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DISPARITIES IN ANTI-VACCINE VIEWS: TWITTER CONTENTS ANALYSIS DURING WORLD IMMUNIZATION WEEK

by

Saleh Ibrahim Alzughaibi

A Thesis Submitted in

Partial Fulfillment of the

Requirements of the Degree of

Master of Science

in Health Care Informatics

at

The University of Wisconsin-Milwaukee

May 2020

ABSTRACT

DISPARITIES IN ANTI-VACCINE VIEWS: TWITTER CONTENTS ANALYSIS DURING WORLD IMMUNIZATION WEEK

by
Saleh Ibrahim Alzughaibi

The University of Wisconsin-Milwaukee, 2020
Under the Supervision of Jake Luo, PhD

The emergence of social media platforms provides an opportunity to exchange health-related information and express opinions on health-related issues. The researchers' adoption of social media contents in the health research domain is attributed to the easy accessibility of a large number of perspectives and views in limited time and less effort. The analysis of social media contents, such as Twitter, allows researchers to examine people's perceptions about specific crucial topics, such as vaccinations.

The researcher aims to collect and measure data on the current motivations and reasons for opposing vaccination and understand vaccine-skeptics claims against vaccines. This study presents a descriptive quantitative analysis of the contemporary claims against vaccines during the World Immunization Week 2019. The researcher collected 27266 vaccine-related tweets from April 24 – 30, 2019. These tweets were analyzed to characterize key terms and their connections, classified into pre-defined groups, and sentimentally analyzed to identify the anti-vaccine tweets.

The tweets analysis captures the anti-vaccine tweets and groups them into themes that were initially created after a manual scanning of a 6,000 tweet sample. The classification and sentiment analyses resulted in 4,181 tweets out of the collected tweets being distributed over eight themes of anti-vaccine views. The results highlight vaccine-skeptics perceptions and

motivations not to vaccinate their children. They also view the vaccine's biggest concern among posters which is worrying about vaccine's side effects. The analysis also reveals the anti-vaccine tweets timeline during the World Immunization Week, the top hashtags that were associated with the tweets, and the geo-location posting of these tweets worldwide.

The interdisciplinary study of health-related issues in Twitter leads to a better understanding of public concerns and views which will result in greater response to such critical health issues and find solutions to raise health awareness among societies. Advancing the knowledge of methods and patterns of social media contents analyses is becoming an essential tool for the public health domain. Working toward this goal, this study used emerging data analysis approaches to reveal opinions and views against vaccines from Twitter contents to help find solutions to this contemporary critical health issue.

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To

My parents,

My wife,

My two boys

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Introduction

Opposition to vaccinations is not a new concept. The first documented cases of it can be traced back to the early 19th century when anti-vaccination sentiments rose in cases such as opposition to the smallpox vaccine, controversies of the safety and efficacy of the diphtheria, tetanus, and pertussis (DTP) vaccine, the measles, mumps, and rubella (MMR) vaccine, and the use of a mercury in the vaccines as preservative (Wolfe & Sharp, 2002). Throughout history, anti-vaccination campaigns have occurred in many ways, for different reasons. Some people rejected vaccines because of the belief that vaccines do the body more harm than benefit, while others refused vaccines because of religious beliefs. Furthermore, some anti-vaxxers believed that vaccination risks outweigh the benefits which led many parents to express concerns about the medical risks of vaccines such as causing autism.

The World Health Organization (WHO) has described vaccines as the greatest public health achievement and an effective way to prevent diseases. Also, the WHO aims to build a free preventable-diseases society to save millions of children's lives worldwide (WHO, 2019a). In 2018, around 5.3 million children died from preventable causes such as pneumonia, diarrhea, and malaria, and more than half of these deaths could be prevented by vaccinations (WHO, 2018). Thanks to vaccines, many diseases have been eradicated and have almost disappeared globally such as smallpox and polio (Delany, Rappuoli, & De Gregorio, 2014). The vaccine's purpose is to prepare the body to resist the diseases faster and more effectively by training the body to fight very small amounts of weak or dead viruses, bacteria, or toxins which saves millions of lives every year (Wolfe & Sharp, 2002). However, some of the vaccines may cause minor to severe

side effects, such as, redness, soreness, and some may even cause comas and seizures. These side effects led some parents to worry about the safety of vaccines.

For these reasons, people started to raise their health concerns and worries about vaccines over different social media platforms. The platform Twitter, for example, has provided another opportunity for seeking health information. Many studies have shown an increase in the total number of people who are looking for answers for health-related questions and searching for other people's comments on their health issues over the Twitter platform. This increase in the use of Twitter as a health information source is attributed to many different factors. The way that Twitter platform allows users to reach individuals from diverse backgrounds and encourages people to be active participants, as well as providing the option to post a message and allow others to respond is what makes Twitter unique.

In the health research domain, the adoption of social media platforms in health research created an opportunity to reach a large number of perspectives and views in a limited amount of time and with less effort. Also, Twitter platform was used to spread awareness and knowledge during natural disasters and outbreaks, and to educate and correct misunderstandings regarding information about health-related topics. Currently, there is a rise in social media content analysis, such as Twitter, to explore online activities and their impacts on societies (Takhteyev, Gruzd, & Wellman, 2012). Social media contents have been utilized in many wide settings, such as detecting a real-time event and evaluating word-of-mouth communication on a topic (Sakaki, Okazaki, & Matsuo, 2010). Twitter data analysis gives researchers a better opportunity to explore and understand the current issue of any matter from people's perspectives.

Analyzing vaccine related tweets allows researchers to examine the anti-vaccine motivations to oppose vaccination. This study aims to collect the current reasons and causes that anti-vaxxers maintain against vaccines. The research uses tweets collected during the World Immunization Week 2019, which is the last week of April (April 24-30). This timeframe was chosen because many organizations such as the World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC), and others use this time to post educational tweets about the importance of vaccines. Therefore, many controversial responses to these posts would be expected from vaccine-skeptics.

The research objective of this study is to explore and measure anti-vaccine views on the Twitter platform. In order to pursue this goal, the researcher uses the collected tweets and narratively explores their contents to create categories. Later, text classification and sentiment analysis were performed in order to identify the anti-vaccine views among the collected tweets. A review of such posts on a public platform is likely to enhance our understanding of the critical role that social media platforms, such as Twitter, can play in health communication on issues such as opposition to vaccinations.

Therefore, this study reveals up-to-date insights of vaccine-skeptics views over refusing to vaccinate and also, emphasizes the powerful potential of using social media platforms as a surveillance tool for health communication and information exchange. This work contributes an analysis of tweets related to a particular health issue, as well as presenting different analytical approaches and mechanisms that can be applied to any study case.

Literature Review

- **Twitter Data Analytics:**

Twitter is a micro-blogging website that allows users to post a message, which is called a tweet. The tweeted message can be up to 280 characters long and can include links to other websites, videos, or images. Twitter, which was created in 2006, is considered as the largest micro-blogging service and the third-largest social network site after Facebook and YouTube (Parmelee & Bichard, 2014). By using these social media sites, Twitter and Facebook, users are encouraged to express thoughts, opinions, and a range of essential comments about events in their lives (Paul & Dredze, 2011). According to Twitter's logo, "what's happening in the world and what people are talking about right now," users need to follow others to create their Twitter feed and thus, know what is happening with the topics or people of interest to them (Twitter, 2014). Furthermore, Twitter users can be followed by others too. Being a follower or followed on Twitter means that the user receives all the tweets from those the user follows, and vice versa. However, the user can follow any other account's user. Still, the other user does not need to follow back, since unlike most other social media platforms, such as Facebook or MySpace, following or being followed not requires reciprocation (Kwak, Lee, Park, & Moon, 2010).

Kwak et al. (2010) depicted in their paper the basic typology for a tweet. A tweet could be a statement from the user or Mention by typing the @ symbol before the username when addressing a specific account. It also could be a Retweet which is resending a tweet of another user or a Reply by using @ followed by a user ID (Kwak et al., 2010). Simply stated, a Retweet is reposting action of another users' tweets in your

account. Boyd et al. (2010) described the Retweet as an email forwarding where a user sends messages that have already sent by others, and it is also "the act of copying and rebroadcasting" (Boyd, Golder, & Lotan, 2010).

Furthermore, tweets can include a hashtag (#) before a relevant keyword, phrase, or a topic on Twitter. According to Twitter website, the hashtag symbol (#) was created to categorize tweets and allows people to easily follow and find topics in the Twitter search (Twitter, 2018). The use of the hashtag symbol will help to facilitate users' search for topics of interest and follow the discussion thread of these topics (Larsson & Moe, 2012). Tagging a keyword or a topic will make it easily identifiable. Moreover, to help new users, the Twitter website offers a terms glossary to ease the understanding of various terms used on Twitter (Twitter Glossary, 2020). Table (1) shows some of these terms and their meanings.

The phenomenon of micro-blogging gives Twitter its unique feature because it facilitates easy sharing of messages within a social network. In comparison with other blogging websites, Twitter fulfills fast communication through shorter posts that required little time to write (Java, Song, Finin, & Tseng, 2007). Uniquely, posting a tweet does not require much effort and time from the user. Zhao et al. (2009) emphasized how Twitter being used differently than other social media. On Twitter, users frequently post brief updates about their personal life activities because the length of a tweet is limited and there is a minimal cost to sending or receiving tweets (Zhao & Rosson, 2009). The ability to quickly share interests and fun things happening is what gives Twitter the appearance of a quick and easy means of communication.

Currently, the use of social media platforms has reached its highest number in history - one in three people around the world uses social media platforms (Ortiz-Ospina, 2019). Undoubtedly, with the high use of these platforms and the amount of data generated there, they become an influence tool in people's lives. Around one billion Facebook users jointly spend 20,000 years online every day, whereas, on Twitter, 140 million users generated more than 340 million tweets (Fan & Gordon, 2014). This massive amount of data generated daily is helpful when collected and analyzed properly. By gathering and analyzing the data from social media platforms using specific tools, that will help to understand how people think about particular topics and for organizations and companies to make decisions regarding those topics. From a medical perspective, social media analysis can help understand people's perceptions about specific health topics.

The analysis of social media contents encompasses a three-step procedure that results in useful and helpful information. These steps include capture and gather, understand, and interpret and present the data (Fan & Gordon, 2014). These steps in the data analysis process will result in better decisions because the choices are supported by data that has been substantially collected and analyzed. The first stage is to gather and collect data from the sources. This step allows researchers to identify the interesting and relevant data needed which is done by collecting large amounts of relevant data on the platforms. Also, in this stage, pre-processing steps - such as data modeling and tagging - may be done to enhance and prepare the data for the following level (Fan & Gordon, 2014). Then the gathered data need to be understood. In the second stage, a series of works will follow each other to result in useful and understandable information. The

collected data may contain noisy data, which is additional meaningless data. When the data is cleaned, statistical processing occurs, wherein computational technique and other statistical methods are used to make conclusions from the data. Fan and Gordon (2014) affirmed that this stage is the core of the entire analytics process (Fan & Gordon, 2014). Moreover, after analyzing the data, it is finally the time to interpret and present the results. In this stage, the result of the analysis will be summarized and presented in a clear format. Researchers provide meaning to the collected data, determine the conclusions, and present the significance and implications of the findings. During data interpretation, data visualization, which is the presentation of result in a graphical format, could be used to understand the result better visually which help to understand difficult concepts or identify new patterns (Fan & Gordon, 2014).

Table 1: Twitter Terms Glossary

Twitter Glossary	
Term	Meaning
Follow	Subscribing to a Twitter account to receive tweets.
Follower	Another Twitter account that has followed you to receive your tweets in their home timeline.
Hashtag	Any word or phrase immediately preceded by the # symbol. Hashtags are clickable and can be searched.
Like	Liking a tweet indicates that you appreciate it.
Mention	Mentioning other accounts in your tweet by including the @ sign followed directly by their username is called a “mention”.
Reply	A response to another person’s tweet by clicking the reply icon next to the Tweet you'd like to respond to it.
Retweet	A tweet that you forward to your followers.
Tweet	A tweet is a massage that may contain photos, videos, and text (up to 280 characters).

- **Health Information on Twitter:**

Every day, there are more than 333 million tweets on Twitter from more than 140 million active users (Twitter, 2012). The social media platforms have changed people's relationships with how they seek health information. According to the Pew Research Center's report (2009), 61% of American adult internet users looked for answers for health-related questions and information online, and 41% of them searched for other people's comments on their health issues on the internet. Out of the 61%, around 40% used a social media platform to look for health information or post a health-related comment. On Twitter, 12% of the total adults shared health updates of themselves or saw updates about other people's health matters (Pew Research Center, 2009). Moreover, in an experiment conducted by Mark Dredze and Michael J. Paul to measure if Twitter platform is a useful source for public health information, they found that 1.5 million tweets are health matters from a total of 2 billion tweets that were posted between May 2009 and October 2010. Thus, they concluded that tweets are a useful source of health information (Paul & Dredze, 2011).

