Sentiments in the Online Anti- and Pro-Vaccination Discourse on Twitter

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Abstract

Vaccine hesitancy, which is a term to describe that people have doubts about vaccination and choose to delay or refuse vaccine uptake even though vaccines are readily available, is one of the greatest threats to global health. To effectively promote vaccine uptake and to tackle vaccine hesitancy it is important to gain insight into the vaccination discourse to get a better understanding of why people refuse vaccination. This study aims to examine the sentiments that are expressed in the online vaccination discourse and to research the differences in sentiments between the pro-vaccination majority and the anti-vaccination movement. Dutch-language vaccination-related messages were collected from Twitter ranging from January 2012 until June 2019 and categorised which resulted in 57 anti-vaccination tweets and 354 pro-vaccination tweets. A sentiment analysis and qualitative content analysis was conducted. Both anti- and pro-vaccination tweets contained strong subjectivity and polarity scores, thus tweets on both sides of the discourse were strong in sentiment and no meaningful difference was found. Anti- and pro-vaccination adherents both used more negative feelings than positive feeling words in their tweets. The sentiments in both anti- and pro-vaccination tweets related to a strong sense of in-group identity. Sentiments expressed in tweets posted by anti-vaccination adherents related to the presence of reactance. These findings increase insight into the relevance of social identity and reactance in the decision-making of anti-vaccination adherents and suggest that more attention should be paid to the vaccination discourse on social media platforms such as Twitter. More insight into the online vaccination discourse could improve the understanding of how vaccine hesitancy develops and spreads which is needed to effectively counter vaccine hesitancy.

Keywords: Twitter, anti-vaccination, pro-vaccination, sentiments, subjectivity, polarity, feeling words, in-group identity, reactance

Sentiments in the Online Anti- and Pro-Vaccination Discourse on Twitter

Vaccination coverage has been under pressure for years, causing group immunity to be jeopardized. The Netherlands, like many other countries, has an extensive National Immunisation Programme to protect the population against infectious diseases (National Institute for Public Health and the Environment, 2020). The programme includes vaccination against twelve potentially fatal infectious diseases.

Higher vaccination coverage reduces the risk of future outbreaks of infectious diseases (World Health Organization, 2013). By vaccinating a high percentage of children against a certain disease group immunity can be created and this disease becomes less common or may even disappear altogether. Thereby, children who cannot get vaccinated themselves, due to being too young or due to an underlying cause such as autoimmune disease, are also protected against infectious disease. Worldwide, vaccines currently prevent 2-3 million deaths every year, helping people live longer and healthier lives (World Health Organization, 2018). Vaccines given between 2001 and 2020 are estimated to save US$ 350 billion in cost of illness (Ozawa et al., 2017). In the Netherlands, due to vaccines 6.000 to 12.000 deaths have been prevented between 1953 and 1992 (Van Wijhe, 2018).

To ensure group immunity, vaccination coverage needs to be at least 95% (National Institute for Public Health and the Environment, 2015). Despite the great health and economic benefits, vaccination is not compulsory in the Netherlands causing vaccination coverage to be below the desired 95% in some parts of the country (Knol et al., 2013). For the first time in five years, in 2019 vaccination coverage in the Netherlands has increased slightly compared to the previous year (Van Lier et al., 2020). In the years before that, vaccine coverage in industrialized countries decreased, partly due to an increasing trend towards *vaccine hesitancy* which is a term used to describe people that are doubtful about vaccination and thus choose to delay or refuse vaccine uptake even when vaccines are readily available (Dubé et al., 2013;

McKee & Bohannon, 2016). Globally, vaccination coverage has gone down to 86% (Boseley, 2018). Even though vaccination coverage has increased slightly in the Netherlands, vaccine hesitancy is still ongoing.

The fear of vaccines is nothing new, opposition to vaccination has been around since the rise and spread of vaccine (Hussain et al., 2018). Anti-vaccination adherents refuse to vaccinate themselves or their children due to numerous reasons and perceived fears. Incidences of certain diseases have dropped as a result of successful vaccination programmes which has led to the belief that certain diseases have disappeared and are no longer a risk for public health (McCarthy et al., 2018). Moreover, concerns about vaccines and their potential negative side effects have increased. This leads to vaccine hesitancy and in turn sometimes to vaccine delay or refusal by the beforementioned anti-vaccination adherents (Allred et al., 2005).

Due to technology developments, access to medical information has drastically changed. The nature of Internet allows opinions to be spread widely without being filtered or reviewed (Kata, 2010). Additionally, traditional science-based public health information offered by the government is less influential because more and more people find their information elsewhere, namely on the Internet. Social media platforms have become primary sources for anti-vaccination communities (Ma & Stahl, 2017). Anti-vaccination advocates have taken advantage of this development by widely spreading their messages on social media platforms, increasing the likelihood to reach people who are already vaccine-hesitant or are merely looking for information. The increasing opportunity for anti-vaccination adherents to share their opinion and express their sentiment on social media-platforms has increased their reach and therefore magnified the problem of vaccine refusal and its posing threat to public health. The likelihood that vaccination decisions may be based on misleading information increases because anti-vaccination messages are more and more common to be spread on

social media platforms. Therefore, it is important to understand what messages are presented online, how these messages are presented and why they may be accepted.

Research into the vaccination discourse is largely restricted to traditional media outlets, such as newspapers. Moreover, previous research mostly focuses on the use of misinformation in the anti-vaccination discourse and not much research has been done into sentiments and emotions used in the online vaccination discourse. More insight into the sentiments and opinions that are being shared online, can be helpful to get a better understanding of why certain anti-vaccination messages are accepted and why people become and are anti-vaccination. This can contribute to developing and improving interventions aimed at reducing vaccine refusal and improving vaccine uptake and can help to indicate how social media platforms can be used to achieve this goal.

Therefore, this study aims to generate insight into the sentiments that play a role in the online vaccination discourse on Twitter and to assess whether sentiments expressed by anti-vaccination adherents differ from sentiments expressed by pro-vaccination adherents. A sentiment analysis is conducted to determine the extremity of the sentiments expressed in tweets concerning anti- and pro-vaccination discourse. Furthermore, a qualitative content analysis is conducted to analyse whether those sentiments are related to the presence of in-group identity and psychological reactance.

