Polish Annals of Medicine

Journal homepage: https://www.paom.pl

Research paper

Using social media monitoring tool and Google Trends to study dynamics of vaccination-related online discourse

Anna Kłak[1], Konrad Furmańczyk[1,2], Karolina Sobeczek[1], Filip Raciborski[1], Jan Zając[3], Kamil Rakocy[4], Agnieszka Drab[5], Urszula Religioni[6]

[1] *Department of Environmental Hazards Prevention, Allergology and Immunology, Faculty of Health Sciences, Medical University of Warsaw, Poland*
[2] *Institute of Information Technology, Department of Applied Mathematics, Warsaw University of Life Sciences, Poland*
[3] *Sotrender, Poland*
[4] *KR Consulting, Poland*
[5] *Chair of Preclinical Science, Department of Medical Informatics and Statistics with e-Health Lab, Faculty of Medical Sciences, Medical University of Lublin, Poland*
[6] *School of Public Health, Centre of Postgraduate Medical Education of Warsaw, Poland*

ARTICLE INFO

Article history
Received: January 15, 2024
Accepted: April 29, 2024
Available online: August 19, 2024

Keywords
Vaccine
Vaccinations
Social media
COVID-19
Infodemic
Google Trends

Doi
https://doi.org/10.29089/paom/188125

ABSTRACT

Introduction: Online discourse related to vaccinations is often charged with emotions and include misinformation.

Aim: The main objective of the study is assesment of trends the dynamics of the online vaccination-related discourse published publicly in Polish, using social media monitoring tool and Google Trends.

Material and methods: The study collected the number of mentions with a social media listening tool and the number of queries with Google Trends from July 1, 2018 to October 23, 2022. The analysis included the following sources of the mentions and queries: Twitter, Facebook, online portals, and forums. Data on the COVID-19 vaccination uptake in Poland was also considered.

Results and discussion: A total of 34,596,976 vaccination-related mentions were included in the analysis. Kendall's tau correlation showed a positive statistical association between the daily number of mentions and the number of queries related to vaccination throughout the studied period ($\tau = 0.66$). There was a moderate positive linear association between the number of queries and the number of COVID-19 vaccinations administered in Poland ($R^2 = 0.59$). There was a weak positive linear association between the number of mentions and the number of COVID-19 vaccinations in Poland ($R^2 = 0.23$).

Conclusions: With the increase in the number of COVID-19 vaccinations administered in Poland, corresponding increase in online vaccination-related searches (queries) occurred. Routine analysis of Google Trends combined with Internet and social media monitoring can provide reliable insight regarding public sentiment towards vaccination. Such analysis play a crucial role in formulating health policies and developing educational and promotional initiatives related to vaccination.

Corresponding author: Anna Kłak; Department of Environmental Hazards Prevention, Allergology and Immunology, Faculty of Health Sciences, Medical University of Warsaw, Banacha 1a, 02-091 Warsaw, Poland.
E-mail address: anna.klak@wum.edu.pl

1. INTRODUCTION

In the literature, vaccination has been a subject of research even before the World Health Organization (WHO) declared the coronavirus pandemic in February 2020. Public discourse related to vaccines often includes concerns about possible adverse effects and the dissemination of scientifically unproven information linking vaccination to autism or birth defects in children.[1] Attention is drown to debates about the necessity of vaccinations and distrust in pharmaceutical companies, governments, scientific findings and medical authorities.[2] Notably, there is a deficiency in health policy efforts that use social media to counter conspiracy theories and misinformation, considering that inadequate efforts to inform and educate can reduce parents' willingness to vaccinate their children.[3] Emotions play an important role in shaping the discourse on vaccination.[4–5] As access and exposure to negative information about vaccination on social media increases, users' assessments of vaccination risks and benefits evolve, potentially influencing their decision to receive vaccines.[6]