There are many features that allow Twitter to be an advantageous and effective source of health information. The first one is that, on Twitter, the readers are no longer passive. They can engage and interact with a tweet either by replying to it, retweeting it, or endorsing the tweet by liking or adding it to their favorites (Pershad, Hangge, Albadawi, & Oklu, 2018). Since users can participate in a discussion, it is more likely to show people's different views on specific topics. Moreover, according to Brady R.R.W and et al. (2017), on Twitter, users denote tweets for categorization purposes by hashtags - the pound sign (#) - which helps to consolidate tweets of the same topic (Brady et al.,

2017). This symbol could be a keyword or a phrase to reflect on the tweet's focus of discussion, topic, or theme. The hashtag automatically becomes a clickable link which helps users find all tweets that have the same particular hashtag. Another reason that makes Twitter a popular source of health information is that Twitter allows users to reach and deliver messages to a large group of audiences without exerting much effort or using much time (Park, Rodgers, & Stemmle, 2013). Moreover, Michael J. Paul and Mark Dredze stated that "Tweets are not isolated events." Every tweet occurs at a specific time, in a specific location, by a language, and for certain people.

Thus, collecting tweets from millions of users is a powerful research tool for public health (Paul & Dredze, 2011). Moreover, in comparison with other public health databases, Twitter is an efficient and cost-effective tool for accessing extensive quantities of data about the public for health research purposes (Sinnenberg et al., 2017). Although the characters of a tweet are limited, each tweet contains data and metadata that maximize the use of the tweet for researchers such as twitter's user language and geographic location (Finfgeld-Connett, 2015).

Due to the lack of funds and resources, the use of Twitter platform has increasingly been adopted by health researchers as a tool to gather information (Hart, Stetten, Islam, & Pizarro, 2017). In the health field, Twitter is used in many different ways (Finfgeld-Connett, 2015). Holt (2011), emphasized many examples of how Twitter has been used. In a hospital in the United States, Twitter was used as a tool for collecting feedbacks from former patients about their hospital experiences (Holt, 2011). Furthermore, Twitter was used to spread awareness during natural disasters. In 2009, The Center for Disease Control and Prevention adopted Twitter to distribute information

about H1N1 influenza, and the American Red Cross regularly posts updates in case of storms and natural disasters (Currie, 2009; Fisher & Clayton, 2012). Also, Twitter platform has played a significant role in many health research initiatives (Robillard, Johnson, Hennessey, Beattie, & Illes, 2013). For example, educating and correct mistaken information among the public about antibiotics use, and also, as syndromic surveillance by tracking influenzas epidemics through people's posts (Eysenbach, 2009; Scanfeld, Scanfeld, & Larson, 2010).

- **Vaccines:**

According to the World Health Organization (2019), "Vaccination is one of the most effective ways to prevent diseases." Vaccines save people's lives from diseases caused by viruses and bacteria by helping the body's immune system to identify and fight pathogens (WHO, 2019a). A vaccine contains minimal amounts of weak or dead viruses, bacteria, or toxins that prepares the body to fight diseases faster and more productive (Wolfe & Sharp, 2002). In 2018, around 5.3 million children died from preventable causes such as pneumonia, diarrhea, and malaria, and more than half of these deaths could be prevented by vaccinations (WHO, 2018). In the United States, the Centers for Disease Control and Prevention (CDC), on their website, divided vaccines to gropes: recommended and non-routine vaccines by disease, vaccines recommended by age, and vaccines recommended for travel (CDC, 2012). The CDC annually releases update recommended child and adolescent vaccines schedules from the birth to the age of 18 years (Appendix A and B), and also the diseases and vaccines that prevent them (Appendix C) (CDC, 2019a). Moreover, the CDC states on their website, that side effects could result from any vaccine. Most of the side effects are minor, for example, redness,

soreness, swelling, or fever, although some high-risk severe side effects may occur rarely, such as seizures, coma, or lowered consciousness (CDC, 2015).

- **Anti-Vaccination Movement:**

Since the 19th century, there has been a rise in anti-vaccination sentiments occurring against many different types of vaccine, including the smallpox vaccine, controversies regarding the safety and efficacy of the diphtheria, tetanus, and pertussis (DTP) vaccine, the measles, mumps, and rubella (MMR) vaccine, and the use of a mercury in the vaccines as a preservative (Wolfe & Sharp, 2002). These beliefs surround the fact that vaccines harm children more than benefit them. Between the 1870s and 1880s, a high number of anti-vaccination books and journals appeared, such as the National Anti-Compulsory Vaccination Reporter (1874), and the Vaccination Inquirer (1879) (Porter & Porter, 1988). Furthermore, the persistence of the anti-vaccine movement can be contributed to social media, celebrities, and television shows such as the Oprah Winfrey show, which played a role by spreading fear and supporting the anti-vaccine movement. This caused vaccination rates to suddenly drop (Hussain, Ali, Ahmed, & Hussain, 2018).

- **Skepticism to Vaccines:**

Many individuals are reluctant to vaccinate their children for many different reasons. In 2008, a study conducted on children in an elementary school in San Diego County, California, USA showed that 2.5% of the 39132 total children had not received their MMR vaccine due to personal-belief exemptions while 97% had at least one dose the vaccine (Glasser, Feng, Omer, Smith, & Rodewald, 2016). Although 2.5% seems low rate, those vaccine-rejecters may influence others by spreading their thoughts and alter

vaccine-accepters' opinions (Schmid, MacDonald, Habersaat, & Butler, 2018). Anti-vaxxers have their perceived fears which cause them not to accept vaccines and often cite numerous reasons for not vaccinating.

- **Expressing their right to choose:**

  Vaccine-skeptics claim that they are experts in their children's health and have the right to decide whether to vaccinate their children or not. Susan King (1999) argued that in developed countries, individual rights are highly valued, and the anti-vaccination movement was capitalized on the perspective of the individual (King, 1999). In addition, Robert Wolfe (2002), in his article *Vaccine safety activists on the Internet*, evaluated the contents of anti-vaccination websites and found that the motivations behind anti-vaccination movements were angry parents who felt that their children were damaged by a vaccine and also, the feeling that vaccine was mandated and not a choice, which interferes with the human right to choose medical treatment (Wolfe, 2002). Jennifer A. Reich (2016), in her book *Calling the Shots: Why Parents Reject Vaccines*, explained how many vaccine-skeptics argue that they have the authority to choose what is the best for their children regarding medical decision-making, and they understand their children needs better than physicians. Those parents conduct their own research on the ideal way to manage their children's health, not relying on their doctor's sound medical advice (Reich, 2016). The problem is that this information has no guarantee or evidence of being truly scientific or not. Parents want to be armed with the correct scientific information so that they can balance between the

benefits and risks when making a decision about vaccinating their children (Glanz, Kraus, & Daley, 2015).

- **The medical professional cannot be trusted:**

  Parent-pediatrician communications about vaccines can be considered as the first step needed for a trusting relationship. This discussion about vaccine benefits and side effects is a typical interaction approach (Ball, Evans, & Bostrom, 1998). However, this conversation does not always answer parent's questions, and pediatricians are not always open and trusting on this topic. A study showed that 39% of pediatricians do not accept a patient in their clinics whose parents denied vaccination (Flanagan-Klygis, Sharp, & Frader, 2005). This dismissiveness increases the gap of trust between parents and pediatricians. Moreover, vaccine- skeptics beliefs are often based on distrust of physicians' personal biases or medical research that may not be done on a sufficient number of participants, which affects the reliability of the research (Reich, 2016). A survey study on 1,752 individuals from the state of Oregon and 1,061 individuals from the state New Hampshire to measure the proportion of people who do not trust scientists regarding vaccines founded that 18% and 11%, respectively, did not trust scientists about vaccines (Hamilton, Hartter, & Saito, 2015).

- **Not to risk my child to save another child:**

  Susan King (1999) argued that individuals might refuse to vaccinate their children because the risk of adverse effects remain unchanged while the incidence rate of the disease becomes low with vaccines. Thus, it would be safer for a child to be protected by herd immunity because it leaves the child without risk from a

vaccine (King, 1999). This means that not everyone needs to be vaccinated to prevent diseases spread. The argument over children's health depends on vaccines in order to maintain public health and protect the community seems unconvincing to parents who believe that vaccines place their children at risk to save others (Reich, 2016). Despite the differences in parents' stand on vaccines, it may not be incorrect to have concerns about the risks that vaccines may cause. It is common to be worried about side effects such as allergies, although not everyone believes that vaccine can cause severe illness or death. Alongside such side effects, parents may feel pressure from governments or schools to expose their children to what they think is risky.

- **Artificial immunities and toxic ingredients:**

  Many arguments against vaccines doubt the unnatural development of immunity against diseases. According to the book, *Calling the Shots: Why Parents Reject Vaccines,* Joseph Mercola stated "There is a major difference between natural acquired immunity and vaccine- induced immunity. Obtaining natural immunity has far greater benefits, but this fact seems to be completely overlooked in the United States." This view has shaped parents' argument for avoiding vaccines (Reich, 2016). Although some anti-vaccine communities may recognize vaccines efficacy in preventing diseases, they feel that vaccines are not as natural as the "natural immunity" that is developed by the body when healing itself, and it upsets the natural immunity developing against diseases (Reich, 2016). Therefore, anti-vaccine proponents consider vaccines unnecessary and ultimately harmful to the body.

Moreover, a study conducted to measure parent's concerns about vaccine safety, surveyed 6,207 parents, and found that 35% of parents strongly questioned the safety of vaccine ingredients and want more information to ensure that they were safe to use (Shui, Weintraub, & Gust, 2006). Another study surveyed the perceptions of 376 parents or guardians who had one or more 6-year or younger children indicates that 26% of the total parents or guardians reported that the vaccine ingredients are not safe (Kennedy, LaVail, Nowak, Basket, & Landry, 2011).

According to the Food and Drug Administration (FDA), some vaccines contain Thimerosal, which is a mercury-containing organic compound, as a preservative in multi-dose vials of vaccines to kill or prevent the growth of microorganisms such as bacteria and fungi (United States Food and Drug Administration, 2018). On the other hand, Professor Boyd E. Haley, the Chair of the Department of Chemistry at University of Kentucky stated that it is impossible to determine the "safe level of mercury exposure" since the synergistic effect of other heavy metals, diet, and antibiotics increase the apparent toxicity of low levels of mercury (Haley, 2005). Therefore, there may be support for the argument that vaccines may contain some toxic ingredients.

- **Possibility of long-term side effects of vaccines:**

Doctors have noted that possibility that vaccines may have unknown side effects. These side effects could range from minor to severe, such as nausea or sudden infant death syndrome, however, they are not scientifically proven (Reich, 2016). One of the most publicized side effects that anti-vaccines cite is autism. In

1998, a physician published a hypothesis that the measles, mumps, and rubella (MMR) vaccine may cause the regressive autism-enterocolitis syndrome, which is an autism phenotype (Flaherty, 2011). As a result, parents refrained from vaccinating their children due to curtailment parents' confidence in vaccines. Later, in 2001, the Institute of Medicine concluded that there is no MMR vaccine-autism correlation (DeStefano & Thompson, 2004). However, this did not change many parent's beliefs. Another imagined side effect is that the diphtheria-pertussis-tetanus (DPT) vaccine causes permanent neurologic disability. This claim came about after parents alleged that the DPT vaccine caused mentally and physically disabling conditions to their children (Conis, 2013).

While many studies denied the relationship between the vaccine and any health complications (Reich, 2016), these two incidents still cause ongoing doubts by anti-vaccine parents, despite medical professionals attempts to clarify the side effects of the vaccines during doctor's visits.

- **The Capitalism of vaccine products:**

There has been a significant decrease in the total of vaccines manufacture companies. As of 2004, most of the world's vaccines are manufactured by only five companies, compared to 1967, when there were twenty-six and then again, when the total reduced in 1980 to seventeen companies (Offit, 2005). Recently, there were many issues related to manufacturing, such as contamination and miscalculations in production which led to vaccine shortages (Truong, 2012). In the United States, there have been criticisms against the production of medical products and vaccines, and the way that the Food and Drug Administration (FDA)

regulates them. These criticisms include the safety of the ingredients used in creating vaccines and the tests that must undergo before the FDA approves them for public use. This skepticisms includes the companies' economic profit motivations to investigate the vaccine's side effects that may occur (Reich, 2016). Moreover, parents believe that vaccine manufacturers are greedy and self-interested, and they will continue to refuse vaccinations to protect their children from unknown effects that might be caused by a lack of care from these companies. This argument was raised after a company increased the profit margin of a malaria treatment 5000%, brought into question how the pharmaceutical industry is regulated and the fact that economic benefits are sometimes weighed over health benefits (Mcneil, 2016).

- **The official vaccine schedule and its alternatives:**

  Many vaccine skeptics believe that the CDC official vaccine schedule has too many shots in a short time which may lead a child to be "immune-overload." This is because multiple vaccines are given in a single injection such as DTaP and MMR, and the child start receiving vaccines at a very early age (Hilton, Petticrew, & Hunt, 2006). Thus, in 2007, Dr. Robert Sears proposed two different vaccine schedules, alternative and selective, which offer parents a solution to avoid giving their child multiple vaccines at once. The first option is "Dr Bob's Selective Vaccine Schedule," which provides parents the choice to decline or delay vaccines such as MMR, varicella, hepatitis A, polio, and influenza vaccines, whereas the other option, "Dr Bob's Alternative Vaccine Schedule," is for parents who worry about their children having too many vaccines at a too early age. In

this schedule option, the influenza vaccine will not be given until five years, the hepatitis B vaccine until 2.5 years, and the measles vaccine until three years of age. The child will also visit the doctor every month in the first year, every three months in the second year, every six months until the age of 4 years, and at the age of 5 and 6 years (Offit & Moser, 2009). The vaccine schedule concerns are warranted. However, having an official schedule and proposed schedules increase the concerns and are not helping vaccine skeptics to make decisions.

