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Participatory epidemiology in time of COVID-19 on the example of Sputnik V mild adverse events in Telegram

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Outline

- Sputnik V vaccine
- Social Media Mining, Telegram
- Deep learning for adverse events extraction
- Main results
  - Frequencies of AEs
  - AE co-occurrence

Introduction

- The COVID-19 pandemic is currently one of the most critical global health problems.

Image taken from google.com

Vaccines

- Gam-COVID-Vac (Sputnik V) is a two-dosed vector vaccine based on human adenoviruses
  - Developed by Gamaleya Research Institute of Epidemiology and Microbiology

https://twitter.com/sputnikvaccine

Sputnik V safety profile

- Originally, two papers from clinical trials were published:
  - The first study of I/II phase involving a total of 76 participants
  - Detailed description of serious and rare adverse events; mild adverse events were described only for individuals older than 60

- Logunov DY, Dolzhikova IV, Zubkova OV, et al. Safety and immunogenicity of an rAd26 and rAd5 vector-based heterologous prime-boost COVID-19 vaccine in two formulations: two open, non-randomised phase 1/2 studies from Russia. Lancet. 2020; 396(10255):887–897

- Logunov DY, Dolzhikova IV, Shcheblyakov DV, et al. Safety and efficacy of an rAd26 and rAd5 vector-based heterologous prime-boost COVID-19 vaccine: an interim analysis of a randomised controlled phase 3 trial in Russia. Lancet.2021;397(10275):671–681.

- In contrast to other vaccines, data on mild adverse events (AEs) of Sputnik V was not published.

Social Media and AEs

- The most popular messaging app in Russia is Telegram
  - the 2nd in Russian Apple Appstore ranking, 500M active users overall
  - Besides chatting, Telegram allows to create "channels" for public broadcast
- The largest social media platform is VK.com (more than 500M registered users, about 97M monthly active users)
  - Functionality is very similar to Facebook.com

https://play.google.com/store/apps/details?id=org.telegram.messenger

A. Semenov *et al.*, "Exploring Social Media Network Landscape of Post-Soviet Space," in *IEEE Access*, vol. 7, pp. 411-426, 2019, doi: 10.1109/ACCESS.2018.2885479.

Sputnik_results Telegram group

- Main goal of public Telegram group “Sputnik_results “ is to collect reports of vaccination by Sputnik V
  - There are more than 31k members
  - Administrators of the group delete messages that are not descriptions of adverse reactions
  - People send their reports in plain informal language

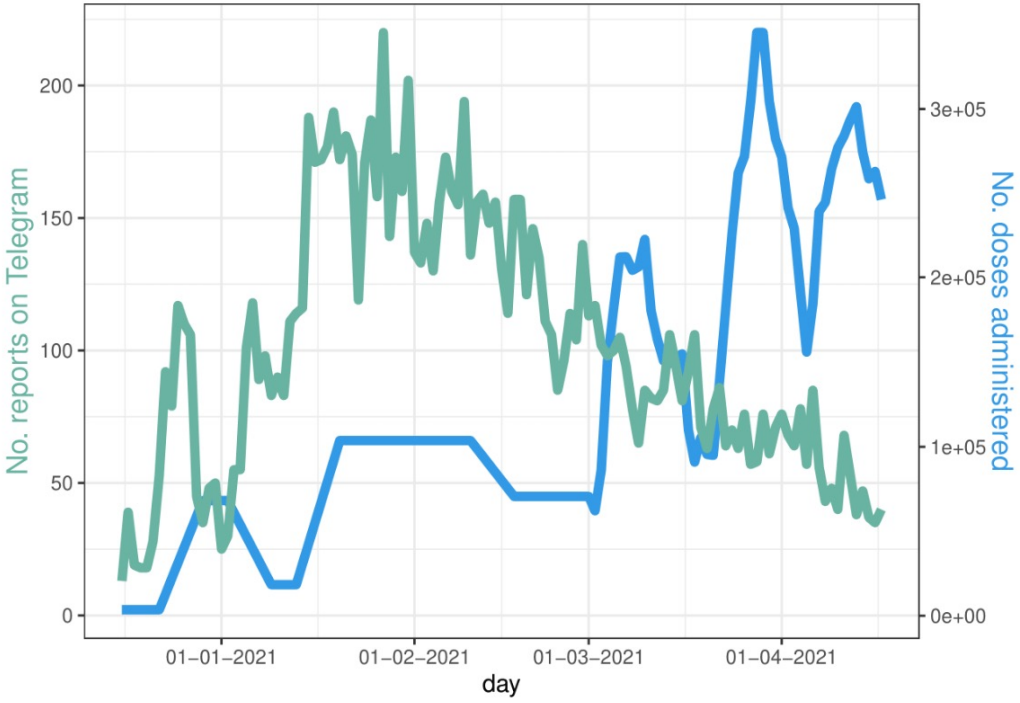
“M, 33. after 12 hours, temp. 39, pain in the arm (the entire shoulder, muscles), nasal congestion, diarrhea. The next day, temp. 38, pain in the arm, nasal congestion.
On the third day, weakness, temperature is normal.”

