

Original Paper

Fight Against the Mandatory COVID-19 Immunity Passport on Twitter: Natural Language Processing Study

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Abstract

Background: To contain and curb the spread of COVID-19, the governments of countries around the world have used different strategies (lockdown, mandatory vaccination, immunity passports, voluntary social distancing, etc).

Objective: This study aims to examine the reactions produced by the public announcement of a binding political decision presented by the president of the French Republic, Emmanuel Macron, on July 12, 2021, which imposed vaccination on caregivers and an immunity passport on all French people to access restaurants, cinemas, bars, and so forth.

Methods: To measure these announcement reactions, 901,908 unique tweets posted on Twitter (Twitter Inc) between July 12 and August 11, 2021, were extracted. A neural network was constructed to examine the arguments of the tweets and to identify the types of arguments used by Twitter users.

Results: This study shows that in the debate about mandatory vaccination and immunity passports, mostly “con” arguments (399,803/847,725, 47%; $\chi^2_6=952.8$; $P<.001$) and “scientific” arguments (317,156/803,583, 39%; $\chi^2_6=5006.8$; $P<.001$) were used.

Conclusions: This study shows that during July and August 2021, social events permeating the public sphere and discussions about mandatory vaccination and immunity passports collided on Twitter. Moreover, a political decision based on scientific arguments led citizens to challenge it using pseudoscientific arguments contesting the effectiveness of vaccination and the validity of these political decisions.

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KEYWORDS

mandatory vaccination; public policy; public health measures; COVID-19; vaccine; social media analysis; Twitter; natural language processing; deep learning; social media; public health; vaccination; immunity; social distancing; neural network; effectiveness

Introduction

During the COVID-19 pandemic, SARS-CoV-2 spread throughout the world and caused 652 million confirmed cases

and more than 6.7 million deaths between January 6, 2020, and December 23, 2022 [1]. To contain and curb the spread of COVID-19, the governments of countries around the world used different strategies, such as lockdown, mandatory vaccination, immunity passports, voluntary social distancing, mask mandates,

minimal room crowding, contact restrictions, and hygiene measures [2-7]. These obligations posed ethical questions [8] and generated a dynamic of change in people's choices and behaviors regarding vaccination and various restrictive measures [9]. A lack of ambition in governmental health campaigns, and more specifically in vaccination programs, can reinforce vaccine refusal behaviors [10]. However, when carried out effectively, these public health measures can positively influence vaccination coverage [11-17]. In a counterintuitive dynamic, abandonment of coercive measures can lead to an increased acceptance of vaccination [6]. Moreover, the dynamics fluctuate under the influence of scientific or political speeches broadcast through mainstream media (newspapers), social media, or the internet [18,19].

This study aims to examine the reactions produced by the public announcement of a binding political decision presented by the president of the French Republic on July 12, 2021. In the early evening, Emmanuel Macron appeared on French television to announce two major constraints: (1) the mandatory use of an immunity passport to access restaurants, cinemas, theaters, museums, bars, swimming pools, long-distance trains, and so forth and (2) mandatory vaccination for caregivers with sanctions such as license revocation and nonpayment of salary. Five days later (July 17, 2021), anti-health measure protests began and mobilized more than 100,000 citizens. On July 25, the National Assembly adopted a law ratifying President Macron's decisions. In this turbulent social and societal context, this study aims to use neural networks and natural language processing (NLP) to examine the reactions of users of the social network Twitter during the month following this July 12 announcement.