- **The World Immunization Week:**

In the last week of April (April 24-30), the world celebrates World Immunization Week which aims to spread the vast benefits and promote the use of vaccines against diseases since immunization saves millions of lives each year. Every year, this celebration has a theme, and in the 2019 campaign, the theme was "#VaccinesWork" (WHO, 2019b). As a part of the campaign, the WHO, CDC and their partners aimed to explain vaccine's value for all children and communities, exhibit the importance of routine immunization to having universal health coverage, and protect the global against life-threatening contagious diseases (CDC, 2019b; WHO, 2019b).

Methodology

The purpose of this study was to examine, explore, and measure the anti-vaccine views that people expressed in their tweets on Twitter platform. Based on the literature review, many anti-vaccine views have been expressed throughout history. Therefore, the aim of this study is to explore and measure if the previous views are still being expressed and whether there are other perspectives against vaccines on the social media platform Twitter during a specific time range – the World Immunization Week. This chapter explains the design and approach of this study taken to answer the research question.

- **Research design:**

  The aim of this descriptive study was to quantitatively and sentimentally analyze the content of posted narrative anti-vaccine views (tweets) on the microblogging website Twitter during the World Immunization Week 2019, April 24-30, 2019. This time was chosen because this week serves as a global public health campaign to help spread awareness and raise rates of immunization against vaccine-preventable diseases worldwide and because of the high number of hashtags were created in that time frame. These hashtags were (#vaccineswork #vaccine #measles #worldimmunizationweek #vaccines #malaria #worldmalariaday #mumps #rubella). For the purpose of collecting the desired tweets, the researcher searched for any tweet that contains the word (Vaccine) and had been posted in that time span. The reason for choosing only this word was to cover most of the anti-vaccine related tweets.

  To answer the research question, a quantitative methodology has been used to explore and measure anti-vaccine views on Twitter. The quantitative research method uses statistical analysis techniques to analyze numerical data to answer the research

question and to generalize findings over a given population (Farrelly, 2013). According to Landrum and Garza (2015), a quantitative researcher employs statistical techniques to reform and answer a complex research question into a number of variables. Using a quantitative research method reduces the researcher subjectivity since this method contains a sample population that represents a larger one (Landrum & Garza, 2015).

Generally, quantitative research is conducted by collecting data, models, and measurements, then determining and comparing the study's variables that are to be represented in data by statistical tests (Martin & Bridgmon, 2012). In this study, the dependent variable has been defined as (anti-vaccine tweets) while the independent was (anti-vaccine views classes). The researcher determined both the dependent and independent variables after inspecting the data manually.

- **Data collection:**

There are many ways to collect Twitter data. One of these ways is by using the Twitter Application Programming Interface (API) platform which provides access to public information on Twitter – this service requires registering an application request on the Twitter Developer website. Through Twitter APIs, the user will have access to users' accounts, tweets, and replies, although this service places limits on the amount of data that users can download, and the cost is relatively high.

In this study, a third-party API service was used to collect the required tweets. The service was provided by Vicinitas which is a website that helps to track hashtags, keywords, and accounts on Twitter, and download real-time and historical tweets using a user-specified set of parameters such as keywords, language, and time ("Vicinitas : Twitter Analytics Tool for Tracking Hashtags, Keywords, and Accounts," 2020). The

service retrieves the actual tweet content as well as its metadata, including information such a tweet's time, location, language, number of retweets and favorites, and username in CSV format.

Vicinitas was used to retrieve tweets from Twitter through searching the term (vaccine) in the given time frame (April 24-30, 2019) and only in the English language. Using these parameters, a total of 27266 tweets were collected, including their metadata, timestamps, and locations. This total is the tweets that have the word (vaccine) in its content, whether it was a pro-vaccine tweet, a normal tweet, or an anti-vaccine tweet. However, text classification is needed to filter the total tweets and determine which are the anti-vaccine tweets.

- **Data sampling and pre-processing:**

The targeted tweets in this study were any anti-vaccine tweet that had been posted on the Twitter platform during World Immunization Week 2019 between April 24 - 30, 2019. These tweets are, for example, any tweet that may support a no-vaccination stance, claiming an issue is caused by vaccines, or against vaccine companies. After collecting the total tweets, 27266 tweets, using Vicinitas website services, the researcher collected a purposeful sample using a random sampling technique. The researcher chose purposive sampling because it will allows for text classification that excludes unwanted tweets which are, in this case, the pro-vaccine, normal, and irrelevant tweets. The purpose of random sampling is to minimized tweets selection bias (Watson, 2015). Therefore, the researcher used random purposive sampling to increase the accuracy of tweets classification.

Before conducting text classification and sentiment analysis, the researcher scanned manually a total of 6000 tweets evenly distributed out of the 27,266 tweets. This random purposively sampling was chosen according to the following: the whole (27,266 tweets) was divided into three thirds, and 2,000 tweets were scanned from each third. After scanning the sample, the researcher chose and collected anti-vaccine tweets that appeared in the 6,000 tweet-sample, then placed them into groups that share the same theme. These themes were created by the researcher based on the literature review and the result of the scanned tweets. From the scanned tweets, a total of 504 tweets were categorized as anti-vaccine tweets (Table 2). The resulted sample was distributed into groups that share the same theme (Table 3). Later, a list of common words was collected from tweets in each group for a text classification process (Table 4). The researcher collected these words without any modification based on factors such as the word relation and meaning to the theme.

Table 2: Scanned Tweet Themes Result

Theme	**Number of tweets from the sample**
Expressing the right to choose	82
Not to risk my child to save another child	3
Contain toxic ingredients	34
Long-term side effects of vaccines	254
The Capitalism of vaccine products	30
The official vaccine schedule and its alternatives	6
Concern about efficacy or safety	84
Concern about other ingredients	11
Total	504

Table 3: Themes Tweet-Samples

Theme	Tweet sample
Expressing the right to choose	I MAY NOT AGREE WITH EVERYTHING RICHIE HAS TO SAY BUT I AGREE 100% THAT SCIENCE IS A LIE. I WILL NOT GET ANY VACCINE. IT IS MY RIGHT TO REFUSE. IF OVER MY DEAD BODY, THEN SO BE IT. SO EVERYONE, TO INCLUDE POTUS TRUMP, HAS BEEN PUT ON NOTICE FOR NO VAXXING
Not to risk my child to save another child	If you believe force vaccinating children who are susceptible to vaccines is "for the well being of others" your not human, your a monster. Your child might get measles which kills less than 0.2 percent of those who catch it. My child WILL die if you force vaccines. #Vaccine
Contain toxic ingredients	Do you still think vaccines are safe? Even when they contain mercury, aluminum, MSG and formaldehyde? https://t.co/bqNcvHdQ3y
Long-term side effects of vaccines	Tetanus Vaccine Causes a New Disease Known as Antiphospholipid Syndrome - sabelmouse: The vaccine junta is... https://t.co/NBwq5IR1gf
The Capitalism of vaccine products	Ahhmmmm it isn't one in a million chance of severe reactions to a vaccine. Do your homework dr. Oh yeah your paid by the big pharm people. My bad, I forgot. https://t.co/AGJkv6DtnM
The official vaccine schedule and its alternatives	Why the list of vaccine varies between government and private hospitals? @MoHFW_INDIA #ProtectedTogether #VaccinesWork #SwasthaBharat
Concern about efficacy or safety	"There are unanswered questions about vaccine safety. We need studies on vaccinated populations based on various

	schedules and doses as well as individual patient susceptibilities that we... https://t.co/n9ujJJJVTS
Concern about other ingredients	This article states that the MMR vaccine is created using the cells from aborted babies: "The MMR vaccine contains a live attenuated measles virus that is grown in . . ., which are self-replicating culture mediums derived from 2-4 month old aborted fetal lung cells." HORRIBLE!! https://t.co/O1GGpaF5J7

Table 4: List of Common Words of Each Theme

Theme	Words
Expressing the right to choose	mandatory, my right, mandates, refuse, our bodies, our choices, choice, compulsory, freedom, forced, not getting, mindful, requirement, no vaccine
Not to risk my child to save another child	die, risk, lives
Contain toxic ingredients	poison ,cancer, ingredient, thimerosal, toxin, mercury, aluminum, MSG, formaldehyde, anti-fertility, metals, adjuvant, propylene glycol, toxicant
Long-term side effects of vaccines	vaccine injurie, injure, kill, neurological, death, sterilization, paralysis, die, autism, antiphospholipid, syndrome, hashimoto, AIDS, cancer, measles, side effect, infertility, dying, sick, autoimmune, paralysed, paralyzed, mumps, liver, measles, ALS, shingles, damage, risk, adverse reaction, seizure, hearing loss, sterilize, worst, caused by, danger, suffer, menopause
The Capitalism of vaccine products	politics, government, regulation, company, profits, liability, corrupt, drug company, distrust, money, fraud, big pharma, conspiracy, confidence, lie, pharma company, sued, sue
The official vaccine schedule and its alternatives	schedule, list, varies, vary
Concern about efficacy or safety	effectiveness, hoax, failure, ineffective, efficacy, scam, lie, working, safety, clinical trial, increase, unsafe, fallacy, safe, effective, benefit, not tested, testing, lab rats
Concern about other ingredients	aborted baby tissue, aborted babies, fetal lung cell, E. coli, human diploid cell, aborted human fetus, monkey kidney cell

Data analysis:

In this study, the researcher conducted a descriptive analysis of the anti-vaccine tweets that were posted during the World Immunization Week 2019. This study shows major statistics about the tweets, including geographic location of the post and tweets' post timeline, as well as, hashtags associated with these tweets. The analysis, also, explains statistics about tweets after the initial classification into eight groups, word frequencies as well as sentiment analysis for the tweets.

- **Text Classification:**

  Text classification, also known as text categorization or text tagging, is the process of assigning a set of pre-defined categories (tags) to a set of unstructured text according to its content. It is used for understanding text automatically because manual text processing is time-consuming and less efficient. Thus, it could be used to replace human decision-makers in order to increase the overall efficacy of the classification process (Miner et al., 2012).

  There are three different approaches to automatic text classification: rule-based systems, machine learning-based systems, and hybrid systems. The rule-based system approach classifies text into groups using a set of linguistic rules. Using this approach limits the chance of obtaining a false positive since it uses a set of defined rules, which is, in this study, the list of words. The second approach is a machine learning-based system, which is a way of classifying text based on past observations instead of manually crafted rules (list of words). By using examples as training data, the approach compares the input text with the training texts included previously in the model. Furthermore, the third approach is the

hybrid system model. This model combines the rule-based system and machine learning-based system approaches, which are used to improve the output result. This approach uses both training text examples and classification of pre-defined rules (Miner et al., 2012).

In this study, the text classification was done by using the MeaningCloud text analytics platform which is a software product that provides APIs that enable users to extract insights from any multilingual unstructured sources. The text classification solution in MeaningCloud is an automated document classification that assigns one or more categories to a text using standard domain-specific taxonomies or user-defined categories. This algorithm combines statistical document classification (machine learning-based) with rule-based filtering in order to obtain a high degree of accuracy and flexibility in a wide range of applications. MeaningCloud text analytics could be integrated into Microsoft Excel (Add-in) to easily embed a text analytics functionality into spreadsheets ("Text Analytics – MeaningCloud text mining solutions," n.d.).

For building a text classification model, the researcher created eight categories, and every category included a label (tag) and a code (univocal identification within the model) associated with it. After that, the researcher specified the classification criteria for this study, which meant applying a hybrid model technique that include a list of words and tweets' examples that resulted from the scanning stage (Figures. 1,2). After applying the model to the total tweets (27,266 tweets), it classified the tweets into the eight categories and added one category which represents tweets that did not follow these themes which, in

this case, was tweets that contained normal or pro-vaccine contents. Moreover, MeaningCloud tool provides a stop words list to eliminate unimportant words for the classification process.