Adverse events extraction

- Goal of our research is to extract adverse events from the Telegram
  - Conduct descriptive analysis
  - Compare with other vaccines' AEs
- Challenges:
  - Data downloading
  - Extraction of the AEs from unstructured text in Russian language
    - Not feasible to extract manually

Data collection

- We have collected 18,833 messages
- After filtering, 11,515 messages were left
- Message time range: 09/12/2020-17/4/2021



Deep learning for NLP

- Deep learning has recently been very successfully applied in many fields, including natural language processing (NLP)
  - Bidirectional Encoder Representations from Transformers (BERT) is a machine learning technique proposed by researchers from Google in 2018
    - BERT is pretrained on hundreds of millions of words, and achieves high accuracy in many NLP tasks
- BERT model pretrained on Russian language is provided by Neural Networks and Deep Learning Lab at MIPT.
  - https://github.com/deepmipt/DeepPavlov

Deep learning for adverse events extraction

- We framed the problem as multi-label classification
  - Each message contains [0, 12] AEs

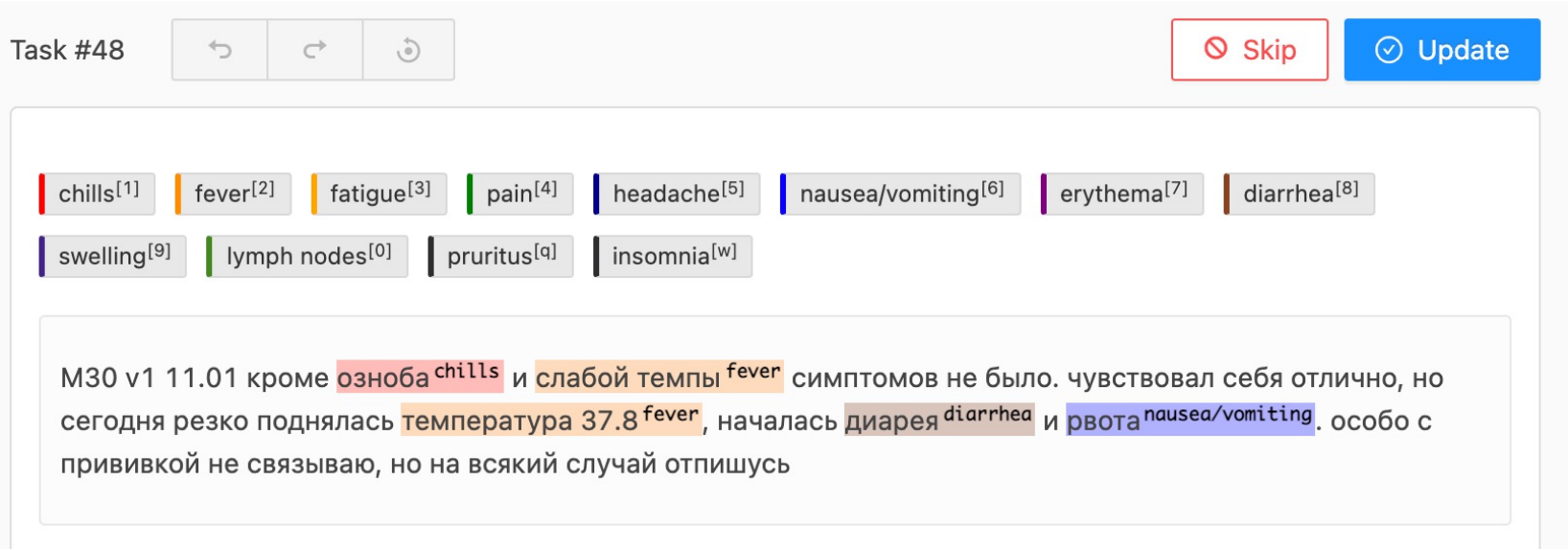
msg	fever	pain	chills	fatigue	nausea	headache	insomnia	lymph.	erythema	pruritus	swelling	diarrhea
47M Все отлично. Никаких побочек.	0	0	0	0	0	0	0	0	0	0	0	0
Ж42 V1 16.04 в 12-00 Сутки прошли, без побочек Чувствую себя отлично, даже место укола не болит	0	0	0	0	0	0	0	0	0	0	0	0
Женщина, 44 года, аутоиммунный тиреоидит, первая часть Спутника 19.01.21 утром, к вечеру температура 37,3, небольшой озноб, вялость, боль в руке, спине и голове (со стороны укола). Наутро температура 36,9, слабость весь день и сонливость. Боль в руке	1	1	1	1	0	1	0	0	0	0	0	0

