infection in the world in recent years has become alarming and has taken the form of a global pandemic. As at 04/04/2020, COVID-19 caused by SARS-CoV-2, has spread to all continents, affecting 181 countries around the world (Priyadarshini et al., 2020).

The disease is transmitted between animals and humans and as of now, the virus has caused significant loss of life around the world. In addition, the spread of the infection and the quarantine was declared as a result of this negatively affected such sectors of the economy as tourism, sphere of physical culture and sports, hotel and restaurant business (MacIntyre, 2020; Zhang Y, 2020; Askar et al., 2021; Selyametov et al., 2021; Zhang H, 2021). Pandemic made it impossible for the entertainment and beauty industries, caused a decrease in the economic growth of the world economy by 1.9 % and led to other severe economic consequences (Albu et al., 2020; Cutler et al., 2020; Dolbneva, 2020; Le et al., 2020; Pak et al., 2020; Radulescu et al., 2021).

The specificity of sports activities involves systemic contact with a significant group of people, the geography of competitions, provides visiting different countries and cities for participation in competitions, constant moving. Therefore, sportsmen are in group of increased risk of infection and spread COVID 19.

The system of physical education and sports has undergone significant adverse changes, and the sports industry has been forced to innovate in fast way. The scientific literature presents research aimed at assessing the physical and social restrictions associated with physical activity and daily exercise by people of all ages around

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the world during the pandemic COVID-19 (Anugrahsari et al., 2021). In particular, the authors proved a decrease the level of physical activity in different groups of the population in different countries. It should be noted that in countries where stricter quarantine restrictions have been introduced, such as Sweden, there is an increasing likelihood of reduced physical activity among elderly population. There have also been significant reductions in all indicators of physical activity of German and Italian adults, which may have adverse effects on their health. is stated that despite the importance of physical activity in adolescence, students aged 15 to 17 years have lost the natural opportunity to engage in physical culture and sports in the usual mode (Piestrzyński et al., 2021).

Scientists from different countries have concluded that the priority for maintaining public health is daily physical and sports activities subject to medical protocols (Ladwig et al., 2021; Anugrahsari et al., 2021).

Due to quarantine restrictions that exclude physical contact and the use of sports facilities and equipment, future physical education teachers have doubts about their professional future (Beiderbeck et al., 2021; Hortigüela-alcalá et al., 2022). Under the influence of the pandemic COVID-19 around the world, there have been changes in the competitive training process. Thus, after the return to play post Covid-19 in Italian Serie A in football, the percentage of injuries to players has increased (Giovannelli et al., 2021). The aerobic endurance of the Padang futsal academy athletes at Padang has decreased (Wenly et al., 2021).

Critical situation of spread disease COVID 19 was the reason of postponment of Olimpic games 2020 for a year and it become a subject of long discussing as for their holding in general. Sportsmen and coaches were in very hard conditions of limited access to sports base, reducing number of competitions of different level, changing training scheme to Olimpic games.

The scientific community responded instantly to the challenges of the pandemic COVID-19. Scientists actively began to study existing threats, investigate issues related to the outbreak and the global consequences of COVID-19 (Birch, 2020; Paules et al., 2020; Priyadarshini et al., 2020).

The leading countries of the world began to actively develop a vaccine, and almost all countries joined the vaccination of the population to overcome the spread of infection (Cohen, 2020; Harrison et al., 2020; Khubchandani et al., 2020).

However, despite the widespread discussion the consequences of the pandemic, most research concerns the economic development of countries and doesn't give answers to questions, which are related with safe sports activities in conditions of pandemic COVID 19. Therefore, at present, the issue of assessing the impact of vaccination on the processes of infection with coronavirus and the course of the disease requires further research. In addition, it is important to determine how the economic and demographic indicators of the country affect the coverage of the population with vaccinations.

Aim of the research - assess the risks of infection COVID 19 in the process of sport activities and study the impact of economic and demographic indicators and vaccination coverage and rate of spread of COVID-19 infection.

Material & methods.

In the process of the study we analyzed the indicators of 100 countries of the world, which, as at 03/25/2020, occupied the first 100 places in the ranking the spread of coronavirus. At the next stages of the study, we considered the rates spread of the infection and the level of vaccination in these countries as at 11/14/2021. The output data was obtained from open Internet sources (according to the Ukrainian portal MinfinMedia and the digital media company Worldometer and others (Worldometer; Coronavirus Monitor; Coronavirus vaccination statistics; Knoema).

