Pak. j. life soc. Sci. (2024), 22(2): 23975-23990 E-ISSN: 2221-7630;P-ISSN: 1727-4915

Pakistan Journal of Life and Social Sciences

www.pjlss.edu.pk

https://doi.org/10.57239/PJLSS-2024-22.2.001710

RESEARCH ARTICLE

The Use of Self-Reports from Social Media as a Source of Data Exemplified by a Study of Adverse Events of the COVID-19 Vaccination

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ARTICLE INFO

Received: May 22, 2024

Accepted: Jul 4, 2024

Keywords

Social Media

Telegram

COVID-19

Adverse Events After Immunization

Self-Report

COVID-19 Vaccine

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ABSTRACT

Data on adverse events from COVID-19 vaccine clinical trials are limited, among other things due to the limited size of the population tested. In addition to clinical trials, information for studies can be collected from social networks. The aim of this study was to investigate the prevalence of short-term adverse events based on self-reports posted on social networks. Data were retrieved from the Telegram platform and then exported to the STATISTICA software for statistical analysis. We use natural language processing techniques to extract textual data. To extract adverse events from the array of textual data, a search was performed in according to the generated patterns. We extracted and analyzed 9268 reports posted by COVID-19 vaccine recipients on the Telegram channel "@covid_dobrovolec". Data collected included sex, age, adverse events, and levels of SARS-CoV-2 antibodies. The results of this study support the results of clinical trials. Social media information is a new source of relevant data on the prevalence and tolerability of adverse events caused by new vaccines. The results obtained from the analysis of self-report data from a Telegram channel confirm the results of clinical trials.

INTRODUCTION

In the modern digital world, social networks are the easiest and most rapid way to obtain and exchange content. As it is easily accessible, short in form, and very user-friendly, it can be utilized for various purposes (Al-Qurishi et al., 2015). Important information can be gathered from social media and messaging apps for scientific research, in addition to controlled clinical trials (Collins et al., 2016; Siddiqui and Singh, 2016; Injadat et al., 2016; Osterrieder, 2013).

In 2015, at the 2nd World Symposium on Web Applications and Networking (WSWAN 2015), the best open-source tools for collecting and visualizing social media content were discussed. Since 11 March, 2020, with the beginning of the global pandemic of a new coronavirus infection (COVID-19) caused by the Severe Acute Respiratory Syndrome 2 (SARS-CoV-2) coronavirus, self-reported social media information has also become the subject of scientific research.

For example, Jarynowski A. et al. (2021) conducted a study of adverse events in response to Gam-COVID-Vac using data from social media. The following text will only discuss the adverse events associated with the use of this COVID-19 vaccine.

The main body of data on the efficacy and safety of this COVID-19 vaccine was obtained from studies in Russia (Sputnik V vaccine, 2021; Logunov et al., 2021; Barchuk and Danilenko, 2021; Barchuk et al., 2021), Argentina (15th Vaccine Report, 2021; Sputnik-V is 78.6%, 2021; Costa, 2021), Hungary (Vokó et al., 2022), San-Marino (Montalti et al., 2021), Iran (Babamahmoodi et al., 2021), and others. For example, a study of the COVID-19 vaccine, which specifically focused on side effects, concluded that "the majority of adverse events after immunization reported in our study were mild and moderate" (Montalti et al., 2021).

The most comprehensive study on the efficacy and safety of the COVID-19 vaccine to date was carried out in Argentina (Side effects, 2021). According to the report of the Argentina Ministry of Health, during the national vaccination campaign against COVID-19 (December 29, 2020, to August 31, 2021), 13,057,335 doses of the COVID-19 vaccine were administered and 41,846 adverse events after vaccination were reported, representing 320.48 reports per 100,000 doses of vaccine administered. Of these, 71.9% were reported by women. For both sexes, the average age of those who reported adverse events was 42.4 years.

According to the Argentinean report, the most frequent adverse events among those immunized with the COVID-19 vaccine were the following (quantity per 100,000 doses in decreasing order):

- headache with myalgia and/or arthralgia (136.17)
- elevated temperature with headache and/or myalgia and/or arthralgia (128.51)
- local reaction without body temperature rise (26.89)
- elevated temperature (16.54)
- pain at the injection site without body temperature rise (11.44)
- pain at the injection site with body temperature rise (8.05)
- gastro-intestinal symptoms with or without elevated temperature (6.09)
- allergy (5.97)

Other adverse events mentioned in the Health Ministry report were even less frequent. All of these adverse events after vaccination have also been reported in other studies, although their frequency varies from country to country. Obviously, in addition to population differences, the frequency of adverse events can depend on many factors which is not always reported in publications. Therefore, it is difficult to draw direct comparisons between these results.

However, in general, the adverse events that occur most frequently in response to the COVID-19 vaccine are comparatively mild flu-like, and in this respect, they do not differ from the adverse events caused by other vector vaccines against COVID-19. The results of our study on the self-reports from the Telegram channel are consistent with this, as well as other reports on the COVID-19 vaccine (Logunov et al., 2021; Barchuk and Danilenko, 2021; Barchuk et al., 2021; 15th Vaccine Report, 2021; Sputnik-V is 78.6%, 2021; Costa, 2021; Vokó et al., 2022; Montalti et al., 2021; Babamahmoodi et al., 2021).

