Report of scientific research on the topic

Synthetic populations and multi-agent models of the spread of acute respiratory infections

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1. Introduction

Since the beginning of the development of living beings, including the awakening of humanity, we living beings have had to share our ecosystems with diverse species and we have generated diverse types of relationships with them and with our environment, which has caused that the flourishing of a group of individuals can affect the niche and its close neighbors and even the population in general.

This is true at all levels, including macroscopic, microscopic, and submicroscopic. The fact that we cannot see some of the smaller species does not imply that they are not there, that happens with viruses, that even being in the submicroscopic order which makes us not be able to see them, they are the most abundant form of life on the planet and are of great importance for the species, they are even considered a genetic vector that facilitates gene transfer between species and a trigger of evolution [1], however, viruses are also responsible for the origin and spread of many diseases, such as Ebola, AIDS, chickenpox, among others, as well as influenza and COVID-19 on which this article will focus.

In 2019 a new disease, COVID-19, caused by the SARS-CoV-2 virus, was announced to the world. On January 11, 2022, according to data from the World Health Organization, there have been 308,458,509 confirmed cases of COVID-19, including 5,492,595 deaths, on January 2020 the World Health Organization Emergency Committee declared a global health emergency based on growing case notification rates at Chinese and international locations [2].

Two years after the declaration of this emergency, humanity has not been able to recover from the damage to health systems, the economy, and in general in all areas of society. Most countries have declared different quarantine periods for their citizens, national and international health authorities have made great efforts to educate citizens on the importance of hygiene, the use of masks, and vaccination, the latter gaining great importance.

Table 1.

World Health Organization
Latest reported counts of cases and deaths (11.01.2022) [3]

	Name	Cases - total	Cases - last 7 days	Cases - last 24 hours	Deaths - total	Deaths - last 7 days	Deaths - last 24 hours
1	**Global**	**308458509**	**16907207**	**1738701**	**5492595**	**45035**	**5150**
2	United States of America	59848136	4697353	354163	831548	11862	393
3	India	35875790	915529	168063	484213	2196	277
4	Brazil	22523907	230679	24382	619981	848	44
5	The United Kingdom	14617318	1195432	142122	150230	1329	76
6	France	11907500	1854631	88607	123104	1486	279
7	Russian Federation	10684204	113992	17525	317687	5500	783
8	Turkey	10042797	446018	65236	83843	1048	141
9	Germany	7581381	342973	45690	114351	1772	322
10	Italy	7554344	1158234	117405	139265	1479	227

Vaccination is the most powerful weapon humanity has against the COVID-19 pandemic to January 11 there are 137 vaccines in clinical development and 194 in preclinical development [4], the speed at which scientific society has reacted and developed as many vaccines is encouraging, but at the same time, the virus in his fast rate of transmission has developed many variants.

Omicron is the last relevant variant, was initially reported to the World Health Organization (WHO) on November 24, 2021, by South Africa and it is a great challenge to scientists and existing vaccines, spreading around 70 times faster in the bronchi, and resistant to two doses of vaccination [5].

