Original article

The Current Epidemic Situation of Infections with Airborne Transmission of Viral Etiology in Ukraine

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Abstract

Background: The infectious diseases of viral etiology with airborne transmission generally dominate in the structure of infectious incidence. ***Objective:*** To determine incidence of viral infections with airborne transmission in the north-eastern region of Ukraine, to research the impact of social and natural factors on the intensity of epidemic process. ***Methods:*** In order to determine the current epidemiological peculiarities of infections with airborne transmission in the north-eastern region of Ukraine, a retrospective and operative analysis of the incidence, reports of vaccination of decreed child population in 2009–2019, demographic and natural indicators. ***Results:*** Trends in the incidence of influenza were characterized by chaotic nature and disorder, acute respiratory viral infections – high intensity and monotony. Significant correlations were established between the incidence of influenza and number and density of the population, the incidence of acute respiratory viral infections and the coefficient of migration population movement. Direct strong correlations were found between social factors and trends in the incidence of rubella and mumps. Coronavirus infection COVID–19 has become the problem for health care facilities in Sumy oblast. ***Conclusion:*** Quantitative and qualitative characteristics of the epidemic process of infections of viral etiology with airborne transmission have changed, which requires new approaches to organization of the system of epidemiological surveillance.

Keywords: Influenza; Coronavirus Infection COVID–19; Measles; Vaccination; Airborne Transmission.

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Introduction

The infectious diseases of viral etiology with airborne transmission generally dominate in the structure of infectious incidence. The proportion of influenza and other acute respiratory viral infections (ARVI) ranges from 80 to 90 %. WHO estimated that annual influenza epidemics cause around 1 bln cases, whereof 3–5 mln cases are severe and 300 000 – 500 000 deaths[1]. The epidemic situation with airborne infections regulated by specific preventive

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means remains tense. Cases of measles, rubella and mumps are discovered both among unvaccinated and vaccinated people[2]. Internal and external migration of global population, environmental disasters and globalization contribute to the rapid spread of viruses, outbreaks[3]. Coronavirus infection COVID–19, firstly discovered in China in December 2019, has caused emergency situation all over the world. It's difficult to predict final results of the pandemic, but the current data on incidence, morbidity are overwhelming[4, 5].

Objective

To determine incidence of viral infections with airborne transmission in the north-eastern region of Ukraine (as exemplified by Sumy oblast), to research the impact of social and natural factors on the intensity of epidemic process.

Materials and Methods

Sumy oblast is situated in the north-east of Ukraine and falls within two natural zones - forest-steppe and Polissia. The climate of the oblast is moderately continental. The population of Sumy oblast as of 01.01.2020 was 1068.2 thousand people, including urban population –741.4 thousand people (69.4 %), rural population – 326.8 thousand people (30,6 %). The average population density was 44.9 people per 1 sq. km.

In order to determine the current epidemiological peculiarities of infections with airborne transmission in the north-eastern region of Ukraine, a retrospective and operative analysis of the incidence of population of Sumy oblast was carried out using data of industrial statistical reporting of the Ministry of Health of Ukraine (state statistical reporting form No.1, monthly, state statistical reporting form No.2), reports of vaccination of decreed child population in 2009–2019.

The demographic indices were examined according to data of the Main Administration of Statistics in Sumy oblast. It has been established that the number of the existing population in 2019 decreased by 13.1 % in comparison with 2015 and amounted to 1081.4 thousand people. The coefficient of natural population movement varied from (–6.9) to (–11.9) per 1,000 population, and the one of migration movement – from 10.5 to (–21.9) per 10,000 population.

Natural indicators (atmospheric temperature, precipitation, relative humidity) were studied according to the Sumy Oblast Department of Hydrometeorology. It was found that the lowest average monthly air temperature was in January and February – (–5.3 ^{0} C), the highest in July – (21.2 ^{0}C); relative humidity – the lowest – in May – 64.7 %, the highest - in December – 87.2 %; precipitation – the lowest precipitation fell in April – 31.5 mm, and the highest – in July – 62.2 mm.