It should be noted that some specific features make studies using self-report from social media a promising option, including transparency, self-explanatory information, representative samples, high mobility, and the low (virtually zero) cost of such studies. In summary, researchers who use social media data have the advantage of obtaining a high-quality representative sample with an ever-growing number of participants and updated data.

MATERIALS AND METHODS

Database Description and Study Population

The study was based on information from self-reports of vaccinated Russian residents submitted to the Telegram messaging app.

A total of 9268 messages from the Telegram channel "@covid_dobrovolec" related to the COVID-19 vaccine were downloaded between April 2020 and July 2021. Of these, 1075 messages (11.6%) were reports uploaded by trial participants, 7319 reports (79.0%) had no data on antibody levels, and 287 reports (3.1%) had omissions in adverse event data or contained data for multiple individuals without the ability to extract reliable information about each.

Therefore, we retrospectively analyzed 587 messages (6.3%). The result was a unique data set of 2658 COVID-19 vaccine-associated events reported by participants. In addition to adverse events, the data included vaccination date, sex, age, and SARS-CoV-2 antibody test levels.

All antibody level data was converted according to international recommendations (WHO/BS, 2020) into BEU/mL using appropriate conversion factors (About the international format, 2021). We took into account the results of antibody testing up to 120 days after the first dose of vaccine.

The data recovered from the messaging app did not contain any personal information, and the analysis was carried out in accordance with the Terms of Service (Terms of Service, 2022). Therefore, the analysis was completely anonymous and was performed in aggregate form, and the study did not require the approval of the ethics committee.

Data Analysis

Data were retrieved from the Telegram platform (Telegram FZ-LLC) and then exported into STATISTICA version 10 software (TIBCO Software Inc., Palo Alto, CA, USA) for statistical analysis.

To extract adverse events, we used natural language processing methods (Angeli et al., 2015). On the basis of multilevel classification, groups of records were generated corresponding to each of the adverse events, and lexemes identifying each of them were defined. The lexemes were used to generate a pattern that was recorded as a regular expression. To extract adverse events from the textual data, a search was performed in accordance with the generated patterns.

All adverse events were divided into two types: systemic and local. Systemic responses included the following: Cough, Diarrhea, Malaise, Myalgia, Fatigue, Fever, Warmth, Chills, Headache, Nausea, and Vomiting. Local responses included local itching, local redness, local swelling, and local pain.

The groups were compared using descriptive statistics (mean values and standard error for indicators with normal distribution). The Student test was used to determine the statistical significance of the differences between the means. Linear regression analysis was employed to estimate the level of immune response. An association between the occurrence of adverse events and the development of antibodies was estimated by ANOVA.

The prevalence of adverse events in different age groups was compared by building a Newcombe confidence interval to estimate the difference between binomial probabilities (Newcombe, 1998).

The relationship between various vaccine-associated adverse events was defined by means of constructing two-way contingency tables and calculating a *p*-value for the exact Fisher's test of two tails.

Statistical data analysis was performed by Statistica for Windows v.10 and Wolfram Research *Mathematica* v.12.0. The statistical importance of the differences was estimated for a significance value of $\alpha = 0.05$.

RESULTS

General Characteristics of Participants

The study involved records from 355 women and 227 men; 5 participants did not specify their sex; 11 did not specify their age. Therefore, women constituted 61% of the study sample and men 39%.

The average age of the study sample was 43.0 ± 13.7 years. In terms of gender, the average age was 44.0 ± 13.7 years for women and 41.9±13.7 years for men.

To estimate differences in the prevalence of adverse events and the development of an immune response, the study sample was divided into groups by sex and age. We identified the following age ranges: Group 1: 18–29 years inclusive; Group 2: 30–40 years; Group 3: 41–50 years; Group 4: 51–65 years; Group 5: over 65 years. Participants who did not specify their age were not included in any of the age groups.

Table 1. Distribution of the study sample by age group (*n* = 576).

	Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**
N	81	204	141	105	45
Average age	25.7 ± 2.9	34.6 ± 3.1	45.2 ± 2.9	57.2 ± 4.5	73.0 ± 6.0

Reported COVID-19 Vaccine-related Adverse Events

At least one adverse event after the administration of the first and second dose was self-reported by 71.6% (420/587) and 68.1% (400/587) of the participants, respectively. The most frequent adverse events after vaccination with both doses were: Fever (45.1% and 44.0%), Warmth (42.4% and 40.6%), Local pain (at injection site) (25.6% and 25.4%), Malaise (25.0% and 19.8%), Fatigue (20.4% and 14.5%), Myalgia (19.9% and 18.1%), Chills (17.4% and 17.4%) and Headache (17.4% and 16.1%). For the first and second doses of the vaccine, the adverse events recorded were represented by the median = 2; and IQR = 0, 4. After the first dose, most of the participants reported two adverse events (13.8%, 81/587); 13.1% reported three adverse events (77/587); 13.6% reported four adverse events (80/587); and only 0.3% reported nine adverse events (see Fig. 1a).