Theoretical Framework

This study is guided by the Social identity theory (SIT; Tajfel, 1982) and the reactance that follows from the strong in-group identity that characterizes members of anti-vaccination movements. Taking this into account, together with the phenomenon that people can fare in affective hot or cold states, certain expectations are formed about the sentiments that can be observed in the anti- and pro-vaccination discourse.

Social Media Platforms and Anti-Vaccination Misinformation

Several studies have been done examining vaccination discourse online. Evidence shows that individuals turn to the Internet for advice about vaccination and suggest that such Internet sources can influence their decision whether to vaccinate themselves or their children (Kata, 2012). Thus, the Internet is a valuable source of information for vaccination decisions which shows the relevance of researching the online vaccination discourse.

Several studies have proven that mass media have the potential to negatively influence vaccine uptake, the uptake of the Measles, Mumps, and Rubella (MMR) vaccine temporarily decreased in the U.S. after the publication of a study that falsely implied a link between the MMR vaccine and autism (Smith et al., 2008), in Italy the influenza vaccine coverage rate decreased by 80% after media reported deaths that occurred after flu shots (Signorelli et al., 2015) and at the height of negative media interest in the MMR vaccine there was a reduction in vaccine uptake which was mirrored by less parental confidence in the safety of the vaccine (Smith et al., 2007). People post about the news they hear from mass media on social media platforms causing these stories to continue to exist online, even when such stories are proven wrong later.

As social media thus have the potential to negatively influence vaccine uptake, it is important to gather insight into the information presented on social media platforms. Anti-vaccination information presented on the Internet is found to often contain misinformation and falsehoods (Kata, 2010). Research showed that vaccine studies on anti-vaccination websites were misrepresented on 88% of websites, this included drawing false conclusions from research, using sources untruthfully, and describing data very selectively. Thus, anti-vaccination information presented online often includes non-factual information and is more likely to be based on opinions. It is interesting to gather insight into sentiments that could follow from those negative opinions about vaccination.

There is a high probability that parents will encounter anti-vaccination information online (Davies et al., 2002), 41% of parents report to be exposed to anti-vaccination content on social media (Gunaratne et al., 2019). Individuals exposed to anti-vaccination content may be more likely to in their turn spread anti-vaccine messages, continuing the cycle of misinformation. A large-scale Internet-experiment showed that accessing vaccine-critical websites for only five to ten minutes increases the perception of risk regarding vaccinations and decreases the perception of risk of omitting vaccinations as well as the intentions to vaccinate; this also translated into parents having their children receive fewer vaccinations than recommended (Betsch et al., 2010). The high likelihood of parents encountering anti-vaccination misinformation online, shows the urgency to study the online vaccination discourse. A deeper understanding of the online discourse could indicate how the Internet could be used as a tool to combat vaccine hesitancy and therefore promote vaccine uptake.

Emotive Appeals and Decision-making

According to a trend analysis of sentiments, public sentiments towards vaccination can fluctuate with vaccination news (On et al., 2019). Positive sentiments increased when news encouraging vaccination was announced and negative sentiments increased when news about epidemic outbreaks was announced. It is interesting to study what sentiments are used in the anti- and pro-vaccination discourse because sentiments could potentially be influenced to eventually be able to promote vaccine uptake. In a study using semantic network analysis as an efficient and effective way to analyse vaccine sentiment, the framing of positive and negative messages within vaccination discourse was revealed which included differences in term valence such as required vaccines versus mandated vaccines and side effects versus adverse effects (Kang et al., 2017). Anti-vaccination websites often include emotive appeals, such as pictures and stories of children who were supposedly harmed by vaccinations (Betsch, 2011).

Sources that include personal, emotive appeals may be more likely to be used in decision-making regarding vaccine uptake, because parents appear to prefer personal information when they search for information on health-related topics (Betsch, 2011). Therefore, it is useful to investigate whether the sentiments expressed in the online vaccination discourse are stronger in anti-vaccination tweets than in pro-vaccination tweets.

Research has also shown that parents favourable to vaccination can be confused by the ongoing debate, leading to vaccine hesitancy (Hussain et al., 2018). The possible transition from pro-vaccination to vaccine hesitancy based on the ongoing debate, is another reason why it is valuable to gain insight of the differences between anti- and pro-vaccination discourse.

Hot versus Cold States

Affect has the capacity to transform people, in different affective states it is almost as if we are different people (Loewenstein, 2005). Affective states are argued to impact decision-making, and in turn actual behaviour. Visceral drives are a feature of everyday experience and exert a substantial effect on behaviour (Nordgren et al., 2006). People in a *hot state* which can be defined as an emotional or aroused state (e.g., angry) are more likely to engage in unplanned, risky behaviour than people in a *cold state* which can be defined as a non-emotional or non-aroused state (e.g., calm). People in hot states tend to underestimate the extent to which their preferences and behaviour will be affected by their affective state which is referred to as the hot-to-cold empathy gap. When people are in a cold state, on the other hand, they fail to appreciate how hot states will influence their preferences and behaviour which is referred to as the cold-to-hot empathy gap. These biases also apply interpersonally, for example when people are not affectively aroused, they tend to underappreciate the impact of hot states on other people's behaviour. Thus, human thinking and behaviour are both state-dependent. Being in a hot state could be relevant for vaccination behaviour because a hot state

such as feeling threatened might influence perceptions of risk and intentions to vaccinate (Betsch et al., 2010).

As anti-vaccination adherents often use emotive appeals in their messages thus are shown to reason from emotion, it is likely that anti-vaccination adherents more often fare in hot states than pro-vaccination adherents. Therefore, it can be expected that anti-vaccination adherents express stronger sentiments in the vaccination discourse following from the hot states they fare in. Subjectivity and polarity scores can be used to determine how strong the sentiment expressed in text is. Subjectivity can be scored to determine whether a text is opinionated or not and polarity can be scored to determine the extremity of that opinion (Yaqub et al., 2018). It is also likely that anti-vaccination adherents use different *feeling words* in their tweets than pro-vaccination adherents, as anti-vaccination adherents are shown to reason from emotion. Feeling words can be defined as words that describe the emotion a person is feeling. Thus, it is expected to detect more subjectivity and polarity in tweets posted by anti-vaccination adherents than in tweets posted by pro-vaccination adherents and to detect different feeling words in anti-vaccination tweets than in pro-vaccination tweets.