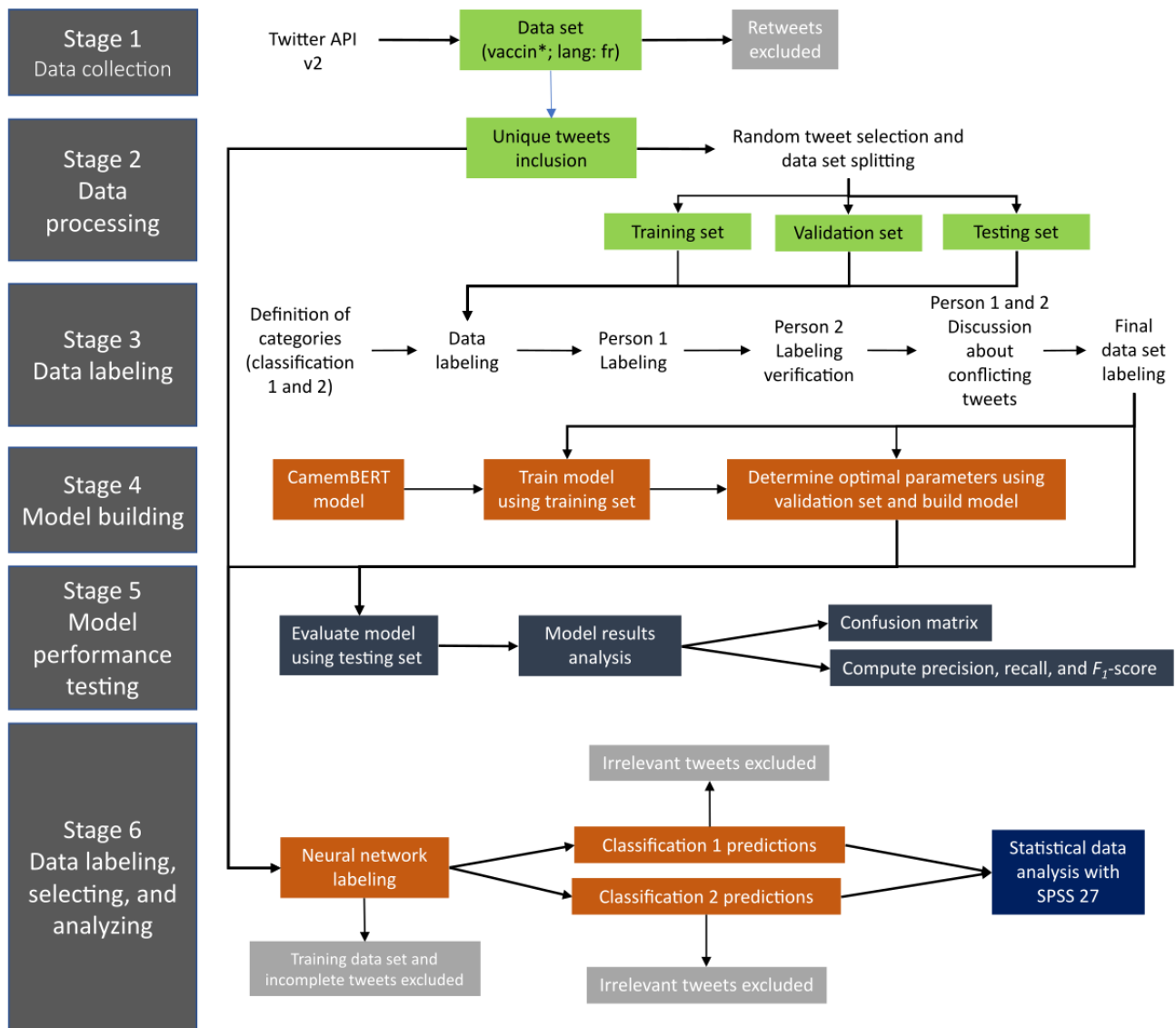
Methods

Data Collection

To measure the reactions produced by the French president's measures, messages posted on Twitter, namely, tweets, between July 12 and August 11, 2021, were extracted with the following request: "vaccin lang: fr," which included vaccines, vaccination, vaccinated, and so forth. This time span was chosen to allow proper measurement of the reactions following Macron's announcement on Twitter users, namely, tweeters. A previous study focusing on the analysis of the dissemination of messages during the COVID-19 pandemic [20] shows that the activity surrounding a tweet decreases very sharply, in 4 hours (for a retweet) or 3 days (for a quote), following its publication on Twitter. In addition, July 2021 was the month with the highest number of tweets on vaccination during the entire COVID-19 pandemic, with a growth rate of 142% over the previous month. Consequently, this 1-month duration is long enough to measure the chosen effect and short enough to avoid measuring other, parasitic effects. Our knowledge of the social context of the debate on the mandatory immunity passport confirms this methodological choice.

After the tweets were downloaded, 1,782,176 were stored in a database. The data set contained 901,908 unique tweets published by more than 231,373 unique tweeters (see the complete flowchart in [Figure 1](#)). Unique tweets and retweets were identified by applying a Python (Python Software Foundation) script to the Twitter API. No duplicates were identified during the labeling phase of more than 1800 randomly selected tweets.

Figure 1. Flowchart of the study methodology.



Multiclass Classification

To examine the arguments of the tweets, two classifications were developed: (1) arguments for (pros) or against (cons) vaccination or health measures for sentiment analysis and (2) the types of argument used by the tweeters, such as scientific, political, or social. The criteria of the multiclass classifications are provided in [Multimedia Appendix 1](#) with translated examples. In accordance with Twitter’s terms of use under the European General Data Protection Regulation, tweets cannot be shared [21].

Neural Network and Accuracy

Over the past 10 years or so, neural networks have become versatile tools for solving a wide variety of problems, such as regression, classification, and reinforcement learning. The interested reader should refer to the introduction of *Deep Learning with Python* [22] for an up-to-date review. For this study, a pretrained French language neural network model called CamemBERT was used. It was released in 2020 and is considered one of the state-of-the-art French language models [23]. It relies heavily on transformers [24], which brought about

nothing short of a revolution in the NLP field. The CamemBERT belongs to the Bidirectional Encoder Representations from Transformers (BERT) family of models, which are general multipurpose pretrained models that may be used for classification, question answering, translation, and so on. In this study, the CamemBERT model was fine-tuned to make it suitable for classification (see [25] for the comparison of the model performance). PyTorch (Meta AI) implementation of the large version of the CamemBERT model was downloaded from the Hugging Face [26]. When using deep learning models, the text has to be converted to numerical data. For that, we use the specific CamemBERT tokenizer from the Hugging Face. For training, validation, and testing, a total of 1851 unique tweets (randomly selected) were manually labeled by 2 people. As is customary when building a machine learning model, the data set was divided into 3 parts, and we used 1306 tweets for training (ie, fine-tuning the parameters of the model), 145 tweets to set the hyperparameters (essentially, the number of epochs), and 400 tweets to test the final model.

After fine-tuning CamemBERT, we obtained 59% (236/400) accuracy (F_1 -score 55.3%) for classification 1 and 67.6%

(270/400) accuracy (F_1 -score 62.9%) for classification 2. Those results were based on the 400 tweets of the test data set. They were consistent with the results of other recently published studies (see Sauvayre et al [27] and Dupuy-Zini et al [28] for detailed references).

Data Selection

Once the tweets were categorized by the model, all tweets had a label. Then, pursuant to the aim of this study, the labels most relevant to the 2 classifications, that is, the tweets “pro,” “con,” and “noncommittal” for classification 1 and “scientific,” “political,” and “social” for classification 2, were selected and analyzed with SPSS (version 27; IBM Corp) software (Multimedia Appendix 1).

Ethical Considerations

In accordance with the European General Data Protection Regulation, this data collection has been registered with the

Data Protection Officer of the French National Center for Scientific Research (treatment number 2-22120). In addition, all tweets have been anonymized. To ensure the anonymity of tweeters, translated examples of tweets have been provided with some adjustments.