Figure 2: Text Classification Categories

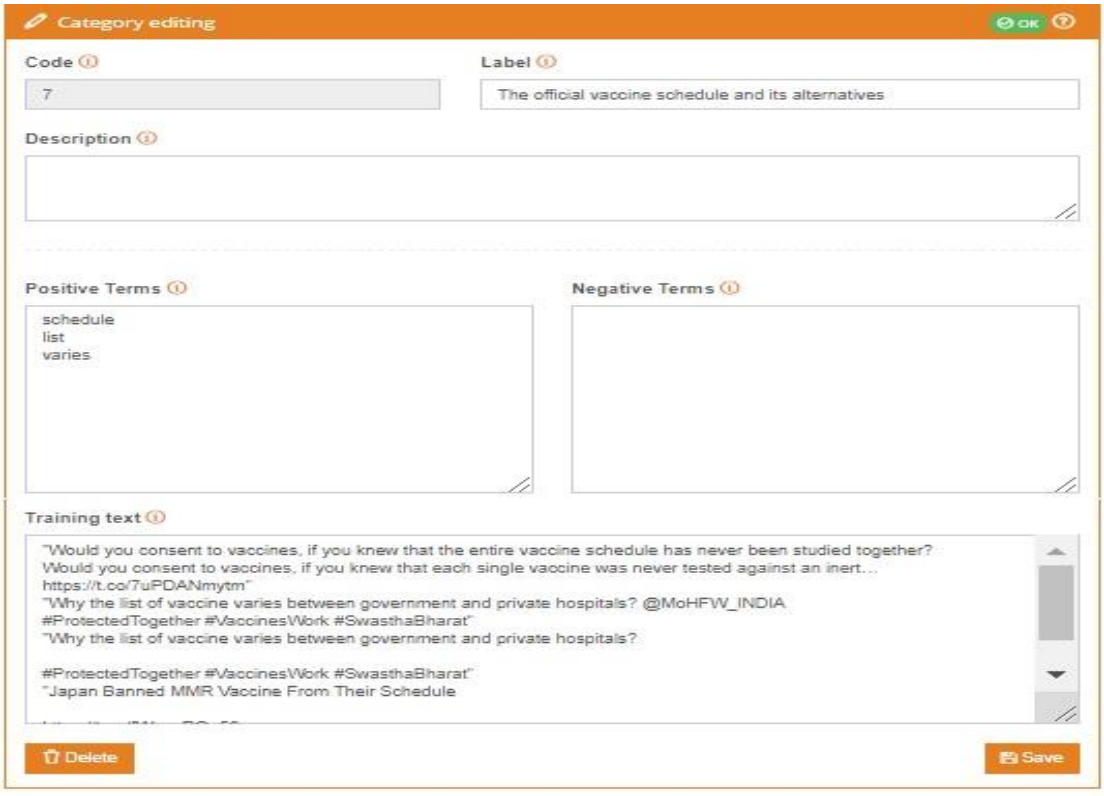

Figure 1: Text Classification Category Editing

- **Sentiment Analysis:**

Sentiment analysis (also known as opinion mining) is the study and analysis of people's opinions, sentiments, emotions, and evaluations from written format sources. This analysis is an automated process of classifying people's opinions as positive, neutral or negative from text data (Liu, 2012). Sentiment analysis is the part of research that allows researchers to determine people's opinions toward different topics and events. According to Liu, B. (2015), the term sentiment analysis has many similar terms that refer to its meaning which all serve similar purposes such as "sentiment analysis, opinion mining, opinion extraction, sentiment mining, subjectivity analysis, affect analysis, emotion analysis, review mining." However, in research, the term sentiment analysis is better known than other terms (Liu, 2015).

There are two main approaches for performing sentiment analysis. The first is the lexicon-based approach which detects the sentiment by calculating the polarity of a given word in a text. In this approach, a dictionary (lexicon) of words associated with the polarities is required to calculate the sentiment score by computing the average of words polarities in the text (Turney, 2001). In sentiment analysis, determining the polarity of words is a crucial and essential task in text categorization and review analysis. The second approach is machine learning-based which is sentiment supervised classification. In this technique, training and testing sets are required: a training set is required for an automated classifier to differentiate between the characteristics of a document, whereas a testing set is designed to evaluate how the classifier works (S. M. Vohra & Teraiya, 2012).

In this study, the researcher used the Microsoft Azure Machine Learning (ML) Studio to perform the sentiment analysis for the tweets dataset. Azure ML Studio is a cloud-based service that can be used in building, testing, and deploying analysis solutions. It provides web service models such as text sentiment analysis API that can be easily integrated and used by Microsoft Excel (Fig. 3) ("What is ML Studio (classic) - Azure | Microsoft Docs," n.d.). This text sentiment analysis API tool is useful for detecting positive, natural, and negative sentiment in Twitter posts by evaluating text data and returning sentiment labels for each tweet. This tool model uses a machine-based learning classification algorithm associated with a pre-trained extensive subjectivity lexicon. This lexicon includes 5,097 negative and 2,533 positive words that are assigned to a strong or weak polarity ("Perform sentiment analysis with Text Analytics REST API - Azure Cognitive Services | Microsoft Docs," n.d.). By applying this tool to the total tweets data, it sentimentally analyzes each tweet as positive, neutral, or negative based on its content (Fig. 4).

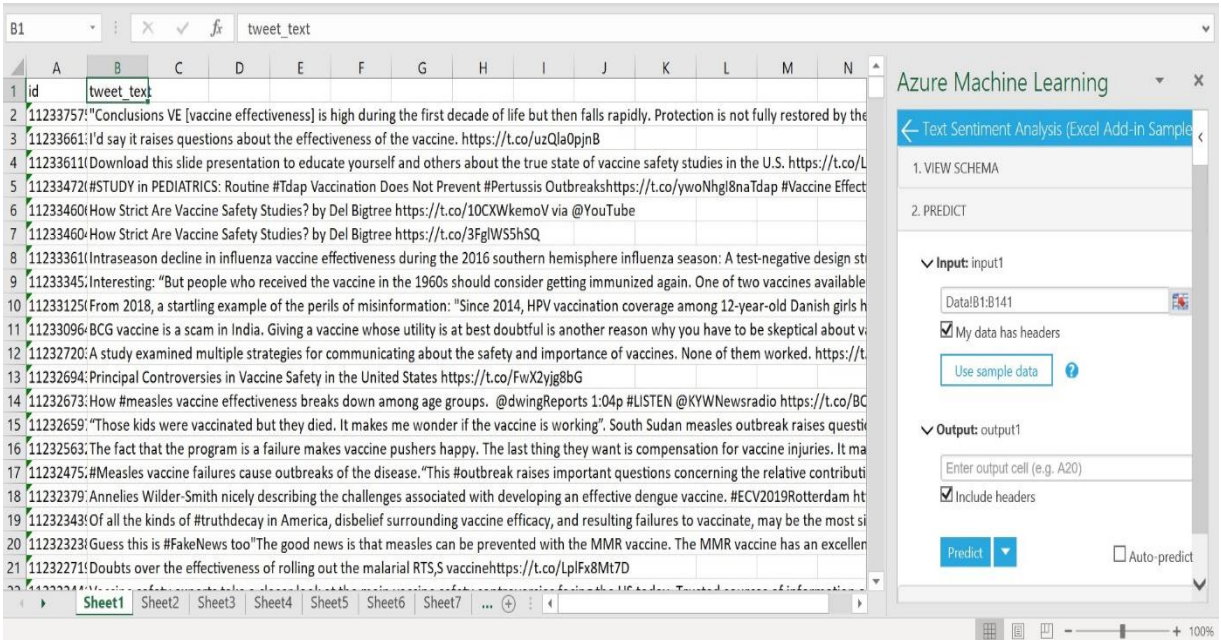

Figure 3: Azure Machine Learning Sentiment Analysis Tool

	A	B	C	D
1	Tweets	Sentiment	Score	
2	"Conclusions VE [vaccine effectiveness] is high during th	negative	0.098039	
3	I'd say it raises questions about the effectiveness of the	positive	0.677909	
4	Download this slide presentation to educate yourself ar	neutral	0.535842	
5	#STUDY in PEDIATRICS: Routine #Tdap Vaccination Does	negative	0.211587	
6	How Strict Are Vaccine Safety Studies? by Del Bigtree ht	neutral	0.541729	
7	How Strict Are Vaccine Safety Studies? by Del Bigtree ht	positive	0.671645	
8	Intraseason decline in influenza vaccine effectiveness d	positive	0.656205	
9	Interesting: “But people who received the vaccine in the	neutral	0.51611	
10	From 2018, a startling example of the perils of misinforr	neutral	0.576893	
11	BCG vaccine is a scam in India. Giving a vaccine whose u	neutral	0.552083	
12	A study examined multiple strategies for communicating	neutral	0.545483	
13	Principal Controversies in Vaccine Safety in the United S	neutral	0.554465	
14	How #measles vaccine effectiveness breaks down amor	positive	0.696935	
15	“Those kids were vaccinated but they died. It makes me	negative	0.048254	
16	The fact that the program is a failure makes vaccine pus	negative	0.420038	
17	#Measles vaccine failures cause outbreaks of the diseas	neutral	0.539961	
18	Annelies Wilder-Smith nicely describing the challenges a	neutral	0.53076	
19	Of all the kinds of #truthdecay in America, disbelief surr	neutral	0.531786	
20	Guess this is #FakeNews too"The good news is that mea	negative	0.143731	
21	Doubts over the effectiveness of rolling out the malarial	neutral	0.585382	
22	Vaccine safety experts take a closer look at the main va	positive	0.735941	
23	If only we had a safe vaccine about which there was no	positive	0.650933	
24	#Pakistan: Deaths follow wave of rumours and a hoax v	neutral	0.539821	
25				

Figure 4: Tweets Sentiment Analysis Result Example

- **Summary:**

The purpose of this quantitative descriptive study was to define and measure anti-vaccine posts on the Twitter platform. The researcher gathered and scanned tweets that mentioned the word (vaccine) during the World Immunization Week to create groups for tweet classification. The researcher then used two tools to analyze and specify anti-vaccine tweets from the sum of tweets which resulted in eight groups of classified anti-vaccine tweets.

Result

The purpose of this study was to explore and measure anti-vaccine views on Twitter. This chapter presents descriptive findings of anti-vaccine tweets using text classification and sentiment analysis tools to address the research objectives. Given the collected data, all of the tweets for this study included the word vaccine, were in the English language, and posted during the World Immunization Week 2019. The total of tweets collected using these criteria was 27266 tweets. After scanning a sample of 6000 tweets, the researcher created a list of classes using the literature review as well as the scanned results. These classes were used to categorize and classify the total collected tweets based on words and tweets sample resulted from the scan process.

- **Tweets classification:**

  After classifying the tweets by using the MeaningCloud platform, a total of 12997 out of the 27266 tweets (47.66 %) were classified as anti-vaccine tweets into eight groups by using a hybrid system model. A combined model of rule-based system and machine learning-based system approaches by using both training text examples and classification pre-defined words. Before classification, each group was previously assigned to a list of words and tweet's examples. This classification tool classified, assigned, and tagged each tweet to its belonging group. Table (5) depicts the total number of tweets in each group. The following tables below describe the classified groups with tweets examples and dominant terms in each group.

Table 5: Tweets Total in Each Theme

Group	Tweets Number	Percentage
Expressing the right to choose	987	7.59%
Concerns about efficacy or safety	619	4.76%
Concerns about other ingredients	9	0.069%
Contain toxic ingredients	507	3.90%
Long-term side effects of vaccines	9601	73.87%
Not to risk my child to save another child	341	2.62%
The Capitalism of vaccine products	742	5.70%
The official vaccine schedule and its alternatives	191	1.46%
Total	12997 tweets	100%

Table 6: Expression the Right to Choose Not to Vaccinate Theme

Expression the right to choose not to vaccinate	
987 tweets out of 12997 (7.59%)	
Tweets examples	The top 20 terms
Mr. President, why aren't you doing something about the vaccine situation? We are counting on YOU to protect our children from forced medical procedures. WHERE ARE YOU!? Mandatory vaccines are a human rights violation. Help us!	word frequency vaccine 910 mandates 334 children 278 japan 271 healthier 233 mmr 216 way 195 leads 195 freedom 143 medical 124 vaccines 106 health 98 forced 83 vaccination 73 measles 70 mandatory 65 choice 62 people 49 amp 43 state 42
Japan Leads the Way: No Vaccine Mandates and No MMR Vaccine = Healthier Children • Children's Health Defense	
WTF is going on with the vaccine debate? Apparently, those calling for mandatory vaccines 'know science' whereas so called 'anti-vaxxers' are idiots who spread dangerous 'disinformation.' Are there really only two positions to take?	
Vaccine mandates are OBEDIENCE training for mass euthanasia https://t.co/rS5hPFpypi	

Table 7: Concerns About Efficacy or Safety of Vaccines Theme

<table>
<tr><th colspan="2">Concerns about efficacy or safety of vaccines</th></tr>
<tr><td colspan="2">619 tweets out of 12997 (4.76%)</td></tr>
<tr><td>Tweets examples</td><td>The top 20 terms</td></tr>
<tr><td>"Conclusions VE [vaccine effectiveness] is high during the first decade of life but then falls rapidly. Protection is not fully restored by the teenage booster. Our findings are consistent with the localized outbreaks we observe in high school children.."</td><td rowspan="6"><table>
<tr><th>word</th><th>frequency</th></tr>
<tr><td>vaccine</td><td>496</td></tr>
<tr><td>safety</td><td>159</td></tr>
<tr><td>effective</td><td>124</td></tr>
<tr><td>malaria</td><td>100</td></tr>
<tr><td>vaccines</td><td>87</td></tr>
<tr><td>safe</td><td>68</td></tr>
<tr><td>health</td><td>68</td></tr>
<tr><td>testing</td><td>65</td></tr>
<tr><td>first</td><td>48</td></tr>
<tr><td>effectiveness</td><td>45</td></tr>
<tr><td>world</td><td>43</td></tr>
<tr><td>new</td><td>43</td></tr>
<tr><td>research</td><td>40</td></tr>
<tr><td>amp</td><td>39</td></tr>
<tr><td>begins</td><td>38</td></tr>
<tr><td>efficacy</td><td>36</td></tr>
<tr><td>widespread</td><td>36</td></tr>
<tr><td>working</td><td>35</td></tr>
<tr><td>vaccineswork</td><td>35</td></tr>
<tr><td>tested</td><td>32</td></tr>
</table></td></tr>
<tr><td>I'd say it raises questions about the effectiveness of the vaccine.</td></tr>
<tr><td>BCG vaccine is a scam in India. Giving a vaccine whose utility is at best doubtful is another reason why you have to be skeptical about vaccine fundoos like @chitrasd</td></tr>
<tr><td>“Those kids were vaccinated but they died. It makes me wonder if the vaccine is working”.
South Sudan measles outbreak raises questions about vaccines</td></tr>
<tr><td>FYI:
Vaccines are a hoax 🖊
& vaccine induced herd immunity is a MYTH! 🐑
😂🤣😳</td></tr>
</table>