Descriptive and analytical techniques of the epidemiological method of research are used in the paper. Statistical processing of the obtained results was performed using generally accepted parametric (indicator of average rate of growth ($R_{gr.}^{aver.}$)/decline ($R_{decl.}^{aver.}$) in incidence, correlation coefficient, seasonality index, seasonality coefficient) criteria of statistics, using STATISTICA 6.0. The results of correlation analysis are presented as paired correlation coefficients. If the correlation coefficient was 0, it was assumed that the relationship between phenomena is absent; in case of 0.1 to 0.29, the connection was evaluated as weak; 0.30 to 0.69 – moderate; 0.70 to 0.99 – strong; 1 – complete.

Ethics approval: Required ethical permissions had been taken from ethical community of Sumy State University.

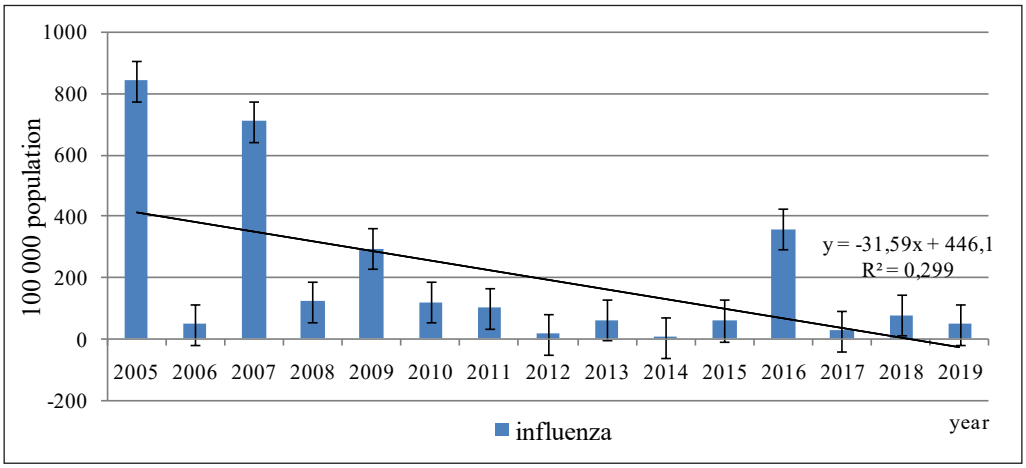

Figure 1. Trends in the incidence of influenza in 2005–2019.

Results

Examining the epidemic situation of influenza and ARVI in Sumy oblast, we have found that in terms of incidence, these infections fall within widespread. The epidemic process of influenza was characterized by chaotic and disordered trends in the incidence. The influenza incidence decreased from 843.5 per 100 thousand people in 2005 to 47.8 in 2019. The lowest incidence was registered in 2014 and amounted to 5.1 per 100 thousand people. In 2016, the incidence rate increased to 359.8 per 100 thousand people. In 2017–2019, the incidence did not exceed 78.1 per 100 thousand people. In general, there was a strong downward trend of the incidence of influenza ($R_{decl.}^{aver.}$= –8.4 %) (Fig. 1)

Trends in the incidence of ARVI in 2005–2019 were characterized by a monotonous course and high intensity. 12.7 % to 20.4 % of the population was involved in the epidemic process. Incidence rates ranged from 12,738.8 per 100 thousand people to 20432.1 without a downward trend ($R_{gr.}^{aver.}$= 0.92 %). The frequency of adenovirus detection from swabs taken from patients with signs of ARVI varied from 0.5 to 10.7 %, respiratory syncytial viruses – from 0.2 to 6.4%, parainfluenza viruses – from 0.2 to 9.1 %.

Except for influenza and ARVI, we have studied the incidence of viral infections with airborne transmission (measles, rubella and mumps), against which vaccination in 12 months of child's life is carried out in Ukraine and revaccination at the age of 6 years with live MMR vaccine.

The epidemic situation with measles, rubella and mumps in Sumy oblast was relatively favourable. The epidemic process was characterized by a downward trend of the incidence of rubella ($R_{decl.}^{aver.}$= –15.4 %), mumps ($R_{decl.}^{aver.}$= –7.3 %) and measles ($R_{gr.}^{aver.}$= 4.2 %).

The highest incidence of measles was registered in 2006 - 75.9 per 100 thousand people. In 2011, 2013 and 2016, no cases of measles were registered in the region at all. In 2018 and 2019 the incidence increased and amounted to 27.2 and 23.4 per 100 thousand people respectively. The incidence of rubella in 2019 compared to 2005 decreased by 220 times and amounted to 0.3 per 100 thousand people. The incidence of mumps in 2019 was 3.5 times lower than in 2005 and amounted to 1.7 per 100 thousand people (Fig. 2).