Results

Overview

Most of the tweets (399,803/847,725, 47%; Table 1) were against political measures (immunity passport and mandatory vaccination) or expressed doubts about the effectiveness of the vaccine. In contrast, the arguments used by the tweeters (classification 2) were balanced between scientific (317,156/803,583, 39%), political (245,515/803,583, 31%), and social (240,912/803,583, 30%).

Table 1. Neural network prediction of classification 1 and classification 2.

Type of classification	Number of tweets, n (%)
Classification 1 sentiment	
Noncommittal	180,288 (21)
Pro	267,634 (32)
Con	399,803 (47)
Classification 2 arguments	
Scientific	317,156 (39)
Political	245,515 (31)
Social	240,912 (30)

Sentiment and Argument Time Lines

The time series of classification 1 (Figures 2 and 3) were examined. The impact of the French president’s announcement was stronger on July 13, the day after his public declaration.

Moreover, whatever the date, “con” tweets were more numerous than other types of tweets (“pro” or “noncommittal”). Indeed, there is a statistical link between classification 1 and the dates of the tweets grouped every 4 weeks ($\chi^2_6=952.8$; $P<.001$).

Figure 2. Time series of classification 1 sentiment (pro, con, and noncommittal) from July 12 to August 11, 2021, inclusive.

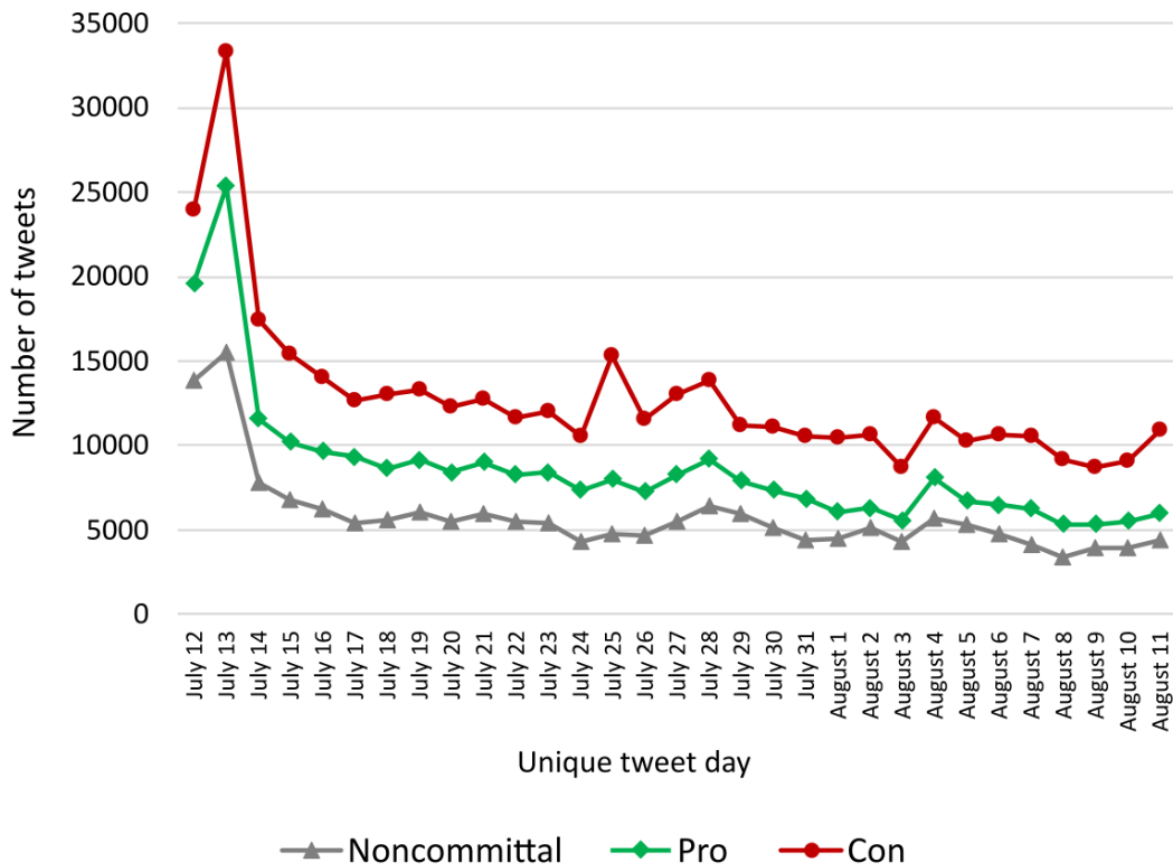
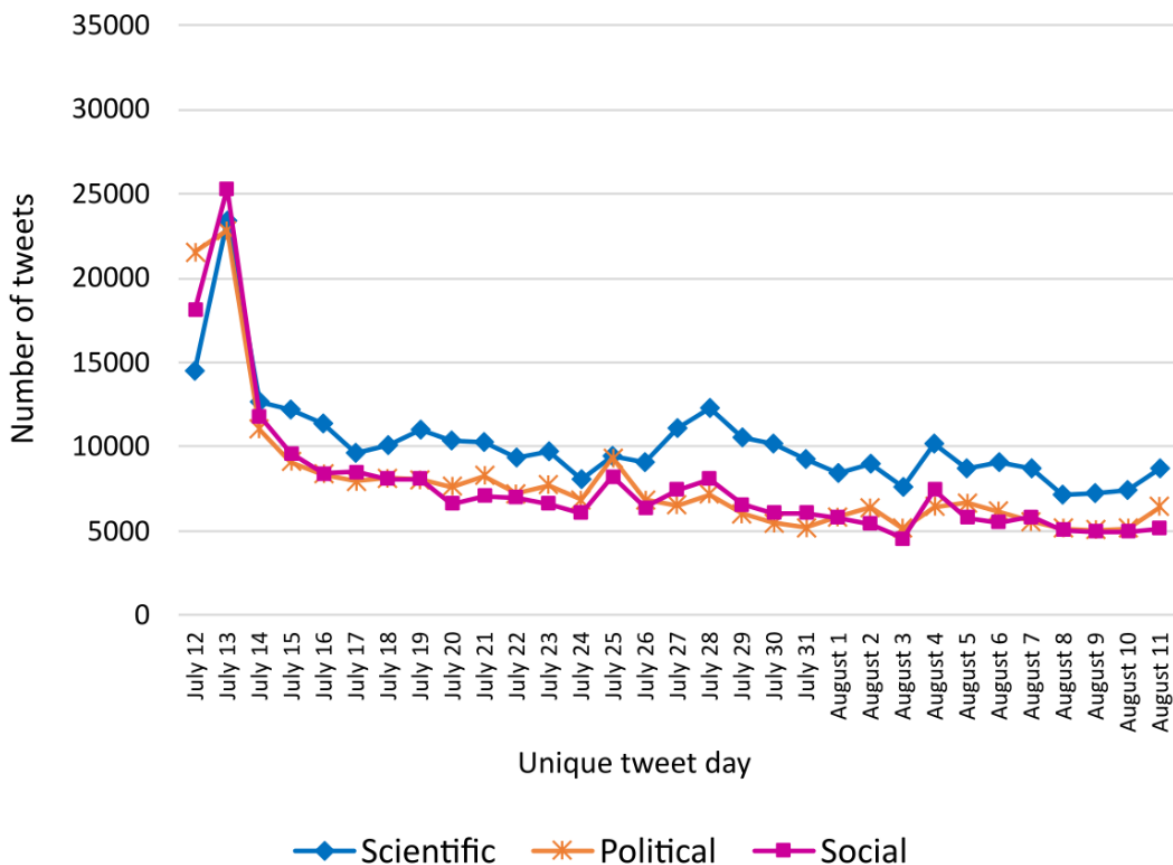