Table 8: Concerns About Other Ingredients in Vaccines Theme

<table>
<tr><th colspan="2">Concerns about other ingredients in vaccines</th></tr>
<tr><td colspan="2">9 tweets out of 12997 (0.069%)</td></tr>
<tr><td>Tweets examples</td><td>The top terms</td></tr>
<tr><td>Open up the instagram about the aborted baby tissue in vaccine. https://t.co/89JS7zTbzJ</td><td rowspan="4"><table><tr><th>word</th><th>frequency</th></tr><tr><td>aborted</td><td>6</td></tr><tr><td>vaccine</td><td>6</td></tr><tr><td>babies</td><td>5</td></tr><tr><td>pray</td><td>4</td></tr><tr><td>mmr</td><td>4</td></tr><tr><td>cells</td><td>3</td></tr><tr><td>tissue</td><td>1</td></tr></table></td></tr>
<tr><td>This article states that the MMR vaccine is created using the cells from aborted babies: "The MMR vaccine contains a live attenuated measles virus that is grown in . . ., which are self-replicating culture mediums derived from 2-4 month old aborted fetal lung cells." HORRIBLE!!</td></tr>
<tr><td>Pray for the aborted babies being used for vaccine science and pray for the babies being injected with them. Pray for the families of those that will be injured by promoting the MMR. @POTUS @FLOTUS @VP @realDonaldTrump @IvankaTrump @SecretaryCarson</td></tr>
<tr><td>#liberty #vaccineinjuryisreal #separationofstateandpharma Are you kidding me?! @realDonaldTrump Shame on you for promoting a vaccine that is created from aborted babies!</td></tr>
</table>

Table 9: Vaccines Contain Toxic Ingredients Theme

<table>
<tr><th colspan="2">Vaccines contain toxic ingredients</th></tr>
<tr><td colspan="2">507 tweets out of 12997 (3.90%)</td></tr>
<tr><td>Tweets examples</td><td>The top 20 terms</td></tr>
<tr><td>Dr. Robotnik: I am not anti-vaccine. I am anti-thimerosal, anti-mercury. They have taken some of the mercury laden thimerosal out of vaccines. NOT ALL!</td><td rowspan="5"><table>
<tr><th>word</th><th>frequency</th></tr>
<tr><td>vaccine</td><td>391</td></tr>
<tr><td>cancer</td><td>290</td></tr>
<tr><td>colorectal</td><td>151</td></tr>
<tr><td>phase</td><td>138</td></tr>
<tr><td>human</td><td>130</td></tr>
<tr><td>trials</td><td>115</td></tr>
<tr><td>first</td><td>107</td></tr>
<tr><td>success</td><td>98</td></tr>
<tr><td>mercury</td><td>47</td></tr>
<tr><td>via</td><td>40</td></tr>
<tr><td>vaccines</td><td>39</td></tr>
<tr><td>novel</td><td>35</td></tr>
<tr><td>flu</td><td>35</td></tr>
<tr><td>aluminum</td><td>30</td></tr>
<tr><td>results</td><td>30</td></tr>
<tr><td>shows</td><td>30</td></tr>
<tr><td>positive</td><td>29</td></tr>
<tr><td>hpv</td><td>27</td></tr>
<tr><td>new</td><td>27</td></tr>
<tr><td>safe</td><td>27</td></tr>
</table></td></tr>
<tr><td>Do you still think vaccines are safe? Even when they contain mercury, aluminum, MSG and formaldehyde?</td></tr>
<tr><td>Flu vaccine contains 25,000 times more mercury than is legally allowed in drinking water</td></tr>
<tr><td>#DATALOVE! I’m a Mom raising a 29yr old vaccine injured autist here! Ummm pretty sure aluminum was in the MMR along w/many other toxic ingreds that changed his life forever!We both know the CDC HAS NEVER TESTED ANY VACCINE INGREDIENT for efficacy or safety! 🆘#believemoms!ᴜs#maga</td></tr>
<tr><td>Dirty Vaccines: Every Human Vaccine Tested Was Contaminated With Metals and Debris in New Study</td></tr>
</table>

Table 10: Long-Term Side Effects of Vaccines Theme

<table>
<tr><th colspan="2">Long-term side effects of vaccines</th></tr>
<tr><td colspan="2">9601 tweets out of 12997 (73.87%)</td></tr>
<tr><td>Tweets examples</td><td>The top 20 terms</td></tr>
<tr><td>2019 DOJ Report on Vaccine Court Reveals Vaccines Continue to Injure and Kill People: $110 MILLION in Damages Paid Out First Quarter</td><td rowspan="7"><table>
<tr><th>word</th><th>frequency</th></tr>
<tr><td>vaccine</td><td>7044</td></tr>
<tr><td>measles</td><td>6082</td></tr>
<tr><td>get</td><td>1090</td></tr>
<tr><td>children</td><td>1055</td></tr>
<tr><td>people</td><td>1031</td></tr>
<tr><td>people</td><td>1031</td></tr>
<tr><td>born</td><td>961</td></tr>
<tr><td>via</td><td>923</td></tr>
<tr><td>mmr</td><td>865</td></tr>
<tr><td>outbreak</td><td>698</td></tr>
<tr><td>cases</td><td>662</td></tr>
<tr><td>autism</td><td>554</td></tr>
<tr><td>health</td><td>502</td></tr>
<tr><td>mumps</td><td>421</td></tr>
<tr><td>shingles</td><td>407</td></tr>
<tr><td>deaths</td><td>313</td></tr>
<tr><td>risk</td><td>285</td></tr>
<tr><td>child</td><td>234</td></tr>
<tr><td>campaigns</td><td>231</td></tr>
<tr><td>banning</td><td>229</td></tr>
</table></td></tr>
<tr><td>HPV vaccine carries 25% chance of lifelong sterilization, study finds</td></tr>
<tr><td>Shingles vaccine responsible for causing huge number of shingles cases, vaccine injuries</td></tr>
<tr><td>“Mass Sterilization”: Kenyan Doctors Find Anti-fertility Agent in UN Tetanus Vaccine | Humans Are Free</td></tr>
<tr><td>COURT DOCUMENTS SHOWING MMR CAUSED AUTISM: RETWEET
Vaccine Court Awards Millions to Two Children With Autism https://t.co/4ASDDoUZD9 via @HuffPostLife</td></tr>
<tr><td>Remember: Vaccines can cause serious health problems
including brain inflammation and autoimmune disorders, allergies, ear infections, and more
There's a strong association between vaccine complications,...</td></tr>
</table>

Table 11: Not to Risk My Child to Save Another Child Theme

Not to risk my child to save another child	
341 tweets out of 12997 (2.62%)	
Tweets examples	The top 20 terms
If you believe force vaccinating children who are susceptible to vaccines is "for the well being of others" your not human, your a monster. Your child might get measles which kills less than 0.2 percent of those who catch it. My child WILL die if you force vaccines. #Vaccine	
People absolutely need to be vaccinated. I got mine as a child and the measles vaccine helped save my life. My children got there shots and no ill effects. Get your kids vaccinated, it could very well save there lives.	
Start here.-No medication is 100% safe for all pops. & studies r being conducted to identify what may increase your child's susceptibility.--Is MY Child at Risk for Vaccine-Injury?	
My Child Is Vaccine Free Because Vaccines Carry Risk https://t.co/Njc35SsRPL	
"Both unvaccinated and vaccinated individuals are at risk from exposure to those recently vaccinated. Vaccine failure is widespread; vaccine-induced...	

word	frequency
vaccine	247
lives	196
save	97
children	85
vaccines	85
vaccineswork	72
malaria	49
people	48
risk	41
amp	41
worldimmunizationweek	41
health	39
protect	37
world	35
year	32
million	31
vaccinated	30
die	29
immunizations	29
public	26

Table 12: The Capitalism of Vaccine Products Theme

The Capitalism of vaccine products	
742 tweets out of 12997 (5.70%)	
Tweets examples	The top 20 terms
They cant afford to admit the truth, government is liable for all vaccine injuries... that's thousands and thousands of damaged children. Ask the parents, they know.	
The way vaccines are packaged and distributed is often driven primarily by politics and government regulation — and not by medical concerns. | @ryanmcmaken	
big pharma might want to consider a measles only vaccine if they really care about health. medical community needs to push them to more responsibility or anti vax fever will keep growing and kids will die :(https://t.co/FmRNemfyzb	
CDC Blocks Testimony by Vaccine Whistleblower in Medical Malpractice Case - CDC and Fraud - WeeksMD https://t.co/Ew8ceP4gqU	
Flu Vaccine Recalled Due To Defective Government Tracking Microchips https://t.co/fW6jHFDHKX via @theonion	
Why liability shield for pharma and no talk of injured kids? Super cruel. Why no talk of vaccine shedding? Vaccine safety in the numbers US requires? Cover up, sure looks like it. Baby body not designed for these many dozes of Al, dead cells, etc etc	

word	frequency
vaccine	547
government	121
big	115
pharma	113
vaccines	99
people	87
measles	78
conspiracy	78
money	76
anti	74
amp	66
trump	48
fraud	47
liability	47
company	46
get	44
mmr	44
children	42
cdc	41
safety	40

Table 13: The Official Vaccine Schedule and Its Alternatives Theme

The official vaccine schedule and its alternatives	
191 tweets out of 12997 (1.46%)	
Tweets examples	The top 20 terms
Would you consent to vaccines, if you knew that the entire vaccine schedule has never been studied together? Would you consent to vaccines, if you knew that each single vaccine was never tested against an inert… https://t.co/7uPDANmytm	word frequency vaccine 149 schedule 122 immunization 52 vaccines 47 baby 39 list 31 diseases 29 week 27 national 26 infant 26 cdc 25 needs 23 learn 21 amp 21 child 19 prevent 17 comfort 16 get 16 visits 16 vaccineswork 15
It’s so crazy to me that if a parent follows the vaccine schedule, their child will have 35 vaccines by the time they are 18 months old.... wonder if you could name every vaccine they had? All 35? Crazy.	
Delayed vaccine schedule is still delayed poisonings , change my mind.	
US vaccine schedule is insane. Why do we need so many vaccines at birth? They are NOT safe. I got hardly any and am fitter than most. It's just corrupt medical complex. There is NO sympathy for kids injured by Vaccines. No doing proper safety studies. INHUMANE CRUEL FARCE https://t.co/paUN0VuQyz	
"U.S. vaccine schedule starts within 24 hrs of birth w HepB dose & follows up w 20 to 22 vaccine doses in first year alone. No other developed country administers as many vaccine doses in first 2 yrs of life. U.S. has highest infant mortality rate of all industrialized countries"	

- **Sentiment Analysis:**

The second step in this study was to sentimentally analyze the classified tweets from the previous step. The anti-vaccine tweets (12997) that were identified in the classification stage were emotionally analyzed by using the Microsoft Azure Machine Learning tool. This tool uses the MPQA subjectivity lexicon to automatically classify opinions as positive, neutral, or negative.

As it can be observed from the figure (5), the tool assorted the previous classified groups to whether it is a positive, neutral, or negative tweet. It also depicted the total number of positive, neutral or negative opinions in each classified group. Based on the result, from the anti-vaccine tweets (12997), the total positive opinions were 5050 tweets (38.85%), whereas neutral tweets were 3766 tweets (28.97%) and negative tweets were 4181 (32.16%). The table (14) shows each group's statistics with its total positive, neutral, and negative tweets.

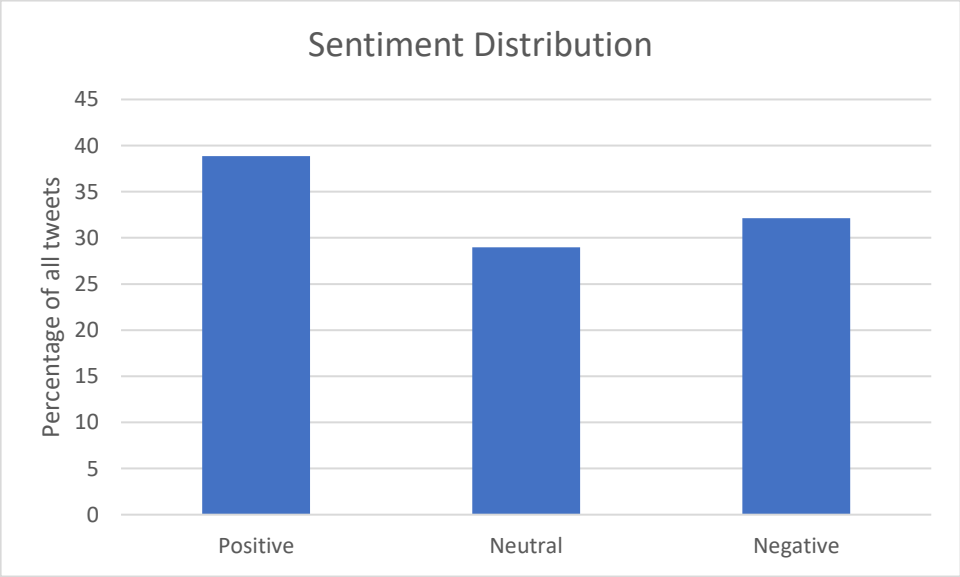

Figure 5: Sentiment Analysis Distribution Result

Table 14: Tweets Sentiment Analysis Result

Group	Positive	Neutral	Negative	Total
Expressing the right to choose	425	254	308	987
Concerns about efficacy or safety	264	187	168	619
Concerns about other ingredients	2	1	6	9
Contain toxic ingredients	223	152	132	507
Long-term side effects of vaccines	3592	2808	3201	9601
Not to risk my child to save another child	156	96	89	341
The Capitalism of vaccine products	299	204	239	742
The official vaccine schedule and its alternatives	89	64	38	191
Total	5050	3766	4181	12997 tweets

- **Negative sentiment analysis:**
    - **Timeline and top hashtags:**

Since the main objective of this study was to measure and explore the anti-vaccine tweets, further analyses for negative sentiment tweets were conducted to explain in depth some of the characteristics that are carried in these tweets such as date, time, hashtags, and geographic location of the posts. Form the sentiment analysis, the negative sentiment tweets were collected (4181 tweets), and date, time, and geographic location posts were extracted. Figure (6) illustrates tweets post timeline during the World Immunization Week, and table (15) shows the top ten hashtags that were used in some of the tweets.