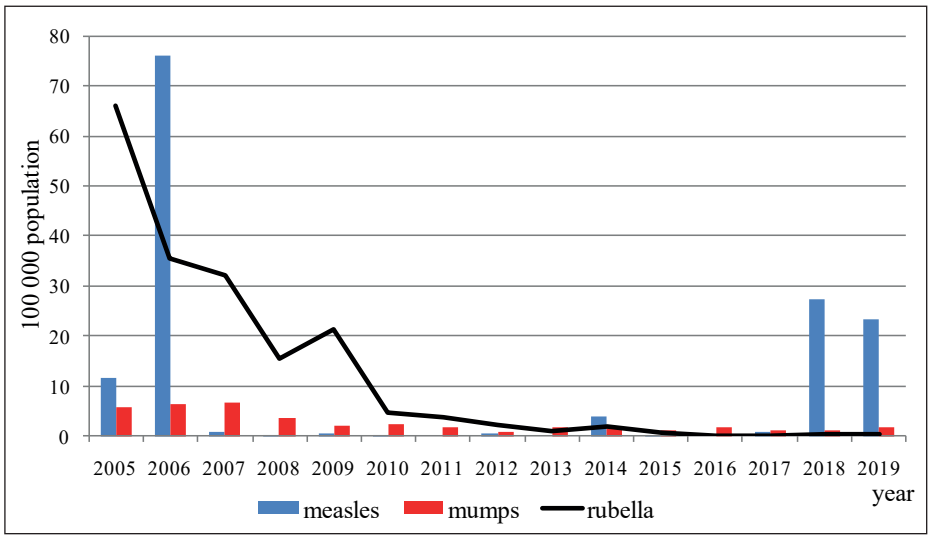

Figure 2. Trends in the incidence of measles, rubella and mumps in 2005-2019.

Examining monthly distribution of cases of measles, rubella and mumps, it has been established that rubella was most often detected in March (22.3 %), measles – in April (21.7 %), mumps – in November (19.1 %) (Fig. 3).

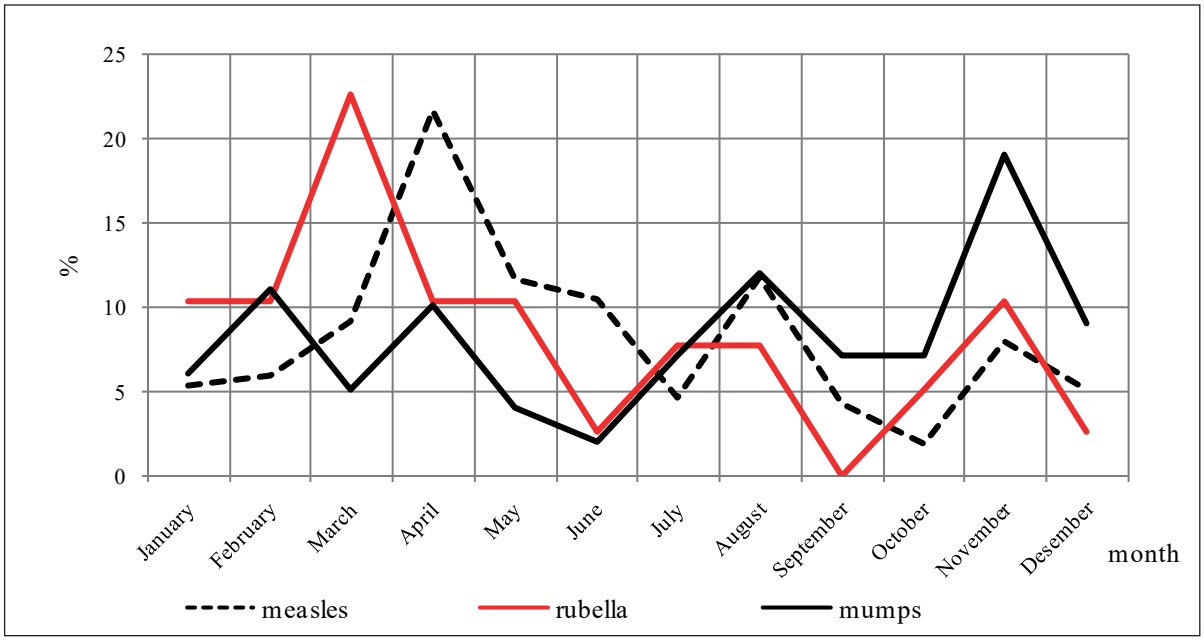

Figure 3. Monthly distribution of cases of measles, rubella, mumps (%)