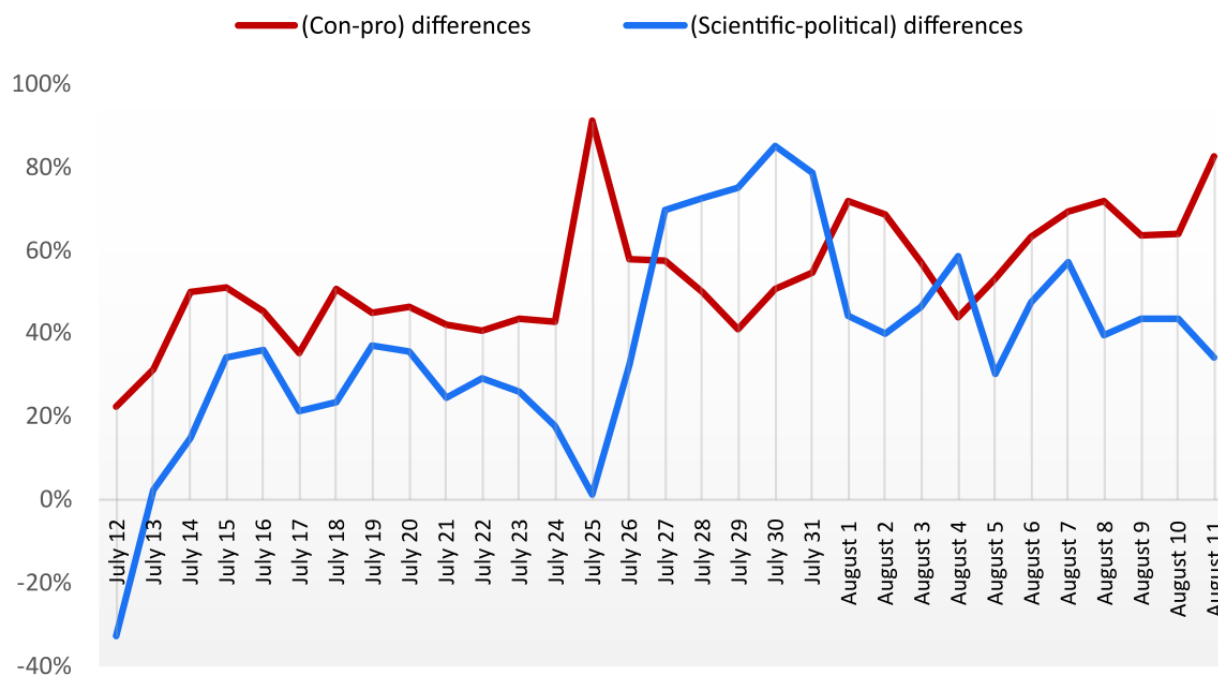
Figure 3. Time series of classification 2 (scientific, political, and social) from July 12 to August 11, 2021, inclusive.



Classification 2 focuses on the arguments of the tweets. We expected to see more political tweets following the announcement of a political decision. However, except for those posted on the first day, July 12, the tweets contained more scientific than political arguments. Indeed, there is a statistical link between classification 2 and the dates of the tweets grouped every 4 weeks ($\chi^2_6=5006.8$; $P<.001$). These data show that the main argument used and spread on Twitter after the political health measure was scientific and not political.

In addition, the relative difference between the most frequent arguments (“con” and “scientific”) in each category and the most contested (“pro” and “political”) made it possible to identify a particular date, that is, July 25 (Figure 4). On July 25, the “con” tweets experienced a significant increase of 91% (15,313/8017; Multimedia Appendix 2). On the other hand, “scientific” tweets stood out from “political” tweets at the end of July (27 to 31), with a difference oscillating between 70% (11,122/6551) and 85% (10,149/5487; Multimedia Appendix 3).