Social Identity Theory

According to SIT individuals see the social world in terms of in-groups and out-groups, they develop favourable biases towards members of their own in-group and make judgements about others based on this in-group bias. People attain their identity and their beliefs about how they should behave from the social group they belong to (Hogg, 2016). People tend to make comparisons between their own in-group and out-groups and go to great lengths to protect the superiority of their in-group. To maintain those group boundaries, people tend to glorify their in-group by expressing positive attitudes towards their in-group and people tend to derogate the out-group by expressing negative attitudes towards the out-group (Hong et al., 2006).

When applying the theory to this study, anti-vaccination adherents possibly express positive attitudes towards their in-group by using more positive sentiments when talking of anti-vaccination adherents and their negative attitudes towards the out-group by using more negative sentiments when talking about pro-vaccination adherents. Us-versus-them thinking is a strong driver of behaviour. Rather than following their actual personal opinion on certain behaviour, individuals can be motivated to engage in a certain behaviour because they believe that is favourable behaviour in their in-group.

Members of the anti-vaccination group share a strong sense of in-group identity and identify themselves as among the wise group compared to the pro-vaccination out-group (Attwell & Smith, 2017). Us-versus-them thinking which occurs among people with a strong in-group identity and thus among anti-vaccination adherents who see pro-vaccination adherents as the out-group, could lead to hot affective states and reactance towards the pro-vaccination majority.

Reactance

The anti-vaccination movement shows a large degree of *reactance* (Hornsey et al., 2018). Reactance is a motivational state that is aroused when people feel like their decisional freedom is threatened or restricted and this arousal is often expressed in anger (Brehm, 1966). Reactance and the beforementioned strong sense of in-group identity shared by anti-vaccination adherents can also be linked to each other. More reactant individuals are found to possess a greater in-group identity (Dowd et al., 2001). Moreover, reactance may also occur when one observes reactance among a valued in-group, following from a strong sense of in-group identity.

Reactance leads people to resist social influence (Brehm & Sensenig, 1966), people high in reactance are more likely to resist all attempts of others to influence them. For anti-vaccination adherents who are shown to be high in reactance, this could mean that they are

more likely to resist attempts of pro-vaccination adherents that try to persuade them to vaccinate. As the frequency and intensity with which people display reactance differs (Hong & Faedda, 1996), it is interesting to investigate if sentiments and the extremity of those sentiments are related to the presence of reactance in the vaccination discourse.

As existing research has shown that being in a hot state has a great influence on intentions, decision-making, and behaviour and could therefore also impact vaccine uptake, it is important to pay extra attention to such hot states and following stronger sentiments when researching the vaccination discourse. Thus, there is a possibility that the hot states anti-vaccination adherents fare in, lead to more extreme sentiments which might be found in higher subjectivity and polarity scores found in anti-vaccination tweets than in pro-vaccination tweets. Also, it is found that anti-vaccination adherents are often high in reactance following from a strong sense of in-group identity and that anti-vaccination information often contains emotive appeals. Combining these insights, we can argue that it is likely that anti-vaccination adherents use stronger sentiments than pro-vaccination adherents.

Currently, there is a knowledge gap in the existing research because the sentiments that play a role in the online vaccination discourse and whether these sentiments differ between anti- and pro-vaccination discourse have not yet been investigated. A better understanding could be used by policy makers to develop and improve interventions aimed at tackling vaccine hesitancy and promoting vaccine uptake which is essential to protect the population from infectious diseases and therefore improve public health. As existing research has shown the relevance of sentiments expressed on social media platforms and its impact on vaccination decisions, Twitter is a suitable platform to use when researching the sentiments used in the vaccination discourse.

Research Question

Advocates of pro-vaccination typically focus on correcting misinformation, thus viewing vaccine hesitancy as an "educational" problem. However, in order to develop an effective approach to promote vaccine uptake, it is needed to look beyond vaccine hesitancy as an educational problem. It is important to gain insight into the vaccination discourse to get a better understanding of why people refuse vaccination. Therefore, this study will seek to assess what sentiments play a role in the anti- and pro-vaccination discourse on Twitter by answering the following main question and three sub questions:

Do sentiments used by anti-vaccination adherents differ from sentiments used by pro-vaccination adherents in the online vaccination discourse?

- Do tweets posted by anti-vaccination adherents contain stronger subjectivity and polarity scores than tweets posted by pro-vaccination adherents?

- Do anti-vaccination adherents use different emotive appeals and feeling words in their tweets than pro-vaccination adherents?

- If anti-vaccination adherents use strong sentiments, is this related to the presence of-ingroup identity and psychological reactance?

The aim of this study is to research the sentiments that can be observed in the vaccination discourse and to research the differences in sentiments between the pro-vaccination majority and the anti-vaccination movement. The following expectations regarding sentiments in the vaccination discourse might be useful when analysing the data:

1. As within the vaccination discourse anti-vaccination adherents have been shown to more often fare in hot states and reason from emotion than pro-vaccination adherents, I expect to find that the sentiments concerning the vaccination discourse differ between anti- and pro-vaccination adherents. I expect to find stronger

subjectivity and polarity scores that indicate stronger sentiments in anti-vaccination tweets than in pro-vaccination tweets.

2. As anti-vaccination adherents are more likely to fare in hot states and reason from emotion than pro-vaccination adherents, I also expect to find different emotive appeals and feeling words in anti-vaccination tweets than in pro-vaccination tweets.

3. If anti-vaccination adherents are shown to use strong sentiments, I expect this to be related to the presence of in-group identity and the following psychological reactance among anti-vaccination adherents.

Method

Study Design

The data used in this study are collected as part of a larger study that researches the online vaccination discourse. Multiple other analyses are conducted using the same data set. In this section, only information relevant for the current study is described.

In order to gain more insight into the sentiments that play a role in the online vaccination discourse, a sentiment analysis was conducted to detect the subjectivity and polarity of the tweets collected in the context of the larger study described above. A qualitative content analysis was also conducted. Qualitative content analysis allows in-depth insight into the sentiments expressed in tweets posted by anti- and pro-vaccination adherents.