The discussion about the rapidly spreading infectious disease began in December 2019. The WHO declared an infodemic earlier than a pandemic, noting that information about coronavirus was spreading faster than the disease itself.[7] In the initial phase, due to the lack of knowledge about the new disease, the online debate included not only the information on how to avoid and treat the infection, but also considerations related to the etiology of the disease and theories denying the existence of a pandemic.[8] Social media posts were filled with emotions such as anger, fear and helplessness.[9] The topic of a COVID-19 vaccine emerged in the spring of 2020, more than six months before its implementation.[10] As the COVID-19 vaccine was introduced and concerns about side effects increased, fake news about the vaccination and its side effects spread online.[11] Social media analyses of content published during the COVID-19 pandemic do not agree on the popularity and spreading speed of posts depending on their sentiment.[8,12–14]

2. AIM

The main objective of the study is assessment of trends online vaccination-related discourse published publicly in Polish, using a social media monitoring tool and Google Trends. The specific objectives of the study are: to analyse the dynamics of the discourse by tracing the number of online vaccination-related mentions and queries over time; to analyse the relation between the number of vaccination-related mentions and their source; to analyse the relation between the number of vaccination-related mentions and queries, and the dynamics of the COVID-19 vaccination uptake in Poland.

3. MATERIAL AND METHODS

3.1. Data sources

3.1.1. SentiOne

Social media monitoring and listening refers to a process of finding, tracking, collecting data from social media platforms, and analyzing online conversations related to a specific topic. SentiOne (SentiOne, Gdansk, Poland)[15] is a social media listening tool that allows for gathering, monitoring, and analysing online content based on keywords. This tool uses natural language processing algorithms, web robots and parallel data processing. A quantitative analyses of online vaccination-related content available in Polish was conducted based on data collected with SentiOne.[16] Following keywords were selected: 'fałszywa pandemia,' 'plandemi*,' 'zajob,' 'stop nop' (short for adverse vaccination effect), 'stopnop,' 'stop-nop,' 'zaszczepi*,' 'szczepi*,' 'antyszczepi*' ['fake pandemic,' 'plandemic*,' 'slammed,' 'stop vae,' 'stopvae,' 'stop-vae,' 'vaccinat*,' 'vacci*,' 'antivaccine*']. An asterisk means that all words beginning with the given string are searched. A total of 34,596,976 mentions were collected form four online sources: Facebook, forums, portals and Twitter (Table 1). Dimensions such as mention source (social media) and time (day/week/month) were selected for analysis.

3.1.2. Google Trends

In analyses using the Google Trends tool, the searched term 'vaccination' was analyzed for the area of Poland.[17] The data was downloaded on October 26, 2022, at 11:23. Google Trends provides insights into the relative number of searches (queries) for a given term compared to the total number of searches on Google. The numbers represent the interest level in the search in relation to the highest point on the chart. A value of 100 indicates peak popularity, while a value of 50 indicates half the popularity. A value of 0 indicates insufficient data, but it does not necessarily mean that users are not searching that specific query.

3.1.3. Epidemiological data

Data on the number of people vaccinated against COVID-19 in Poland were also analyzed: first dose, second dose, first booster, second booster, sum: first dose plus first booster plus second booster, sum of all doses. The data was taken from the following public domains:

(1) European Centre for Disease Prevention and Control;[18]
(2) Central Statistical Office.[19]

Table 1. Number of mentions analyzed in SentiOne.

Source	SentiOne on a monthly basis	SentiOne on a weekly basis
Facebook	14 874 851	14 873 742
Forums	419 933	419 762
Portals	11 167 701	11 166 948
Twitter	8 134 491	8 133 838
Total	**34 596 976**	**34 594 290**

3.1.4. Time interval

Data from July 1, 2018 to October 19, 2019 (data downloaded on January 7, 2021) and data from October 20, 2019 to October 23, 2022 (data downloaded from October 20 to 27, 2022) were analyzed. The downloaded data was aggregated in Python 3.8.8 in the pandas 1.2.4 library.

3.2. Statistical analysis

The statistical analysis used Kendall's tau correlation coefficient and the classical method of least squares to determine simple regressions between the number of mentions in each source and the number of queries. The R^2 coefficient of determination was used to assess the goodness of fit for the linear regression models. All the obtained models indicated a positive association between the pairs of variables. Due to the non-stationarity of the analysed time series, statistical significance was not determined and only Kendall's tau coefficient and coefficient of determination were presented as measures of association (similarity) between the time series.