- We have chosen 12 classes:
  - fever, pain, chills, fatigue, nausea/vomiting, headache, insomnia, lymph nodes enlargement, erythema, pruritus, swelling, diarrhea

Deep learning for adverse events extraction

- In order to use DL models such as BERT, they should be “tuned”
  - It needs training examples: texts and classes that these texts belong to.
- Training examples are usually generated manually, then the model learns from it.

Deep learning for adverse events extraction, labeling



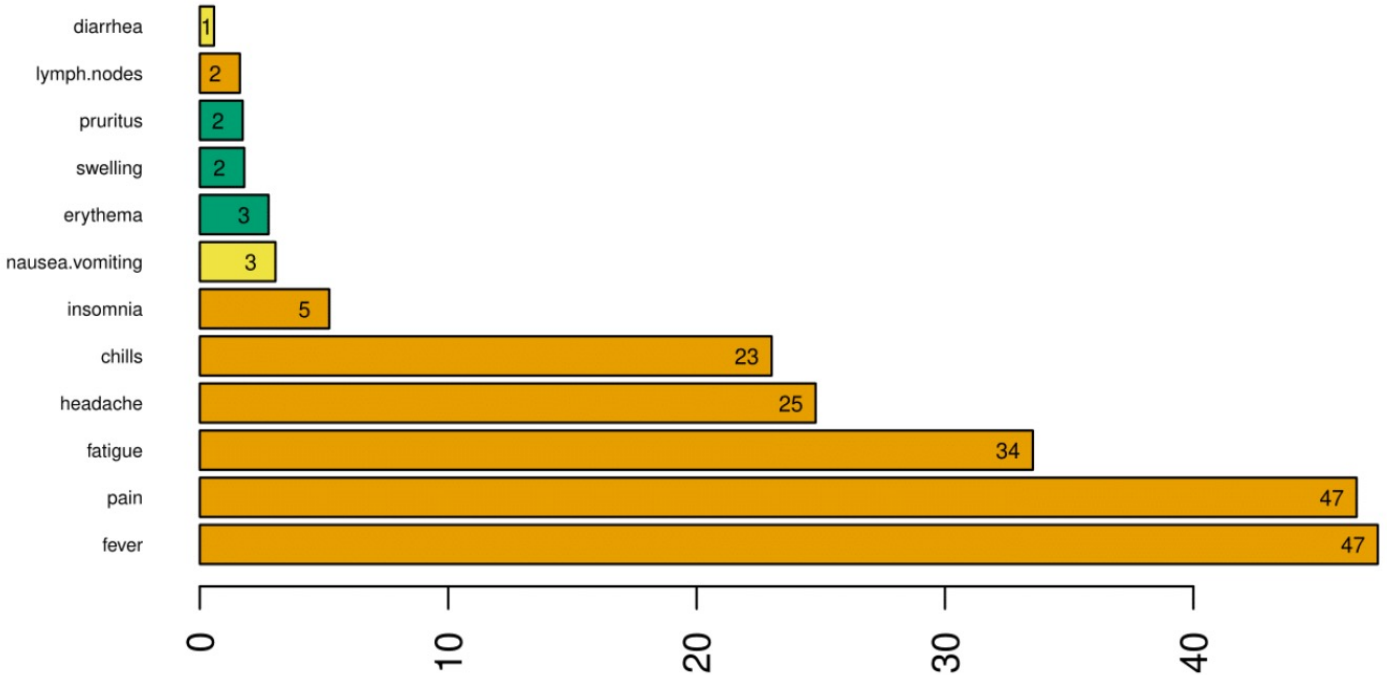
https://labelstud.io/

Model Evaluation

	Micro			Macro	
	AUC	Precision	F1	Precision	F1
LSTM	0.969±0.002	0.866±0.024	0.769±0.033	0.514±0.048	0.431±0.042
BERT	0.991±0.002	0.915±0.016	0.920±0.002	0.863±0.025	0.858±0.006

