

Study of Influence of Public Opinion about Vaccination on COVID–19 Immunization

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Abstract—This study is aimed at assessing impact of public opinion about vaccination on immunization against COVID-19 and, as a result, implementation of measures for the non-proliferation of morbidity among the population. The study differs from previous ones in the following areas: 1) posts from the most popular social network in Russia, VKontakte, are analyzed for the first time; 2) influence of intensity of the epidemic process and attitude of the population to vaccination on inoculation coverage is considered; 3) lag effect and influence on running time of indicated factors on vaccination, are considered. Morbidity dynamics in Russia and vaccination rate were analyzed according to the portal "Our World in Data". Attitude of population to vaccination is determined through sentiment analysis of posts of Vkontakte in 2021. Assessment of dependence of people's attitude to vaccination and implementation of immunization process, as well as the spread of viral infection, is studied using Granger causality test. The results of the article can be used in solving problems of increasing effectiveness of implementation of state anti-epidemic measures and management of vaccination process.

Index Terms—Granger test, epidemic process, coronavirus, anti-epidemic measures, COVID–19

I. INTRODUCTION

Vaccination is one of the most effective tools for forming collective immunity of population [1]. Attitude of the population to vaccination and their appeal to medical organizations depends on state strategy to inform people, including on use of specific prevention methods during a pandemic [2]. For example, 85% of Indians is ready to vaccinate against COVID–19, if government media will build their confidence in the health sector and provide explanations about alleged threats and contraindications to vaccination [3]. And the WHO has named indecision regarding vaccines as one of the ten main threats to global health in 2019 [4].

Now, various methods are used in research on public opinion to vaccination issues: questionnaires and surveys of respondents, bibliometric analysis, text analysis of posts from social networks. For instance, in [4] predictors showing readiness of Belgians to be inoculated are identified with the help of survey and regression analysis. Intension of the French people is carried out using results of online survey and logistic regression. It demonstrates that in most cases unwillingness to be vaccinated in most cases is associated with fear of harm to health [5]. But practical experience shows utilizing such approach requires significant resources to obtain representative samples.

Bibliometric analysis permits to conduct research on manuscripts of scientists on assessment of implementation of specific measures to curb the incidence of COVID–19 [6]. Analyzing 395 scientific articles using the 'bibliometrix 3.0' package of R–studio, Ad. Nasir et al. (2020) have revealed that the number of publications devoted to the coronavirus has been gradually increasing since 2010 [7]. The main areas of discussion of issues related to the pandemic are the socio–economic consequences of epidemic diseases and the epidemiology of COVID–19 [8]. Method of analysis is quite effective for conducting research on the subject under study, but results obtained have a lag effect — conducting research and preparing scientific publications takes considerable time, which is not effective enough when developing measures to contain any pandemic.

Study of posts from social networks confirms studies conducted by surveys: reluctance of people to be vaccinated is associated with expectation of side effects [9]. Methodology for parsing posts and their analysis is improved [10]. Number of users of social networks has been growing rapidly during recent years [11]. This is confirmed by increasing in the use

of intellectual analysis methods in healthcare [12].

Attitude towards immunoprophylaxis against COVID-19 in Russia can be characterized as distrust of a specific vaccine and approval of vaccination in general as an effective technology for combating epidemics [13]. The key strategy is "waiting" [14]. At the same time, studies conducted in this direction describes using tools for analyzing social networks in Russia as a whole, without working out practical aspects of their applying.

A. Authors' contributions

Our study fills above said gap in the literature. It differs from the previous ones in the following: 1) posts from the most popular social network in Russia, VKontakte (VK), which is among the top 10 most popular resources in Russia, ranking fourth [15], are analyzed; 2) influence of intensity of the epidemic process and attitude of the population to vaccination on inoculation coverage is considered; 3) application of Granger causality test permitting to estimate lag effect and influence on running time of various factors on vaccination in Russia is envisaged.

II. DATA AND METHODS

The study included the following stages: 1) forming a data set; 2) analysis of posts from the social network in Vkontakte; 3) investigation of causal relationship between indicators characterizing the epidemic process, attitude to vaccination, coverage of the population to vaccination using the Grainger test; 4) analysis of obtained results.