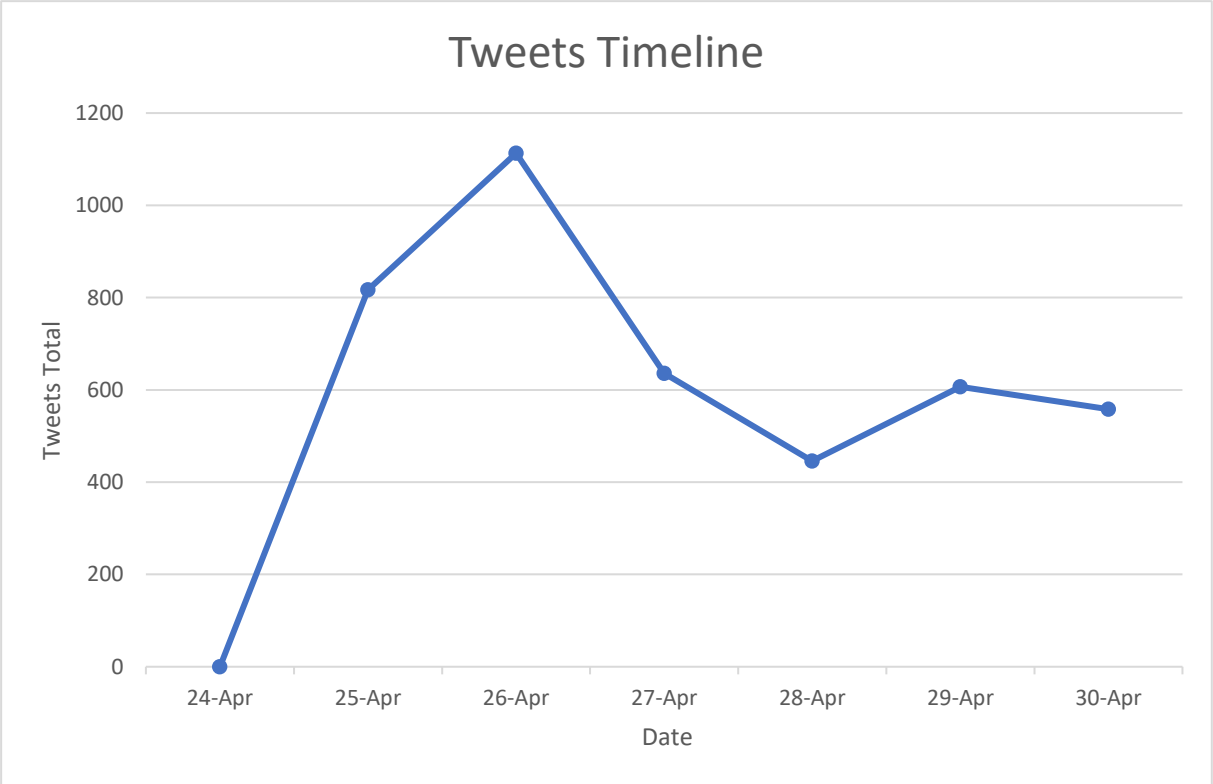

Figure 6: Negative Tweets Timeline

Table 15: Top Ten Hashtags Tweets Total

Top 10 hashtags	
#vaccine	362 tweets
#measles	230 tweets
#vaccines	222 tweets
#vaccineswork	166 tweets
#worldimmunizationweek	35 tweets
#malaria	25 tweets
#mumps	14 tweets
#worldmalariaday	12 tweets
#rubella	8 tweets
#thursdaythoughts	1 tweet
Total	1075 tweets

- **Geographic location:**

Among the collected negative sentiment tweets (4181), 2042 tweets only have geo-location associated that indicates from where the user posted the tweet, whereas other tweets were either have no location associated or have irrelevant text such as “living on the moon” or “the whole world.” All of the 2042 tweets have precisely geo-locations in from of city or country names. Figure (7) presents a global distribution of the negative sentiment tweets. By far, the United States of America was the most tweet-originated country. Table (16) lists all of the countries with their tweets total.

Figure 7: World Map of the Negative Sentiment Tweets

Table 16: Total of Negative Tweets in Each Country

Country	Tweets	Country	Tweets
Afghanistan	1	Maldives	1
Australia	46	Mexico	7
Bangladesh	2	Netherlands	10
Belgium	8	Nicaragua	1
Brazil	1	Nigeria	25
Bulgaria	1	Norway	4
Cameroon	1	New Zealand	6
CANADA	105	Pakistan	12
Chad	1	Palestine	1
China	1	Panama	3
Colombia	4	Peru	1
Costa Rica	1	Philippines	6
Cyprus	2	Poland	2
Denmark	2	Portugal	3
Ecuador	1	Saudi Arabia	3
Egypt	3	Singapore	1
Ethiopia	1	Somalia	1
Finland	2	South Africa	16
FRANCE	7	South Korea	8
Georgia	1	Spain	8
Germany	10	Sweden	9
Ghana	2	Sweden	1
India	43	Switzerland	10
Indonesia	3	Thailand	2
Ireland	31	Turkey	1
Israel	8	United Kingdom	130
Italy	9	Ukraine	3
Jamaica	3	United Arab Emirates	4
Japan	3	United States of America	1437
Jordan	2	Venezuela	4
Kenya	8	Vietnam	3
Laos	1	Zambia	1
Madagascar	2	Zimbabwe	1
Malaysia	1		

- **Summary:**

In this chapter, the researcher exhibited the results and analysis of the two steps tweets classification and tweets sentiment analysis to address the study's main objectives, which are to examine and measure the anti-vaccine posts on the Twitter platform. The tweets classification for the total initial collected tweets was conducted based on tweet's examples and list of words which resulted in eight groups. Later, these groups were emotionally analyzed and classified into positive, neutral, and negative sentiments. Further analyses were performed for the negative sentiment tweets to show tweets post timeline, the top ten hashtags were used, and geographic locations for these posts worldwide. The next chapter covers further results discussion.

Discussion

The use of Twitter as a health communication tool is growing rapidly due to the increase in the number of people who use this social media platform for health-related updates and information. In comparison with other social media platforms, Twitter's unique features facilitate easy message sharing within a social network. Every day on Twitter, more than 340 million tweets are posted by 140 million users (Fan & Gordon, 2014). Due to the limitation of funds and the ease of collecting social media views, the use of Twitter platform has been increasingly adopted by health researchers as a tool to gather health-related information (Hart et al., 2017). By collecting and analyzing data from social media platforms, researchers will be able to understand different people's views about specific topics.

The purpose of this quantitative descriptive study was to find, explore, and measure anti-vaccine perceptions on Twitter platform during the World Immunization Week April 24-30, 2019. Since the 19th century, anti-vaccine views have risen in many forms including opposition to the smallpox vaccine, controversies over the safety and efficacy of the diphtheria, tetanus, and pertussis (DTP) vaccine, the measles, mumps, and rubella (MMR) vaccine, and the use of a mercury in the vaccines as a preservative (Wolfe & Sharp, 2002). Vaccine-skeptics have their perceived fears and numerous reasons not to accept vaccines. Between the 1870s and 1880s, a high number of anti-vaccination books and journals appeared, such as the National Anti-Compulsory Vaccination Reporter (1874), and the Vaccination Inquirer (1879) (Porter & Porter, 1988). The literature review revealed the most common reasons for vaccine-deniers to oppose vaccination. The below-listed views have been expressed throughout time against vaccination:

- The right to choose
- Distrusted medical professionals
- Not to risk my child in favor of others
- Vaccines contain toxic ingredients
- Vaccines cause long-term side effects
- The Capitalism of vaccine products
- The official vaccine schedule is confusing

After a preliminary review of 6,000 tweets out of the total gathered 27,266 tweets, it appeared to the researcher that, in addition to the previously listed reasons, there are two other claims against vaccines. These claims are people's concern that some vaccines may be produced using aborted fetal tissue cells while the other belief is that these vaccines are not effective or safe by any means. Interestingly, the scanned sample also showed that there were no tweets mentioning any distrust or suspicion of the medical professionals' knowledge, abilities, or honesty.

Therefore, to serve the main study goal, these reasons were used as references and themes for identifying and classifying the 27,266 tweets, which resulted in 12,997 tweets being divided across the eight themes. The classified tweets were later sentimentally analyzed to identify the negative content tweets which serve in this study as anti-vaccine tweets. Based on the sentiment analysis, anti-vaccine tweets were only 4,181 tweets (32.16%) of the total classified tweets (12,997).

- **Expressing the right to choose:**

  Parents argue that vaccines should not be mandatory and ask for the right to refuse to vaccinate their children. In developed countries, the anti-vaccine movement was built on the perspective that individual rights are of high value (King, 1999). A study conducted on the anti-vaccine websites' contents by Robert Wolfe (2002) showed that the parents' anger over vaccines was attributed to injuries obtained by children in relation to

the vaccines, as well as the fact that vaccines are mandatory, which is perceived to interfere with the right to choose or refuse medical treatment (Wolfe, 2002). Furthermore, the parents claim that they understand their children's needs better than physicians, and they conduct their own research for what is ideal for their children's health, and not relying on their doctor's medical information (Reich, 2016).

The sentiment analysis for the collected tweets showed that demanding the right to choose whether to vaccinate or not tweets were the subject of 308 tweets, which account for 7.36 % of the total negative tweets (4,181) during the World Immunization Week. People in these tweets asked that the government not mandate vaccines and give the option to opt out. One of the tweets expressed the concern of living in the United States because of the required vaccination, while another tweet asked to follow Japan where people have the option to choose. Another tweet asked to stop mandating vaccinating healthier children and asked the authorities not to forget to consider kids' vaccine-injurie.

- **Not to risk my child to save another child:**

Some tweets claimed that since there are side effect risks from vaccinating children, parents will refuse to vaccinate their child and will rely on other people's immunities. According to Susan King (1999), the unvaccinated people will depend on herd immunity to be safe from vaccines' side effects (King, 1999). Some parents feel pressure from governments to vaccinate their children which they believe is risky, because parents believe that vaccines place their children at risk in order to save others, thus contradicting the claim that they protect the community and public health overall (Reich, 2016).

In the analysis, the tweets that contained this argument totaled 89 tweets – around 2.12 % of the total negative tweets (4,181). Generally, some tweets argued that not every child should be vaccinated since some diseases are rare. Thus, saving the child from possible side effects outweighs the positive effects of vaccinating. Some tweets, however, supported the idea of keeping vulnerable kids away from school, since some vaccines may not work and can still cause negative side effects. Some parents also think that others should not care whether or not their child is vaccinated.

- **Contains toxic ingredients:**

Many parents question the ingredients contained in vaccines and their safety. A survey was conducted on 6,207 parents revealed that 35% of the parents have the desire to know whether or not vaccine may have toxic ingredients while another study showed that 26% of 376 parents reported that vaccine ingredients are not safe (Kennedy et al., 2011; Shui et al., 2006). The FDA, on its website, states that some vaccines contain Thimerosal, which is a mercury-containing organic compound, as a preservative in multi-dose vials of vaccines to kill or prevent the growth of microorganisms such as bacteria and fungi (United States Food and Drug Administration, 2018). The FDA statements spread worries and doubts among parents. Therefore, these uncertainties regarding the safety of the ingredients in vaccines supports the argument that vaccines may contain toxic ingredients.

The tweets analysis showed that some parents are still worried and will continue not to vaccinate. Out of the 4,181 tweets, 132 tweets (3.15%) clearly describes the causes of vaccine-skepticism. One tweet demanded people oppose vaccines because it contains thimerosal and mercury in the ingredients. Another tweet argued that the amount of

mercury exceeds what is allowed in drinking water. These tweets provide solid reasons for questioning the vaccines safety. A third tweet demanded authorities not to allow vaccine-producer companies add mercury and if they do, not to exempt them from lawsuits.

- **Long-term side effects of vaccines:**

Throughout time, the side effects of vaccines have been considered the main reason for parents not to vaccinate their kids. The side effects vary from minor, such as nausea to severe, such as sudden infant death syndrome (SIDS) (Reich, 2016). In 1998, a hypothesis was published claiming that the measles, mumps, and rubella (MMR) vaccine may cause autism, which resulted in many parents refraining from vaccinating their children (Flaherty, 2011). Furthermore, not only was there an issue with the MMR vaccine, but the diphtheria-pertussis-tetanus (DPT) vaccine was claimed to cause permanent neurologic disability. This claim came up after parents alleged that the DPT vaccine caused their children to have mentally and physically disabling conditions (Conis, 2013). These two supposed side effects are still touted by some anti-vaccine parents, despite any denial on the part of medical professionals of the relationship between these vaccines and their complications.