The distribution of measles cases was above the average, except for April, in March (9.2 %), May (11.7 %), June (10.5 %) and August (11.8 %). The seasonality rate of measles was 53.04 %, and the seasonality index was 1.13. Increase in the incidence of rubella was observed, except for March, in January (10.3 %), February (10.3 %), April (10.3 %) and May (10.3 %). The seasonality rate was 53.04 %, and the seasonality index was 1.8. The epidemic process of mumps was characterized by a discrete distribution of cases. Except for November, increase in the incidence was observed in February (11.1 %) and in August (12.1 %). The seasonality rate of mumps was 28.3 %, and the seasonality index was 0.4.

The coronavirus infection caused by SARS-CoV-2 became another disease that has complicated the epidemic situation of viral infections with airborne transmission. The first cases of coronavirus infection caused by SARS-CoV-2 (COVID-19) in Sumy oblast were recorded in March 2019 (Fig. 4).

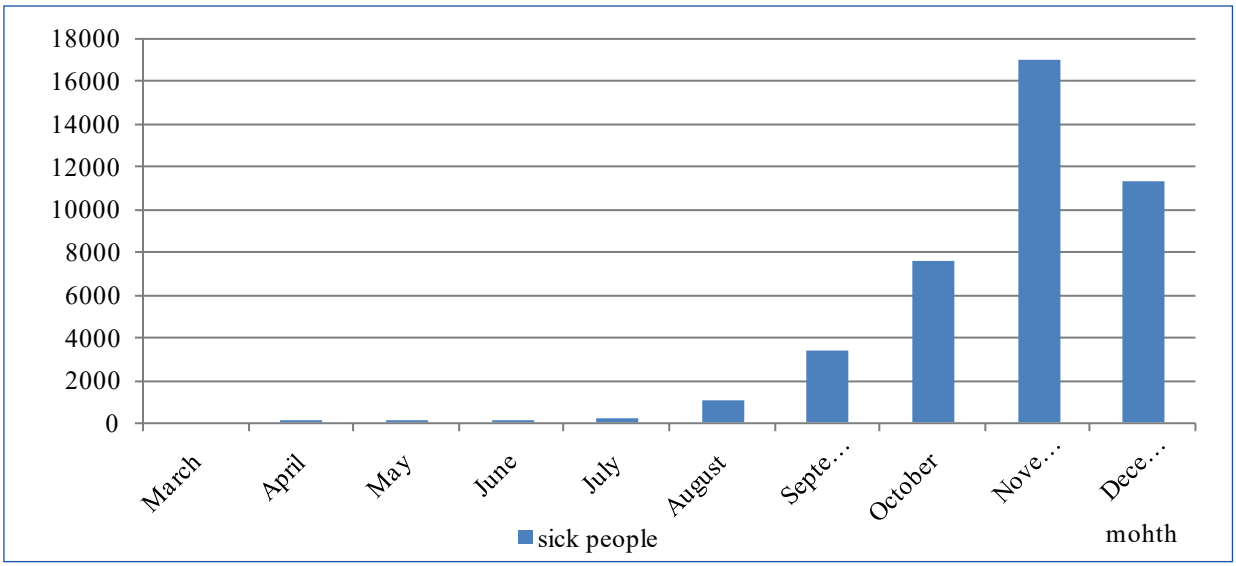

Figure 4. Frequency of COVID-19 detection in 2020.

Frequency of the detection of coronavirus infection COVID-19 increased almost by 900 times during 9 months (March-November) in 2020. In December the rate of COVID-19 decreased by 33.3 % in comparison with November. By the beginning of 2021, almost 3.8 % of the population of oblast had already fallen ill with COVID-19.