4. RESULTS

4.1. Number of vaccination-related mentions (SentiOne) and queries (Google Trends) over time

In Google Trends, the largest increase in vaccination-related queries in Poland was observed between December 2020 and January 2021, as well as April–May 2021 and December 2021 i February 2022. In contrast, the number of mentions measured by SentiOne began to rise as early as March 2020, reaching its peak in December 2020 – January 2021 and December 2021 February 2022 (Figure 1). Kendall's tau coefficient showed a positive statistical association between the daily number of mentions (SentiOne) and the number of queries (Google Trends) throughout the study period ($\tau = 0.66$) and as of December 2019 ($\tau = 0.58$).

4.2. Relation between the number of vaccination-related mentions in Polish and their source (i.e., Twitter, Facebook, Portals, Online Forums)

The highest number of mentions related to vaccination in Polish (SentiOne) occurred on Facebook, followed by Twitter and online portals, with the lowest number on forums. The first significant increase in the number of mentions occurred in the 16th week of 2020 (i.e. April 13–19). The peak number of mentions occurred in the 53rd week of 2020 (i.e. December 28, 2020 – January 3, 2021), respectively: Facebook – 612,525, Twitter – 312,731, portals – 202,941, and forums – 7,965 (Figure 2). Kendall's tau coefficient showed a greater statistical association between the information source (SentiOne) and the the COVID-19 pandemic period (i.e. December 2019) compared to the pre-pandemic period.

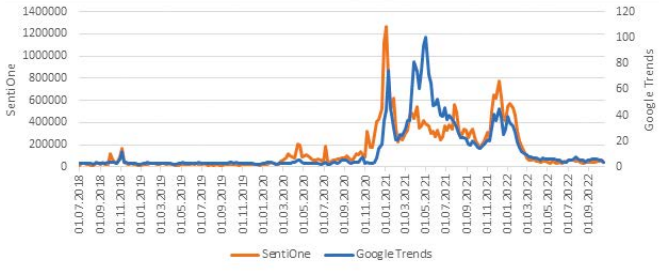

Figure 1. Daily number of mentions (SentiOne) and queries (Google Trends) about vaccination in Poland relative to time.

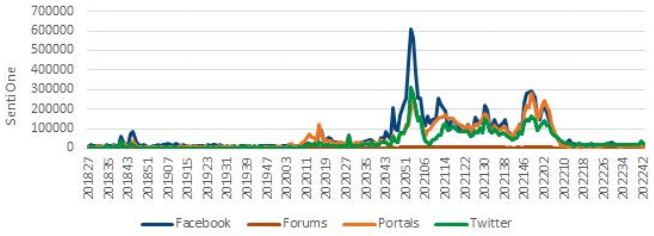

Figure 2. Weekly number of mentions of the topic of vaccination in Poland relative to the source. The designations on the category axis indicate the year and week in a given calendar year.

4.3. Number of vaccination-related mentions and queries in relation to the dynamics of the COVID-19 vaccination uptake in Poland

The increase in the number of vaccination-related queries in Poland (Google Trends) coincides with an increase in the total number of COVID-19 vaccinations (first dose and first and second boosters) administered in the country in the period from week 52 of 2020 (i.e. December 27) until the 39th week of 2022 (i.e. September 26 – October 2). Peaks in the number of queries related to the topic of vaccinations measured with the Google Trends tool were observed in the second week of 2021 (value: 75), and then in the 18th week of 2021 (i.e. May 3–9) and week 49 of 2021 (i.e. December 6–12), taking values respectively: 100 and 45. In contrast, the highest sum of vaccinations administered was observed in week 19 of 2021 (i.e. May 10–16), the 49th week of 2021 and the 2nd week of 2022 (i.e. January 10–16), taking the values respectively: 1,300,638; 1,269,642; 1,162,083 (Figure 3). Kendall's tau coefficient showed a positive statistical association for the analyzed variables ($\tau = 0.62$). However there was no direct correspondence

Figure 3. Weekly number of queries related to the topic of vaccination in Poland relative to the sum of the number of COVID-19 vaccinations (first dose and first and second boosters) administered in Poland from the 52nd week of 2020 (i.e. December 27) through the 39th week of 2022 (i.e. September 26 – October 2). The designations on the category axis indicate the year and week in a given calendar year.

between the weekly totals for vaccination-related mentions (SentiOne) and the number of COVID-19 vaccinations (first dose and first and second boosters) administered in Poland during the same period (from week 52 of 2020 to week 39 of 2022). Kendall's tau coefficient showed a weak positive statistical association for these analyzed variables ($\tau = 0.48$).

