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Analysis of the epidemic situation of the COVID-19 coronavirus infection in Ukraine

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Abstract: The epidemic process of COVID-19 in the world developed rapidly. The situation with morbidity, despite the establishment of quarantine, the introduction of restrictive anti-epidemic measures, and vaccination, remains difficult. The results of research on the influence of meteorological factors on the dynamics of the incidence of COVID-19, hospitalization, and mortality are ambiguous and contradictory. The purpose of this study is to analyze the indicators of morbidity, hospitalization, and mortality from COVID-19 in Ukraine, and to establish the level of influence of meteorological factors on them. A high variation in morbidity, hospitalization, and mortality rates was observed in Ukraine, in 2020–2021. A total of 3 waves of disease growth were established. The curve of hospitalization indicators of patients with COVID-19 had a correlation dependence on the incidence curve r= 0.766 ($p < 0.05$), the maximum rates of hospitalization and mortality were registered in September–December 2021. A direct strong correlation was established between the frequency of registration of cases of COVID-19 and mortality — r= 0.899 ($p < 0.05$). Most cases of COVID-19 were registered in the cold season, the least in June–August. Inverse correlations of moderate strength were established between the indicators of morbidity, hospitalization, and mortality and air temperature levels ($-0.370 < r < -0.461$). Direct correlations of average strength ($0.538 < r < 0.632$) were established with the levels of relative air humidity.

Keywords: coronavirus infection COVID-19, epidemiological situation, morbidity, correlations.

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Introduction

The SARS-CoV-2 virus, which was first identified in December 2019, has caused significant damage to more than 200 countries around the world. The coronavirus infection (COVID-19) spread rapidly from one country to another [1, 2]. In March 2020, the WHO announced a global pandemic of COVID-19 [3].

The first cases of COVID-19 were registered in Ukraine in March 2020. The epidemic process developed rapidly, and several waves of rising morbidity were observed [4]. The situation with morbidity, despite the establishment of quarantine, the introduction of restrictive anti-epidemic measures, and vaccination, remained difficult.

To date, healthcare institutions and governments around the world continue to make efforts to establish full control over COVID-19 [5]. However, more than 25 million people have already been infected, and more than 0.8 million have died from the coronavirus infection.

It is known that weather conditions are a significant factor affecting the health of the population. This fact was no exception for COVID-19 [6–9].

However, the impact of natural factors on the dynamics of the incidence of COVID-19, hospitalization, and mortality has not been sufficiently studied. And the results of individual studies are ambiguous and contradictory [8–10].

Research objective – to analyze the indicators of morbidity, hospitalization, and mortality from COVID-19, and establish the level of influence of weather factors on them in the example of the Sumy region.

Materials and Methods

The article analyzes the reports, oand perational information of the Ministry of Health of Ukraine regarding the situation with COVID-19, the weekly report "The epidemic situation of the incidence of COVID-19 in the Sumy region" for the period from 29.02.2020 to 31.12.2021. Reports of monitoring indicators of meteorological factors and the state of atmospheric air pollution were provided by the Sumy Regional Center of Hydrometeorology.

Epidemiological and statistical research methods are used in the work.

To analyze the variation of the characteristics of the studied population, an indicator that takes into account the values of all observation units was used, namely, the mean square deviation (standard deviation). The mean square deviation was determined by the formula: $\delta = \sqrt{\Sigma d2/n}$; where n is the number of observations in the studied population; x is the value of the option; X is the arithmetic mean; $d = x–X$ is the deviation of each option from the arithmetic mean. The coefficient of variation (C) was calculated using the formula $C = \delta/X \cdot 100\%$. The higher the coefficient of variation, the greater the variability of this feature. If C <10% — there is a low level of

variability; C = 10–25% — there is an average level of variability; C >25% — level of variability is high. For the analysis of dynamic series, indicators of absolute growth (or decrease) and rate of growth (or decrease) were used. The absolute growth (or decrease) is the difference between a certain level of the series and the previous one. The growth rate is the ratio of absolute growth for the current period to the absolute level of the previous period, expressed as a percentage. Correlations were evaluated by correlation coefficients: r = 0.01–0.29 — weak, r = 0.3–0.69 — medium, r = 0.7–1.0 — strong, r = 1.0 — full.

The research used statistical methods of data processing and graphical presentation of results using the Microsoft Office Excel software package, STATISTICA 6.

Sumy region is located in the northeast of Ukraine. The population of the region as of 01.01.2021, was 1,053,500 people, and the population density was 47.7 people/km^2. The share of the urban population is 66.7%, and people over 60 years old are 26.5%.