During the tweets' analysis, the theme long-term side effects of vaccines was, by far, the most tweeted topic accounting for three-quarters of the total tweets. In this theme, the number of tweets was 3,201 tweets (76.56%) out of the total negative tweets (4,181). The tweets in this theme were centered on the vaccine's side effects and its complications. Some tweets claimed that the officials hide important information about vaccines' side effects from the public, while another tweet stated that a family received

compensation from a vaccine-autism suit and $110 million had been awarded in damages to all of the families in the suit. These two tweets are only a fraction of the examples of messages that serve to increase concern among already hesitant parents about whether or not to vaccinate their kids. Moreover, not only autism but many tweets also mentioned that the Mumps vaccine reduces fertility in adolescents and, further claimed that the Tetanus vaccine caused “Mass Sterilization” among young women and girls of childbearing age. Other tweets demanded that parents stop vaccinating infants because of the massive rise in vaccine injuries, neurological disorders, autism, and autoimmune disorders. Besides, infants cannot tolerate these toxins since, in this stage, their immune systems are not developed yet. Finally, many posters believed that there were no deaths because of measles disease. However, there were over 100 death incidents happened after introducing the Measles vaccine. Thus, many posters believed that vaccines are the cause of the severe conditions that happened to their children.

- **The Capitalism of vaccine products:**

There are many criticisms against vaccine-producer companies, including the notion that they do not care about people's interests and abilities, which was an argument made by an anti-vaccine group after one company doubled the price of Malaria vaccine thousand times. This argument motivated some parents to refuse to vaccinate their children, in order to protect them from the unknown effects of the vaccines, caused by the fact that the regulations placed on the pharmaceutical companies do not weigh public benefits over economic benefits (Mcneil, 2016). Moreover, there were many issues related to pharmaceutical manufacturing, such as contamination and miscalculations during production (Truong, 2012). In the United States, anti-vaccines group critiqued the

Food and Drug Administration (FDA) on the regulations they placed on vaccine-producer companies. This critique involved the FDA vaccines' ingredients safety tests and the investigation into vaccine's side effects that were done before granting approvals (Reich, 2016). Over time, the number of vaccine-producer companies has shrunk. In 2004, most of the world's vaccines are manufactured by only five companies, whereas in 1967, there were twenty-six and the total reduced again in 1980 to seventeen companies (Offit, 2005). It appeared that some of the companies bankrupted, whereas others were united into one company, which turned the vaccine market into a monopoly.

Analyzing the tweets in this theme, it appeared that there were 239 tweets – around 5.71% of the total negative tweets (4,181). The views were varied between asking for more regulation and accusing the authorities of default. Posters demanded authorities investigate and hold the vaccine-producer companies accountable for vaccine-injuries. Others accused some companies of creating the Measles outbreak epidemic to increase the revenue from selling more vaccines, and asked authorities to stop these companies from threatening their children. Another argument accused doctors of receiving benefits from vaccine-producer companies for prescribing and recommending these vaccines without explaining the vaccine's side effects to parents. Finally, anti-vaccine groups believed that this negligence happened because pharma companies are immune from lawsuits involving vaccines.

- **The official vaccine schedule and its alternatives:**

In this theme, many vaccine-skeptics believe that the CDC official vaccine schedule is over-loaded. Due to this schedule, the child receives many vaccines at an early age in a very short period of time. These vaccines, such as DTaP and MMR, are

combination vaccines that are given to a child in one injection, which the child may not be able to tolerate (Hilton et al., 2006). To solve this issue, Dr. Robert Sears proposed two different vaccine schedules, alternative and selective, which offer parents a solution to avoid giving their child multiple vaccines at once. This solution gives parents the option to decline or delay some vaccines until the child becomes older (Offit & Moser, 2009). Having an official schedule and other proposed schedules may increase concerns and worries among parents.

During the analysis, there were only 38 tweets in this theme – 0.9 % of the total negative tweets (4,181). In this theme, there were many claims against the official vaccines schedule. One post argued that the CDC official schedule was never studied in its entirety for its safety on the baby's body. Another post emphasized one study that showed that no study had been conducted on the current schedule and doubted if it ever would be in the future. Posters claimed that in terms of side effects, the current schedule would definitely create autistic babies because of the number of vaccines given at an early age. Another demanded the authorities reexamine and refine the current schedule since no country in the world vaccinates the same amount as the United States. The post continued to argue that the United States has the highest infant mortality rate of all developed countries because of the high amount of vaccines that are introduced to the baby in the first year only. Another post demanded sympathy from authorities for those children who have been injured by vaccines and enforce proper safety tests on the current vaccination schedule. Moreover, posters questioned the differences in vaccines' schedule. In some countries, there is a difference between the government-enforced vaccination schedule and the ones given by private hospitals within the same country, which

increases the doubt among-skeptics. On the other hand, some doctors, in the US, give parents the option to delay certain vaccines. However, anti-vaccination proponents still believe that delaying some vaccines is merely delaying poisonings.

- **Concern about efficacy or safety:**

In general, the tweets in this theme concerned whether vaccines are effective and safe. The total tweets in this theme were 168 tweets (4.01%) of the total negative tweets (4181).

In general, the tweets in this theme are concerned with whether or not vaccines are effective and safe. The total tweets in this theme were 168 tweets (4.01%) of the total negative tweets (4,181).

In terms of efficacy, the twitter posts showed suspicion about vaccine efficacy. One tweet thought that some vaccines are not effective at all or show very little effect on people and demanded that authorities stop these vaccines until a more effective one can be developed, while another post claimed that vaccines are only 40% effective. Other posters accused some companies of lying in the test results that they submitted to the government, in order to sell more vaccines. Not only companies but also government agencies were blamed on knowing some vaccines were not effective before they were approved anyways. A post mentioned that the CDC announced that in 2019, flu vaccines had been less effective in preventing infection. Due to this uncertainty, posters lost their belief in vaccines and stopped vaccinating their families. One user tweeted that they had vaccinated against both the flu and chickenpox and had them both later, leading them to thinking that the anti-vaccine movement is correct.

Furthermore, some posts discussed how happy they were that their parents did not vaccinate them, going against school vaccination requirements. They believed that what their parents did was right because vaccines currently produced mainly negative side effects on the community. Moreover, other posts referred to an independent analysis revealed that the MMR vaccine is not safe, producing evidence that the United States paid money to vaccine-injured families, and questioning why the government would do so if the vaccines were truly safe. Regarding experimental vaccines, posters expressed their anger over not sufficiently testing vaccines before applying them and accused vaccine-producer companies of using some African countries' needs to test these vaccines and using these people as “lab rats.”

Aside from the tweets in this theme, there was no mention of any study found addressing people’s concern about vaccines' efficacy. However, many papers were published measuring vaccines’ side effects after administrating them to people.

- **Concern about other ingredients:**

By far, this theme had the fewest number of negative tweets. The number of tweets was only six tweets, based on the sentiment analysis, account for around 0.14% out of the total negative tweets (4,181). In this theme, posters expressed their worries on vaccines’ contents. The tweets in this theme were meant for non-toxic ingredients concerns. People in this theme opposed vaccines because some vaccines contents include human or animal cells. Many tweets believed that the MMR vaccine contain aborted fetal lung cells and tissues in its ingredient list and not only human cells, but also animal cells. Other tweets argued that some vaccines have monkey kidney cells as an additive and bacteria such as E. coli. Posters asked people to look at the ingredients before

vaccinating, believing that people will stop vaccinating if they know about these ingredients.

As studies show in the literature review, parents were against some vaccines because some contain toxic ingredients such as mercury. However, there was no mention of opposition to vaccinations because they may contain fetal or animal cells. Further investigation on vaccines' ingredients is needed to whether or not these claims are true.

- **Based on trends:**

The negative tweets were posted at different times throughout the World Immunization Week (April 24-30, 2019). Based on the information from the given tweets and the sentiment analysis tool, tweets posting time fluctuated over the period. On the first day (April 24), there was no negative tweets detected by the sentiment analysis tool. However, the following two days (April 25 and 26), the tweets posting reached its highest point- over 800 tweets on 25th and around 1100 tweets on the 26th. Later, the postings remained between 400-600 tweets per day until the last day. However, it is important to note that a manual scan of the tweets showed that on the 25th and 26th, there were some tweet duplications by many users. There was one tweet that was posted over 30 times on the 26th only.

Moreover, users used many hashtags to spread and index their tweets. Only 1,075 tweets have hashtags out of the total negative tweets (4,181). The most used hashtag was #vaccine – 362 tweets. This word clearly defines the tweets since all of them are about vaccines. Interestingly, the #vaccineswork hashtag was used only 166 times, especially since this hashtag was the slogan for the World Immunization Week for 2019. The

hashtags also included some diseases names such as #mumps, #measles, #malaria, and #rubella.

Regarding the geo-location of the negative sentiment tweets, there were only 2,042 Twitter accounts that shared their geographic location. These accounts were from 67 countries worldwide. According to the analysis results, more than 70% of these accounts were from the United States of America, with the United Kingdom coming in second place (7%) and Canada in third (5%). According to the Centers for Disease Control and Prevention (CDC) by the end of the year 2018, two large measles outbreaks had occurred in the state of New York and lasted for around ten months until it was cleared in July 2019. About 1,114 measles cases were reported by the CDC during that period (Patel et al., 2019). Based on CDC statistics, in March and April of 2019, the number of measles cases was the highest it has been - 303 and 342 cases respectively ("Measles | Cases and Outbreaks | CDC," 2019). Thus, people in the United States had a higher anti-vaccine sentiment, which they expressed during World Immunization Week.

- **Limitation:**

This study has many limitations that need to be acknowledged. These limitations are divided between collecting and analyzing the tweets. The first limitation is the search keyword. In this analysis, the tweets were collected based on including the word (vaccine) in the tweet which limited involving all the views on vaccines on Twitter. Furthermore, the search was only performed on tweets in English, which limited the views mainly to countries and people who speak and write in English.

However, it is also important to note that the tweets search was completed in a limited timeframe which could also account for some of the results. For example, in this

analysis, the World Immunization Week 2019 took place in the middle of the United States measles outbreak. Finally, the study used one of many social media platforms for collecting data. Thus, the limitation of using Twitter only also limits the views about vaccinations.

- **Conclusion:**

Vaccine opposition has deep roots over history including the objection to the smallpox vaccine, controversies over the safety and efficacy of diphtheria, tetanus, and pertussis (DTP) vaccine, the measles, mumps, and rubella (MMR) vaccine, and the use of chemical substances in the vaccines. The anti-vaccine movement has resulted from parents' desire to express caring behavior by protecting their children from harming. This analysis of the anti-vaccine tweets showed parents' motivation to refuse vaccines for their children's benefit, despite the false assumptions that they base their claims on. Moreover, studying social media content allows researchers to analyze the public's concerns and views on health-related issues, allowing for deeper understanding and a quicker way to find solutions to these issues. Advancing the understanding of methods and patterns of analysis for these media is becoming an essential tool for the public health domain. Toward this goal, this study used emerging data analysis approaches that bring principles and practices from health informatics, data analytics, and geographical analysis to understand such contemporary critical health issues better and to help find solutions to raise health awareness among societies.

References

Ball, L. K., Evans, G., & Bostrom, A. (1998, March). Risky business: Challenges in vaccine risk communication. *Pediatrics*. https://doi.org/10.1542/peds.101.3.453

Boyd, D., Golder, S., & Lotan, G. (2010). Tweet, Tweet, Retweet: Conversational Aspects of Retweeting on Twitter. In *2010 43rd Hawaii International Conference on System Sciences* (pp. 1–10). IEEE. https://doi.org/10.1109/HICSS.2010.412

Brady, R. R. W., Chapman, S. J., Atallah, S., Chand, M., Mayol, J., Lacy, A. M., & Wexner, S. D. (2017). #colorectalsurgery. *The British Journal of Surgery*, *104*(11), 1470–1476. https://doi.org/10.1002/bjs.10615

CDC. (2012). Vaccines and preventable diseases. Retrieved September 28, 2019, from https://www.cdc.gov/vaccines/vpd/index.html

CDC. (2015). Possible side effects from vaccinations. Retrieved September 28, 2019, from https://www.cdc.gov/vaccines/vac-gen/side-effects.htm

CDC. (2019a). Recommended Child and Adolescent Immunization Schedule for ages 18 years or younger, United States, 2019. Retrieved September 28, 2019, from https://www.cdc.gov/vaccines/schedules/hcp/imz/child-adolescent.html

CDC. (2019b). World Immunization Week 2019. Retrieved October 10, 2019, from https://www.cdc.gov/globalhealth/immunization/wiw/index.html

Conis, E. (2013). A mother's responsibility: Women, medicine, and the rise of contemporary vaccine skepticism in the United States. *Bulletin of the History of Medicine*, *87*(3), 407–435. https://doi.org/10.1353/bhm.2013.0047

Currie, D. (2009). Public health leaders using social media to convey emergencies: New tools a boon. *The Nation's Health*, *39*(6).