Study Population and Sampling

This study analysed Dutch-language messages from the social media platform Twitter. As Twitter is a 13+ platform, it is theoretically possible that the analysed messages contained messages posted by minors. However, considering the topic under investigation it can reasonably be expected that people that posted the messages are at least 18 years old and not part of vulnerable populations. As all messages were Dutch, it can be determined to a certain

degree that the country from which the posts originated is the Netherlands. Furthermore, for

all analyses an anonymized version of the data set was used to avoid individuals becoming

identifiable.

Data Collection Procedure

For this study an existing qualitative database of online Twitter vaccination discourse

was used. The database contains nearly 85.000 tweets that were collected ranging from

January 2012 until June 2019 and are all Dutch-language vaccination-related messages. The

data were collected by a combination of web crawling and Twitter application programming

interface (API) in order to concur with Twitter's Terms of Service. Web crawling was

conducted in accordance with the provisions of Twitter's robots.txt

(https://twitter.com/robots.txt). The following search terms were used:

- Hashtags: #vaccineren, #ikvaccineer, #ikvaccineerniet, #vaccinatiegraad,

    #vaccinatieschade, #antivaxx, #provaxx, #antivax, #provax, #antivaxxer, #provaxxer,

    #mazelen

- Keywords: vaccineren, vaccineer, vaccinatie, vaccinatietwijfel, antivaxx, provacc,

    antivax, provax, antivaxxer, provaxxer

For every selected tweet, the tweet ID, the twitter handle of the person posting the tweet

(i.e., their username), the tweet itself, information about the moment the tweet was posted,

and if applicable, images included in the tweet and/or the URLs the tweet referred to, were

extracted.

Data Analysis

The data were analysed through qualitative content analysis using Excel and NVivo.

Preliminary data cleaning was conducted to improve digital legibility and analysability of the

tweets. The data cleaning consisted of switching all upper case to lower case and removing

URLs, usernames, numbers, punctuations, extra spaces between words and one-character long words. Discourse analysis was employed to categorize and structure the online vaccination discourse. A randomly selected subset of the sample consisting of 2000 tweets was coded manually in Excel. The tweet valence was determined by categorizing the tweets into anti-vaccination, pro-vaccination, hesitant, not relevant, relevant but neutral, and relevant but unclear. Categorizing the subset of 2000 tweets resulted in 57 anti-vaccination tweets, 354 pro-vaccination tweets and 67 hesitant tweets. The difference in the amount of anti- and pro-vaccination tweets could be explained by the finding that in general anti-vaccination adherents post less new tweets than pro-vaccination adherents (Germani & Biller-Adorno, 2021). Pro-vaccination individuals seemed more prone to generate new content.

For this study specifically, the sentiments used in the collected tweets were researched. A sentiment analysis was performed in Excel through Natural Language Processing (NLP) by using a validated lexicon-based approach to detect feeling words and extract subjectivity and polarity from the tweets. Subjectivity of tweets was researched by determining the number of feeling words that are used in the tweets. Subjectivity classification was performed to classify tweets as opinionated or not opinionated. Polarity of tweets was researched by determining the extremity of the feeling words, the polarity of the tweets was discerned to determine the extremity of the sentiment expressed by the writer with respect to the topic under discussion thus whether the tweet expressed a positive, a neutral or a negative opinion. The average subjectivity and polarity scores of anti-vaccination tweets and of pro-vaccination scores were determined and compared to research whether anti-vaccination adherents used stronger sentiments in their tweets than pro-vaccination adherents. A subjectivity score close to 1 indicates a subjective text, thus the closer to 1 the subjectivity score of a text the more subjective a text is. A polarity score close to -1 and 1 indicates a respectively negative and

positive sentiment, thus the closer to -1 and 1 the polarity score the more polarity is detected in a text.

Tweets with a subjectivity score of 0.6 or higher and an objectivity score lower than -0.6 and higher than 0.6 thus tweets with scores indicating stronger sentiments were selected for further analysis. In the existing literature it is not indicated what threshold can best be used to determine whether a text is strong in sentiment. This threshold was chosen for practical reasons, it captured a sample not too large to analyse but large enough to draw conclusions from. The reason to select the tweets with stronger sentiments for further analysis was that these tweets were most likely to contain statements that were emotive and to contain feeling words which were expressed out of reactance.

The selected tweets were analysed through qualitative content analysis using NVivo. The first step was to read the selected tweets. Meaningful categories were established in a code tree. By using axial coding, the data were linked to these categories.

First, qualitative content analysis was used to research what kind of feeling words and emotive appeals occurred in both the anti-vaccination tweets and in the pro-vaccination tweets, to explore what sentiments were expressed on both sides of the vaccination discourse.

Secondly, it was researched whether in the anti-vaccination tweets with stronger sentiments a strong sense of in-group identity was expressed. This was done by examining statements that indicated positive attitudes towards their in-group and negative attitudes towards their out-group. As comparison, it was also researched whether in pro-vaccination tweets with stronger sentiments a strong sense of in-group identity could be detected, also by examining statements that indicated positive attitudes towards their in-group and negative attitudes towards their out-group.

Lastly, it was researched how psychological reactance related to anti-vaccination and pro-vaccination tweets by looking for statements made about decisional freedom being

threatened and statements where psychological arousal or anger were expressed about that possible threat. Furthermore, it was researched whether statements about compulsory vaccination were expressed in pro-vaccination tweets as such statements may heighten reactance among anti-vaccination adherents.

Data Management

The data is stored for a period of ten years following the final publication according to FSBS protocol. The data set is stored securely on an institutional drive (OneDrive) with access limited to the researchers involved, both during the research and for data storage. All parties involved agreed not to store copies of the data on other data drives and the data will not be shared with other parties. Based on the description of the research methods, other researchers can replicate this study by using newly collected data. If the data is requested for verification, data will only be shared under a data transfer agreement.

Ethics

The Faculty Ethics Review Board of the Faculty of Social and Behavioural Sciences has given permission for the research with document number 20-693. Data collection occurred before the current FETC guidelines came into place. Therefore, a Data Protection Impact Assessment (DPIA) is written in correspondence with the Research Data Management Support of the Utrecht University and the privacy contact employee of the Faculty of Social and Behavioural Sciences, and will be submitted to the Data Protection Officer of the Utrecht University.