To assess the impact on the scale and rate spread of the infection of economic and demographic indicators we used such indicators as population density (PD), persons/km2; average life expectancy (LE), years; nominal gross domestic product per capita (GPN), USD, GDP per capita at Purchasing Power Parity (GPP), USD; Human Development Index (HDI). The next group of investigated factors is consisted of indicators related to the number of vaccinations from the beginning of immunization, in particular VD - vaccines administered, number of doses, million; VD, % - the proportion of those vaccinated in the country, %; PV - the number of people who have undergone full vaccination, million; PV, % - the proportion of people fully vaccinated in the country, %. In addition, the country's place in the ranking in terms of the number of infected for two periods was taken into account: at the beginning and at the end of the research (Rang 0 and Rang, respectively).

The set of dependent variables consists of: I_2 - the incidence, the number of people, D_2 - the mortality, the number of people; R_2 is the number of recovered people as at 11/14/2021, then - at the end of the study; (I_0, D_0, R_0 - indicators as at 03/25/2020, then - at the beginning of the study).

The analysis of the initial data according to the Shapiro-Wilk test showed that for all the studied indicators they are not subject to the normal distribution law (Kashuba et al., 2020). Therefore, the average values are presented by the median Me and the inter-quarter interval (Q_3-Q_1), and Spearman's ordinal correlation coefficient ρ was used for the correlation analysis.

Statistical analysis was carried out using the program Statistica v.10.0 (Stat Soft, USA).

The critical level of significance of the correlation was taken as the value $\alpha = 0.05$ ($p < 0.05$).

Results.

It was defined that average increase of disease was 561197.5 (231071.5-1817349.0) cases, mortality – 10310.0 (29467.0-2302.5) cases, increased morbidity was 155710.0 (553531.0-35714.6) %. At the same time, the average number of used vaccines was 6336998 (1940920.0-24361179.0) doses, and the proportion of fully vaccinated people was 58.0 (68.0-35.0) %.

We compared the data spread of disease COVID-19 at the beginning and at the end of the study and noticed that there is a direct statistically significant ($p < 0.05$) correlation between the number of registered cases of infections at the end of the study and the cases of mortality ($\rho = 0.242$) at the beginning of the study, between the cases of mortality at the end of the study and the number of deaths ($\rho = 0.333$) at the beginning of the study, between the number of recovered people at the end of the study and the number of deaths ($\rho = 0.215$) at the beginning of the study period (Table 1).

We proved the hypothesis that stated following: the number of deaths is growing together with an increase in the incidence. It should be noted that during the period from the first to the final stage of study, COVID-19 treatment protocols, preventive measures were actively developed. According to our results, there is link between the incidence and the number of recovered people at the final stage of the study ($\rho = 0.927$) at that time as at the first stage, this dependence was less ($\rho = 0.463$).

Table 1

Correlation matrix of indicators of the spread of the disease at the beginning and at the end of the study period

Indicators	Spearman Rank Order Correlations ρ; * - marked correlations are significant at p <,05000					
	I_0	D_0	R_0	I	D	R
I_0	1,000	0,756*	0,463*	0,157	0,170	0,142
D_0	-	1,000	0,420*	0,242*	0,333*	0,215*
R_0	-	-	1,000	0,145	0,143	0,158
I	-	-	-	1,000	0,927*	0,990*
R	-	-	-	-	1,000	0,914*
D	-	-	-	-	-	1,00

In addition, we can notice, that the number of sick people at the current moment does not correlate with any indicator characterizing the incidence at the beginning of the study ($0.142 < \rho < 0.170$; $p > 0.05$).

The hypothesis was confirmed: in each of the studied periods, the number of deaths and those who recovered grows along with an increase in the number of infected.

Investigating the level of vaccination coverage of the population, we proved the presence of direct statistically significant ($p < 0.05$) correlations between the number of used vaccines and the number of infected ($\rho = 0.396$), deaths ($\rho = 0.471$) and those who recovered ($\rho = 0.337$) at the beginning of the study. Similar correlations can be traced for the number of people fully vaccinated in the country (Table 2).