Table 1: Evaluation results, testing dataset, stratified k-fold with $k = 5$

Classes of AEs reported

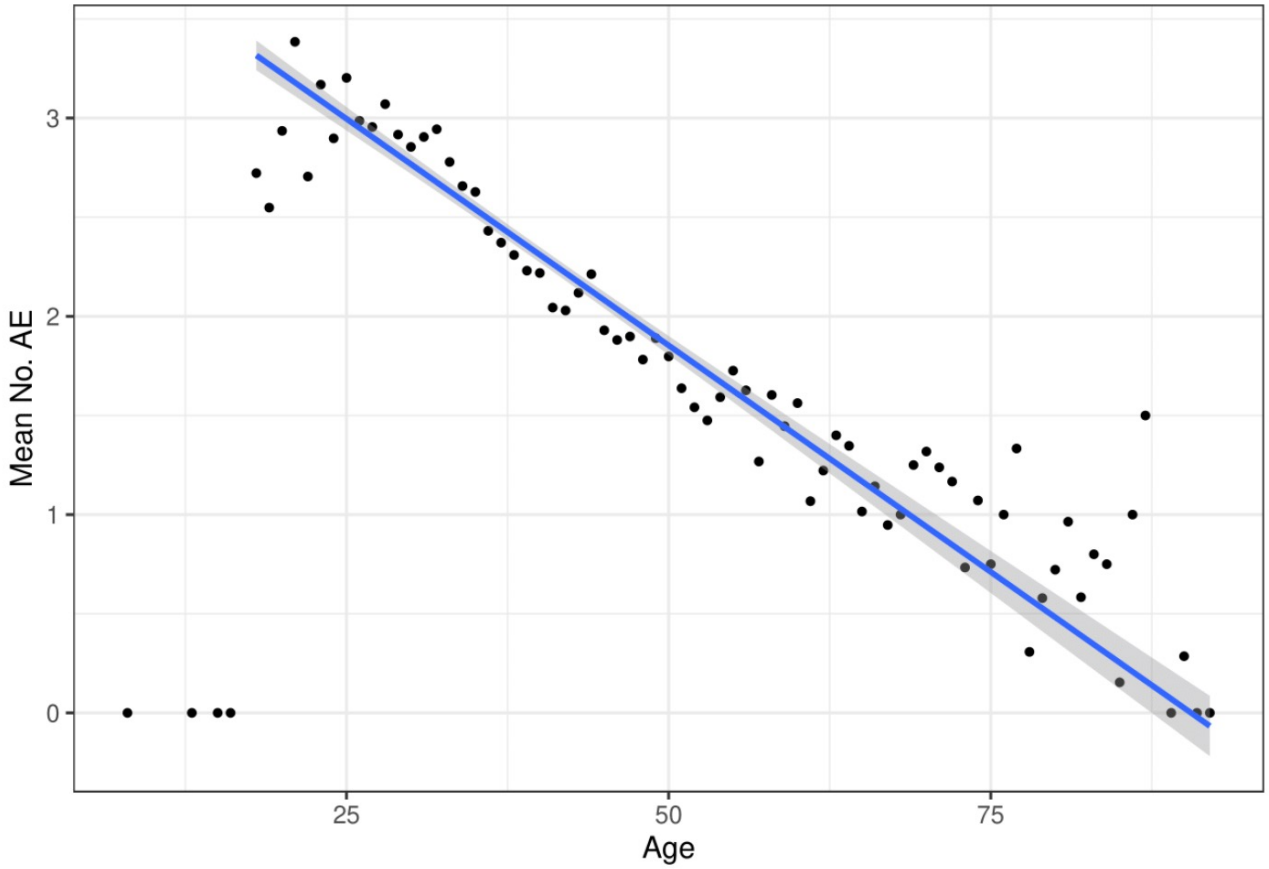


	fever	pain	insomnia	fatigue	nausea/ vomiting	headache	erythema/ redness	pruritus	swelling	lymph nodes enlargement	diarrhea	chills
Frequency	47.4%	46.6%	5.2%	33.5%	3.0%	24.8%	2.7%	1.7%	1.8%	1.6%	0.6%	23.0%