5. DISCUSSION

5.1. Key results

The highest interests in vaccination-related topics among Polish-speaking Internet users were observed when COVID-19 vaccination became available in Poland for specific occupational and/or age groups (December 2020 – January 2021, April–May 2021 and December 2021 – February 2022). The first observed increase in in mentions and queries (December 2020 – January 2021) coincides with the introduction of COVID-19 vaccination in Poland, starting on December 27, 2020. Another notable increase in April to May 2021 followed the European Medicines Agency's (EMA) confirmation of a positive benefit-risk ratio for AstraZeneca's vaccine on April 7, 2021.[20] Additionally, on April 20, 2021, the Polish Ministry of Health announced the vaccination schedule for April and May.[21] In contrast, the increase in inquiries observed in December 2021 – February 2022 aligned with the EMA's issuance, on December 20, 2021, of a positive scientific opinion for conditional marketing authorization of Novavax's Nuvaxovid vaccine.[22] The highest number of mentions related to vaccination in Polish (SentiOne) occurred on Facebook, followed by Twitter and online portals, with the lowest number on forums. The increase in the number of queries (Google Trends) coincides with the increase in the total number of performed COVID-19 vaccinations. At the same time, the weekly number of mentions (SentiOne) does not corresponds with the COVID-19 vaccination uptake. The results suggest that as the number of COVID-19 vaccinations increased in Poland, the public was more likely to seek information on vaccination than to post or share them.

5.2. Strengths and limitations of the study

The study's strength lies in its comprehensive qualitative approach to online content related to COVID-19 vaccination. By using tools that consider both mentions and queries, and incorporating a diverse dataset, the study provides a holistic perspective. Considering the number of COVID-19 vaccinations administered in Poland allows for the observation of the relationship between vaccination-related mentions and queries and the dynamics of COVID-19 vaccination uptake.

The main limitation of the study relates to the use of keyword 'vaccination' in the analysis performed with Google Trends. While this approach captures relevant data it may overlook synonyms searched by Internet users. Different phrases related to vaccination, may show different strength of correlation with data on the number of people vaccinated against COVID-19. The search terms and behavior of Internet users are not constant, which means that the increase in interest in searching for the phrase 'vaccination' can be explained by the interest generated by the introduction of a 'new' vaccine. Additionally, Google Trends does not provide data for all locations, making it difficult to develop an appropriate model at the local level. The SentiOne tool uses artificial intelligence-based algorithms for selection of related mentions, but choosing the right keywords is extremely important and may lead to inclusion bias. Companies with censorship policies that own social media platforms filter out keywords related to anti-vaccine discourse. Such policies encourage the anti-vax community to develop a new language, including neologisms like referring to vaccines as 'ketchup' or 'preparate.' Such keywords were not included in the analysis. A limitation of the survey is that knowledge about vaccination is not uniform in the public and the search terms may not reflect the actual issue the Internet user wishes to explore. In addition, the study did not include mentions from all social platforms such as Instagram, blogs or reviews.

5.3. Reference to literature on the subject

In Poland, other Internet studies examining interest in topics related to the COVID-19 pandemic have utilized tools such as Google Trends, SentiOne, Twitter API, EventsRegistry, considered various social media including Facebook, Twitter, Instagram, TikTok, blogs, forums, portals, and compared trends with the rise of COVID-19 cases and deaths.[23,24] The trend analyses presented in these articles align with the findings of our research.