It is important to acknowledge and reflect on the ethical issues that this research into the online vaccination discourse raises. Even though the tweets that were collected are publicly available and part of regular, public discourse, users of Twitter reasonably do not expect that their tweet(s) will be used for research purposes. Moreover, the people whose tweets are collected cannot provide active consent for the analysis of their tweets. Precautions

were taken to ensure that analyses and publications on the data set will never result in individuals becoming identifiable. For all analyses an anonymized version of the data set was used, where the username has been removed. Furthermore, quotes will never be reported, as these could be entered into a search engine and traced back the individual that posted it. Only full anonymous, aggregate-level analyses will be reported.

Results

Subjectivity and Polarity Scores

The subjectivity and polarity scores of the collected anti- and pro-vaccination tweets were determined by performing a sentiment analysis through Natural Language Processing (NLP) and are presented in Table 1. The average subjectivity score of the collected tweets that were coded as anti-vaccination was 0.78. The average subjectivity score of 0.78 indicated that on average the anti-vaccination tweets were opinionated. The average subjectivity score of the collected tweets that were coded as pro-vaccination was 0.72. The average subjectivity score of 0.72 indicated that on average the pro-vaccination tweets were also opinionated. Furthermore, the average negative polarity score of the anti-vaccination tweets was -0.55 and the average positive polarity score was 0.58. The average negative polarity score of the pro-vaccination tweets was -0.57 and the average positive polarity score was 0.52. The average positive and negative polarity scores indicated that in both the anti- and in the pro-vaccination tweets polarity was detected and that the polarity was strong in both positive and negative sentiments that were expressed.

From the average subjectivity and polarity scores, it was concluded that tweets posted by both anti- as pro-vaccination adherents contained strong sentiments. There was no meaningful difference in average subjectivity or polarity scores between anti-vaccination tweets and pro-vaccination tweets. Thus, sentiments in tweets posted by anti-vaccination adherents were not stronger than sentiments in tweets posted by pro-vaccination adherents.

Tweets on both sides of the vaccination discourse contained strong subjectivity and polarity scores and thus sentiments expressed in both pro- and anti-vaccination tweets were strong.

The tweets with a subjectivity score of 0.6 or higher and an objectivity score lower than -0.6 or higher than 0.6 were considered tweets with strong sentiments. This threshold resulted in 33 anti-vaccination tweets and 214 pro-vaccination tweets with strong sentiment which were used for further qualitative content analysis.

Table 1

Subjectivity and Polarity Calculation of Anti- and Pro-Vaccination Tweets

Metric	Average score anti-vaccination tweets	Average score pro-vaccination tweets	Scale
Subjectivity	0.78	0.72	0 to 1
Positive polarity	0.58	0.52	0 to 1
Negative polarity	-0.55	-0.57	-1 to 0

Feeling Words

The anti- and pro-vaccination tweets that were selected for qualitative content analysis were coded according to meaningful categories established in a code tree. The number of references and frequencies that were found are presented in Table 2.

The collected anti- and pro-vaccination tweets both used relatively few positive feeling words compared to negative feeling words. In the anti-vaccination tweets 23 references were found that contained negative feeling words and 3 references that contained positive feeling words. In the pro-vaccination tweets 56 references were found that contained negative feeling words and 17 references that contained positive feeling words.

The anti-vaccination adherents expressed anger towards parents who inoculate their children with vaccinations containing toxic fluids, poison and other garbage that will infect children with certain diseases. Also, anti-vaccination adherents expressed outrage towards the pro-vaccination majority and found it offensive that they are often put aside neglectful towards the health of their children, while they think that they are making the right decision to not have their children vaccinated. Anger was also expressed in pro-vaccination tweets. Pro-vaccination adherents were mostly angry about parents who put their own children and the children of others at risk by not vaccinating. Pro-vaccination tweets often contained references to anti-vaccination adherents as being dumb, irresponsible, and anti-social. Pro-vaccination adherents expressed that they find it incomprehensible that parents would not have their children vaccinated.

When positive feeling words were being used in the discourse, it was often in a sarcastic comment and thus not meant in a positive manner. Positive feeling words used by anti-vaccination adherents were also to express admiration towards their in-group for being able to think for themselves and not being influenced by the pro-vaccination majority. Positive feeling words were used by pro-vaccination adherents to express admiration and gratitude towards the national vaccination program and campaigns supporting this program.

Thus, the emotive appeals and feeling words used in anti-vaccination tweets did not differ from the emotive appeals and feeling words used in pro-vaccination tweets, as both anti- as pro-vaccination adherents used more negative feeling words than positive feeling words. The negative feeling words stated in anti- and pro-vaccination tweets were both most often used to express anger.

Table 2

Anti- and Pro-Vaccination Codes and their Number of References and Frequency

Codes	Anti-vaccination		Pro-vaccination	
	References	Frequency	References	Frequency
Negative feeling words	23	70.0%	56	26.2%
Positive feeling words	3	9.1%	17	7.9%
Positive attitude towards in-group	8	24.2%	22	10.3%
Negative attitude towards out-group	18	54.5%	66	30.8%
Reactance	13	39.4%	0	0.0%
Compulsory vaccination	-	-	23	10.7%

Note. The references are the number of times a code was found in the anti- or pro-vaccination tweets. The frequency is calculated by dividing the number of references by the total number of anti- or pro-vaccination tweets used for coding and multiplied by 100 to calculate the percentage.

In-group Identity and Reactance

Both anti-vaccination adherents and pro-vaccination adherents made statements in their tweets that differentiated between in-groups ("us") and out-groups ("them") as explained by SIT (Tajfel & Turner, 1979). By glorifying the in-group and derogating the out-group, the anti- and pro-vaccination adherents maintained these in-/out-group boundaries. In tweets posted by anti-vaccination adherents the sentiments that were expressed often related to the psychological reactance that follows from their in-group identity.

Positive Attitude towards the In-group

Anti-vaccination adherents differentiated themselves from pro-vaccination adherents by glorifying the in-group, in the anti-vaccination tweets 8 references were found in which

anti-vaccination adherents expressed a positive attitude towards their in-group. Statements in the collected anti-vaccination tweets that expressed positive attitudes towards the in-group were about being able to think for themselves, making the right decision not to participate in the vaccination programme and not being convinced by lies from the government, pharmaceutical governments, and pro-vaccination adherents. Also, it was mentioned how healthy they are and feel despite of not being vaccinated or even because they are not vaccinated.