After the second dose, most of the participants reported three adverse events (15.7%, 92/587); nine adverse events were reported by only 0.2% (1/587); while 11 adverse events were reported by 0.3% (2/587) (see Fig. 1b).

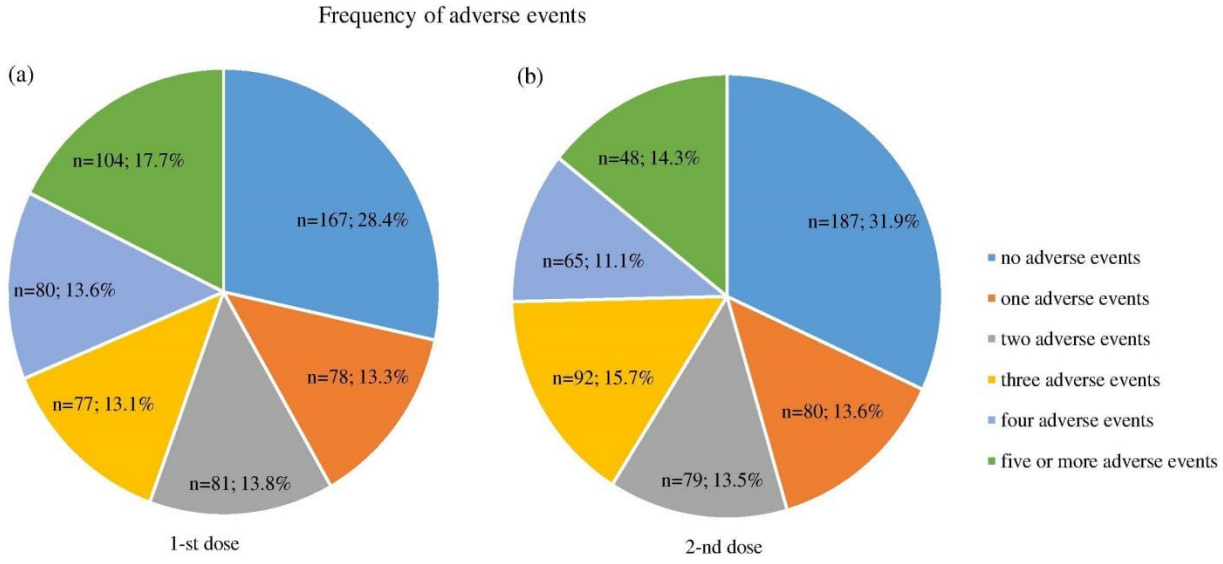

Figure 1. The overall number of reported adverse events of the COVID-19 vaccine. (a) After the first dose of vaccine, (b) after the second dose of vaccine.

A retrospective analysis of the reports posted by the vaccinated recipients in the Telegram channel revealed the most frequent types of adverse events after the administration of each dose of the vaccine (see Fig. 2).