A. Dataset

Parameter of "The number of newly detected cases of COVID-19 per million people per day" is used as an indicator characterizing the intensity of the implementation of the epidemic process in Russia, and value of "The number of fully vaccinated people per million people" in weekly section from January, 2021 to December, 2021 is utilized as inoculation rate. These data are taken from Our World in "Data website" (<https://github.com/owid/covid-19-data/tree/master/public/data>) [16, 17].

From January to December, 2021 posts having keywords of "Vaccine", "Vaccination", "Sputnik V", "Sputnik Light", "CoviVac", "EpiVacCorona" are downloaded from VK. Parsing is performed with the help of "Target Hunter" (<https://targethunter.ru/>). The parser was configured to download posts with geolocation corresponding to Russia.

B. Data Cleaning

Before analysis, posts are preprocessed: numbers, punctuation marks, stop words, hashtags, and so on are removed.

C. Methods

Library of nltk is used for calculations in combination with VADER Sentiment Analysis [18]. "Compound" is figured out. The Compound score is a metric that calculates the sum of all the lexicon ratings which have been normalized between -1 (most extreme negative) and $+1$ (most extreme positive). To

assess the interests of people within framework of vaccination, a word cloud is built, which is a visualization of frequency of words in the text in the form of a weighted list.

Relationship between vaccination rates and the spread of a new coronavirus infection in Russia is determined by Granger causality test. Tests are performed for lags of $m = 2, 3, 4, 5, 6, 7, 8, 9$. Library of statsmodels of Python 3.8 is utilized.

III. EMPIRICAL RESULTS

A. Characteristics of the Epidemic Process in Russia caused by COVID-19 and vaccination rate

The epidemic process in Russia caused by COVID-19 is characterized by a high level of instability. It is illustrated by Fig. 1 and Fig. 2.

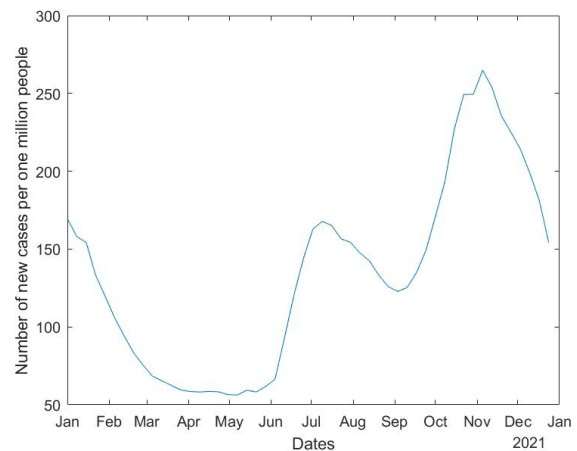


Fig. 1. New cases in Russia in 2021.

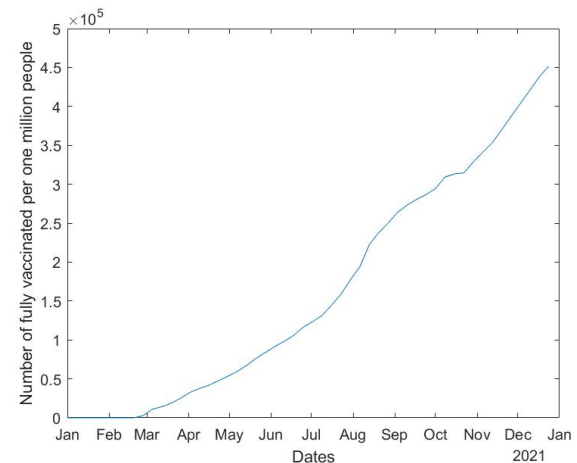


Fig. 2. Vaccinations in Russia in 2021.

A decrease in the number of cases was noted in summer, in autumn and winter incidence began to grow again, the highest rates were noted in December 2021. It is caused by a mutation of the virus, an increase in its virulence, the appearance of new

strains. Active vaccination of the Russian population began in January 2021 using vaccines of domestic production. The most commonly utilized vaccine is Sputnik V. According to vaccination rate, there is a gradual increase in the number of people who are fully inoculated, with maximum in December 2021.