Pro-vaccination adherents also expressed positive attitudes towards their in-group, in the pro-vaccination tweets 22 references were found in which pro-vaccination adherents expressed a positive attitude towards their in-group. They referred to themselves and other pro-vaccination adherents as smart, well-informed, and sensible. In pro-vaccination tweets it was stated that pro-vaccination adherents are not only protecting their own health but also helping society to stay healthy. It was also mentioned that children who are vaccinated should have more rights than non-vaccinated children, by only accepting vaccinated children to schools and kindergartens and not allowing non-vaccinated children.

Negative Attitude towards the Out-group

Anti-vaccination adherents differentiated themselves by derogating the out-group, 18 references were found in which anti-vaccination adherents expressed a negative attitude towards the out-group. The out-group anti-vaccination adherents most often referred to was people who vaccinate themselves or people who get their children vaccinated. Negative attitudes towards the dominant pro-vaccination majority were expressed in the anti-vaccination tweets. Anti-vaccination adherents thought people who have their children vaccinated are dumb and put their children in danger. Anti-vaccination adherents even called pro-vaccination adherents "retarded" and described them as "going crazy" and accused them of spreading fake information. It was stated that pro-vaccination adherents are unable to think

for themselves and that people who vaccinate themselves or their children are just "following the herd".

However, pro-vaccination adherents were not the only group considered to be the out-group by anti-vaccination adherents. Also, the government and pharmaceutical companies were categorized as out-groups. Negative attitudes towards the government and pharmaceutical companies were expressed in the anti-vaccination tweets. Anti-vaccination adherents accused the government of scaring society with fake news to get people to vaccinate. Furthermore, anti-vaccination adherents accused pharmaceutical companies of being corrupt. Pharmaceutical companies were accused of misleading people to get vaccinated for their own profit which can lead to deadly consequences. Pharmaceutical companies were even compared to the mafia and said to carry out satanic rituals and barbaric practices.

Pro-vaccination adherents also expressed negative attitudes towards the out-group, 66 references were found in which pro-vaccination adherents expressed a negative attitude towards the out-group. The out-group pro-vaccination adherents referred to was the anti-vaccination movement, pro-vaccination adherents even thought of several names for the out-group such as "anti-vaxxers" and "anti-vaccination lunatics". Pro-vaccination adherents often mentioned that it is anti-social not to vaccinate and that by not vaccinating anti-vaxxers put not only their own children but also the rest of society at danger. It was even stated in pro-vaccination tweets that not vaccinating your children is irresponsible and that it is child abuse. Furthermore, pro-vaccination adherents argued that many anti-vaccination adherents are hypocritical because while refusing vaccination they often do use for example medication.

Reactance

In the anti-vaccination tweets it was not directly stated that anti-vaccination adherents felt like their own decisional freedom is being threatened. However, in the anti-vaccination

tweets 13 references were found in which anti-vaccination adherents expressed anger or psychological arousal towards impingements on their freedom. It was stated by anti-vaccination adherents that the government persuades people to get vaccinated by scaring society with fake information. Also, anti-vaccination adherents stated that the pharmaceutical industry misleads people to get vaccinated for their own profit. The psychological arousal and anger expressed by anti-vaccination adherents was towards the government and the pharmaceutical industry. Fear of dangerous vaccination practices performed by the pharmaceutical industry was expressed. Furthermore, anti-vaccination adherents expressed anger towards the government and called it ridiculous and dangerous that people were being persuaded to vaccinate. Thus, even though vaccination is not compulsory in the Netherlands, anti-vaccination adherents expressed fear for impingements on their freedom and felt like their decisional freedom is threatened by influences from the government and the pharmaceutical industry. Anti-vaccination adherents stated that people who do get vaccinated do not truly act out of free will ("just following the herd"). Anti-vaccination adherents showed concern about their freedom in their tweets.

In pro-vaccination tweets no references were found in which pro-vaccination adherents expressed fear of impingements on their freedom. However, in the pro-vaccination tweets 23 references were found in which pro-vaccination adherents advocated for reducing the rights of unvaccinated people or in which they advocated for compulsory vaccination. It was argued that schools and kindergartens should be able to refuse access to children who are not vaccinated. Some pro-vaccination adherents even argued that vaccination should be mandatory and that parents who refuse to have their children vaccinated should be convicted of child abuse and should be suspended of their parental authority. Such statements in pro-vaccination tweets could enhance the fear of losing decisional freedom amongst anti-

vaccination adherents. However, vaccination is not compulsory in the Netherlands; all Dutch citizens have the free choice to get vaccinated or not.

Both anti-vaccination adherents and pro-vaccination adherents expressed positive attitudes towards their in-group and negative attitudes towards the out-group in their tweets. Thus, the sentiments expressed in both anti-vaccination tweets and pro-vaccination tweets related to the presence of a strong sense of in-group identity. Among anti-vaccination adherents the sentiments also related to their psychological reactance because they felt like their decisional freedom was threatened which was expressed in anger. Anti-vaccination adherents thus showed a low tolerance for impingements on their freedom in their tweets. In tweets posted by pro-vaccination adherents sentiments did not relate to psychological reactance.

Discussion

In order to gain insight into the vaccination discourse and to get a better understanding of why people refuse vaccination this study was conducted. The aim of this study was to research the sentiments expressed in the vaccination discourse and to research differences in sentiments between the anti-vaccination movement and the pro-vaccination majority. First, it was researched whether sentiments expressed by anti-vaccination adherents differed from sentiments expressed by pro-vaccination adherents by determining the average subjectivity and polarity scores of anti- and pro-vaccination tweets and by determining whether those average scores differed between anti-and pro-vaccination tweets. As anti-vaccination adherents have been shown to more often fare in hot states and reason from emotion than pro-vaccination adherents it was expected to find stronger subjectivity and polarity scores in anti-vaccination tweets than in pro-vaccination tweets which would indicate stronger sentiments in anti-vaccination tweets than in pro-vaccination tweets. The findings of this study clearly showed high subjectivity and polarity in both anti- and pro-vaccination tweets and thus

showed strong sentiments in both anti-vaccination tweets and in pro-vaccination tweets. However, the differences in average subjectivity and polarity scores between anti- and pro-vaccination tweets were small and thus not meaningful. Therefore, the tweets posted by anti-vaccination adherents did not contain stronger subjectivity and polarity than tweets posted by pro-vaccination adherents, as was expected.