orange - systemic, green - local, yellow - gastric

Age against number of AEs reported

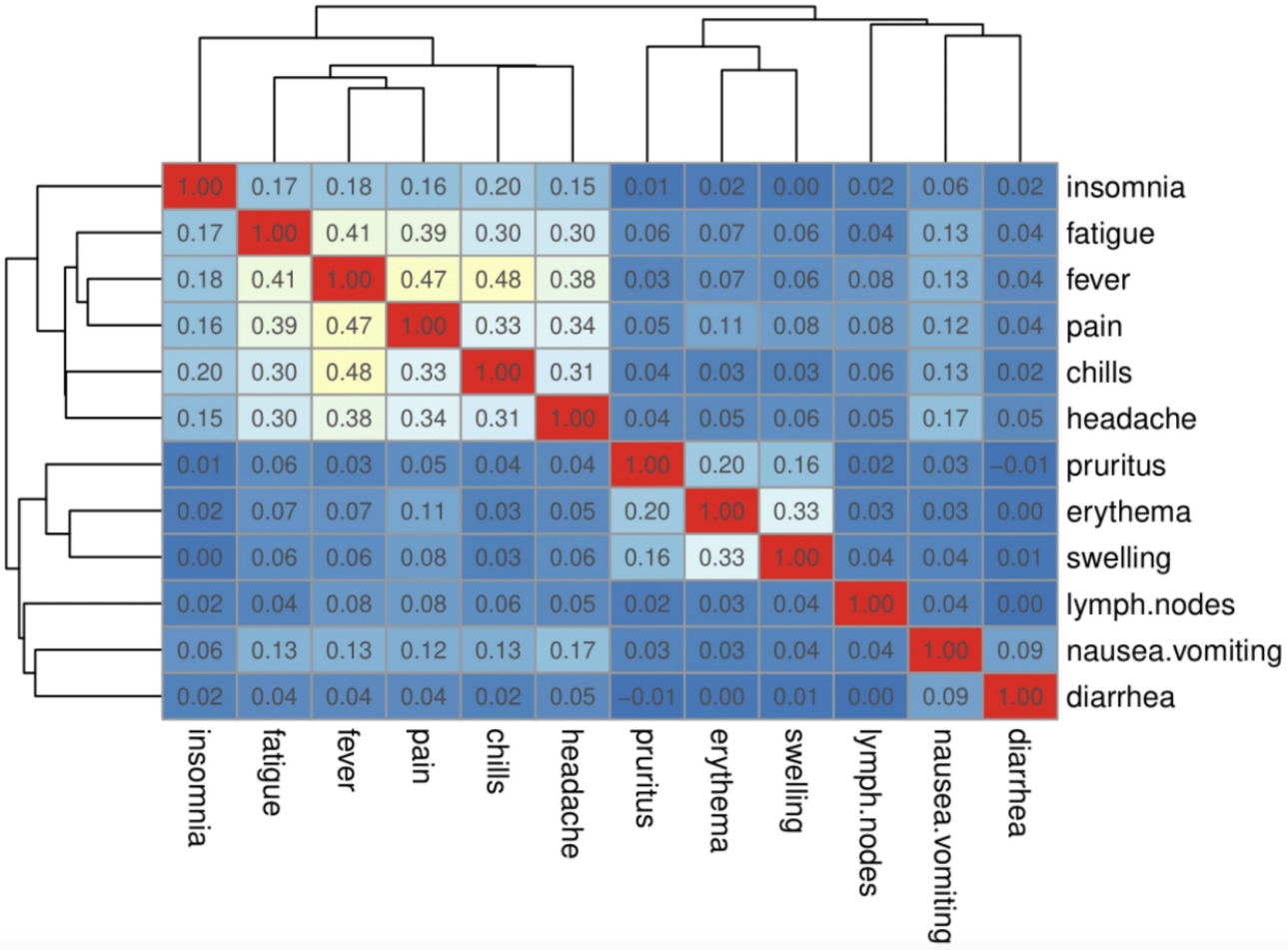
$$\beta = -.0457 \pm .0014$$



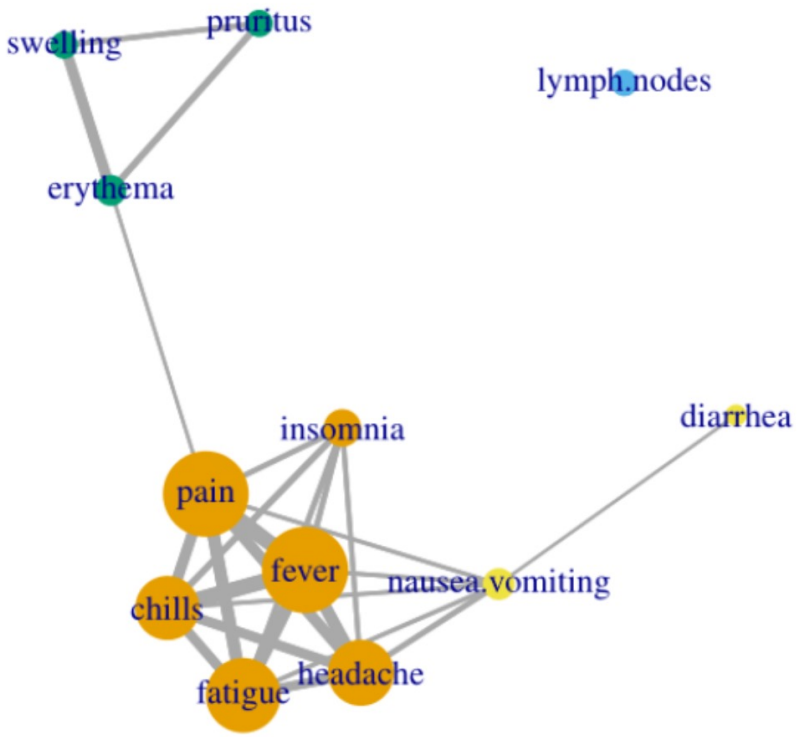
Comparison between various groups

gender	No. AE	OR	P-value	dose	No. AE	OR	P-value
male	2.1	1.20	$2{\cdot}10^{-16}$	first	2.2	1.13	$1.7{\cdot}10^{-5}$
female	2.5			second	1.9		