B. Analysis of Posts about Vaccination from "VKontakte"

During study period, 14247 posts related to the discussion of vaccination issues in Russia have been downloaded from VK. Weekly distribution of them is shown in Fig. 3. There is an increase in interest in vaccination issues in winter, summer, and autumn. In spring, people's interest in vaccination decreases.

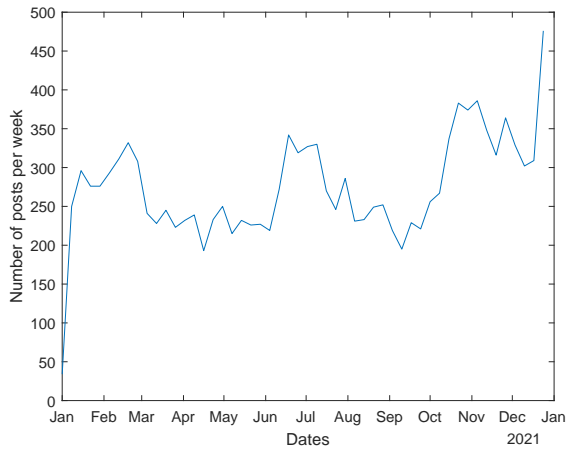


Fig. 3. Weekly distribution of posts.

Weekly chart of tonality values is given in Fig. 4. Analysis of Fig. 4 allowed us to conclude that in January there was a neutral attitude of population to vaccination, which then changed to a positive one, and in February–March population of Russia was neutral about vaccination issues again.

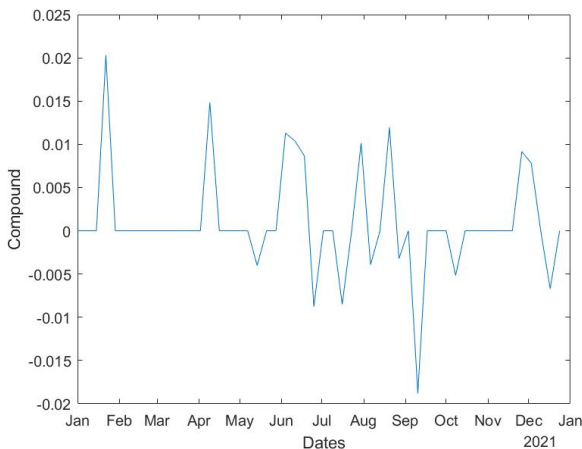


Fig. 4. Weekly chart of tonality values.

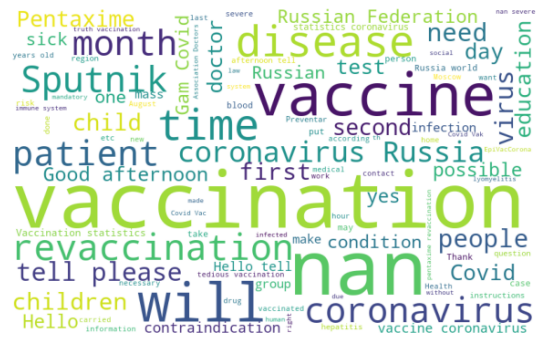


Fig. 5. Word cloud.

Cloud of frequently used words is illustrated by Fig. 5. Population is mainly interested in statistics of morbidity, including children's, as well as the effectiveness of implementation of inoculation processes. People are also into vaccination of children. At the same time, there are no words about side effects of vaccination among frequently encountered words, which allows us to conclude that public is poorly curious about consequences of vaccination. It is illustrated by Table I.