Secondly, in this study it was researched whether anti-vaccination adherents used different emotive appeals and feeling words in their tweets than pro-vaccination adherents. It was expected that anti-vaccination adherents used different emotive appeals and feeling words than pro-vaccination adherents, because anti-vaccination adherents are more likely to fare in hot states and reason from emotion than pro-vaccination adherents. In the qualitative analysis of the tweets with strong sentiments it was found that negative feeling words were more often used than positive feelings words on both sides of the vaccination discourse, thus there was no difference found in the use of emotive appeals and feeling words between anti- and pro-vaccination tweets as was expected.

At last, it was researched whether the strong sentiments used in the vaccination discourse were related to the presence of in-group identity and the following psychological reactance. It was expected that a strong sense of in-group identity and psychological arousal and anger would be expressed in the anti-vaccination tweets and that this would not be found in the pro-vaccination tweets. It was identified that both anti-vaccination adherents and pro-vaccination adherents categorized people into in-groups and out-groups. In both anti-vaccination tweets and in pro-vaccination tweets the out-group was always negatively evaluated, and the in-group was always positively evaluated. Negative attitudes towards the out-group were more often identified than positive attitudes towards the in-group. The sentiments expressed in tweets posted by anti-vaccination adherents were related to the presence of reactance which was not the case in tweets posted by pro-vaccination adherents.

Overall, the sentiments used by anti-vaccination adherents only differed in one regard from sentiments used by pro-vaccination adherents, namely the sentiments expressed in anti-vaccination tweets related to their psychological reactance and thus to the fear of losing decisional freedom which was not expressed by pro-vaccination adherents.

This study demonstrated that reactance and insights from SIT are related to sentiments expressed in the online vaccination discourse. Anti- and pro-vaccination adherents made social categories of "us" and "them" in their tweets by glorifying their in-group and derogating the out-group, in line with SIT (Tajfel, 1982). In line with the finding in earlier research that members of the anti-vaccination group share a strong sense of in-group identity and identify themselves as among the wise group compared to the pro-vaccination out-group (Attwell & Smith, 2017), anti-vaccination adherents in their tweets showed negative attitudes towards the pro-vaccination majority. Sentiments expressed in the tweets posted by anti-vaccination adherents related to reactance which is line with the finding in earlier research that anti-vaccination movements are high in reactance (Hornsey et al., 2018).

The sentiments expressed in tweets posted by anti-vaccination adherents were strong and more negative feeling words than positive feeling words were used. This aligns with earlier research where it was found that anti-vaccination websites often include emotive appeals (Betsch, 2011). However, tweets posted by pro-vaccination adherents were just as strong in sentiment as the tweets posted by anti-vaccination adherents and also contained more negative feeling words than positive feeling words. Beforehand, it was expected that anti-vaccination tweets would contain stronger subjectivity and polarity and thus stronger sentiments than pro-vaccination tweets, because anti-vaccination adherents are more likely to fare in hot states and are shown to reason from emotion (Betsch, 2011). However, findings from this study showed that there was no meaningful difference in subjectivity and polarity scores between anti- and pro-vaccination tweets thus contrast with this expectation.

Moreover, emotive appeals and feeling words that were expressed in the collected tweets did also not differ between tweets posted by anti-vaccination adherents and tweets posted by pro-vaccination adherents. In tweets on both sides of the discourse relatively more negative feeling words than positive feeling words were used. This contrasted with the expectation that anti- and pro-vaccination adherents would use different feeling words. However, this finding could be explained by the sense of in-group identity of both anti- and pro-vaccination adherents to which sentiments in their tweets related. More negative feelings words than positive feeling words were found on both sides of the discourse, because both anti- and pro-vaccination adherents often expressed negative attitudes towards the out-groups in their tweets.

According to the Increasing Vaccination Model (IVM), vaccination results from: 1) what people think and feel; 2) social processes; and 3) direct behaviour change (Brewer, 2021). The first proposition of this model is that what people think and feel motivates vaccination uptake. What people think and feel is expressed in sentiments, thus the IVM showcases the importance to study the subjectivity and polarity of vaccination tweets. In line with this model, strong subjectivity and polarity scores were found in the vaccination tweets. The second proposition of this model is that social processes motivate vaccine uptake. The IVM thus also showcases the importance to study social processes such as in-group identity. Therefore, the finding in the current study that in the collected vaccination tweets negative attitudes are expressed towards out-groups and positive attitudes are expressed towards in-groups is also in line with the IVM.

Strengths and Limitations

This study has revealed important insights into the sentiments that were expressed on the social media platform Twitter regarding the vaccination discourse. Studying the vaccination discourse online by using data collected from Twitter offered a unique

opportunity to research online vaccination rhetoric which could not be captured by using other research methods such as surveys or focus groups. In this study statements of anti- and pro-vaccination adherents could be researched in circumstances with a low degree of moderation and a high degree of anonymity which encouraged the explicitness of the statements. This study has revealed important insight into sentiments that are expressed in real-time online posts without interference of a researcher in the interaction between Twitter users. Moreover, by using Twitter as a source it was possible to combine web crawling and Twitter application programming to collect data from both the pro-vaccination side of the discourse and the anti-vaccination side of the discourse which gave the opportunity to compare differences between the two.

Another strength of this study was the interdisciplinarity which could be found in the combination of using concepts from the field of psychology as a theoretical framework and using qualitative methods to analyse the data to from a detailed understanding of how sentiments play a role in the vaccination discourse. The interdisciplinarity of this study was essential to further insight into the vaccination discourse in a way not available using research methods of only one discipline.

However, this study was not without limitations. The results from the collected tweets showed a snapshot of time. Sentiment regarding vaccination may change over time, longitudinal research should address reproducibility of this study. Another limitation was the limited number of both anti- and pro-vaccination tweets. Categorizing the subset of 2000 tweets resulted in 57 anti-vaccination tweets and 354 pro-vaccination tweets which could have implications for the replicability of this study and the generalizability of the tweets. It is unclear to which extent the limited number of collected tweets provides insight into the extensive vaccination discourse on Twitter. Future research is needed to address replicability

of this study. Future research may also include a larger sample of tweets to address generalizability of this study. Coding a larger number of tweets could be achieved by using an algorithm that can code tweets which can be developed based on the subset of tweets that is already coded manually.