In 2020 the incidence of COVID-19 in the region amounted to 3837.3 per 100 thousand people. Herewith, the mortality rate was 1.3 %. Women accounted for 60.9 % in the gender structure of patients. In the age structure persons aged 18 to 65 years old prevailed – 83.3 %. People in the age of 65 years old and elder accounted for 13.1 %, 0 to 17 years old – 3.6 %.

We have separately analyzed monthly distribution of cases of measles, rubella, mumps in 2019 and 2020 and a sharp decrease in the frequency of cases in 2020 has been established compared with 2019 ($p < 0.05$).

Probably, the preventive measures implemented against COVID-19 (following proper hand hygiene and respiratory manners) have proved to be successful against other anthroponotic infections of viral etiology with airborne transmission.

In order to determine factors, which can influence trends in the incidence of airborne infections, we have identified vaccination rates of decreed group of child population against measles, rubella and mumps (Fig. 5).

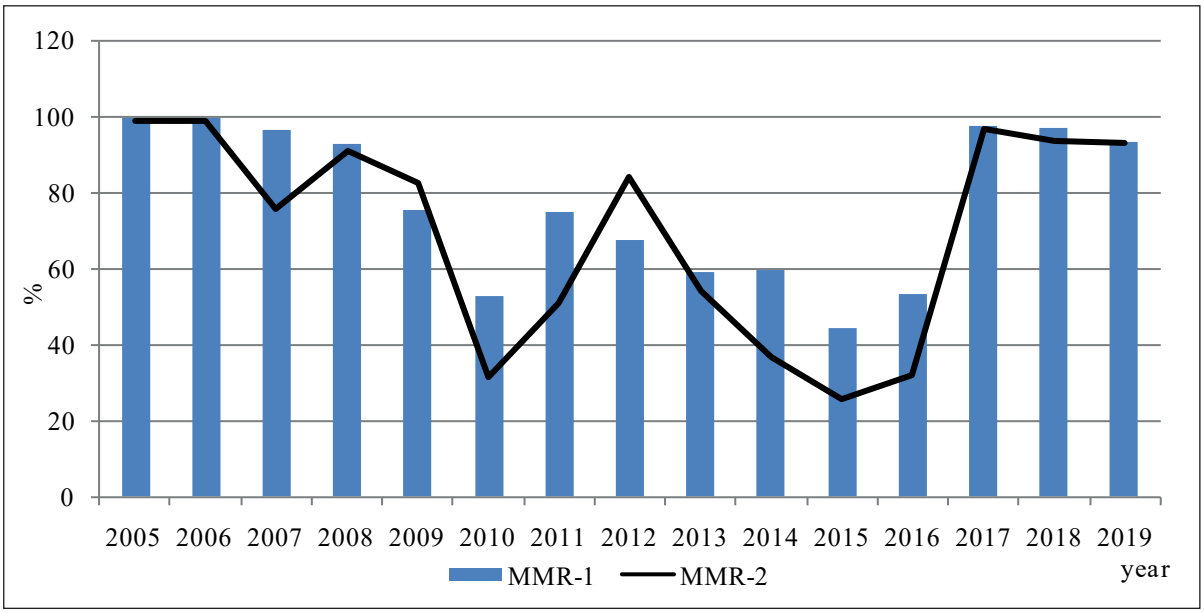

Figure 5. MMR–1 vaccination rates (12 months of the child's life) and MMR–2 revaccination (6 years of the child's life)

The level of MMR–1 vaccination (12 months of the child's life) was discovered to vary from 44.5 % to 98 % ($R_{gr.}^{aver.}$= 0.8 %) and MMR–2 revaccination (6 years of the child's life) – from 25.6 % to 97.3 % ($R_{decl.}^{aver.}$= –6.7 %). In other words, a downward trend of vaccination coverage of the decreed child population was observed.

Herewith, it should be noted that according to the correlation analysis, we failed to directly establish a positive impact of the vaccination on decrease in the incidence of measles, rubella and mumps.

Examining the impact of natural factors on trends in the incidence of measles, rubella and mumps, a correlation analysis of monthly distribution of cases of incidence and average monthly atmospheric temperature, precipitation, relative humidity was carried out. It was found that the frequency of monthly distribution of cases of measles is inversely correlated with monthly humidity ($p < 0.05$) (table 1).