Initially, online attitudes toward the COVID-19 vaccine were mainly negative, but as vaccines became more widely administered, a decrease in COVID-19 vaccine hesitancy was observed, accompanied with a gradual increase in positive public attitudes toward vaccination.[25–28] Anti-vaccination arguments primarily focused on concerns about safety of the vaccine due to its rapid development and limited human testing. Conspiracy theories emerged suggesting secret microchip implantation during the vaccination for the purpose of taking control of the society.[29,30] The initial limited vaccines availability prompted authorities to introduce a vaccination schedule that prioritized specific citizen groups over others. In many countries the COVID-19 vaccination remained optional, but Covid Certificate was necessary for some daily activities and travelling. The topic of mandatory COVID-19 vaccination has appeared in public discourse particularly among individuals working in high-exposure occupations. Arguments against vaccination often mentioned that the vaccine primarily benefit pharmaceutical companies, the virus is relatively harmless, the infection can be overcome without vaccination, and that the vaccine side effects pose greater risk than the disease itself.[31,32] Vaccine hesitancy may be linked to fear of side effects and doubts about vaccine efficacy, and may be related to vaccine origin and political factors.[33,34]

The increased online interest surrounding COVID-19 presented an opportunity for the scientific community to spread reliable information while cautioning against the dangers of publishing and disseminating false information.[35–38] Disseminating information that contradicts cur-

rent medical knowledge poses a threat to public health.[39] Exposure to misinformation correlates with the reduced vaccination intent, knowledge about pandemics and vaccines correlates with the trust in information sources and public opinion.[40,41] Social media is the fastest and primary source of information for a growing segment of the population, thus true information about vaccination should be effectively communicated through these platforms.[42,43] In the battle against misinformation, it is crucial to leverage existing strategies, to involve celebrities and influencers, whose posts reach wide audiences and set trends, as well as to consider involving pro-vaccination bots.[2,44,45]

During the COVID-19 pandemic, government decisions influenced social media trends and public interest in COVID-19 and vaccination against the disease. Social media serves as a mirror reflecting emotions of the public regarding various protective vaccinations, including those against human papillomavirus (HPV), measles-mumps-rubella (MMR), and other childhood vaccinations.[43,46,47] Understanding these emotions is curtail for decision-makers to formulate informed policies that align with societal norms.[48] The impact of online discourse on patients' health knowledge is significant.[49] Monitoring behavior of social media users can serve as a predictive tool for managing infectious disease outbreaks, as social media does not only reflects existing reality, but also shapes it.[9]

6. CONCLUSIONS

(1) The dynamics of the vaccination-related discourse published publicly in Polish depends on the timing of the COVID-19 pandemic and the introduction of the COVID-19 immunization. With the pandemic's onset an upward trend in vaccination-related occurred in the Polish-language Internet space.
(2) There is a clear positive association between the number of vaccination-related mentions (SentiOne) and the number of queries (Google Trends) in Polish since the pandemic.
(3) Vaccination topic was the most popular on Facebook and Twitter. Pro-vaccine activities along with educational and informational campaigns should prioritize Facebook. Additionally, monitoring Twitter's popularity is essential to determine whether to run educational campaigns on this platform.
(4) Analysing the dynamics of online public discourse makes it possible to observe the level of public interest in vaccination-related topic, which is important for designing adequate immunization promotion programs. Such analysis play a crucial role in formulating health policies and developing educational and promotional initiatives related to vaccination.

Conflict of interest
None declared.

Funding
Medical University of Warsaw, No. NZC/1/Z/MBS/N/21; to AK.

Acknowledgements
We would like to thank Mrs. Jolanta Grygielska for her suggestions and support in the design of the survey concept.