TABLE I
DISTRIBUTION OF DOWNLOADED POSTS BY AGE, GENDER OF THEIR AUTHORS, AND AVERAGE VALUES OF THEIR TONALITY

Age category of authors of posts, years	Men		Women	
	Number of posts for 2021	Average value of posts' tonality	Number of posts for 2021	Average value of posts' tonality
Up to 17	0.00	0.00	10.00	0.00
17–21	567.00	0.00	2134.00	0.05
22–35	2467.00	-0.06	5471.00	-0.04
36–60	1897.00	0.1	1456.00	0.03
61–75	46.00	0.00	174.00	0.10
76–90	10.00	0.00	15.00	0.05

Issues of vaccination are most actively discussed by women, in particular, the 22 to 35 years old. Men are less interested in it than women, the total number of posts published by them is 4987. Similarly to women, men aged 22–35 are the most active in discussing. Teen-agers and seniors have little interest in these issues. An insignificant number of posts of seniors may also be associated with an insufficient level of computer technology skills. On average, women and men aged 22–35 years have a negative attitude to vaccination, men aged 36–60 years and women aged 17–21 years, 36–60 years, 61–75 years have a positive attitude.

C. Causality Test

Table II shows results of calculations of Granger test for indicators characterizing attitude of Russian population to vaccination, the development of the epidemic process and the coverage of the population with vaccination.

The following designations are used in Table II: X — "Attitude of Russian population to vaccination" does not Granger Cause of number of new cases of COVID-19 per

TABLE II

RESULTS OF GRANGER TEST FOR INDICATORS CHARACTERIZING ATTITUDE OF RUSSIAN POPULATION TO VACCINATION, DEVELOPMENT OF EPIDEMIC PROCESS AND COVERAGE OF POPULATION WITH VACCINATION

Lag, m	X		Y		Z		V	
	F	P	F	P	F	P	F	P
2	0.25	0.78	0.23	0.79	1.07	0.35	0.95	0.39
3	0.93	0.44	0.38	0.77	0.96	0.42	1.29	0.29
4	1.10	0.37	1.01	0.41	0.91	0.46	2.09	0.10
5	1.08	0.39	1.86	0.13	1.75	0.15	1.88	0.12
6	1.13	0.37	1.39	0.25	1.36	0.26	3.10	0.02
7	1.30	0.29	1.27	0.30	2.30	0.02	2.36	0.04
8	1.63	0.16	1.10	0.39	2.41	0.04	1.84	0.11
9	1.33	0.26	0.87	0.56	2.02	0.08	1.72	0.14

one million people; Y — number of new cases of COVID-19 per one million people does not Granger Cause of "Attitude of Russian population to vaccination"; Z — "Attitude of Russian population to vaccination" does not Granger Cause of "Number of fully vaccinated people per one million"; V — "Number of fully vaccinated people per one million" does not Granger Cause of "Attitude of Russian population to vaccination"; F — F -test; P — P -value.

According to performed calculations given in Table II, it is revealed that change in attitude of Russian population to vaccination changes number of vaccinated at lags 7, 8, and vice versa, dynamics of change in number of vaccinated changes attitude of population to vaccination at lags 6, 7. Level of morbidity does not affect attitude of Russians to vaccination.

IV. CONCLUSION

Based on the conducted research, the following conclusions can be made. Russian people are actively discussing vaccination issues on social networks. At the same time vaccination's side effects are not important for them. Besides, people are worried about mandatory vaccination of children. In addition, we can see sharp variability from positive attitude to vaccination to negative one, while level of positivity and negativity is low, and most posts are neutral. Obtained results are confirmed by [4, 9, 10].

Moreover, attitude of people to vaccination changes level of vaccination coverage with a lag effect, which manifests itself after 7–8 weeks. Conversely, change in vaccination coverage of population changes attitude of people to it after 6–7 weeks. Therefore, active discussion on social networks contributes to an increase of vaccinated rate, modifies attitude to vaccination, and under sufficient elaboration of its methodology, it can be an effective tool for formation of collective immunity against COVID-19.

Although the results are valid and can be used to compare feature scores, there are a few limitations. Analysis of social networks does not allow us to solve issues of coverage of the entire population: some people are either not registered in VK, or does not express their opinion in the form of posts. Additional development of tools for assessing public opinion on vaccination issues of persons who do not show sufficient activity in social networks is required.

Results of this manuscript can be used in solving problems of increasing effectiveness of implementation of government anti-epidemic measures and management of the vaccination process. In the future, it is planned to conduct research on issues of assessing quality of implementation of strategies for medical awareness of the population and the formation of their loyalty to healthcare system.

V. DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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