Figure 4. Time series of relative differences between con and pro (red line) and scientific and political (blue line) arguments.



Discussion

Principal Findings

The goal of this study is to examine the reactions following the public announcement of a binding political decision presented by the president of the French Republic, Emmanuel Macron, on July 12, 2021, and the arguments used by French-speaking users of Twitter. The main results show that published tweets were more likely to be negative than positive and more scientific than political.

The Mandatory Effect

Vaccination obligations and sanctions had different levels of acceptance within different populations. Indeed, although half of Polish citizens accepted mandatory vaccinations, only one-quarter accepted the sanctions imposed by the Polish government [29]. However, in Finland, the more a person favored mandatory vaccination, the more they favored sanctions [30]. The inhabitants of South America (Colombians and Salvadorans) accepted mandatory vaccination more than Spaniards [31]. However, only 27.8% of Cypriots accepted mandatory vaccination [4] versus 73% of Germans [32]. The introduction of the immunity passport in France increased

vaccination coverage against COVID-19 [16], but this increase did not mean acceptance of the health measures. This can be seen by examining the arguments that spread on Twitter during the month following President Macron’s announcement. Indeed, the examined tweets more often contained arguments against health measures and against mandatory vaccination (399,803/847,725, 47%), and they more often contained scientific arguments to justify their point of view (317,156/803,583, 39%). Disagreement with public policies, in particular the vaccine passports, was also found in English negative tweets examined between April 1, 2021, and August 1, 2022 [33].

One might expect tweets about vaccination to be more often negative because oppositional tweets would be more active. However, the literature is not consensual on this topic: studies analyzing tweets using NLP, similar to this study, discovered a majority of positive tweets [34], but others discovered a majority of negative tweets [33,35]. In our study, the discourse of French speakers collected on Twitter showed how strongly the French were divided about health measures in the summer of 2021.

Dynamics of the Debate

One might expect a political decision to engender more political arguments. However, President Macron's political decision quickly became a topic of scientific debate. Users in support of health measures presented mainstream scientific arguments, while users opposing such measures presented distorted and contested versions of these arguments, corresponding to the wave of disinformation identified on social media [36]. It therefore seems that the legitimacy of a public health decision fueled by a scientific discourse leads tweeters to attack the scientific arguments on which the decision is based rather than the political decision itself.

Mandatory Vaccination for Caregivers

The collected data showed that a significant increase in the opposition rate occurred on 1 date in particular: July 25, 2021, the date on which the French government enacted a law requiring caregivers to be vaccinated and including penalties. While the obligation for caregivers (including clinicians) to be vaccinated was presented as an ethical necessity to protect their patients [37], this question divided the French. On Twitter, French-speaking tweeters expressed their disagreement with the deprivation of a fundamental right, namely, individual freedom. The debate then focused on opinions in opposition to this measure, mobilizing both scientific and political arguments.

Science Divides Twitter Users

The dynamics of the debates at the end of July 2021 took a more scientific turn because the main justification for the mandatory caregiver vaccination lay in a scientific argument. This argument was that people who are vaccinated spread less virus than people who are not vaccinated, in short, that the vaccine limits the spread of the virus. These arguments were then strongly debated on Twitter at the end of July. On July 30, an article published in a blog on the Mediapart newspaper website claimed that the COVID-19 vaccine was dangerous [38]. The article was quickly withdrawn, but the idea was relayed on Twitter. Finally, on July 31, 2021, the New York Times [39] relayed a report from the Centers for Disease Control and Prevention (CDC) claiming

that people who are vaccinated transmitted SARS-CoV-2 more than others. The article was then posted on the CDC website [40] and fueled the heated "pros" and "cons" debates on Twitter. Finally, Macron's debate, occurring in July and August 2021, shows that pseudoscience arguments were used to contest political measures. The consequences of pseudoscience dissemination on social media are to possibly lead more individuals to avoid the health care system and might increase their medical care delay and the mortality risk of these social media's skeptical patients.

Limitations

This study has several limitations. First, the data were collected only from Twitter, which is a specific social media platform. Even if the message reflects the debate occurring in the "real world," the result cannot be generalized to other social media. Second, the study focused on tweets containing the word "vaccine" and its derivatives without further selections. Third, the neural network methodology used needs to be improved to analyze very short texts such as tweets. Fourth, the data were collected on a specific time span (July and August), which reflects a specific moment of the debate about mandatory vaccines. Further research needs to be conducted to generalize the obtained results about the consequences of a political measure justified by scientific arguments.

Conclusions

This study shows that during July and August 2021, social events permeating the public sphere and discussions about mandatory vaccination and immunity passports collided on Twitter. In France, binding political decisions to contain it was presented to the French on July 12. The antisanitary pass demonstrations and the spreading of pseudoscientific theories contesting the effectiveness of vaccination occurred during the rebound of the COVID-19 pandemic. In this context, binding political decisions caused a resurgence of messages on Twitter, mobilizing arguments against vaccination and the health record and scientific arguments challenging the validity of these decisions.

Data Availability

The data sets analyzed during this study are available from the corresponding author on reasonable request. The data sets generated during this study are not publicly available due to the Twitter's terms of use under the European General Data Protection Regulation, tweets cannot be shared [21]. In addition, the full codes used to create the neural network are available on GitHub [41].

Conflicts of Interest

None declared.

Multimedia Appendix 1

Classification criteria and definitions.

[\[PDF File \(Adobe PDF File\), 19 KB-Multimedia Appendix 1\]](#)

Multimedia Appendix 2

Number of tweets as a function of the classification 1.