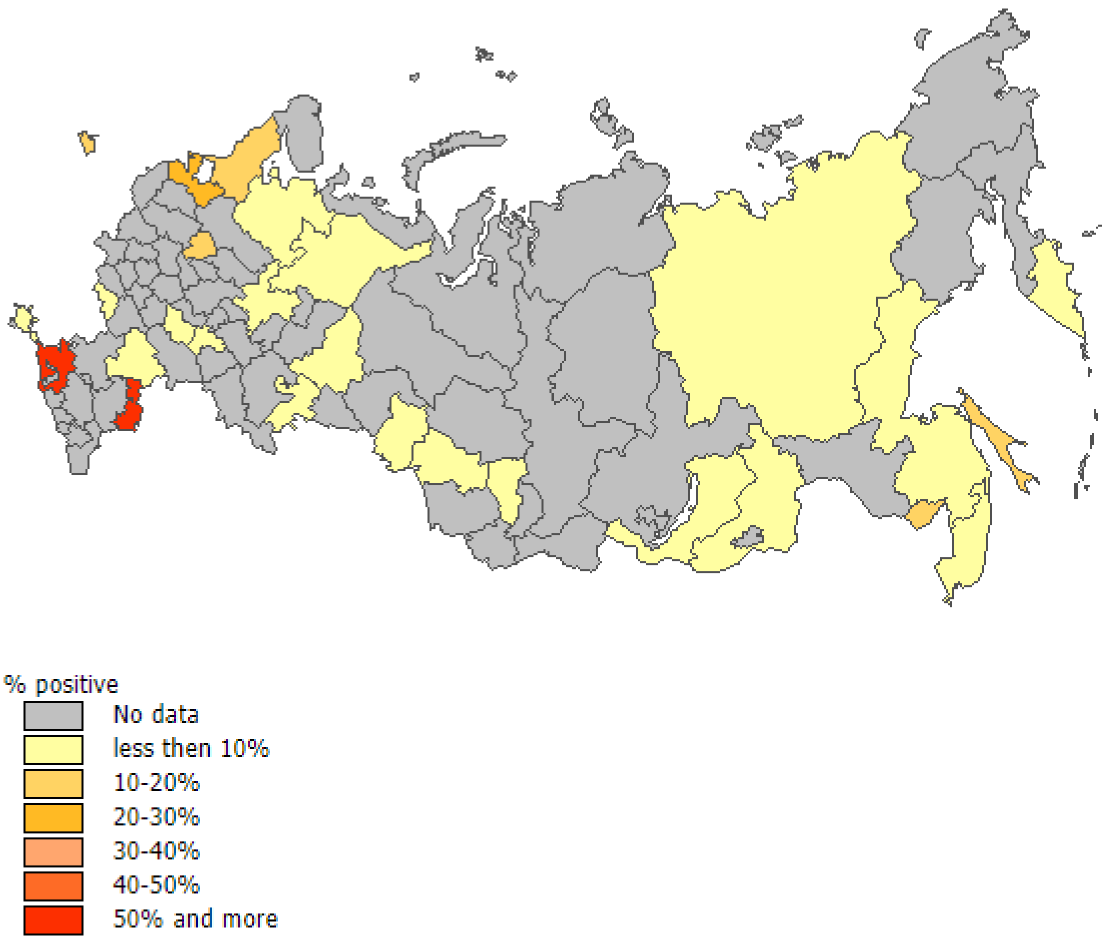
Table 2.
World Health Organization, Summary of vaccine performance against variants of concern (data as of 8 January 2022) [6]