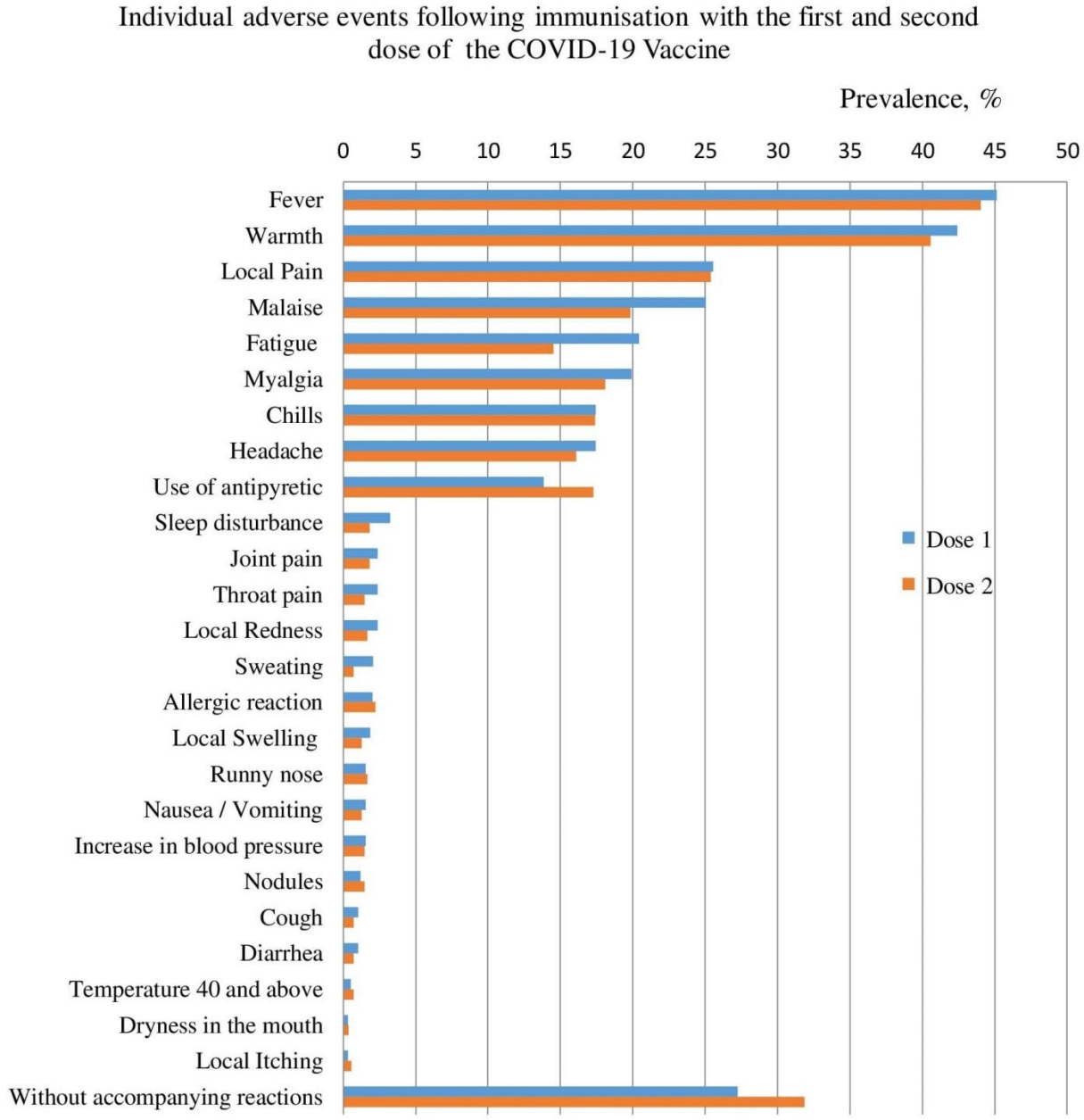

Figure 2. The prevalence of adverse events in those immunized with both doses of the COVID-19 vaccine.

Following the administration of both doses of the vaccine, the recipients reported more frequently the following events: Fever, Warmth, Local Pain, Malaise, Fatigue, Myalgia, Chills, Headache (14.5–45.1%). The adverse events were rare, Temperature 40 and above, Dryness in the mouth, and Local itching (0.34–0.73%). In the following, we analyze the eight most prevalent adverse events.

Differences in the prevalence of symptoms were estimated for statistical significance after the first and second dose. The differences in the prevalence of Malaise ($p=0.01$) and Fatigue ($p=0.001$) were

found to be significant. Both of these symptoms tended to occur less frequently after the second injection.

Analysis of the Prevalence of Adverse Events by Sex after Each Dose of the Vaccine

We compared the prevalence of adverse events between men and women after each dose of the vaccine (see Table 2). Participants who did not specify their gender were excluded from this type of analysis.

Table 2. The prevalence of adverse events after the administration of the first and second dose of the COVID-19 vaccine in men and women (*n* = 582).

Symptom	Prevalence after first injection		p-level	Prevalence after second injection		p-level
	Men	Women		Men	Women	
Fever	41.0	47.9	> 0.05	39.2	47.3	> 0.05
Warmth	38.3	45.1	> 0.05	34.8	44.5	0.048
Malaise	22.9	26.2	> 0.05	21.6	18.9*	> 0.05
Chills	18.1	17.3	> 0.05	13.2	20.3	> 0.05
Local Pain	18.1	30.1	0.014	16.7	31.3	0.003
Fatigue	16.7	22.8	> 0.05	11.9	16.1*	> 0.05
Headache	15.0	19.2	> 0.05	13.7	17.5	> 0.05
Myalgia	14.5	23.7	> 0.05	16.7	18.9	> 0.05

Note: * denotes a significant difference in the prevalence of symptoms after the first and second injection, $p < 0.05$

Analysis of Table 2 shows that after the first injection Local Pain was more frequent among women than among men ($p<0.05$). After the second injection, statistically significant differences were found between men and women in the prevalence of Local Pain and Warmth ($p<0.05$).

Note that there were no statistically significant differences in the prevalence of adverse events among men after the first and second injection.

Analysis of the Prevalence of Adverse Events by Age after Each Dose of the Vaccine

In biomedical studies, age, like sex, is a confounder that should be taken into account. We analyzed the efficacy and safety of the COVID-19 vaccine according to the age of the participants (The first interim data, 2021).

The comparison was based on the frequencies of the eight most common symptoms (Fever, Warmth, Malaise, Local Pain, Headache, Myalgia, Chills, Fatigue) by age group (Table 3). Participants who did not specify their age were excluded from this type of analysis.

Assuming the significance level $\alpha = 0.05$, we estimate the significance of the difference in the prevalence of each symptom in a particular age group compared to its prevalence in another age group. Comparisons were made separately after the administration of each dose of the vaccine.

Table 3. The prevalence of symptoms in the age groups after the first and second dose of the vaccine (n=576).