Table 1. Correlation analysis of monthly distribution of cases of measles, rubella, mumps and atmospheric temperature, precipitation, humidity (r)

Natural factors	Correlation coefficient (r)		
	measles	rubella	mumps
Atmospheric temperature (^{0}C)	r= 0.238 p=0.459	r= –0.336 p= 0.289	r= –0.266 p= 0.405
Precipitation (mm)	r= –0.308 p= 0.333	r= –0.304 p= 0.339	r= –0.503 p= 0.098
Humidity (%)	r= –0.599 p= 0.042	r= 0.053 p= 0.871	r= 0.420 p= 0.178

Examining the probability of indirect influence of demographic factors on the intensity of epidemic process, correlations were found between the incidence of measles, rubella, mumps and indicators of population, natural and migratory population movement, population density (table 2).

Table 2. Correlation analysis of dependence of the incidence of measles, rubella, mumps on demographic rates (r)

	Correlation coefficient (r)				
	Population	Child population	Coefficient of natural population movement	Coefficient of migration population movement	Population density (per 1 km^2)
Measles	r= 0,223 p= 0.42	r= 0,342 p= 0.22	r= –0,416 p= 0.12	r= –0,519 p= 0.05	r= 0,211 p=0.45
Rubella	r= 0,875 p= 0.0003	r= 0,956 p= 0.0002	r= –0,737 p= 0.000	r= –0,536 p= 0.04	r= 0,856 p=0.00007
Mumps	r= 0,836 p= 0.0001	r= 0,905 p= 0.0001	r= –0,685 p= 0.005	r= –0,530 p= 0.04	r= 0,835 p=0.00014
Influenza	r= 0,610 p=0.02	r= 0,676 p=0.01	r= –0,650 p=0.01	r= –0,218 p=0.44	r= 0,586 p=0.023013
Acute respiratory viral infections	r= –0,568 p= 0.03	r= –0,565 p= 0.03	r= 0,145 p= 0.61	r= 0,626 p= 0.01	r= –0,587 p=0.02

As may be seen from table 2, in contrast to natural factors, social factors nowadays significantly affect the manifestations of the epidemic process of viral infections with airborne transmission. Direct reliable ($p < 0.05$) correlations were established between the indicators of population and density and trends in the incidence of influenza, rubella, mumps. A moderate direct correlation was established between the incidence of ARVI and indicators of migration population movement ($p < 0.05$).

Discussion

Infection with airborne transmission occurs very easily, so infections with aspiration transmission are the most common[6, 7]. Influenza and other ARVI are registered worldwide. Influenza epidemics occur in the European region annually in autumn and winter, during which the infection affects approximately 20 % of the population[8].

In Sumy oblast, which is located in the north-eastern region of Ukraine in 2019, the incidence of influenza, compared to 2005, decreased by 17.7 times and amounted to 47.8 per 100 thousand people. In general, 0.8% of the current population of the region fell ill with influenza in 2005, in 2019 – 0.05%. Epidemiologists predicted the inevitability of influenza pandemic, as in the twentieth century the duration of period between pandemics did not exceed 40 years, and the last pandemic occurred in 1977. Increase in the incidence of influenza in 2005, 2007, 2009 and 2016 was associated with activation of the pathogen, changes in the antigenic structure of the

influenza virus and low levels of immune protection in human population.

The incidence of ARVI in population was much higher than that of influenza. ARVI was most often caused by adenoviruses and parainfluenza viruses. The incidence of ARVI exceeded the incidence of influenza in 16.4 times in 2005, 325.3 times – in 2019. During the years of the highest rise in the incidence of influenza 0.8 % of the population was involved, ARVI – 20.4 %. Herewith, it should be noted that in 2005–2019, except for 2009–2010 epidemic season, no deaths related to influenza and ARVI were registered in the region. In 2009–2010, 0.02 % of patients died from influenza caused by A/H1N1.

Thus, the epidemic situation of influenza and ARVI in the north-eastern region of Ukraine is complex and uncontrolled. Influenza preventive vaccination in Ukraine, as in most countries of the world, was aimed at individual protection of persons, mainly those belonging to the medical risk group[9]. First of all, people who were in orphanages, homes for disabled and elderly were vaccinated. Vaccination coverage rates did not exceed 1.1 % of the existing population of oblast and could not significantly influence the overall epidemic situation. In addition, according to other scientists, the effectiveness of influenaza vaccine is low and ranges from 25 % to 53 %[10].