Table 2

Correlation matrix. The relationship between the indicators spread of the pandemic and the degree of coverage of the population with vaccination

Indicators	Spearman Rank Order Correlations ρ; * - marked correlations are significant at p <,05000						
	I_0	R_0	D_0	VD	VD, %	PD	PD, %
I_0	1.000	0.756*	0.463*	0.396*	0.352*	0,427*	0.390*
R_0	-	1.000	0.420*	0.471*	0.103	0,491*	0.128
D_0	-	-	1.000	0.337*	0.194	0,339*	0.188
VD	-	-	-	1.000	0.204*	0,994*	0.110
VD, %	-	-	-	-	1.000	0,243*	0.944*
PD	-	-	-	-	-	1.00	0.169
PD, %							1.000

At the same time, the percentage indicators of population coverage with vaccinations turned out to be less informative: it was found that only the number of infected people at the beginning of the study had a statistically significant ($\rho = 0.352$; $p < 0.05$) effect on the proportion of people vaccinated in the country. Thus, the spread of the disease in the previous phase of the study led to an increase in the amount of used vaccine.

Correlation analysis made it possible to establish the following statistically significant ($p < 0.05$) correlations between vaccination coverage and economic and demographic indicators, number of people who have got full vaccination significantly depends on life expectancy ($\rho = 0.720$), GDP per capita ($\rho = 0.522$), GDP

per capita purchasing power parity (ρ = 0.548), human development index (ρ = 0.700). As you can see, the closest direct statistically significant (p <0.05) correlation was found between the human development index and the proportion of the fully vaccinated population, which indicates a wider coverage of the population with vaccinations in countries with a higher standard of living.

The same direct correlations are between the paticular economic and demographic indicators and the number of proportion of vaccinated people. At the same time, it was proved that there were no statistically significant correlations between the economic and demographic indicators and the number of the used vaccine (p> 0.05) (Fig. 1).

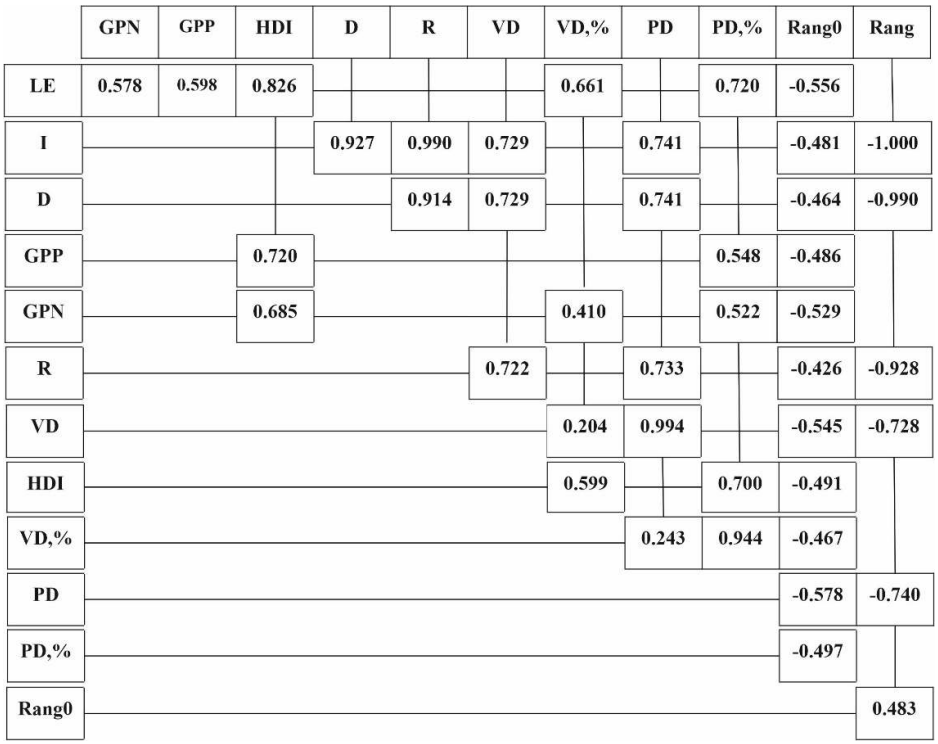

Fig. 1. Correlation matrix of the studied indicators (correlations are significant at p <0.05).

Therefore, on the one hand, life expectancy and the human development index of the population directly depend on the wealth level of the country as a whole and the purchasing power of the population, on the other hand, these indicators depend on the proportion of population coverage with vaccination and the proportion of the population that have got full vaccination.

At the same time, the presence of statistically significant relationships between economic and demographic indicators and indicators characterizing the spread of the disease was not established (-0.199 ≤ ρ ≤ 0.03; p > 0.05). Thus, the country's economic and demographic indicators do not affect the incidence of COVID-19.