Furthermore, to safeguard anonymity of the people posting the tweets and to avoid individuals becoming identifiable, an anonymized version of the data set was used. In this anonymized version of the data set for every selected tweet, the twitter handle and potential images or URLs the tweet referred to were extracted. The downside of safeguarding this anonymity was that interpretation of the tweets was more difficult because information in some tweets was missing such as images or links that were referred to, which made it harder to understand certain statements. Furthermore, the missing twitter handle made it impossible to follow threads and retrace the messages someone might have been responding to in their tweet. These threads could have been helpful to gain a better understanding of the statements made in the tweets regarding the vaccination discourse.

The possibility of researcher bias must also be considered in this type of research. Several safeguards were built into the design of this study to minimize the possibility of bias. The data collection was conducted systematically by using hashtags and keywords that ensured that both anti- and pro-vaccination tweets were taken into account. Throughout the process of coding the valence of the collected tweets, some tweets were more difficult to interpret and to determine whether they were pro- or anti-vaccination. Those tweets were discussed with several researchers to reach an agreement about the valence and to improve reliability. Furthermore, throughout the qualitative content analysis memos were kept, allowing for noting of surprising results and further reflection of those results.

Moreover, this study only focused on the vaccination discourse on Twitter. However, the online vaccination discourse is more extensive and also takes place on other social media platforms. On Twitter the number of characters people can use in their post is limited which influences the extensiveness of information in a post and may also have implications for the type of person that is attracted to make use of this platform. Other social media platforms may include posts with more extensive information and may attract another type of people which could provide insight into a different type of discussion. Therefore, it is important to be cautious about generalizing the results to the whole online vaccination discourse and to not draw general conclusions about anti- and pro-vaccination adherents. Future research may include data from other types of social media platforms such as social media platforms that allow people to post more extensive information.

Recommendations for Future Research

While this study has revealed insights into the sentiments that were expressed on Twitter, the results did not provide a complete view of the more extensive online vaccination discourse that also takes place on other social media platforms. In future research it would be interesting to collect data from other social media platforms such as Facebook or online discussion forums such as 4chan to examine whether sentiments regarding vaccination on other types of social media platforms are comparable to sentiments found on Twitter.

Moreover, while this study has revealed insights into the sentiments regarding vaccination that were expressed online, the question of how these sentiments relate to offline sentiments about vaccination and actual vaccination behaviour remains unanswered. Twitter users have the opportunity to stay anonymous by choosing their own twitter handle. By hiding behind anonymity, they are not subjected to society's social norms when expressing sentiments and making fierce statements in their tweets. An interesting step in future research

is to conduct in-depth interviews with anti- and pro-vaccination adherents to examine the influence of sentiments expressed in the online vaccination discourse on offline attitudes and behaviour.

Furthermore, in future research it would be a logical next step to collect tweets that are posted after the coronavirus outbreak. Following a global review of social and behavioural drivers of vaccination, it is proposed that neoliberal logic and social exclusion might interact to cause vaccine hesitancy regarding COVID-19 vaccination and vaccination in general (Wiysonge et al., 2021). It is argued that these concepts could help with monitoring changes and trends in vaccine hesitancy to detect vaccine concerns early. Global information exchange has been boosted by social media, leading to viral sharing of opinions and false information. It can be hard for the public distinguish whether something is true or not and to tell whether certain (false) risks only apply to COVID-19 vaccines or also apply to vaccines in general. Because the coronavirus and COVID-19 vaccines have been the centre of attention globally since the coronavirus outbreak, it should be considered that sentiments regarding vaccination in general might have changed. Therefore, it would be interesting to investigate the sentiments regarding vaccination against COVID-19 and regarding vaccination against other infectious diseases in tweets posted after 2019.

Implications and Recommendations for Policy and Intervention Practice

The findings of this study have important societal implications. This study showed that strong sentiments are expressed in the online vaccination discourse and that sentiments in anti-vaccination tweets were related to reactance. Strong sentiments expressed in anti-vaccination tweets can be problematic because social media platforms are increasingly important as a source of information and sources that include emotive appeals appear to be used in decision-making regarding vaccine uptake. Thus, such anti-vaccination messages presented online have the potential to negatively impact vaccine uptake.

Furthermore, as reactance is shown to lead people to resist social influence (Brehm & Sensenig, 1966) the relation of sentiments in anti-vaccination tweets to the presence of reactance expressed in their statements is an interesting finding. The reactance among anti-vaccination adherents makes it more likely that they will go to great extent to resist attempts of others to influence them making them hard to be persuaded to vaccinate themselves or their children. Reducing reactance among anti-vaccination adherents could be an effective intervention target.

According to the ICM, social processes that include constructs such as social norms, altruism and sharing through social media could be effective intervention targets to increase vaccination uptake. As this study shows, in the online vaccination discourse negative attitudes towards out-groups are often expressed. These negative attitudes towards the out-group follow from a strong in-group identity which could be a social process to target in interventions aimed at increasing vaccination uptake.

Conclusion

By analysing the sentiments expressed in the online vaccination discourse, this study showed that strong sentiments were expressed on Twitter in anti-vaccination tweets and in pro-vaccination tweets and that sentiments expressed by anti-vaccination adherents related to the presence of psychological reactance that follows from a strong sense of in-group identity. Thereby it increased insight into the relevance of social identity and reactance in the decision-making of anti-vaccination adherents. This study suggests that it is important to pay more attention to the vaccination discourse on social media platforms such as Twitter, because in today's digital world such platforms are important sources of information that people use to base their vaccination decisions upon.

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Appendix: Code tree

Name	Files	References
Anti-vaccination		
Feeling words		
Negative feeling words	1	23
Positive feeling words	1	3
In-group identity		
Negative attitude towards out-group	1	18
Positive attitude towards in-group	1	8
Reactance	1	13
Decisional freedom threatened	1	13
Anger	1	5
Psychological arousal	1	8
Pro-vaccination		
Compulsory vaccination	1	23
Feeling words		
Negative feeling words	1	56
Positive feeling words	1	17
In-group identity		
Negative attitude towards out-group	1	66
Positive attitude towards in-group	1	22