Age group	Group 1		Group 2		Group 3		Group 4		Group 5	
Injection / Symptom	1	2	1	2	1	2	1	2	1	2
Fever	0.618	0.549	0.546	0.519	0.418 12	0.411 1	0.286 123	0.333 12	0.178 123	0.267 12
Warmth	0.598	0.510	0.503	0.503	0.418 1	0.383 12	0.229 123	0.267 12	0.178 123	0.222 123
Malaise	0.333	0.304	0.279	0.257	0.234	0.149 12	0.190 1	0.124 12	0.133 12	0.267 4
Local Pain	0.333	0.216	0.344	0.322	0.227 2	0.248	0.171 12	0.171 2	0.022 1234	0.067 1234
Headache	0.284	0.206	0.202	0.197	0.135 1	0.142	0.133 1	0.143	0.044 12	0.022 1234
Myalgia	0.255	0.196	0.279	0.251	0.220	0.170	0.067 123	0.124 2	0.022 123	0.067 2
Chills	0.235	0.167	0.203	0.213	0.164	0.150	0.114 1	0.152	0.067 12	0.067 2
Fatigue	0.206	0.147	0.230	0.153	0.234	0.184	0.181	0.105	0.089	0.067

Note: the superscripts mark the age groups in which the prevalence was significantly different from the prevalence of the symptom in a particular group after a particular injection.

As can be seen from Table 3, the oldest age group demonstrated minimal differences in the prevalence of adverse events among the other age groups.

Regarding the symptoms Fever, Warmth, Local Pain, and Chills, significant differences in their prevalence in the age groups were found to be approximately the same after the first and second dose of the vaccine.

For the Malaise symptom, the difference in its prevalence in age groups after the first injection was less pronounced than after the second. Furthemore, after the second injection, the prevalence of this symptom in the younger age groups (Groups 1 and 2) was significantly higher than in the older age groups (Groups 3 and 4). On the contrary, in Group 5 the prevalence of this adverse event after the second injection was considerably higher than in Group 4, without being significantly different from the other age groups.

For the symptom Headache, the age-related differences after the first dose of the vaccine were less pronounced, while after the second injection its prevalence in Group 5 was significantly lower than in the other age groups.

After the first injection, Myalgia was found to be more frequent in younger age groups (Groups 1, 2, 3) compared to Groups 4 and 5. After the second injection, this symptom practically demonstrated the same prevalence level of in all age groups.

Symptom Fatigue was significantly more prevalent after the first injection in Group 5 compared to the other age groups. After the second dose of the vaccine, the differences in the prevalence of Fatigue by age group leveled out.

It should also be noted that a similar comparison of prevalence after the first and second injection of the vaccine within each age group did not reveal any significant differences for any of the symptoms.

Analysis of Immune Response Development

Participants undertook antibody tests 120 days after vaccination to monitor the development of the immune response to SARS-CoV-2. Each of the vaccinated participants underwent one to three such tests.

Table 4 shows the number of vaccinated recipients who underwent SARS-CoV-2 antibody tests, the average number of days that elapsed after the administration of the first dose of the vaccine, and the mean number of antibodies in BEU/ml. The test time was calculated in days from the date of the first dose, regardless of the fact and date of the second injection.

Table 4. Relationship between the average number of days after vaccination and antibody count (*n* = 587).

Test number	Number vaccinated	Mean number of days after the first dose of the vaccine	Mean antibody count, BEU/ml
1	587	36	263.7
2	85	44	300.2
3	13	65	310.0

The data in the table demonstrate an increase in antibody count from day 36 to day 65 after the first dose.

To reveal the dependence of antibody count on the time elapsed after the first dose, a regression analysis was performed. We constructed a simple linear regression model that describes the dependence of antibody count on the time elapsed after the first dose of the vaccine before the test. The model is described by the equation:

$$Y = 4.36 \cdot X + 107.15$$

where Y is the antibody count and X is the number of days after the first injection of the vaccine.

The model reflects a trend towards growth in antibody count with time, which provides evidence of developing immunity against SARS-CoV-2 over 120 days after the administration of the first dose of the COVID-19 vaccine in a considerable proportion of the vaccinated recipients. The model is statistically significant, p=0.0005.

Differences in the Development of Antibody Response to SARS-CoV-2 as a Function of Sex and Age

Differences in the development of the antibody response to SARS-CoV-2 according to sex and age were identified with variance analysis. The results of the analysis are presented in Table 5. Participants who did not specify their gender and age were excluded from this type of analysis.

Table 5. Relationship between mean SARS-CoV-2 antibody count and recipient's sex (n=582).

Factor	N	Mean antibody count	95% CI
Both sexes	582	270.5	246.3 – 294.8
Women	355	286.2	253.2 – 319.1
Men	227	246.1	211.3 – 280.9

No sex-related differences in antibody response to SARS-CoV-2 were revealed after vaccination.

The dependence of the mean SARS-CoV-2 antibody count on age was approximated by the construction of a nonlinear regression model.

The model is given by:

$$Y = \frac{152.136 - 46.026 \cdot X}{1.473 \cdot 10^{-9} \cdot X^{19.250} + 1} + 232.828$$

where Y is the level of antibodies following vaccination, and X is the age group number.

Figure 3 shows that the model adequately reflects the trends in mean antibody count in the age groups depending on the average age of recipients in a given group. In particular, vaccine-induced antibody production was on average the highest among the youngest recipients (under 30 years), gradually decreasing to a level of approximately 240–250 BEU / ml in age groups starting with 41 years, and staying unchanged on average in all age groups seniors. An analytical representation of this trend is well described by the function used in (Brain and Cousens, 1989).