In addition, at the initial stage of the research, we could observe moderate inverse correlations between the studied economic and demographic indicators (with the exception of population density) and the country's place in the ranking by the number of infected (-0.556 ≤ ρ ≤ -0.481; p <0.05). It can be noticed, that the spread of coronavirus occurred at a lower rate in countries with higher economic and demographic indicators. However, there is fact that the revealed trend did not persist and the spread of the disease does not depend on the economic and demographic indicators of the country. At the same time, there is a moderate direct statistically significant (p <0.05) correlation (ρ = 0.483) between the places of the country in the ranking by the number of infected at the beginning and at the end of the study, which indicates an increase in the prevalence of the disease at this stage of the study in countries with a higher place in the ranking and at the same time, there is a decrease in the spread of infection in countries with a lower incidence rate. And, again, at both stages of the study, an inverse correlation was established between the country's rating by the number of infected and the number of got vaccines. Moreover, the tightness of the recorded link increased at the second stage of the study: for vaccination - from ρ = -0.545 to ρ = -0.728, for full vaccination - from ρ = -0.578 to ρ = -0.740. Thus, it can be argued that an increase in the number of got vaccines leads to a decrease in the country's place in the ranking in terms of the number of infected. Therefore, vaccination has been proven to be an effective measure to stop the spread of infection around the world.

Analyzing the obtained data we wanted to establish the following link: how the level of vaccination among the population affects the rates of spread infection and the mortality rate from coronavirus. We can see it at picture (Table 3), in the issue of overcoming the spread of infection, the decisive role is played by the level of coverage of the population with vaccination in a broad sense, that is, the amount of vaccine used for the first and repeated vaccinations. The presence of a direct close statistically significant ($p < 0.05$) correlation between the volume of the administered vaccine and the number of infected ($\rho = 0.729$) and the number of people who recovered ($\rho = 0.722$), as well as a noticeable correlation with the number of deaths ($\rho = 0.729$). Similar correlations exist between the prevalence of the disease and the number of people who got full vaccinations. Thus, an increase the number of infected and the number of deaths due to the disease leads to an increase the number of used vaccines, while an increase in the number of used vaccines supports an increase the number of people who have recovered.

Discussion.

At present, there is a widespread discussion among scientists about the global consequences of the pandemic. Moreover, it should be noted that scientific research is mainly focused on predicting analysis of economic losses (Perkova, 2020; Shastri et al., 2020) and predicting the dynamics of the epidemiological process (Boudaoui et al., 2021; Khurshid et al., 2021). It can not solve problem according safe sports activity (Beiderbeck et al., 2021; Ratten et al., 2021). At the same time participation in the sport events provide sportsmen awareness about spread in a country depending on its economics and demographic indicators, impact the level of vaccination coverage on area and speed of spread COVID 19 infection. Studying the materials related to the analysis of the scale of the spread and consequences of the coronavirus disease, we drew attention to the study by Ishaani Priyadarshini et al. (2020), aimed at analyzing the spread of the disease on continents and regions, and it was found that there are at least 74.23% of registered cases of a pandemic, and the death rate is 5.36%. In addition, based on the data of a significant number of scientific works, the authors analyzed the losses incurred in various sectors of the economy and assessed the potential loss of their income as a result of the quarantine. In particular, it provides a forecast of losses for the tourism industry due to travel restrictions, the sports industry, the film industry for the postponement or cancellation of events, aviation due to the reduction or cancellation of flights. We have to note that, scientists have selected the top 10 countries most affected by the COVID-19 outbreak for analysis (Top 10 countries with active cases).

Scientists are also worried about the threats posed by the pandemic COVID-19 to national economies. Taking into account the experience of developed countries, O.V. Krasota (2021) systematized measures of economic policy to cope with the crisis and proposed ways to restore the country's macroeconomic stability. In turn, L.L. Shamileva et al. (2020) investigated the trend of a staff reduction by industry, such as, in construction, in the service sector and represented calculations of the expected volume of release of labor and an increase of the number of unemployed during the crisis period.

Regarding the second line of research we noticed that for the mathematical description of the course of the spread of disease and mortality as a result of the disease, as a rule, scientists use SIR / SEIR models and their modifications, which are standard tools for predicting the development of epidemics. These models of the development of epidemics in time are based on a system of ordinary first order differential equations. The models take into account the population of the territory (country, region), is divided into groups (at risk; infected, recovered), and also, depending on the modification, take into account the decrease the number of infected through mortality, the duration of the incubation period, etc. We have to stress that the dynamics of the spread of COVID-19 in various countries, for example, China, Italy, France, was studied (Shamileva et al.; 2020) on the basis of the above models. At the same time, a research team of 1,300 volunteer professionals from around the world created the online platform CoronaTracker. This platform aims to provide statistics on the spread of the virus based on daily observations and analyze news on COVID-19 (Fanelli, 2020). Using predictive modeling, scientists have developed forecasts for the spread of COVID19, taking into account the response to the disease from the population of countries. And now they are widely used to model the number of infected people with a new type of coronavirus SARS-CoV-2 (Hamzaha et al.; 2020).