	WHO Emergency Use Listing (EUL) Qualified Vaccines[+]							Vaccines without WHO EUL[+]		
	AstraZeneca-Vaxzevria/SII - Covishield	Beijing CNBG-BBIBP-CorV	Bharat-Covaxi	Janssen-Ad26.COV 2.S	Moderna-mRNA-1273	Pfizer BioNTech-Comirnaty	Sinovac-CoronaVac	Anhui ZL-Recombinant	Gamaleya-Sputnik V	Novavax-Covavax
Alpha[39,40]										
Summary of VE*	Protection retained against all outcomes									
- Severe disease	$\leftrightarrow_{2}$	-	-	-	$\leftrightarrow_{2}$	$\leftrightarrow_{6}$	-	-	-	-
- Symptomatic disease	$\leftrightarrow$ to $\downarrow_{5}$	-	-	-	$\leftrightarrow_{1}$	$\leftrightarrow_{4}$	-	-	-	$\downarrow_{1}$
- Infection	$\leftrightarrow$ to $\downarrow_{4}$	-	-		$\leftrightarrow_{3}$	$\leftrightarrow_{3}$	-	-	-	-
Neutralization	$\leftrightarrow$ to $\downarrow_{9}$	$\leftrightarrow_{1}$	$\leftrightarrow_{2}$	$\leftrightarrow_{5}$	$\leftrightarrow$ to $\downarrow_{15}$	$\leftrightarrow$ to $\downarrow_{48}$	$\leftrightarrow$ to $\downarrow\downarrow_{8}$	$\leftrightarrow_{2}$	$\leftrightarrow$ to $\downarrow_{3}$	$\downarrow_{2}$
Beta[41–44]										
Summary of VE*	Protection retained against severe disease; reduced protection against symptomatic disease; limited evidence									
- Severe disease	-	-	-	$\leftrightarrow_{1}$	$\leftrightarrow_{1}$	$\leftrightarrow_{3}$	-	-	-	-
- Symptomatic disease	$\leftrightarrow$ to $\downarrow\downarrow\downarrow_{2}$	-	-	$\leftrightarrow_{1}$	$\leftrightarrow_{1}$	$\leftrightarrow_{2}$	-	-	-	$\downarrow\downarrow\downarrow_{1}$
- Infection	-	-	-	-	$\leftrightarrow_{1}$	$\downarrow_{1}$	-	-	-	-
Neutralization	$\downarrow$ to $\downarrow\downarrow_{11}$	$\downarrow_{3}$	$\downarrow_{2}$	$\downarrow$ to $\downarrow\downarrow_{9}$	$\downarrow$ to $\downarrow\downarrow_{26}$	$\downarrow$ to $\downarrow\downarrow_{57}$	$\downarrow$ to $\downarrow\downarrow\downarrow_{7}$	$\leftrightarrow$ to $\downarrow_{3}$	$\downarrow$ to $\downarrow\downarrow_{4}$	$\downarrow\downarrow$ to $\downarrow\downarrow\downarrow_{2}$
Gamma										
Summary of VE*	Unclear impact; very limited evidence									
- Severe disease	$\leftrightarrow_{1}$	-	-	-	$\leftrightarrow_{1}$	$\leftrightarrow_{2}$	-	-	-	-
- Symptomatic disease	$\leftrightarrow_{1}$	-	-	-	$\leftrightarrow_{1}$	$\leftrightarrow_{1}$	-	-	-	-
- Infection	$\leftrightarrow_{1}$	-	-	-	$\leftrightarrow_{1}$	$\leftrightarrow_{1}$	$\leftrightarrow_{1}$	-	-	-
Neutralization	$\leftrightarrow$ to $\downarrow_{4}$	-	-	$\leftrightarrow$ to $\downarrow_{5}$	$\downarrow_{10}$	$\leftrightarrow$ to $\downarrow_{28}$	$\downarrow_{5}$	$\leftrightarrow_{1}$	$\downarrow t_{1}$	$\downarrow_{1}$
Delta[45]										
Summary of VE*	Protection retained against severe disease; possible reduced protection against symptomatic disease and infection									
- Severe disease	$\leftrightarrow_{3}$	-	-	$\downarrow_{1}$	$\leftrightarrow_{3}$	$\leftrightarrow_{6}$	-	-	-	-
- Symptomatic disease	$\leftrightarrow$ to $\downarrow\downarrow_{6}$	-	$\downarrow_{1}$	-	$\leftrightarrow_{2}$	$\leftrightarrow$ to $\downarrow_{5}$	-	-	-	-
- Infection	$\leftrightarrow$ to $\downarrow_{4}$	-	-	$\downarrow\downarrow\downarrow_{1}$	$\leftrightarrow_{3}$	$\leftrightarrow$ to $\downarrow_{3}$	-	-	-	-
Neutralization	$\downarrow_{13}$	$\downarrow_{2}$	$\leftrightarrow$ to $\downarrow_{3}$	$\leftrightarrow$ to $\downarrow\downarrow_{9}$	$\leftrightarrow$ to $\downarrow_{14}$	$\leftrightarrow$ to $\downarrow_{39}$	$\downarrow$ to $\downarrow\downarrow\downarrow_{8}$	$\leftrightarrow$ to $\downarrow_{2}$	$\downarrow$ to $\downarrow\downarrow_{3}$	$\downarrow_{1}$
Omicron										
Summary of VE*	Reduced protection against infection and symptomatic disease; possible reduced protection against severe disease; limited evidence									
- Severe disease	-	-	-	-	-	$\downarrow\downarrow/\downarrow\downarrow\downarrow_{1}$	-	-	-	-
- Symptomatic disease	$\downarrow\downarrow\downarrow_{1}$	-	-	-	$\downarrow\downarrow_{1}$	$\downarrow\downarrow\downarrow_{1}$	-	-	-	-
- Infection	-	-	-	-	$\downarrow\downarrow\downarrow_{1}$	$\downarrow\downarrow\downarrow_{2}$	-	-	-	-
Neutralization	$\downarrow\downarrow\downarrow_{3}$	-	-	$\downarrow\downarrow_{1}$	$\downarrow\downarrow\downarrow_{12}$	$\downarrow\downarrow\downarrow_{20}$	$\downarrow_{1}$	-	$\downarrow\downarrow\downarrow_{1}$	$\downarrow\downarrow_{1}$