References

1 Karafillakis E, Larson HJ; ADVANCE consortium. The benefit of the doubt or doubts over benefits? A systematic literature review of perceived risks of vaccines in European populations. *Vaccine*. 2017;35(37):4840–4850. https://doi.org/10.1016/j.vaccine.2017.07.061.
2 Ortiz-Sánchez E, Velando-Soriano A, Pradas-Hernández L, et al. Analysis of the Anti-Vaccine Movement in Social Networks: A Systematic Review. *Int J Environ Res Public Health*. 2020;17(15):5394. https://doi.org/10.3390%2Fijerph17155394.
3 Dubé E, Gagnon D, MacDonald NE; SAGE Working Group on Vaccine Hesitancy. Strategies intended to address vaccine hesitancy: Review of published reviews. *Vaccine*. 2015;33(34):4191–4203. https://doi.org/10.1016/j.vaccine.2015.04.041.
4 Marchetti F, Verazza S, Brambilla M, Restivo V. Rotavirus and the web: analysis of online conversations in Italy during 2020. *Hum Vaccin Immunother.* 2022;18(1):2002087. https://doi.org/10.1080%2F21645515.2021.2002087.
5 Wang Y, McKee M, Torbica A, Stuckler D. Systematic Literature Review on the Spread of Health-related Misinformation on Social Media. *Soc Sci Med*. 2019;240:112552. https://doi.org/10.1016/j.socscimed.2019.112552.
6 Karafillakis E, Martin S, Simas C, et al. Methods for Social Media Monitoring Related to Vaccination: Systematic Scoping Review. *JMIR Public Health Surveill*. 2021;7(2):e17149. https://doi.org/10.2196/17149.
7 Editorial. The COVID-19 infodemic. *Lancet Infect Dis*. 2020;20(8):875. https://doi.org/10.1016/S1473-3099(20)30565-X.
8 Illari L, Restrepo NJ, Johnson NF. Losing the battle over best-science guidance early in a crisis: COVID-19 and beyond. *Sci Adv*. 2022;8(39):eabo8017. https://doi.org/10.1126/sciadv.abo8017.
9 Jarynowski A, Wójta-Kempa M, Belik V. Perception of "coronavirus" on the Polish Internet until arrival of SARS-CoV-2 in Poland. *Piel Zdr Publ*. 2020;10(2):89–106. https://doi.org/10.17219/pzp/120054.
10 Kalichman SC, Eaton LA, Earnshaw VA, Brousseau N. Faster than warp speed: early attention to COVD-19 by anti-vaccine groups on Facebook. *J Public Health (Oxf)*. 2022;44(1):e96–e105. https://doi.org/10.1093/pubmed/fdab093.
11 Harper T, Attwell K. How Vaccination Rumours Spread Online: Tracing the Dissemination of Information Regarding Adverse Events of COVID-19 Vaccines. *Int J Public Health*. 22;67:1604228. https://doi.org/10.3389/ijph.2022.1604228.

12 Chon MG, Kim S. Dealing with the COVID-19 crisis: Theoretical application of social media analytics in government crisis management. *Public Relat Rev*. 2022;48(3):102201. https://doi.org/10.1016/j.pubrev.2022.102201.

13 Zhang W, Mukerjee S, Qin H. Topics and Sentiments Influence Likes: A Study of Facebook Public Pages' Posts About COVID-19 Vaccination. *Cyberpsychol Behav Soc Netw*. 2022;25(9):552–560. https://doi.org/10.1089/cyber.2022.0063.

14 Ngai CSB, Singh RG, Yao L. Impact of COVID-19 Vaccine Misinformation on Social Media Virality: Content Analysis of Message Themes and Writing Strategies. *J Med Internet Res*. 2022;24(7):e37806. https://doi.org/10.2196/37806.

15 SentiOne. *SentiOne*. 2020. https://sentione.com. Accessed: July 3, 2024.

16 Kłak A, Furmańczyk K, Nowicka PM, et al. The Relationship between Searches for COVID- 19 Vaccines and Dynamics of Vaccinated People in Poland: An Infodemiological Study. *Int J Environ Res Public Health*. 2022;19:13275. https://doi.org/10.3390/ijerph192013275.

17 Google Trends. *Szczepienie*. https://trends.google.com/trends/explore?geo=PL&q=szczepienie. Accessed: July 3, 2024.

18 ECDC. *Data on COVID-19 Vaccination in the EU/EEA*. https://www.ecdc.europa.eu/en/publications-data/data-covid-19-vaccination-eu-eea. Accessed: October 26, 2022.

19 GUS. *National censuses*. https://bdl.stat.gov.pl/bdl/metadane/cechy/4180?back=True. Accessed: October 26, 2022.

20 European Medicines Agency. *AstraZeneca's COVID-19 vaccine: EMA finds possible link to very rare cases of unusual blood clots with low blood platelets*. https://www.ema.europa.eu/en/news/astrazenecas-covid-19-vaccine-ema-finds-possible-link-very-rare-cases-unusual-blood-clots-low-blood. Accessed: September 25, 2023.