Results

In 2020–2021, the incidence rate of COVID-19 varied in the Sumy region. There were 3 waves of rising morbidity: from 03.10.2020 to 08.01.2021, from 13.03.2021 to 07.05.2021, and from 25.09.2021 to 31.12.2021. In the first wave of increased incidence, most cases of COVID-19 were registered on 15.11.2020 (819.3 per 100,000 population), in the second wave — on 11.04.2021 (829.8 per 100,000 population), and on the third wave — on 04.11.2021 p. (1684.9 per 100,000 population). As can be seen from Fig. 1, in the third wave of the rise in morbidity, the maximum values of the indicators exceeded the previous ones by more than 2 times (Fig. 1).

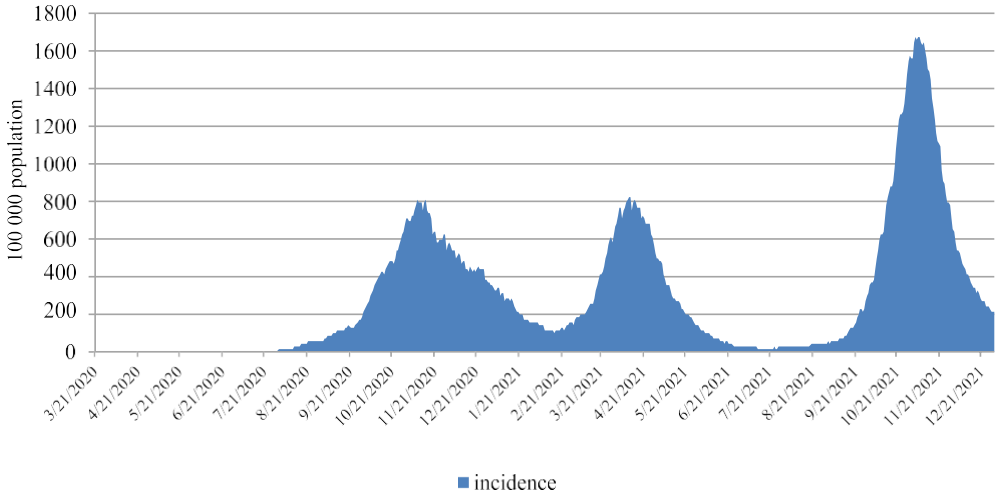

Fig. 1. Dynamics of the incidence of COVID-19 in the Sumy region in 2020–2021.

Several waves of growth in the hospitalization of patients with COVID-19 were also observed in the studied period. In the period from 26.01.2021 to 01.02.2021, the hospitalization rate reached 9.5 per 100,000 population, from 18.03.2021 to 19.05.2021 it was 14.8 per 100,000 population, from 21.09.2021 to 31.12.2021 — 15.3 per 100,000 population (Fig. 2).

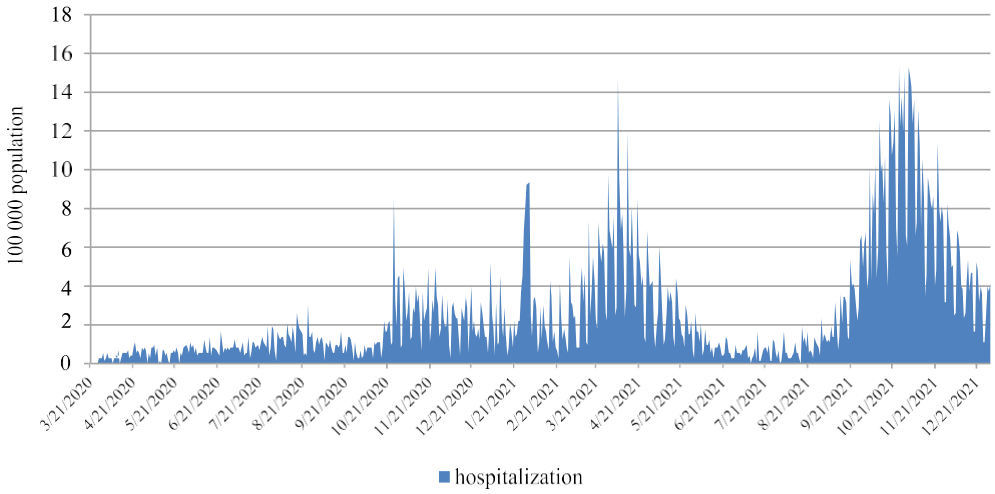

Fig. 2. Dynamics of hospitalization of patients with COVID-19 in the Sumy region in 2020–2021.