Infectious diseases are a global problem, on which scientists are continuously working[11, 12]. With introduction of vaccination, the incidence of infectious diseases has decreased worldwide[13, 14]. Measles, rubella and mumps are similar by the way of pathogen transmission, plans of preventive and disease control methods. Herewith, despite similarity and common immunization schedule, similar results to reduce the incidence of these infections could not be achieved. Rates of drawdown of the incidence of rubella 2.1 times exceeded rates of drawdown of the incidence of mumps, of measles – in 3.7 times.

According to WHO, before the widespread measles vaccination in 1963, major epidemics occurred approximately every 2–3 years. Measles caused up to 2.6 million deaths annually. Vaccination has reduced the measles mortality in the world by 73 %[15]. At the same time, despite the progress made in the fight against this infection, since 2010 a steady increase in the incidence of measles has been observed in the world. The infection migrates from country to country, from continent to continent[16, 17]. Increase in the incidence was in most cases due to unvaccinated population. However, in some regions, the proportion of measles patients who have previously been vaccinated with measles vaccine has reached 50 %[18].

In the north-eastern region of Ukraine, despite the general trend of decline in the incidence, in 2018 and 2019 there was its increase. These indicators exceeded average indicator of many years that was 9.7 per 100 thousand people, more than 2.5 times. There is no doubt that the deterioration of measles epidemic situation was indirectly influenced by the decrease in vaccination against measles. In 2010–2016, average vaccination rate was only 58.8 %. At the same time, due to scheduled vaccination, the group of people, who has had measles, decreased in the population. And consequently, the level of post-infectious immunity decreased. Against the background of high levels of migration, when the proportion of people susceptible to measles in the population increases, conditions are created for a stable transmission of the pathogen among the population.

Rubella is an acute viral disease that is less contagious than measles. Most people who get rubella have a mild course of the disease. However, rubella can cause miscarriage and congenital development defects in a child. 168 countries of the world out of 194 have already introduced rubella vaccination. Nowadays, the situation with the incidence of rubella in the world is ambiguous. The number of registered cases decreased by 97 %, however, only about 100,000 cases of congenital rubella syndrome are registered annually[19, 20].

Official statistical reports of the Ministry of Health of Ukraine lack information on the incidence of congenital rubella. Therefore, it is impossible to quantify the role of rubella virus in formation of somatic pathology, impact on the course of pregnancy and formation of congenital malformations in newborns. According to the results of our study, it was found that in the north-eastern region of Ukraine there is a strong downward trend in the incidence of rubella. In 2018 and 2019, the incidence was more than 30 times lower than average one of many years (12.4 per 100 thousand people). However, the average vaccination rate against rubella for the period of 2010–2016 was also only 58.8 %. We believe that one of the reasons for reduction in the incidence of rubella is that scheduled vaccination against rubella has recently begun in Ukraine (since 2002), so the population has a large stratum of people

who has gotten over rubella. That is, the presence in the structure of population immunity against rubella, not only post-vaccination immunity, but also postinfection immunity, contributes to a rapid reduction in the incidence.

Mumps in modern conditions remains one of the most common and contagious infections in the world. Large-scale introduction of immunization against mumps in the European region began in the 1980s. After that, the epidemic situation in many European countries has improved[21].

The researchers found that in Ukraine, thanks to immunoprophylaxis, the cyclicity of mumps was levelled down. The last highest incidence of mumps in Ukraine was in 1998. Then the incidence rate was 147.5 per 100 thousand people[22].

According to the results of our study average long-term incidence of mumps was 2.7 per 100 thousand people. In 2019, compared to 2005, the incidence was 3.5 times lower.

We were unable to establish a reliable inverse correlation between the rates of vaccination of the decreed group of child population against measles, rubella and mumps and incidence.

Thus, with a single vaccination schedule, the nature of the epidemic process of measles, rubella and mumps differs. All of the above indicates that humoral immune response is unevenly formed to various components of MMR combined vaccine. Probably, the immune response to rubella virus antigens is maximal. A similar conclusion was made by other scientists who studied manifestations of the epidemic process and rubella in modern conditions[23].