Like the rest of humanity, Russia has not been exempt from this problem, there are studies [8] that show that the climate of the area shared by Russia, Ukraine, and Belarus favors the spread of the virus, the government has made great efforts to slow the advance of the pandemic but as in the world in general, the speed of its advance has not been able to be slowed by government entities. Climatic factors such as temperature, relative humidity, seasonal temperature, sunlight, wind speed take on the characteristics of Russia's varied geography, which in turn imprint hemispheric characteristics and make them suitable for the spread of the virus[9].

According to World Health Organization (WHO) in Russian Federation, from 3 January 2020 to 12 January 2022, there have been 10.702.150 confirmed cases of COVID-19 with 318.432 deaths, with 17.946 new cases in the last 24 hours [7].

Figure 1.
Results of PCR detections of SARS-CoV-2 in Russia [10]



Although the number of cases ending in death and clinical occupancy is not as abundant, influenza remains an important public health factor, and is currently an additional vector for the transmission of COVID-19, its presence in Russia continues to be monitored by the National Influenza Center in Saint Petersburg, and even more so with the direct relationship to the current pandemic.

Figure 2.
Geographic distribution of RT-PCR detected influenza viruses in cities under surveillance in Russia, week 52 of 2021[10]

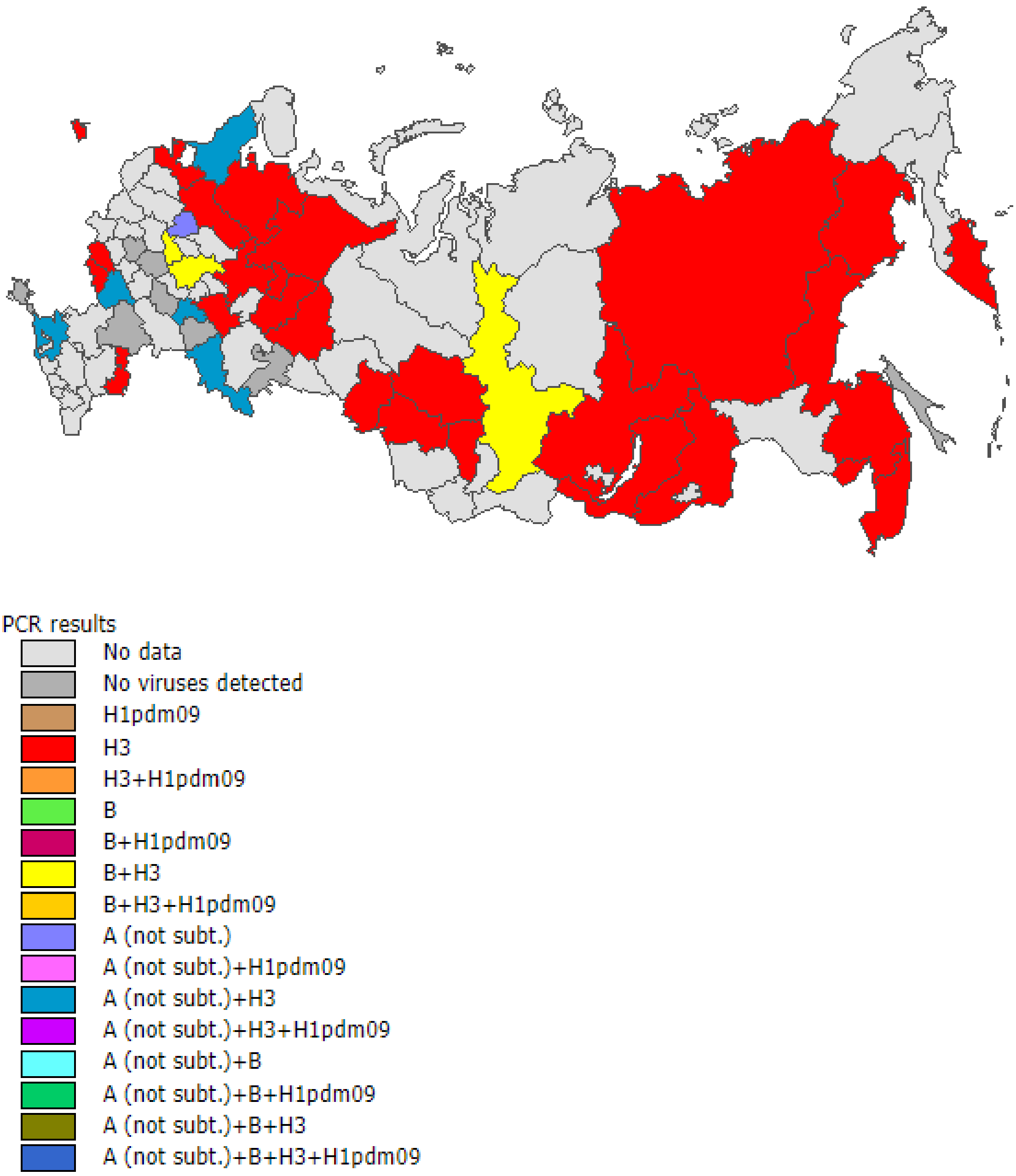


Figure 3.
Influenza and ARVI morbidity per 10.000 population in 61 cities under surveillance in Russia, seasons 2020/21 and 2021/22[10]

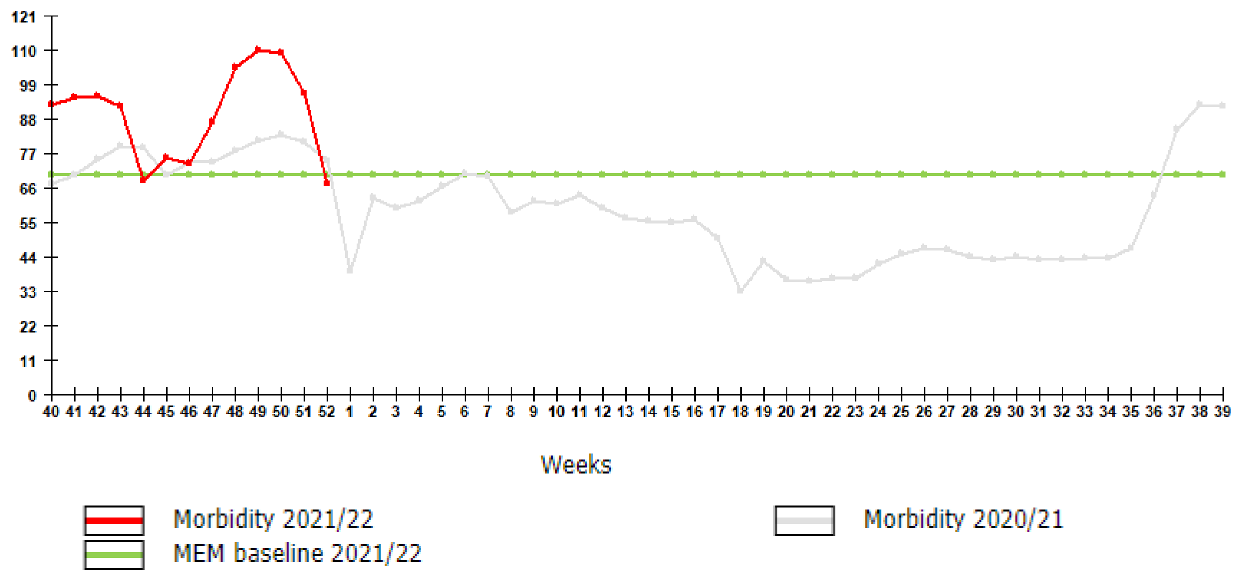


Table 3.
Results of influenza and other ARVI detection by RT-PCR in Russia, week 52 of 2021

