Pro, Anti or Neutral? The unfolding of Covid-19 Vaccine Hesitancy on Reddit

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Extended Abstract

The Covid-19 pandemic has resulted in the death of over 6.5M people worldwide. Vaccines have been essential in containing the spread of infectious diseases, including Covid-19. However, the acceptance of such vaccines often evolves unexpectedly, due in part to online information and misinformation that polarize the public debate, potentially threatening a timely uptake. To shed light on this issue, in an effort to inform future campaigns seeking to increase vaccine uptake, this study analyzes the unfolding of the discussion about Covid-19 vaccination on social media, in particular on *Reddit*. Specifically, in this work, we focus on the temporal evolution of this phenomenon, the arguments involved in the discussion, and the potential presence and effect of echo chambers. To investigate these questions, we used a combination of network science and machine learning, identifying a network of subreddits where such discussions took place from January 2020 to August 2021, and training two machine learning classifiers to categorize over 26 million posts according to their *Pro*, *Anti* or *Neutral* stance about *vaccination*.

We started by identifying a set of 8 subreddits discussing Covid-19 vaccination, including 3 with clear *pro-vaccine* stances, 4 with clear *anti-vaccine* stances and one neutral. Then, we created a 2-hops *crossposts network*, i.e., following the crossposts in these subreddits. We filtered out links and nodes not statistically significant with a network backboning technique (Serrano, Boguná, and Vespignani, 2009), yielding a final network of 289 nodes. Finally, we downloaded all available submissions from those subreddits. In order to follow the opinions about vaccination, we trained two nested machine learning text classifiers to first a) identify posts about Covid-19 and b) identify if those posts were explicitly *pro-vaccination*, *anti-vaccination* or *neutral* on the subject. We manually labelled two datasets for the corresponding tasks and fine-tuned a state-of-the-art Transformer neural network for our tasks (Liu et al., 2019). We reached good classification results, respectively *0.94* and *0.91* ROC-AUC scores. We proceeded by predicting labels for the entire dataset and found 11.7% of submissions to be about Covid-19. Of these posts, 79.3% did not express a strong leaning on vaccines, 14% expressed anti-vaccine statements, and only 6.6% pro-vaccine ones. By counting the daily number of posts belonging to the different stances, we explored how the discussion about vaccination evolved over time. Fig. 1 shows that the volume of polarized opinions follows crucial events that happened during 2020 and 2021. Even if the volume of posts increased drastically following the announcement of Pfizer's Covid-19 vaccine, a large number of anti-vaccination posts, more than the double volume of pro-vaccination ones, started to circulate on Reddit when the Covid-19 vaccine where not even available. The anti-vaccination posts increased since November 2020, with a steeper increase during the weeks preceding the US announcement of the vaccine mandate for federal employees. The pro-vaccination discourse follows closely but with less accentuated spikes and an overall lower engagement on Reddit. After that, the discourse about vaccination gradually faded. Additional analysis of the topics discussed, automatically extracted with Latent Dirichlet Allocation (Blei, Ng, and Jordan, 2003), explains some of these

behaviours. The most common topics discussed in the area against vaccination, indeed, included school/job vaccine mandates, with users opposing vaccines because they felt forced into becoming vaccinated, followed by concerns about vaccine safety and side effects. We found *conspiracist-like* religious and "control" topics, which include arguments mentioning "hell" and the "implant of chips", only in smaller proportion. Conversely, the most prominent topics in the pro-vaccination area, mainly discussed reassuring vaccination experiences and recommend vaccine uptake, but also discussed the side effects of the vaccine. Lastly, we investigated the presence of echo chambers, i.e., a reinforcement mechanism happening on polarized topics in which users of one opinion only interact with those of a similar same one. Fig. 2 displays as pie charts the fraction of *anti*, *pro* and *neutral* posts in each subreddit of the crossposts network. Our preliminary results show that, at a macro-level in the network, subreddits in which a certain opinion is predominant are clustered, like the group of anti-vaccination subreddits in the top right of the Figure. Surprisingly, we found that even in seemingly polarized subreddits, we can always find the presence of both opposing stances at the micro-level. These results suggest that even if users of one opinion disseminate their stance in subreddits of similar opinion via crossposts, they always find users supporting the opposite one. Hence, we did not encounter the presence of echo chambers in the debate about Covid-19 vaccination, similar to Cinelli et al. (2021) for political polarization on Reddit. In conclusion, our preliminary results show that, on Reddit, the anti-vaccination opinion was present to a larger extent compared to pro-vaccination opinion, and followed the unfolding of important external events with arguments of concern about mandates and safety. We also found that the spontaneous and proactive engagement of users of one stance with users of a different stance lowered or eliminated the echo chamber effect, unveiling the existence on the platform of channels of communication which promoted discussion. Such channels are fundamental to favour opinion change and could be targeted to increase vaccine uptake. Our work provides a novel look into the reasoning behind vaccine hesitancy and opens the door for a better understanding of vaccine hesitancy, insightful to mitigate the proliferation of disinformation.