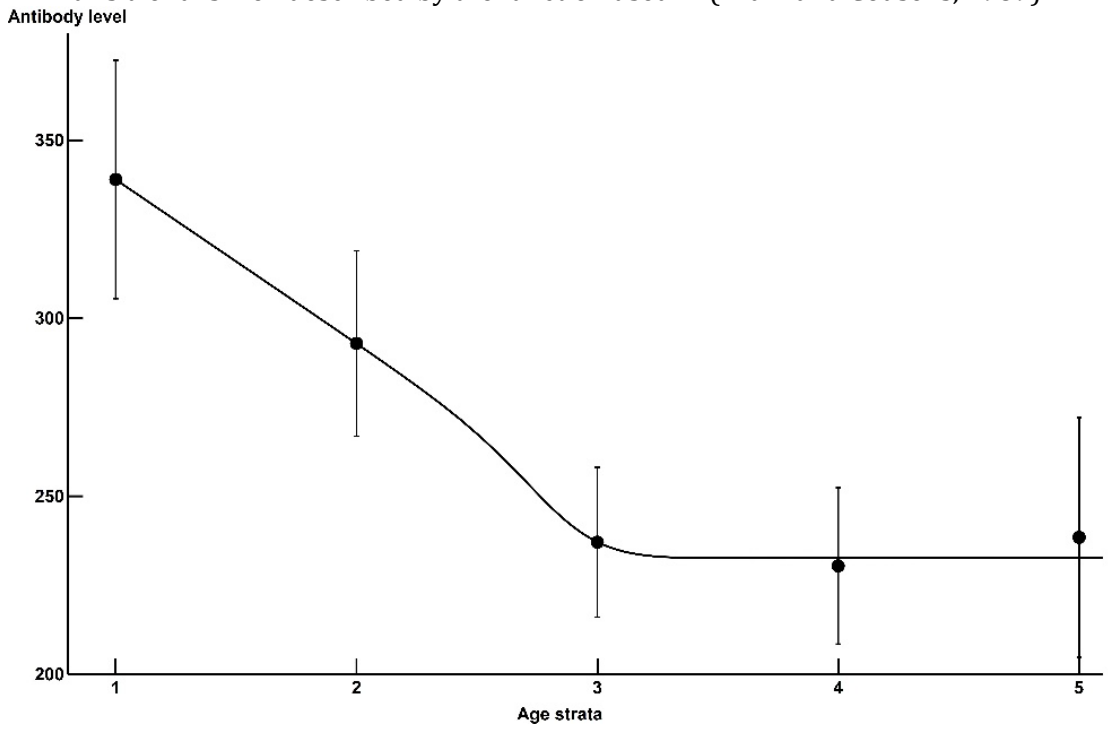

Figure 3. Dependence of SARS-CoV-2 antibody production on age group.

The dots represent values of antibody production in a given group; the whiskers represent standard error of the mean.

Analysis of the Relationship between Adverse Events and SARS-CoV-2 Antibody Count

We analyzed the dependence of antibody count on the presence or absence of vaccine-related adverse events after the first and second dose of the vaccine for the entire sample.

The results of the analysis of variances in SARS-CoV-2 antibody counts depending on the manifestation of adverse events are shown in Table 6.

We revealed a trend toward growth in the SARS-CoV-2 antibody count in vaccinated recipients with a manifest symptom of all *adverse events*. However, statistically significant differences were found only for the symptoms of Fever, Warmth, and Myalgia after the second dose of the vaccine ($p<0.05$).

Table 6. Relationship between mean SARS-CoV-2 antibody count and manifestation of adverse events for the entire sample.

Symptom	Manifestation of an adverse event	N	Average number of antibodies	p-level

Fever	no	272	267.1	< 0.001
	yes	240	387.7	
Warmth	no	292	268.0	< 0.001
	yes	220	397.5	
Myalgia	no	413	301.7	< 0.001
	yes	99	415.2	

Then, we performed a similar analysis within each age group. Table 7 presents the results of the analysis of variances between the mean SARS-CoV-2 antibody counts and the manifestation of adverse events by age group.

Table 7. Relationship between mean SARS-CoV-2 antibody count and manifestation of adverse events by age group.

Age group	**Group 1**		**Group 2**		**Group 3**		**Group 4**		**Group 5**	
Fever										
Symptom prevalence, %	56.8%		51.5%		41.1%		33.3%		26.7%	
Manifestation of an adverse event	no	yes	no	yes	no	yes	no	yes	no	yes
Average number of antibodies	323.5	511.0	286.7	394.0	260.1	327.2	238.6	336.4	225.7	306.7
p-level	0.019		0.034		0.142		0.043		0.325	
Warmth										
Symptom prevalence, %	53.1%		49.5%		38.3%		26.7%		22.2%	
Manifestation of an adverse event	no	yes	no	yes	no	yes	no	yes	no	yes
Average number of antibodies	326.8	522.4	281.8	403.2	258.9	334.2	246.3	343.6	233.4	296.6
p-level	0.013		0.016		0.102		0.060		0.475	
Myalgia										
Symptom prevalence, %	21.0%		22.5%		17.0%		12.4%		6.7%	
Manifestation of an adverse event	no	yes	no	yes	no	yes	no	yes	no	yes
Average number of antibodies	391.4	598.5	317.8	423.3	282.6	324.7	261.2	351.2	239.1	349.1
p-level	0.034		0.074		0.470		0.180		0.434	