However, there is an opinion that this forecasting method has noticeable shortcomings, one of which is the instability of the obtained solutions, which prevents the construction of a reasonable forecast of the development of the epidemiological process for more than one week (Stepanov, 2020). V.V. Boyarintsev and his co-authors (2020) argue that it is possible to overcome this shortcomings by focusing on the patterns of development the epidemic process based on an analysis of the total number I(t) of infected individuals. And, as an additional argument in favor of such an approach, it indicates the availability of statistical data - registered cases of the disease at the time the start of forecasting.

Among other studies related to predicting the spread of infection and the risk of mortality, our attention was attracted by the study of V.S. Stepanov (2020), where the author proposed to use a linear multiple regression model to estimate the regional mortality rate from COVID-19. The proposed model includes data on the prevalence of active carriers of SARS-CoV-2 in the initial period of the development of the epidemic and takes into account the indicators of the provision of hospitals with resources such as ventilators in intensive care units,

doctors from sanitary and epidemiological groups, an infectious disease doctor, nurses and beds for "infectious diseases type", which can also be useful in building process of models the SEIR class.

Concerning sport, scientists study impact of coronavirus epidemic on economic aspects of its development and as E.Yu. Perkova (2020) stated, they discuss questions of economic effectiveness sports mega-events, creation of facilities, prospect of using large sport objects, profit from touristic traffic.

Scientists are widely discussing the problems the spread of coronavirus in certain regions and countries, studying the dynamics of the incidence and mortality rate as a result of the disease, constructing mathematical models for the further development of the epidemic, and predicting the number of deaths. However, we can see constant epidemic process, absence the reduction of infected people. Furthermore, there is negative impact of unfavourable epidemic situation in the world for holding sports events and sport development in general. Thus, we have a lot of questions, to modeling the parameters of the epidemiological process do not lose their relevance and will continue to remain in the focus of the interests among the scientific communities.

Conclusions.

According to statistics, at present, the epidemiological process continues. Despite the fact that sportsmen are in group with increased risk of infection and spread COVID 19, scientific research are concentrated at analysis of economic loses and at projection of epidemic process. However, sportsmen awareness about dynamics of indicators that characterize pandemic COVID 19 is important component of preparing to competitions and allow saving their health and avoiding infection in the conditions of pandemic COVID 19. Therefore for safe sports activity it is important to and study research, that are focused on analysis and assessment of effectiveness used measures, definition of impact economics and demographic indicators in countries on prevalence and disease, impact of vaccination on virus spread etc.

Therefore, an important step to overcome the epidemic COVID-19 disease is to analyze the dynamics of indicators characterizing it, assess the effectiveness of the taken measures, establish the impact of economic and demographic indicators of countries, the scale of the spread and course of the disease, determine the impact of vaccination on the spread of the virus.

Despite our hypothesis, the spread of the infection does not depend ($p < 0.05$) on the population density in the country. Also, population density does not affect ($p < 0.05$) the rates of recovery and deaths due to illness.

It has been established that a higher level of well-being of the country as a whole and the purchasing power of the population in particular, an increased human development index and life expectancy have a positive effect on the level of coverage of the population with vaccinations. Thus, these economic and demographic indicators correlate statistically significantly with particles of vaccinated ($0.410 \leq \rho \leq 0.661$; $p < 0.05$) and fully vaccinated people ($0.522 \leq \rho \leq 0.672$; $p < 0.05$).

The spread of infection in countries, an increase the number of people currently suffering, as well as an increase in mortality from coronavirus lead to an increase the volume of used vaccine and leads to an increase the proportion of the population covered by vaccination. On the other hand, an increase the number doses of used vaccine and an increase the number of people who received two doses, leads to an increase the number of overcame the disease.

It is clear that this research does not cover all questions about pandemic COVID-19. Moreover, data that were studied at this research constantly updated.

The epidemiological process continues and negatively influences on sport development. Therefore, further research is planned to be directed to the construction the model spread of the disease and its mathematical justification for predicting the further development of the epidemiological process.

Conflicts of interest - The authors declare no conflict of interest.

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