References

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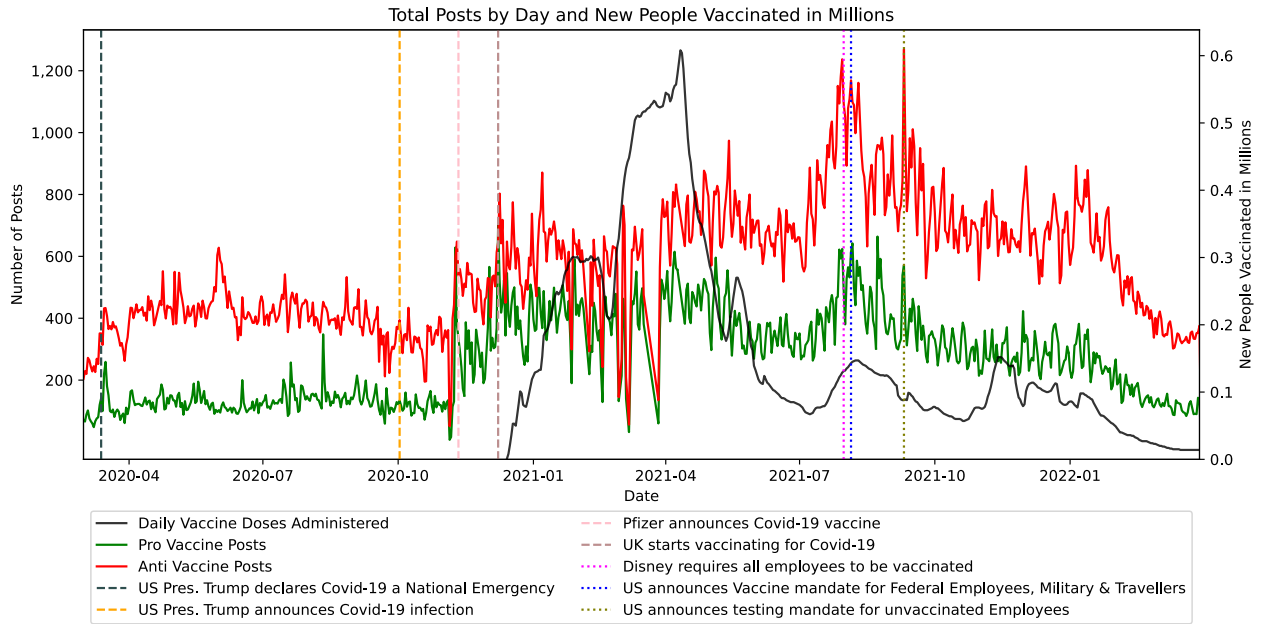
Figure 1: Number of pro/anti-vaccination daily submissions. Vertical lines represent important events.
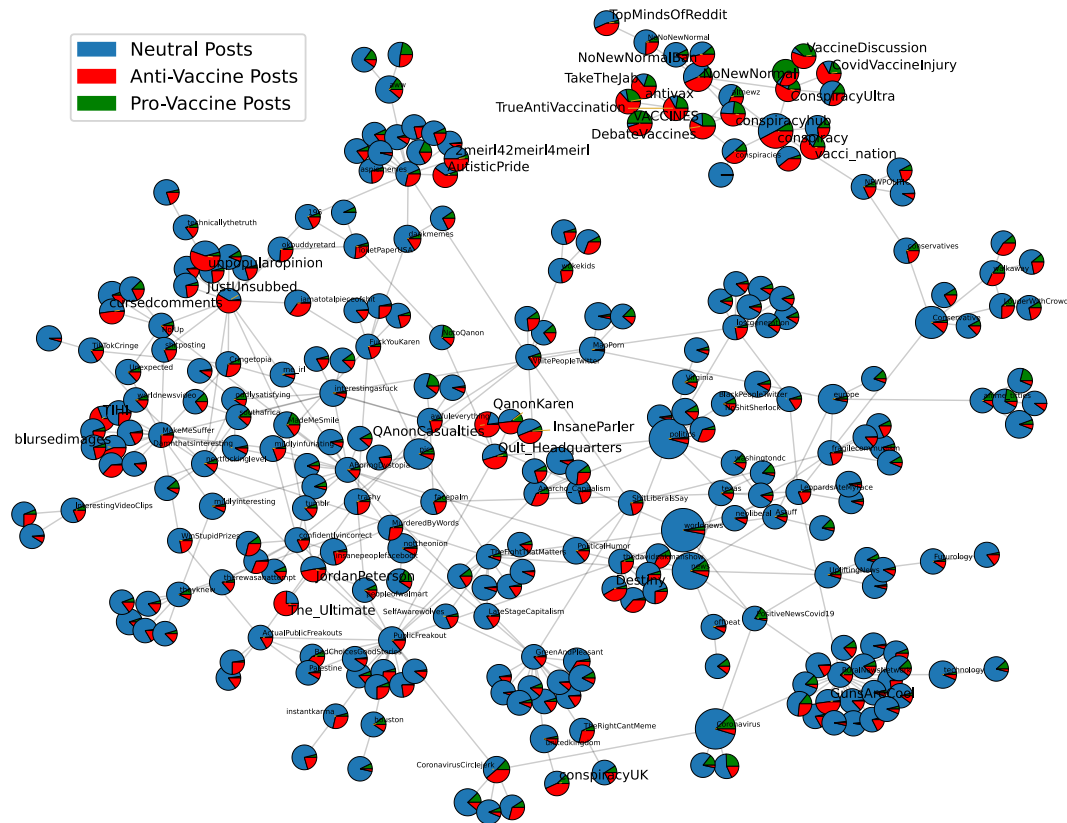

Figure 2: Crossposts network. Nodes and edges respectively represent subreddits and the presence of crossposts. The color in the pie-charts show the fracion of vaccine stances.