The SARS-CoV-2 antibody counts in vaccinated subjects with a manifest vaccine-induced reaction were found to be higher than in those without symptoms for all age groups. However, this effect was statistically significant ($p<0.05$) for all three symptoms only in the youngest participants (Group 1). Thus, for example, in the next group by age (Group 2), the antibody count in vaccinated recipients with a manifest symptom was statistically significantly higher than in those with no such symptom

for two symptoms. In the oldest group, antibody counts in those vaccinated with a manifest symptom and those without manifest symptom were not significantly different for any of the three symptoms studied. Table 7 also shows a decrease in the proportion of participants with manifest symptoms of vaccine-induced reactions with an increase in the age of the vaccinated. Therefore, the prevalence of the Fever symptom in the vaccinated decreased from 56.8% in the first age group to 26.7% in the fifth age group; the prevalence of the Warmth symptom decreased from 53.1% to 22.2%; and Myalgia from 21.0% to 6.7%, respectively.

DISCUSSION

According to Argentinean researchers, "Reactogenicity can contribute to misperceptions (prejudices) against vaccination. A person could perceive a vaccine as excessively reactogenic and could reject additional doses, or a healthcare professional could advise against it. Reaching and maintaining high vaccine coverage is critical to the success of vaccination programs, and these kinds of misperceptions jeopardize the effort" (Pagotto et al., 2021, p. 6). The objective of this study was to investigate the prevalence of short-term adverse events after the administration of the COVID-19 vaccine and analyze the development of the immune response based on self-reported data from Russian vaccinated residents on social media (Telegram app). In addition, the study was designed to close the information gaps on vaccination tolerance in different age and sex groups.

Social media potential to instantly access up-to-date information is much greater than official statistics (Al-Qurishi et al., 2015; Collins et al., 2016; Siddiqui and Singh, 2016; Injadat et al., 2016; Osterrieder, 2013). Telegram, with 35 million users, is the most popular social media service among Russians (Telegram Audience Research, 2022). Studies of this kind initiated at the grassroots level and conducted with direct participation of lay people of any trade and age help reduce concerns and may play a key role in increasing trust in society in vaccination in general, and the COVID-19 vaccine in particular (Jarynowski et al., 2021). This study showed that observation through self-reports posted by recipients on social media provides useful and valuable information that could help conduct further scientific research.

Our study showed that at least one adverse event after the first and second dose of the vaccine was self-reported by 71.6% (420/587) and 68.1% (400/587) of the participants, respectively. The data of the study are consistent with the results obtained by Argentinean researchers of the COVID-19 vaccine (15th Vaccine Report, 2021; Pagotto et al., 2021), who reported that 71.3% of the vaccinated mentioned a minimum of one complication, presumably related to vaccination. The average age of the men and women in that study was also close to that of our sample (42 years).

A somewhat higher prevalence of adverse events was found in a study carried out in Iran among healthcare workers in Birjand (Zare et al., 2021), with at least one adverse event after vaccination with the COVID-19 vaccine reported by 81.9%. In both Argentina and Iran, the studies were carried out among vaccinated healthcare workers.

Differences in the frequency of adverse events in the studies mentioned above can be explained by different factors, such as the phase of the pandemic and various demographic and population characteristics of the samples studied.

In the present study, recipients most frequently reported experiencing Fever, Warmth, Local Pain, Malaise, Fatigue, Myalgia, Chills, and Headache (14.5–45.1%). Rare adverse events reported were Temperature 40 and above, Dryness in the Mouth, and Local Itching (0.34–0.73%). The most frequent adverse events associated with the COVID-19 vaccine among healthcare workers in Birjand (Iran) were Local Pain (62.1%), Myalgia (42.5%), Fatigue (43.9%), Fever (40,6%), and Headache (Zare et al., 2021). In the Argentinean study of the COVID-19 vaccine (15th Vaccine Report, 2021), the most prevalent complications were Local Pain (42%), Myalgia (58%), Headache (33%), and Fever (40%).

In our study, 17.28% of the recipients reported taking painkillers to alleviate adverse events. It was observed (Alghamdi et al., 2022) that taking painkillers to alleviate the side effects associated with COVID-19 vaccination was common in Saudi Arabia among healthcare workers and the general population.

We found that after the first dose more women reported local adverse events than men ($p < 0.05$). After the second injection, statistically significant differences between men and women were found in the prevalence of Local Pain and Warmth ($p < 0.05$). Similar results were obtained in other studies on side effects of COVID-19 vaccines (Jarynowski A. et al., 2021; Menni et al., 2021; Gee et al., 2021), as well as in the study among healthcare workers in Argentina (Pagotto et al., 2021), which may indicate sex-related reactivity to the vaccine. At the same time, the Iranian study of the vaccine revealed a comparable frequency of adverse event reports among men and women (Zare et al., 2021). This result should be interpreted with caution, since the conclusions on sex-related side effects of the COVID-19 vaccines are still not compelling. Therefore, for example, our study was based on self-reports from social networks, and the possible cause of women`s reports may be the fact that women are more interested and concerned about health, are more likely to share their health experiences on the Internet, and tend to be more open to personal information (Elnegaard et al., 2015).