Correlation matrix



Network of AEs symptoms

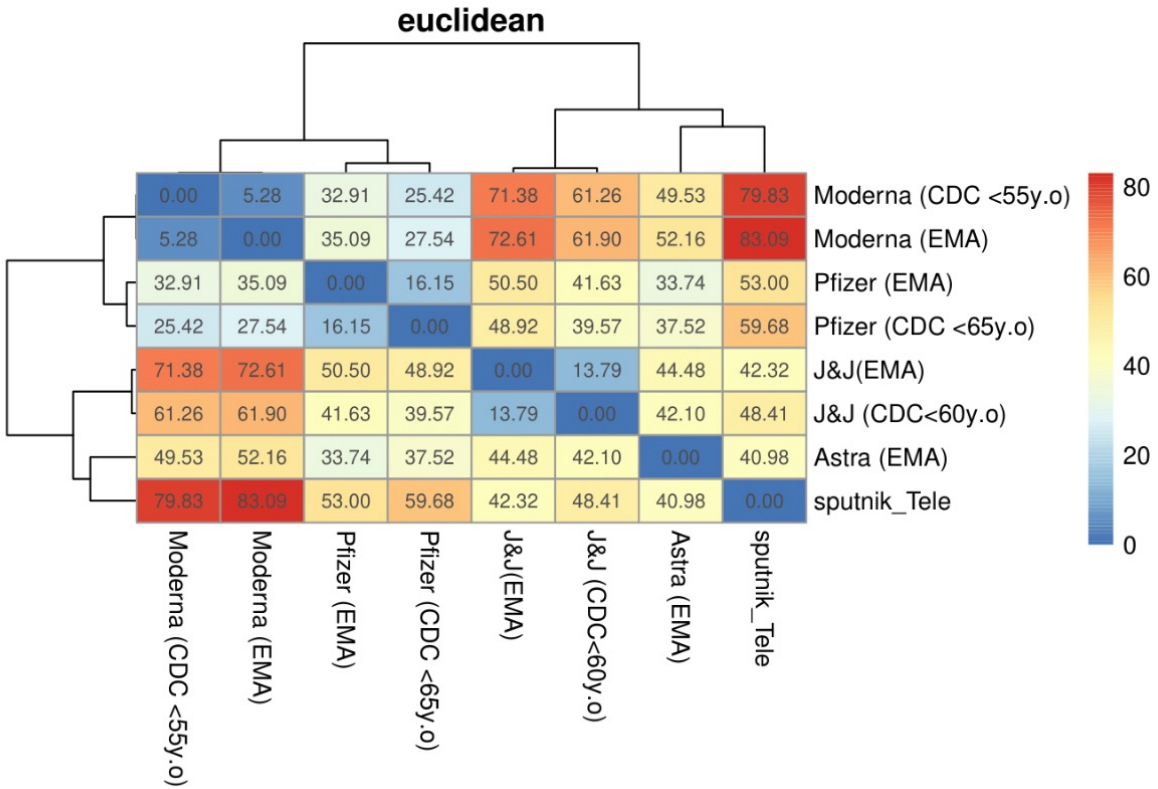


orange - systemic, green - local, yellow - gastric

AEs for Sputnik V and other vaccines.

	pain	headache	fatigue	fever	chills	nausea
AstraZeneca (EMA)	54.20	52.60	53.10	41.50	31.90	21.8
Johnson&Johnson (EMA)	48.60	38.90	38.20	14.00	5.00	14.2
Moderna (CDC $<$ 55y.o)	90.10	62.80	67.60	17.40	48.30	21.3
Pfizer (EMA)	80.00	50.00	60.00	30.00	30.00	5.00
Pfizer (CDC $<$ 65y.o)	77.80	51.70	59.40	15.80	35.10	10.00
sputnik_Tele	46.57	24.80	33.54	47.43	23.02	3.00
Johnson&Johnson (CDC $<$ 60y.o)	59.80	44.40	43.80	12.80	5.00	15.5
Moderna (EMA)	92.00	64.70	70.00	15.50	45.40	23.00

AEs for Sputnik V and other vaccines.



Summary of main results

- Initially, reporting frequency increases, then decreases after a peak
- Most complaints are about pain (47%), fever (47%), fatigue (34%) and headache (25%)
- Revealed adverse events profile of Sputnik V are comparable with other COVID-19 vaccines
  - Sputnik V AEs are more similar to other vector than mRNA vaccines.
- Women report 1.2 more AEs than men
- Count of reported AEs decreases with age ($\beta = .05$ per year)

Conclusions

- Sputnik V vaccine safety profile of mild AE is more similar to vector than mRNA anti-COVID vaccines
- Self-reporting in Telegram is most likely to underestimate gastric symptoms (as diarrhea with 0.6% occurrence).
- Participatory so called "clinical trials" can provide meaningful information, and this phenomenon should be carefully investigated.

Thank you!

Preprint is available at
https://preprints.jmir.org/preprint/30529

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