Mortality rates from COVID-19 varied with a general upward trend. In the period from 18.10.2020 to 10.11.2020 the mortality rate was 1.12 per 100,000 population, from 15.03.2021 to 18.05.2021 — it was 1.49 per 100,000 population, from 30.09.2021 to 30.12.2021 — 3.18 per 100,000 population (Fig. 3).

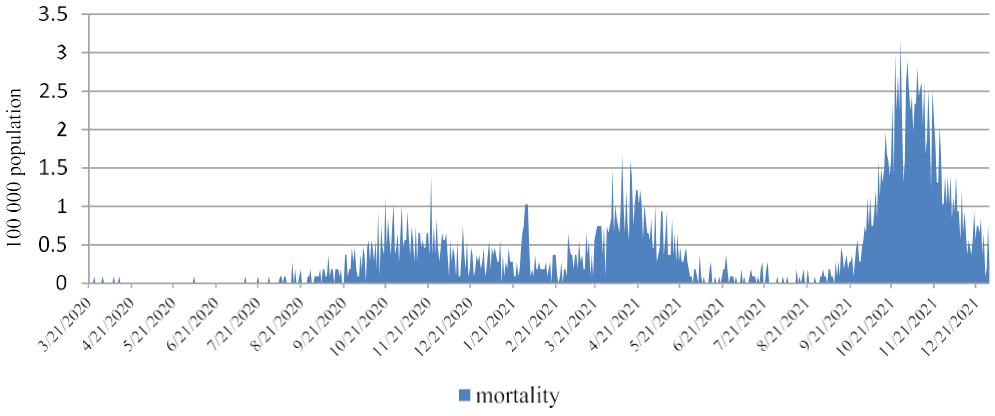

Fig. 3. Dynamics of mortality from COVID-19 in the Sumy region in 2020–2021.

In addition, we found that in the studied period, the correlation coefficient between the frequency of registration of cases of COVID-19 and hospitalization was r = 0.766; the correlation coefficient between the frequency of registration of cases of COVID-19 and mortality was r = 0.899; and the correlation coefficient between hospitalization and mortality was r = 0.796 ($p < 0.05$). That is, a direct strong correlation was established between the above indicators. The above indirectly indicated that at the first signs of an increase in morbidity, it is necessary to take measures to prepare the hospital base for a wave of patients. At the same time, the fact of finding a direct strong dependence between hospitalization and mortality still needs rethinking and additional study. And first of all, in our opinion, it would be a review at the state level of indications for hospitalization of patients with COVID-19.

As can be seen from Fig. 1, 2, and 3 dynamic series of morbidity, hospitalization, and mortality from COVID-19 consist of indicators that fluctuated significantly. The value of the mean square deviation for the variation series of morbidity indicators was $\delta = 363.9$, the coefficient of variation C = 121.3%; hospitalization — $\delta = 2.9$, coefficient of variation C = 111.5%; lethality — $\delta = 0.6$, coefficient of variation C = 146.3%; that is, they were high and exceeded 25%, which indicated the need to level the dynamic series. To solve this problem, we used the method of smoothing the dynamic series using the group means (Table 1).

As the data in Table 1 show, morbidity, hospitalization, and mortality rates were the lowest in the warm period of the year — in June–August, both in 2020 and 2021. From March–May 2020 to September–November 2021, the number of registered cases of COVID-19 increased by 749,114 cases, or 226.5 times, of hospitalized patients — by 6333 cases, or 17.5 times; of the dead — by 1224 cases, or 306 times.

Table 1. Seasonal fluctuations of group mean indicators of morbidity, hospitalization, and mortality in 2020–2021 in the Sumy region.

Year	Month	Group mean		
		Morbidity (abs. number)	hospitalization (abs. number)	mortality (abs. number)
2020	March–May	1107	128	1
	June–August	5837	352	7
	September–November	136,509	585	134
2020–2021	December–February	94,353	754	98
	March–May	148,064	1307	202
	June–August	15,478	269	22
	September–November	250,812	2239	409

We analyzed the dynamic range of morbidity, hospitalization, and mortality from COVID-19 by indicators of absolute growth (or decrease) and rate of growth (or decrease) (Table 2).

As the data in Table 2 show, the largest absolute growth and rate of growth in morbidity, hospitalization, and mortality were established in September–November 2021. The above-mentioned indicators were also significant from December 2020 to February 2021.

Table 2. Absolute growth and growth rate of morbidity, hospitalization, and mortality from COVID-19 in 2020–2021 in the Sumy region.