We discovered a strong relationship between the development of vaccine-associated side effects and age. Analysis has shown that the oldest age group had the lowest prevalence of adverse events among the other age groups. The studies of the COVID-19 vaccine from Argentina and Iran also reported that the prevalence of side effects of the vaccine among the elderly was lower compared to other age groups (15th Vaccine Report, 2021; Pagotto et al., 2021; Zare et al., 2021). Jarynowski A. et al. (2021) discovered that the number of adverse events decreased linearly depending on age. The study carried out in San Marino (Montalti et al., 2021) analyzed in detail the reactions of the older people (60+) to COVID-19 vaccination and showed that the frequency of reports of the absence of side effects gradually increased from 10.4% in the 18–39 years group to 63.2% in the 80–89 years group. Our study provided a similar result: the prevalence of a symptom was reduced from the youngest group to the oldest 2–3 times. This result is supported by numerous studies and clinical trials of other vaccines against COVID-19 (Vokó et al., 2022; Babamahmoodi et al., 2021; The Moderna COVID-19 Vaccine, 2022; Pfizer-BioNTech COVID-19 Vaccine, 2022).

Our study also suggested a trend towards a higher average SARS-CoV-2 antibody count in those vaccinated with manifest adverse events. However, this effect was statistically significant ($p<0.05$) only among the youngest participants. For the oldest group, none of the symptoms studied, manifested or not, was associated with any *significant* difference in antibody count in the vaccinated. This observation is consistent with the conclusion in (Kim et al., 2022); more severe and longer-term side effects were found to be associated with high levels of SARS-CoV-2 antibodies.

Researchers have found (Jeong et al., 2021) that the average number of antibodies measured about three months after vaccination was higher in groups with manifest adverse events.

A study (Lemos et al., 2021) conducted among healthcare workers vaccinated against SARS-CoV-2 also reported that participants with higher antibody counts had more manifest symptoms of adverse events.

A similar effect was also observed in a study in patients infected with SARS-CoV-2. Therefore, Zhang et al. (2020) reported that a higher viral load and a higher level of antibodies were associated with a more severe disease state in patients. At the same time, Coggins et al. (2021) did not reveal any correlation between the severity of symptoms associated with the vaccine and vaccine-induced antibody titers. It is not yet clear what mechanisms influence more manifested vaccine-induced adverse events and lead to a higher number of antibodies, so further large-scale studies are needed.

When interpreting the results of our study, one should bear in mind some of its limitations. Our sample consisted exclusively of Russian residents who posted their self-reports to Telegram. Thus, the results may prove to be specific to the population of Russia in the current phase of the pandemic, and should not be extrapolated to other cohorts or other phases of the pandemic. It may also be assumed that self-reports on Telegram are posted by more active and better educated people (in all age groups) and, as a consequence, those who are more responsible towards their health. On the contrary, those less informed about how to stay healthy and lead a healthy lifestyle and therefore, likely to have more health problems, including more comorbidities, fell outside the study sample. At the same time, Telegram users may prefer to be cautious about some adverse events and report them selectively (Elnegaard et al., 2015). For instance, participants may have underreported their gastro-intestinal problems. It should also be noted that the symptoms reported by participants in their self-reports only partially reflect the prevalence of these symptoms in the entire population of the vaccinated. Consequently, our study may only add to current clinical studies rather than replace them.

The strength of our study is the representative sample in terms of age group coverage and the commensurate size of these groups.

CONCLUSIONS

Social media information is a new source of relevant data on the prevalence and tolerability of adverse events caused by new vaccines.

As this study suggested, the results obtained from the analysis of self-report data from a Telegram channel confirmed the results of clinical trials. Self-reports on social networks provide relevant information on adverse events of new vaccines, help to reassure people who have doubts about vaccine efficacy and tolerance, and help to alleviate concerns about vaccination against COVID-19 in general.

AUTHOR CONTRIBUTIONS: Conceptualization, E.D.K., T.A.M. and V.G.P.; formal analysis, V.G.P., T.A.M., A.A.Z. and E.D.K.; data curation, A.A.Z., E.D.K. and T.A.M.; writing—original draft preparation, V.G.P., T.A.M. and E.D.K.; writing—review and editing, V.G.P. and E.D.K.; visualization, T.A.M.; project administration, E.D.K. All authors have read and agreed to the published version of the manuscript.

FUNDING: This research received no external funding.

DATA AVAILABILITY STATEMENT: The data that support the findings of this study are available from the authors upon reasonable request.

ACKNOWLEDGMENTS: The research team would like to thank Vladimir Butygin for help with Data extraction and consultations. We would also like to thank Ilia Jarmoshenko, the Director of Institute of Industrial Ecology, Ural Branch of the Russian Academy of Science for the idea of this research.

CONFLICTS OF INTEREST: The authors declare no conflict of interest.

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