[\[PDF File \(Adobe PDF File\), 60 KB-Multimedia Appendix 2\]](#)

Multimedia Appendix 3

Number of tweets as a function of the classification 2.

[\[PDF File \(Adobe PDF File\), 60 KB-Multimedia Appendix 3\]](#)

References

1. WHO Coronavirus (COVID-19) dashboard—overview. World Health Organization. 2022 Dec 23. URL: <https://covid19.who.int> [accessed 2022-12-27]
2. Coker MO, Subramanian G, Davidow A, Fredericks-Younger J, Gennaro ML, Fine DH, et al. Impact of DHCWs' safety perception on vaccine acceptance and adoption of risk mitigation strategies. *JDR Clin Trans Res* 2023 Feb 22;8(2):188-197 [FREE Full text] [doi: [10.1177/23800844211071111](https://doi.org/10.1177/23800844211071111)] [Medline: [35191352](https://pubmed.ncbi.nlm.nih.gov/35191352/)]
3. Fernández-Marín H, Bruner-Montero G, Portugal-Loayza A, Miranda V, Dominguez AEV, Ortega-Barría E, et al. Dynamics of mask use as a prevention strategy against SARS-CoV-2 in Panama. *Int J Environ Res Public Health* 2021;18(24):12982 [FREE Full text] [doi: [10.3390/ijerph182412982](https://doi.org/10.3390/ijerph182412982)] [Medline: [34948592](https://pubmed.ncbi.nlm.nih.gov/34948592/)]
4. Giannakou K, Kyprianidou M, Heraclides A. Attitudes and determinants of mandatory vaccination against COVID-19 among the general population of Cyprus: a nationwide cross-sectional study. *Vaccines (Basel)* 2022;10(3):438 [FREE Full text] [doi: [10.3390/vaccines10030438](https://doi.org/10.3390/vaccines10030438)] [Medline: [35335070](https://pubmed.ncbi.nlm.nih.gov/35335070/)]
5. König M, Winkler A. The impact of government responses to the COVID-19 pandemic on GDP growth: does strategy matter? *PLoS One* 2021 Nov 5;16(11):e0259362 [FREE Full text] [doi: [10.1371/journal.pone.0259362](https://doi.org/10.1371/journal.pone.0259362)] [Medline: [34739509](https://pubmed.ncbi.nlm.nih.gov/34739509/)]
6. Okamoto S, Kamimura K, Komamura K. COVID-19 vaccine hesitancy and vaccine passports: a cross-sectional conjoint experiment in Japan. *BMJ Open* 2022 Jun 01;12(6):e060829 [FREE Full text] [doi: [10.1136/bmjopen-2022-060829](https://doi.org/10.1136/bmjopen-2022-060829)] [Medline: [35710243](https://pubmed.ncbi.nlm.nih.gov/35710243/)]
7. Phelan AL. COVID-19 immunity passports and vaccination certificates: scientific, equitable, and legal challenges. *Lancet* 2020 May 23;395(10237):1595-1598 [FREE Full text] [doi: [10.1016/S0140-6736\(20\)31034-5](https://doi.org/10.1016/S0140-6736(20)31034-5)] [Medline: [32380041](https://pubmed.ncbi.nlm.nih.gov/32380041/)]
8. Persad G, Emanuel EJ. The ethics of COVID-19 immunity-based licenses ("immunity passports"). *JAMA* 2020 Jun 09;323(22):2241-2242 [FREE Full text] [doi: [10.1001/jama.2020.8102](https://doi.org/10.1001/jama.2020.8102)] [Medline: [32374357](https://pubmed.ncbi.nlm.nih.gov/32374357/)]
9. Almusbah Z, Alhajji Z, Alshayeb Z, Alhabdan R, Alghafli S, Almusabah M, et al. Caregivers' willingness to vaccinate their children against COVID-19 in Saudi Arabia: a cross-sectional survey. *Cureus* 2021;13(8):e17243 [FREE Full text] [doi: [10.7759/cureus.17243](https://doi.org/10.7759/cureus.17243)] [Medline: [34540469](https://pubmed.ncbi.nlm.nih.gov/34540469/)]
10. Seale H, McFadden K, Dyda A, Kaufman J, Heywood A. The pendulum has swung: how do we ensure a life course approach to immunisation in Australia? *Front Public Health* 2021;9:801176 [FREE Full text] [doi: [10.3389/fpubh.2021.801176](https://doi.org/10.3389/fpubh.2021.801176)] [Medline: [35186875](https://pubmed.ncbi.nlm.nih.gov/35186875/)]