21 Gov.pl. https://www.gov.pl/web/psse-mielec/kalendarz-i-harmonogram-szczepien-przeciw-covid-19. Accessed: September 25, 2023.

22 National Institute of Public Health – National Institute of Hygiene. *The fifth COVID-19 vaccine authorized in the European Union*. https://szczepienia.pzh.gov.pl/piata-szczepionka-przeciw-covid-19-dopuszczona-do-obrotu-w-unii-europejskiej/. Accessed: September 25, 2023.

23 Burzyńska J, Bartosiewicz A, Rękas M. The social life of COVID-19: Early insights from social media monitoring data collected in Poland. *Health Informatics J*. 2020;26(4):3056–3065. https://doi.org/10.1177/1460458220962652.

24 Jarynowski A, Wójta-Kempa M, Belik V. Trends in interest of COVID-19 on Polish Internet. *Przegl Epidemiol*. 2020;74(2):258–275. https://doi.org/10.32394/pe.74.20.

25 Wawrzuta D, Klejdysz J, Jaworski M, et al. Attitudes toward COVID-19 Vaccination on Social Media: A Cross-Platform Analysis. *Vaccines (Basel)*. 2022;10(8):1190. https://doi.org/10.3390/vaccines10081190.

26 Qorib M, Oladunni T, Denis M, et al. Covid-19 vaccine hesitancy: Text mining, sentiment analysis and machine learning on COVID-19 vaccination Twitter dataset. *Expert Syst Appl*. 2023;212:118715. https://doi.org/10.1016/j.eswa.2022.118715.

27 Hussain Z, Sheikh Z, Tahir A, et al. Artificial Intelligence-Enabled Social Media Analysis for Pharmacovigilance of COVID-19 Vaccinations in the United Kingdom: Observational Study. *JMIR Public Health Surveill*. 2022;8(5):e32543. https://doi.org/10.2196/32543.

28 Gesualdo F, D'Ambrosio A, Agricola E, et al. How do Twitter users react to TV broadcasts dedicated to vaccines in Italy? *Eur J Public Health*. 2020;30(3):510–515. https://doi.org/10.1093/eurpub/ckaa022.

29 Skafle I, Nordahl-Hansen A, Quintana DS, et al. Misinformation About COVID-19 Vaccines on Social Media: Rapid Review. *J Med Internet Res*. 2022;24(8):e37367. https://doi.org/10.2196/37367.

30 Islam MS, Sarkar T, Khan SH, et al. COVID-19-Related Infodemic and Its Impact on Public Health: A Global Social Media Analysis. *Am J Trop Med Hyg*. 2020;103(4):1621–1629. https://doi.org/10.4269/ajtmh.20-0812.

31 Stamm TA, Partheymüller J, Mosor E, et al. Coronavirus vaccine hesitancy among unvaccinated Austrians: Assessing underlying motivations and the effectiveness of interventions based on a cross-sectional survey with two embedded conjoint experiments. *Lancet Reg Health Eur*. 2022;17:100389. https://doi.org/10.1016/j.lanepe.2022.100389

32 Furman FM, Zgliczyński WS, Jankowski M, et al. The State of Vaccine Confidence in Poland: A 2019 Nationwide Cross-Sectional Survey. *Int J Environ Res Public Health*. 2020;17(12):4565. https://doi.org/10.3390/ijerph17124565

33 Zaprutko T, Kremin Y, Michalak M, et al. Social Attitude to COVID-19 and Influenza Vaccinations after the Influenza Vaccination Season and between the Second and Third COVID-19 Wave in Poland, Lithuania, and Ukraine. *Int J Environ Res Public Health*. 2022;19(4):2042. https://doi.org/10.3390/ijerph19042042.

34 Nguyen QC, Yardi I, Gutierrez FXM, et al. Leveraging 13 million responses to the U.S. COVID-19 Trends and Impact Survey to examine vaccine hesitancy, vaccination, and mask wearing, January 2021-February 2022. *BMC Public Health*. 2022;22(1):1911. https://doi.org/10.1186/s12889-022-14286-3.