Year	Month	Morbidity		Hospitalization		Mortality	
		absolute growth	rate of growth or decrease in %	absolute growth	rate of growth or decrease in %	absolute growth	rate of growth or decrease in %
2020	March–May	–	–	–	–	–	–
	June–August	+2515	+75.7	+672	+175.5	+17	+425
	September–November	–11675	–200.0	+700	+66.4	+380	+1809.5
2020–2021	December–February	+265,546	+1516.4	+508	+28.9	–106	–26.4
	March–May	+161,133	+56.9	+1657	+73.2	+312	+105.8
	June–August	–397,747	–89.5	–3113	–79.4	–541	–89.1
	September–November	+706,002	+1520.4	+5909	+732.2	+1162	+1760.6

Assuming that meteorological factors could influence the speed of the spread of COVID-19, in order to study the level of this influence, we studied the reports of the Sumy Regional Center of Hydrometeorology (Table 3).

We calculated the group average for air temperature, wind speed, and relative humidity (Table 4).

In order to determine the relationship between weather factors and indicators of morbidity, hospitalization, and mortality, we calculated correlation indicators. It was found that moderate inverse correlations were established between air temperature levels and indicators of morbidity, hospitalization and mortality. The influence of wind speed on the studied indicators was insignificant. The highest level of the correlation coefficient is established between relative humidity and morbidity, hospitalization, and mortality (Table 5).

Table 3. Average monthly indicators of air temperature, wind speed, and relative humidity in the Sumy region in 2020–2021.

Year	Month	Air temperature (°C)	Wind speed (m/s)	Relative humidity (%)
2020	March	5.6	10.8	63.7
	April	7.8	7.8	50.5
	May	12.5	11.2	75.1
	June	21.7	11.2	65.7
	July	20.5	8.2	68.2
	August	19.4	8.7	65.2
	September	16.9	10.6	61.3
	October	11.4	9.4	70.1
	November	2.5	7.7	89.8
	December	–2.8	8.9	86.6
2021	January	–3.9	9.2	87.4
	February	–7.1	8.9	80.9
	March	0.6	9.6	73.9
	April	7.4	10.0	71.1
	May	14.7	10.5	67.7
	June	20.2	9.7	68.7
	July	23.4	8.4	64.9
	August	21.5	9.1	67.2
	September	11.9	8.8	76.2
	October	6.6	8.8	72.6
	November	2.9	9.7	84.8
	December	–3.0	9.5	89.0

Table 4. Seasonal fluctuations of the group average of air temperature, wind speed, and relative humidity in 2020–2021 in the Sumy region

Year	Month	Group average		
		air temperature (°C)	wind speed (m/s)	relative humidity (%)
2020	March–May	8.6	9.9	63.1
	June–August	20.5	9.4	66.4
	September–November	10.3	9.2	73.6

Table 4. cont.

Year	Month	Group average		
		air temperature (°C)	wind speed (m/s)	relative humidity (%)
2020–2021	December–February	–4.6	9.0	84.9
	March–May	7.6	10.0	70.9
	June–August	21.7	9.1	66.9
	September–November	7.1	9.1	77.9
	December	–3.0	9.5	89

Table 5. Indicators of correlation between weather factors and indicators of morbidity, hospitalization, and mortality (r).

Weather factors	Correlation coefficient (r)		
	morbidity	hospitalization	mortality
Air temperature	–0.461	–0.372	–0.370
Wind speed	–0.204	–0.134	–0.172
Relative humidity	0.632	0.541	0.538

In addition, the correlation coefficient between indicators of air temperature and wind speed and relative humidity was, respectively, r = –0.012 and r = –0.764, and wind speed and relative humidity — r = –0.589. Therefore, in the conditions of the Sumy region, the higher the air temperature, the lower the relative air humidity. As the wind speed increases, air humidity will decrease.

Discussion

The epidemiological situation with COVID-19 in Ukraine in 2020–2021 was difficult [11]. A high variation of morbidity rates was observed (C= 121.3 %). The epidemic process of COVID-19 had a wave-like nature. A total of 3 waves of disease growth were identified: in October–December 2020, March–May 2021, and September–December 2021, and the amplitude of the third wave was the highest and exceeded the previous ones by more than two times.

The curve of hospitalization rates of patients with COVID-19 had a correlation dependence on the incidence curve r = 0.766 ($p < 0.05$), indicating that it also had a wave-like appearance. The maximum hospitalization and mortality rates were registered in September–December 2021. A direct strong correlation was established between the frequency of registration of cases of COVID-19 and mortality — r = 0.899

($p < 0.05$). This indirectly indicated that it is impossible to claim that hospitalization is a factor of a favorable prognosis for the patient. On the contrary, there is scientific evidence that nosocomial infections caused by P. aeruginosa, Klebsiella spp., and S. aureus, often occur in patients with prolonged hospitalization due to COVID-19 [12]. And these infections, as is known, complicate the course and worsen the prognosis of the disease.