11. Gao L, Su S, Du N, Han Y, Wei J, Cao M, et al. Medical and non-medical students' knowledge, attitude and willingness towards the COVID-19 vaccine in China: a cross-sectional online survey. *Hum Vaccin Immunother* 2022 Nov 30;18(5):2073757 [FREE Full text] [doi: [10.1080/21645515.2022.2073757](https://doi.org/10.1080/21645515.2022.2073757)] [Medline: [35612817](https://pubmed.ncbi.nlm.nih.gov/35612817/)]
12. Kong Y, Jiang H, Liu Z, Guo Y, Hu D. The uptake and vaccination willingness of COVID-19 vaccine among Chinese residents: web-based online cross-sectional study. *Vaccines (Basel)* 2022 Jan 08;10(1):90 [FREE Full text] [doi: [10.3390/vaccines10010090](https://doi.org/10.3390/vaccines10010090)] [Medline: [35062751](https://pubmed.ncbi.nlm.nih.gov/35062751/)]
13. Skjesol I, Tritter JQ. The Norwegian way: COVID-19 vaccination policy and practice. *Health Policy Technol* 2022 Jun;11(2):100635 [FREE Full text] [doi: [10.1016/j.hlpt.2022.100635](https://doi.org/10.1016/j.hlpt.2022.100635)] [Medline: [35531440](https://pubmed.ncbi.nlm.nih.gov/35531440/)]
14. Sun Y, Li B, Li N, Li B, Chen P, Hao F, et al. Acceptance of COVID-19 vaccine among high-risk occupations in a port city of China and multifaceted strategies for increasing vaccination coverage: a cross-sectional study. *Risk Manag Healthc Policy* 2022;15:643-655 [FREE Full text] [doi: [10.2147/RMHP.S352947](https://doi.org/10.2147/RMHP.S352947)] [Medline: [35444478](https://pubmed.ncbi.nlm.nih.gov/35444478/)]
15. Wang S, Nicholas S, Maitland E, Leng A. Individual preferences for COVID-19 vaccination under the China's 2021 national vaccination policy: a discrete choice experiment study. *Vaccines* 2022 Mar 31;10(4):543 [FREE Full text] [doi: [10.3390/vaccines10040543](https://doi.org/10.3390/vaccines10040543)] [Medline: [35455292](https://pubmed.ncbi.nlm.nih.gov/35455292/)]
16. Ward JK, Gauna F, Gagneux-Brunon A, Botelho-Nevers E, Cracowski JL, Khouri C, et al. The French health pass holds lessons for mandatory COVID-19 vaccination. *Nat Med* 2022 Feb;28(2):232-235 [FREE Full text] [doi: [10.1038/s41591-021-01661-7](https://doi.org/10.1038/s41591-021-01661-7)] [Medline: [35022575](https://pubmed.ncbi.nlm.nih.gov/35022575/)]
17. Zheng YB, Sun J, Liu L, Zhao YM, Yan W, Yuan K, et al. COVID-19 vaccine-related psychological stress among general public in China. *Front Psychiatry* 2021;12:774504 [FREE Full text] [doi: [10.3389/fpsy.2021.774504](https://doi.org/10.3389/fpsy.2021.774504)] [Medline: [34950070](https://pubmed.ncbi.nlm.nih.gov/34950070/)]
18. Lee M, You M. Direct and indirect associations of media use with COVID-19 vaccine hesitancy in South Korea: cross-sectional web-based survey. *J Med Internet Res* 2022;24(1):e32329 [FREE Full text] [doi: [10.2196/32329](https://doi.org/10.2196/32329)] [Medline: [34870605](https://pubmed.ncbi.nlm.nih.gov/34870605/)]
19. Lieneck C, Heinemann K, Patel J, Huynh H, Leafblad A, Moreno E, et al. Facilitators and barriers of COVID-19 vaccine promotion on social media in the United States: a systematic review. *Healthcare* 2022;10(2):321 [FREE Full text] [doi: [10.3390/healthcare10020321](https://doi.org/10.3390/healthcare10020321)] [Medline: [35206935](https://pubmed.ncbi.nlm.nih.gov/35206935/)]
20. Dinh L, Parulian N. COVID-19 pandemic and information diffusion analysis on Twitter. *Proc Assoc Inf Sci Technol* 2020;57(1):e252 [FREE Full text] [doi: [10.1002/pra2.252](https://doi.org/10.1002/pra2.252)] [Medline: [33173813](https://pubmed.ncbi.nlm.nih.gov/33173813/)]