Viruses are constantly circulating among the population, and therefore the incidence is recorded during the year. In the north-eastern region of Ukraine, cases of measles were most frequently registered in April, rubella in March, mumps and infectious mononucleosis in November. At the same time, we were unable to establish a pronounced seasonality in the intra-annual trends in the incidence of measles, rubella, and mumps. Thus, it is likely that nowadays natural factors have little impact on the monthly distribution of cases. According to the results of the correlation analysis, only one inverse statistically significant ($p < 0.05$) moderate correlation was established between the frequency of measles registration and relative humidity.

Researchers have found that manifestations of the epidemic process of infectious disease depend not only on the relationship of susceptible and non-susceptible individuals in the population, but also on the influence of social, biological and natural factors. Social and biological factors are interrelated, and herewith, the importance of each of them is determined by the level of population immunity[2].

We have found that that in the north-eastern region of Ukraine an increase in the incidence of rubella, mumps and influenza should be expected in case of population growth and increase in population density, in ARVI – in case of increase in the migration population movement coefficient.

The dramatic anthropogenic, behavioral, and social changes that affected humanity and the environment in the last century have accelerated the invasion of new pathogens into the global human population, sometimes with devastating consequences.

Currently, COVID–19 coronavirus infection pandemic has been developing. The fight against this infection has proved to be ineffective throughout the world. According to the results of our study, the first case of coronavirus infection COVID–19 in the region was registered in March 2020. Despite the active epidemic prevention measures carried out in the region, by the end of 2020 about 4 % of the population of oblast went through COVID–19. In the age structure of patients the highest was share of working population – 83.3 %. At the same time, only 3.6 % of the child population was involved in the epidemic process of coronavirus infection COVID-19. Mortality from COVID–19 in the region was 1.3 %. This indicator is much lower than in other countries[24].

However, it should be noted that the quarantine measures carried out against coronavirus infection COVID–19 led to a decrease in the incidence of other anthropogenic viral infections with airborne transmission ($p < 0,05$).

Conclusions

1. Viral infections with airborne transmission continue to occupy a leading position in the structure of infectious diseases in the north-eastern region of Ukraine. In 2005–2019, trends in the incidence of influenza were characterized by chaotic nature and disorder ($R_{decl.}^{aver.} = -8.4$ %), ARVI – high intensity and monotony ($R_{gr.}^{aver.} = 0.92$ %). Significant correlations were established between the incidence of influenza and number and density of the population, the incidence of ARVI and the

coefficient of migration population movement ($p < 0.05$).

2. The epidemic process of measles, rubella and mumps was characterized by a downward trend of the incidence of rubella ($R_{decl.}^{aver.} = -15.4$ %), mumps ($R_{decl.}^{aver.} = -7.3$ %) and measles ($R_{gr.}^{aver.} = 4.2$ %). Fluctuations in the incidence in trends of many years have become stochastic. A negative downward tendency of the level of vaccination of decreed child population against measles, rubella and mumps was observed. In contrast to natural factors (atmospheric temperature and precipitation), which did not affect quantitative manifestations of the epidemic process, direct strong correlations were found between social factors (number of the existing population, population density) and trends in the incidence of rubella and mumps ($p < 0.05$).
3. Coronavirus infection COVID–19 has become the problem for health care facilities in Sumy oblast. For 9 months of 2020, 3.8 % of the region's population became ill with COVID–19. In the age structure persons aged 18 to 65 years old prevailed (83.3 %). Mortality from COVID–19 was 1.3 %. COVID–19 continues to spread in the region.
4. During the period of depopulation processes, intensive migration of the population, reforming the health care system, under the influence of social and economic, environmental factors, globalization, quantitative and qualitative characteristics of the epidemic process of infections of viral etiology with airborne transmission have changed, which requires new approaches to organization of the system of epidemiological surveillance in order to develop effective preventive and epidemic control measures.

Recommendation

The research studied the dynamics of the incidence of viral infections with aerosol transmission mechanism, the influence of individual social and natural factors as well as vaccination on the incidence rate in general. However, this scientific work did not study the age and territorial structure of morbidity and also the effect of concomitant diseases. In the future, it is necessary to create a mathematical model for predicting the epidemic process of viral infections with aerosol transmission mechanism.

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Autors's contribution:

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Editing and approval of final draft: All authors

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