	Number of specimens/number of positive cases	**% positive**
Influenza		
Number of specimens tested for influenza	*4621*	-
Influenza A (not subt.)	*146*	*3,2%*
Influenza A(H1)pdm09	*0*	*0,0%*
Influenza A(H3)	*820*	*17,7%*
Influenza B	*4*	*0,09%*
All influenza	*970*	*21,0%*
Other ARVI		
Number of specimens tested for ARVI	*4316*	-
PIV	*29*	*0,7%*
ADV	*37*	*0,9%*

RSV	*86*	*2,0%*
RhV	*98*	*2,3%*
CoV	*43*	*1,0%*
MPV	*3*	*0,07%*
BoV	*10*	*0,2%*
All ARVI	*306*	*7,1%*
SARS-CoV-2 (COVID-19)		
Number of specimens tested for SARS-CoV-2	*14288*	-
SARS-CoV-2	*2981*	*20,9%*

With the above, we can see how Russia and the world are facing the difficult task of curbing the spread of the virus and face the challenges it poses to their health systems, the different government entities, and its effects on the economy, among others. And as the efforts of different scientists has resulted in the development of various vaccines, protocols, and many study material, as professionals and members of the academy, it is our duty to ask ourselves the question of how from our area we can contribute to the victory over this great challenge, more precisely, how, through the use of big data and machine learning, we can generate knowledge that helps to understand and counteract this pandemic.

To provide a solution to the above, we propose the development of a model to demonstrate applications of AI and machine learning in understanding and forecasting the spread of acute respiratory infections, influence, and COVID in St. Petersburg, by now there are studies for the entire country but not specifically for St. Petersburg.

The great extension of Russia makes that there are great geographic changes between its different cities and therefore its environmental factors vary, which makes it difficult to apply a disease prediction model to the whole country without generating errors, therefore it is necessary to make a specific approach for St. Petersburg given its importance as one of the main cities, and therefore, one of the most populated, and affected by the different respiratory diseases, and currently by the pandemic of COVID-19, this is a great contribution to the city, the country, and society in general.

Bibliography

1. Canchaya, C., Fournous, G., Chibani-Chennoufi, S., Dillmann, M. L., & Brüssow, H. (2003). Phage as agents of lateral gene transfer. Current Opinion in Microbiology, 6(4), 417–424. https://doi.org/10.1016/S1369-5274(03)00086-9
2. Velavan, T. P., & Meyer, C. G. (2020). The COVID-19 epidemic. https://doi.org/10.1111/tmi.13383
3. World Health Organization, Latest reported counts of cases and deaths (11.01.2021))
4. WHO COVID-19 - Landscape of novel coronavirus candidate vaccine development worldwide 12.01.2022
5. Chowdhury, S., Bappy, M. H., Chowdhury, S., Chowdhury, M. S., & Chowdhury, N. S. (2022). Omicron Variant (B.1.1.529) of SARS-CoV-2, A Worldwide Public Health Emergency!. European Journal of Clinical Medicine, 3(1), 5-9. https://doi.org/10.24018/clinicmed.2022.3.1.159
6. WHO, Weekly epidemiological update on COVID-19 - 11 January 2022
7. World Health Organization (WHO), Russain Federeration Pandemic Overview, (12.01.2022)
8. Anders Åslund (2020) Responses to the COVID-19 crisis in Russia, Ukraine, and Belarus, Eurasian Geography and Economics, 61:4-5, 532-545, DOI: 10.1080/15387216.2020.1778499
9. Malay Pramanik, Parmeshwar Udmale, Praffulit Bisht, Koushik Chowdhury, Sylvia Szabo & Indrajit Pal (2020): Climatic factors influence the spread of COVID-19 in Russia, International Journal of Environmental Health Research, DOI: 10.1080/09603123.2020.1793921
10. Ministry Of Health Of The Russian Federation, NATIONAL WEEKLY INFLUENZA BULLETIN OF THE RUSSIAN FEDERATION