21. Twitter controller-to-controller (outbound) data protection addendum. GDPR Twitter. URL: <https://gdpr.twitter.com/en/controller-to-controller-transfers.html> [accessed 2022-04-25]
22. Chollet F. Deep Learning with Python, Second Edition. Shelter Island, New York. Manning Publications; 2021.
23. Martin L, Muller B, Suárez PJO, Dupont Y, Romary L, de la Clergerie ÉV, et al. CamemBERT: a tasty French language model. Association for Computational Linguistics; 2020 Presented at: Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics; July 5-10, 2020; Stroudsburg, PA p. 7203-7219 URL: <https://aclanthology.org/2020.acl-main.0.pdf> [doi: [10.18653/v1/2020.acl-main.645](https://doi.org/10.18653/v1/2020.acl-main.645)]
24. Vaswani A, Shazeer N, Parmar N, Uszkoreit J, Jones L, Gomez AN, et al. Attention is all you need. 2017 Presented at: 31st Conference on Neural Information Processing Systems (NIPS 2017); 2017; Long Beach, California URL: <https://dl.acm.org/doi/pdf/10.5555/3295222.3295349>
25. Cattan O, Ghannay S, Servan C, Rosset S. Etude comparative de modèles transformers en compréhension de la parole en Français. In: Proc. XXXIVe Journées d'Études sur la Parole—JEP 2022. Noirmoutier. International Speech Communication Association-ISCA; 2022:721-730
26. CamemBERT: a tasty French language model. Hugging Face. URL: <https://huggingface.co/camembert/camembert-large> [accessed 2023-09-25]
27. Sauvayre R, Vernier J, Chauvière C. An analysis of French-Language tweets about COVID-19 vaccines: supervised learning approach. JMIR Med Inform 2022;10(5):e37831 [FREE Full text] [doi: [10.2196/37831](https://doi.org/10.2196/37831)] [Medline: [35512274](https://pubmed.ncbi.nlm.nih.gov/35512274/)]
28. Dupuy-Zini A, Audeh B, Gérardin C, Duclos C, Gagneux-Brunon A, Bousquet C. Users' reactions to announced vaccines against COVID-19 before marketing in France: analysis of Twitter posts. J Med Internet Res 2023;25:e37237 [FREE Full text] [doi: [10.2196/37237](https://doi.org/10.2196/37237)] [Medline: [36596215](https://pubmed.ncbi.nlm.nih.gov/36596215/)]
29. Reczulska A, Tomaszewska A, Raciborski F. Level of acceptance of mandatory vaccination and legal sanctions for refusing mandatory vaccination of children. Vaccines 2022;10(5):811 [FREE Full text] [doi: [10.3390/vaccines10050811](https://doi.org/10.3390/vaccines10050811)] [Medline: [35632568](https://pubmed.ncbi.nlm.nih.gov/35632568/)]
30. Slotte P, Karlsson LC, Soveri A. Attitudes towards mandatory vaccination and sanctions for vaccination refusal. Vaccine 2022;40(51):7378-7388 [FREE Full text] [doi: [10.1016/j.vaccine.2022.05.069](https://doi.org/10.1016/j.vaccine.2022.05.069)] [Medline: [35688728](https://pubmed.ncbi.nlm.nih.gov/35688728/)]
31. Iguacel I, Álvarez-Najar JP, Del Carmen Vásquez P, Alarcón J, Orte MÁ, Samatán E, et al. Citizen stance towards mandatory COVID-19 vaccination and vaccine booster doses: a study in Colombia, El Salvador and Spain. Vaccines 2022;10(5):781 [FREE Full text] [doi: [10.3390/vaccines10050781](https://doi.org/10.3390/vaccines10050781)] [Medline: [35632537](https://pubmed.ncbi.nlm.nih.gov/35632537/)]
32. Sprengholz P, Korn L, Eitze S, Felgendreff L, Siegers R, Goldhahn L, et al. Attitude toward a mandatory COVID-19 vaccination policy and its determinants: evidence from serial cross-sectional surveys conducted throughout the pandemic in Germany. Vaccine 2022;40(51):7370-7377 [FREE Full text] [doi: [10.1016/j.vaccine.2022.01.065](https://doi.org/10.1016/j.vaccine.2022.01.065)] [Medline: [35153092](https://pubmed.ncbi.nlm.nih.gov/35153092/)]
33. Ng QX, Lim SR, Yau CE, Liew TM. Examining the prevailing negative sentiments related to COVID-19 vaccination: unsupervised deep learning of Twitter posts over a 16 month period. Vaccines 2022;10(9):1457 [FREE Full text] [doi: [10.3390/vaccines10091457](https://doi.org/10.3390/vaccines10091457)] [Medline: [36146535](https://pubmed.ncbi.nlm.nih.gov/36146535/)]
34. Liu S, Liu J. Public attitudes toward COVID-19 vaccines on English-language Twitter: a sentiment analysis. Vaccine 2021;39(39):5499-5505 [FREE Full text] [doi: [10.1016/j.vaccine.2021.08.058](https://doi.org/10.1016/j.vaccine.2021.08.058)] [Medline: [34452774](https://pubmed.ncbi.nlm.nih.gov/34452774/)]
35. Sv P, Lorenz JM, Ittamalla R, Dhama K, Chakraborty C, Kumar DVS, et al. Twitter-based sentiment analysis and topic modeling of social media posts using natural language processing, to understand people's perspectives regarding COVID-19 booster vaccine shots in India: crucial to expanding vaccination coverage. Vaccines 2022;10(11):1929 Multidisciplinary Digital Publishing Institute [FREE Full text] [doi: [10.3390/vaccines10111929](https://doi.org/10.3390/vaccines10111929)] [Medline: [36423024](https://pubmed.ncbi.nlm.nih.gov/36423024/)]
36. Zarocostas J. How to fight an infodemic. Lancet 2020;395(10225):676 [FREE Full text] [doi: [10.1016/S0140-6736\(20\)30461-X](https://doi.org/10.1016/S0140-6736(20)30461-X)] [Medline: [32113495](https://pubmed.ncbi.nlm.nih.gov/32113495/)]
37. Bester JC. A clinician's obligation to be vaccinated: four arguments that establish a duty for healthcare professionals to be vaccinated against COVID-19. J Bioeth Inq 2022;19(3):451-465 [FREE Full text] [doi: [10.1007/s11673-022-10182-y](https://doi.org/10.1007/s11673-022-10182-y)] [Medline: [35362931](https://pubmed.ncbi.nlm.nih.gov/35362931/)]
38. Mucchielli L, Banoun H, Darles E, Pavan V, Umlil A. Laurent Mucchielli dépublié par Mediapart : sa réaction et son article republié. France-Soir. Paris; 2021 Aug 04. URL: <https://www.francesoir.fr/opinions-tribunes/laurent-mucchielli-depublie-par-mediapart-sa-reaction-et-son-article-republie> [accessed 2022-12-03]
39. Mandavilli A. The New York Times. Vaccinated people may spread the virus, though rarely, C.D.C. reports. 2021 Jul 30. URL: <https://www.nytimes.com/2021/07/30/health/cdc-vaccinated-delta.html> [accessed 2022-12-03]
40. Brown CM, Vostok J, Johnson H, Burns M, Gharpure R, Sami S, et al. Outbreak of SARS-CoV-2 infections, including COVID-19 vaccine breakthrough infections, associated with large public gatherings—Barnstable County, Massachusetts, July 2021. MMWR Morb Mortal Wkly Rep 2021;70(31):1059-1062 [FREE Full text] [doi: [10.15585/mmwr.mm7031e2](https://doi.org/10.15585/mmwr.mm7031e2)] [Medline: [34351882](https://pubmed.ncbi.nlm.nih.gov/34351882/)]
41. NLP-French-model-for-vaccine-tweets. Github. 2022. URL: <https://github.com/cdchauvi/NLP-French-model-for-vaccine-tweets> [accessed 2022-04-25]

Abbreviations

BERT: Bidirectional Encoder Representations from Transformers

CDC: Centers for Disease Control and Prevention

NLP: natural language processing

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