35 Huang X, Wang S, Zhang M, et al. Social media mining under the COVID-19 context: Progress, challenges, and opportunities. *Int J Appl Earth Obs Geoinf*. 2022;113:102967. https://doi.org/10.1016/j.jag.2022.102967.

36 Wahbeh A, Nasralah T, Al-Ramahi M, El-Gayar O. Mining Physicians' Opinions on Social Media to Obtain Insights Into COVID-19: Mixed Methods Analysis. *JMIR Public Health Surveill*. 2020;6(2):e19276. https://doi.org/10.2196/19276.

37 Shaaban R, Ghazy RM, Elsherif F, et al. COVID-19 Vaccine Acceptance among Social Media Users: A Content Analysis, Multi-Continent Study. *Int J Environ Res Public Health*. 2022;19(9):5737. https://doi.org/10.3390/ijerph19095737.

38 Govender I. Social media and health – Is it all good, bad or just ugly? *S Afr Fam Pract*. 2022;64(1):e1–e2. https://doi.org/10.4102/safp.v64i1.5549.

39 Borges do Nascimento IJ, Pizarro AB, Almeida JM, et al. Infodemics and health misinformation: a systematic review of reviews. *Bull World Health Organ*. 2022;100(9): 544–561. https://doi.org/10.2471/BLT.21.287654.

40 Bendezu-Quispe G, Benites-Meza JK, Urrunaga-Pastor D, et al. Mass Media Use to Learn About COVID-19 and the Non-intention to Be Vaccinated Against COVID-19 in Latin America and Caribbean Countries. *Front Med (Lausanne)*. 2022;9:877764. https://doi.org/10.3389/fmed.2022.877764.

41 Xue H, Gong X, Stevens H. COVID-19 Vaccine Fact-Checking Posts on Facebook: Observational Study. *J Med Internet Res*. 2022;24(6):e38423. https://doi.org/10.2196/38423.

42 French J, Deshpande S, Evans W, Obregon R. Key Guidelines in Developing a Pre-Emptive COVID-19 Vaccination Uptake Promotion Strategy. *Int J Environ Res Public Health*. 2020;17(16):5893. https://doi.org/10.3390/ijerph17165893.

43 Klimiuk K, Czoska A, Biernacka K, Balwicki Ł. Vaccine misinformation on social media–topic-based content and sentiment analysis of Polish vaccine-deniers' comments on Facebook. *Hum Vaccin Immunother*. 2021;17(7): 2026–2035. https://doi.org/10.1080/21645515.2020.1850072.

44 Kelly JA, Walsh JL, Christenson E, et al. 1000 Hometown Heroes: Mobilising community social influencers for COVID-19 prevention, care and coping. *Health Soc Care Community*. 2022;30(6):e5703–e5713. https://doi.org/10.1111/hsc.14000.

45 Zhang M, Qi X, Chen Z, Liu J. Social Bots' Involvement in the COVID-19 Vaccine Discussions on Twitter. *Int J Environ Res Public Health*. 2022;19(3):1651. https://doi.org/10.3390/ijerph19031651.

46 Włodarska A, Raciborski F. Characterisation of the online public debate on MMR vaccine against measles, mumps and rubella on the Polish Internet. *Przegl Epidemiol*. 2021;75(3):390–401. https://doi.org/10.32394/pe.75.36.

47 Sobeczek K, Gujski M, Raciborski F. HPV Vaccination: Polish-Language Facebook Discourse Analysis. *Int J Environ Res Public Health*. 2022;19(2):914. https://doi.org/10.3390/ijerph19020914.

48 Yigitcanlar T, Kankanamge N, Preston A, et al. How can social media analytics assist authorities in pandemic-related policy decisions? Insights from Australian states and territories. *Health Inf Sci Syst*. 2020;8(1):37. https://doi.org/10.1007/s13755-020-00121-9.

49 Kłak A, Gawińska E, Samoliński B, Raciborski F. Dr Google as the source of health information – the results of pilot qualitative study. *Pol Ann Med*. 2017;24(2):188–193. https://doi.org/10.1016/j.poamed.2017.02.002.