When conducting an analysis of the dynamic series of mortality, we drew attention to the fact that in the Sumy region, the mortality rate did not exceed 3.2 per 100,000 population. Compared to other countries of the world, it was a low mortality rate [13]. A properly organized system of providing medical assistance to patients with COVID-19, an individual approach, in our opinion, contributed to the successful timely detection and treatment of the disease. There is a lot of scientific data on the risk factors of an unfavorable prognosis of COVID-19 [13, 14]. One of these factors, according to researchers, is a significant share of elderly people in the age structure of the population. We believe that Ukraine does not significantly differ from other European countries in terms of this parameter. In the Sumy region, the share of people over 60 years old in the total population structure was 26.5%.

Wearing masks, hand hygiene, social distancing, banning mass events, closing schools, etc., definitely contributed to reducing the transmission of the pathogen from one person to another. However, we failed to establish the level of influence of these events, which were held not only in Ukraine but also throughout the world.

In Ukraine, until 2021, the measures of public health institutions were the only way to prevent the transmission of COVID-19. The introduction of preventive vaccination against the background of slightly weakened anti-epidemic measures did not lead to a decrease in morbidity, on the contrary, several waves of increase in morbidity were observed. Presumably, in addition to anti-epidemic measures, preventive vaccination, and the level and duration of immunity, a certain role in the dynamics of the spread of COVID-19 was played indirectly by weather factors, since in 2020–2021, an increase in morbidity was observed in autumn.

It should be noted that as of September 1, 2021, according to the data of the Sumy Regional Laboratory Center, 75 % of the population of the region had already been vaccinated with one or two doses of the vaccine. Mostly the most active part of the population of the region was vaccinated. However, this did not affect the new wave of morbidity. Therefore, the level of formed artificial and natural immunity turned out to be insufficient to prevent the emergence of the third wave of disease. According to scientific data, vaccination against COVID-19 reduces the number of hospitalizations and deaths in the initially uninfected population [15].

Analyzing the dynamic series of monthly morbidity, hospitalization, and mortality from COVID-19, it was established that detection of the disease, hospitalization of

patients, and registration of fatal cases were most often observed in the cold season. It was most rarely observed in June–August. We have established the largest absolute growth and rate of growth in morbidity, hospitalization, and mortality in September–November 2021. Other researchers also obtained similar results and explained the decrease in morbidity in the warm season by the fact that, under the influence of high temperatures, rapid evaporation of droplets containing viruses occurs, which prevents their spread [10].

Investigating the nature of the relationship between weather factors and indicators of morbidity, hospitalization, and mortality, we established moderate inverse correlations between air temperature levels and indicators of morbidity, hospitalization, and mortality. At the same time, direct correlations of medium strength have been established between the levels of relative air humidity and indicators of morbidity, hospitalization and mortality.

It is impossible to claim that the results of our study are similar to the results of other researchers since there is evidence in the scientific literature that the frequency of registration of COVID-19 increases if there is a period when the relative humidity of the air decreases or a period when there is an increase in the air temperature. In addition, some researchers claim that there is no correlation between the incidence of COVID-19 and weather factors [9, 10].

In our opinion, and in the opinion of other scientists, the speed of the spread of the SARS-Cov-2 virus, and the level of morbidity, was not so much influenced by weather factors, but rather by the microclimate of the premises where people stayed for a long time, and primarily the speed of air ventilation [10]. The above can be argued, taking into account the fact that the increase in morbidity was observed in the cold season when the crowding of the population was the highest.

Conclusions

In 2020–2021, in the Sumy region of Ukraine, the dynamics of morbidity, hospitalization and mortality from COVID-19 had a wave-like character and were correlationally dependent ($p < 0.05$). The third wave of growth from 25.09.2021 to 31.12.2021 was the most dangerous and was characterized by the highest indicators.

Meteorological factors (atmospheric air temperature, relative air humidity, and wind speed) indirectly affected the intensity of the epidemic process of COVID-19 in the conditions of Ukraine. Inverse correlations of moderate strength were established between the indicators of morbidity, hospitalization and mortality and air temperature levels. Direct correlations of moderate strength were established with the levels of relative air humidity.

Statement of contribution

The manuscript has been read and approved by all authors, and all the authors agreed to the submission of the manuscript to The Editor.

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Conflict of interest

None declared.

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