Delany, I., Rappuoli, R., & De Gregorio, E. (2014). Vaccines for the 21st century. *EMBO Molecular Medicine*, *6*(6), 708–720. https://doi.org/10.1002/emmm.201403876

DeStefano, F., & Thompson, W. W. (2004, February). MMR vaccine and autism: An update of

the scientific evidence. *Expert Review of Vaccines*. https://doi.org/10.1586/14760584.3.1.19

Eysenbach, G. (2009). Infodemiology and infoveillance: framework for an emerging set of public health informatics methods to analyze search, communication and publication behavior on the Internet. *Journal of Medical Internet Research*, *11*(1). https://doi.org/10.2196/jmir.1157

Fan, W., & Gordon, M. D. (2014). The Power of Social Media Analytics. https://doi.org/10.1145/2602574

Farrelly, P. (2013). Choosing the right method for a quantitative study. *British Journal of School Nursing*, *8*(1), 42–44. https://doi.org/10.12968/bjsn.2013.8.1.42

Finfgeld-Connett, D. (2015, October 11). Twitter and Health Science Research. *Western Journal of Nursing Research*. SAGE Publications Inc. https://doi.org/10.1177/0193945914565056

Fisher, J., & Clayton, M. (2012). Who Gives a Tweet: Assessing Patients' Interest in the Use of Social Media for Health Care. *Worldviews on Evidence-Based Nursing*, *9*(2), 100–108. https://doi.org/10.1111/j.1741-6787.2012.00243.x

Flaherty, D. K. (2011). The vaccine-autism connection: A public health crisis caused by unethical medical practices and fraudulent science. *Annals of Pharmacotherapy*, *45*(10), 1302–1304. https://doi.org/10.1345/aph.1Q318

Flanagan-Klygis, E. A., Sharp, L., & Frader, J. E. (2005). Dismissing the family who refuses vaccines: A study of pediatrician attitudes. *Archives of Pediatrics and Adolescent Medicine*, *159*(10), 929–934. https://doi.org/10.1001/archpedi.159.10.929

Glanz, J. M., Kraus, C. R., & Daley, M. F. (2015). Addressing parental vaccine concerns: Engagement, balance, and timing. *PLoS Biology*, *13*(8). https://doi.org/10.1371/journal.pbio.1002227

Glasser, J. W., Feng, Z., Omer, S. B., Smith, P. J., & Rodewald, L. E. (2016). The effect of heterogeneity in uptake of the measles, mumps, and rubella vaccine on the potential for outbreaks of measles: A modelling study. *The Lancet Infectious Diseases*, *16*(5), 599–605. https://doi.org/10.1016/S1473-3099(16)00004-9

Haley, B. E. (2005). Mercury toxicity: Genetic susceptibility and synergistic effects, *2*, 535–542. https://doi.org/10.1588/medver.2005.02.00067

Hamilton, L. C., Hartter, J., & Saito, K. (2015). Trust in Scientists on Climate Change and Vaccines. *SAGE Open*, *5*(3), 215824401560275. https://doi.org/10.1177/2158244015602752

Hart, M., Stetten, N. E., Islam, S., & Pizarro, K. (2017). Twitter and Public Health (Part 1): How Individual Public Health Professionals Use Twitter for Professional Development. *JMIR Public Health and Surveillance*, *3*(3), e60. https://doi.org/10.2196/publichealth.6795

Hilton, S., Petticrew, M., & Hunt, K. (2006). "Combined vaccines are like a sudden onslaught to the body's immune system": Parental concerns about vaccine "overload" and "immune-vulnerability." *Vaccine*, *24*(20), 4321–4327. https://doi.org/10.1016/j.vaccine.2006.03.003

Holt, C. (2011). Emerging technologies: Web 2.0. *Health Information Management Journal*, *40*(1), 33–35. https://doi.org/10.1177/183335831104000106

Hussain, A., Ali, S., Ahmed, M., & Hussain, S. (2018). The Anti-vaccination Movement: A Regression in Modern Medicine. *Cureus*. https://doi.org/10.7759/cureus.2919

Java, A., Song, X., Finin, T., & Tseng, B. (2007). Why we twitter: understanding microblogging usage and communities. *Proceedings of the 9th WebKDD and 1st SNA-KDD 2007 Workshop on Web Mining and Social Network Analysis - WebKDD/SNA-KDD '07*, 56–65. https://doi.org/10.1145/1348549.1348556

Kennedy, A., LaVail, K., Nowak, G., Basket, M., & Landry, S. (2011). Confidence about vaccines in the United States: Understanding parents' perceptions. *Health Affairs*, *30*(6), 1151–1159. https://doi.org/10.1377/hlthaff.2011.0396

King, S. (1999). Vaccination policies: individual rights v community health. We can't afford to be half hearted about vaccination programmes. *BMJ (Clinical Research Ed.)*, *319*(7223), 1448–149. https://doi.org/10.1136/bmj.319.7223.1448

Kwak, H., Lee, C., Park, H., & Moon, S. (2010). What is Twitter, a social network or a news media? In *Proceedings of the 19th international conference on World wide web - WWW '10* (p. 591). New York, New York, USA: ACM Press.

https://doi.org/10.1145/1772690.1772751

Landrum, B., & Garza, G. (2015). Mending fences: Defining the domains and approaches of quantitative and qualitative research. *Qualitative Psychology*, *2*(2), 199–209. https://doi.org/10.1037/qup0000030

Larsson, A. O., & Moe, H. (2012). Studying political microblogging: Twitter users in the 2010 Swedish election campaign. *New Media & Society*, *14*(5), 729–747. https://doi.org/10.1177/1461444811422894

Liu, B. (2012). Sentiment analysis and opinion mining. *Synthesis Lectures on Human Language Technologies*, *5*(1), 1–184. https://doi.org/10.2200/S00416ED1V01Y201204HLT016

Liu, B. (2015). *Sentiment Analysis Mining Opinions, Sentiments, and Emotions*.

Martin, W. E., & Bridgmon, K. D. (2012). *Quantitative and statistical research methods From hypothesis to results*. *Journal of Chemical Information and Modeling*. https://doi.org/10.1017/CBO9781107415324.004

Mcneil, K. A. (2016). The Anti-Vaccination Movement and the Ethics of Care in Parenthood. Retrieved from https://www.proquest.com

Measles | Cases and Outbreaks | CDC. (2019). Retrieved January 28, 2020, from https://www.cdc.gov/measles/cases-outbreaks.html

Miner, G., Elder, J. I., Fast, A., Hill, T., Nisbet, R., & Delen, D. (2012). *Practical text mining and statistical analysis for non-structured text data applications*. Retrieved from https://ebookcentral.proquest.com

Offit, P. A. (2005). Why are pharmaceutical companies gradually abandoning vaccines? *Health Affairs*, *24*(3), 622–630. https://doi.org/10.1377/hlthaff.24.3.622

Offit, P. A., & Moser, C. A. (2009). The problem with Dr bob's alternative vaccine schedule. *Pediatrics*, *123*(1). https://doi.org/10.1542/peds.2008-2189

Ortiz-Ospina, E. (2019). The rise of social media - Our World in Data. Retrieved September 19, 2019, from https://ourworldindata.org/rise-of-social-media

Park, H., Rodgers, S., & Stemmle, J. (2013). Analyzing health organizations' use of twitter for

promoting health literacy. *Journal of Health Communication*, *18*(4), 410–425. https://doi.org/10.1080/10810730.2012.727956

Parmelee, J. H., & Bichard, S. L. (2014). Politics and the Twitter Revolution: How Tweets Influence the Relationship between Political Leaders and the Public. *Public Opinion Quarterly*, *78*(1), 197–199. https://doi.org/10.1093/poq/nft075

Patel, M., Lee, A. D., Clemmons, N. S., Redd, S. B., Poser, S., Blog, D., … Gastañaduy, P. A. (2019). National Update on Measles Cases and Outbreaks — United States, January 1–October 1, 2019. *MMWR. Morbidity and Mortality Weekly Report*, *68*(40), 893–896. https://doi.org/10.15585/mmwr.mm6840e2

Paul, M. J., & Dredze, M. (2011). You Are What You Tweet: Analyzing Twitter for Public Health. *Fifth International AAAI Conference on Weblogs and Social Media*. Retrieved from https://www.aaai.org/ocs/index.php/ICWSM/ICWSM11/paper/viewPaper/2880

Perform sentiment analysis with Text Analytics REST API - Azure Cognitive Services | Microsoft Docs. (n.d.). Retrieved December 30, 2019, from https://docs.microsoft.com/en-us/azure/cognitive-services/text-analytics/how-tos/text-analytics-how-to-sentiment-analysis?tabs=version-2

Pershad, Y., Hangge, P., Albadawi, H., & Oklu, R. (2018). Social Medicine: Twitter in Healthcare. *Journal of Clinical Medicine*, *7*(6), 121. https://doi.org/10.3390/jcm7060121

Pew Research Center. (2009). *The Social Life of Health Information*. Retrieved from https://www.pewresearch.org/internet/2009/06/11/the-social-life-of-health-information/

Porter, D., & Porter, R. (1988). The politics of prevention: anti-vaccinationism and public health in nineteenth-century England. *Medical History*, *32*(3), 231–252. https://doi.org/10.1017/s0025727300048225

Reich, J. A. (2016). *Calling the Shots : Why Parents Reject Vaccines*. New York University Press. Retrieved from https://ebookcentral.proquest.com/lib/uwm/detail.action?docID=4045238.

Robillard, J. M., Johnson, T. W., Hennessey, C., Beattie, B. L., & Illes, J. (2013). Aging 2.0: Health Information about Dementia on Twitter. *PLoS ONE*, *8*(7).

https://doi.org/10.1371/journal.pone.0069861

S. M. Vohra, & Teraiya, J. B. (2012). A Comparative Study Of Sentiment Analysis Techniques. *Journal Of Information, Knowledge And Research In Computer Engineering*, (October), 313–317. https://doi.org/10.13140/2.1.4255.0722

Sakaki, T., Okazaki, M., & Matsuo, Y. (2010). Earthquake shakes Twitter users: Real-time event detection by social sensors. In *Proceedings of the 19th International Conference on World Wide Web, WWW '10* (pp. 851–860). https://doi.org/10.1145/1772690.1772777

Scanfeld, D., Scanfeld, V., & Larson, E. L. (2010). Dissemination of health information through social networks: Twitter and antibiotics. *American Journal of Infection Control*, *38*(3), 182–188. https://doi.org/10.1016/j.ajic.2009.11.004

Schmid, P., MacDonald, N. E., Habersaat, K., & Butler, R. (2018). Commentary to: How to respond to vocal vaccine deniers in public. *Vaccine*, *36*(2), 196–198. https://doi.org/10.1016/j.vaccine.2016.09.065

Shui, I. M., Weintraub, E. S., & Gust, D. A. (2006). Parents Concerned About Vaccine Safety. Differences in Race/Ethnicity and Attitudes. *American Journal of Preventive Medicine*, *31*(3), 244–251. https://doi.org/10.1016/j.amepre.2006.04.006

Sinnenberg, L., Buttenheim, A. M., Padrez, K., Mancheno, C., Ungar, L., & Merchant, R. M. (2017). Twitter as a Tool for Health Research: A Systematic Review. *Am J Public Health*, *107*(1), 1–8. https://doi.org/10.2105/AJPH.2016.303512

Takhteyev, Y., Gruzd, A., & Wellman, B. (2012). Geography of Twitter networks. *Social Networks*, *34*(1), 73–81. https://doi.org/10.1016/j.socnet.2011.05.006

Text Analytics – MeaningCloud text mining solutions. (n.d.). Retrieved December 25, 2019, from https://www.meaningcloud.com/

Truong, V. A. (2012). The pediatric vaccine stockpiling problem. *Vaccine*, *30*(43), 6175–6179. https://doi.org/10.1016/j.vaccine.2012.07.066

Turney, P. D. (2001). Thumbs up or thumbs down? (p. 417). https://doi.org/10.3115/1073083.1073153

Twitter. (2012). Twitter turns six. In *Twitter Blog* (p. http://blog.twitter.com). Retrieved from https://blog.twitter.com/official/en_us/a/2012/twitter-turns-six.html

Twitter. (2014). About Twitter. *Twitter About*. Retrieved from https://about.twitter.com/en_us.html

Twitter. (2018). How to use hashtags. Retrieved September 18, 2019, from https://help.twitter.com/en/using-twitter/how-to-use-hashtags

Twitter Glossary. (2020). Glossary. Retrieved January 13, 2020, from https://help.twitter.com/en/glossary

United States Food and Drug Administration. (2018). Thimerosal and Vaccines. *Vaccine Safety and Availability*, 1–8. Retrieved from https://www.fda.gov/vaccines-blood-biologics/safety-availability-biologics/thimerosal-and-vaccines

Vicinitas : Twitter Analytics Tool for Tracking Hashtags, Keywords, and Accounts. (2020). Retrieved February 17, 2020, from https://www.vicinitas.io/

Watson, R. (2015). Quantitative research. *Nursing Standard (Royal College of Nursing (Great Britain) : 1987)*, *29*(31), 44–48. https://doi.org/10.7748/ns.29.31.44.e8681

What is ML Studio (classic) - Azure | Microsoft Docs. (n.d.). Retrieved February 17, 2020, from https://docs.microsoft.com/en-us/azure/machine-learning/studio/what-is-ml-studio

WHO. (2018). Children : reducing mortality. Retrieved September 28, 2019, from https://www.who.int/en/news-room/fact-sheets/detail/children-reducing-mortality

WHO. (2019a). WHO | Vaccines.

WHO. (2019b). World Immunization Week 2019. Retrieved October 10, 2019, from https://www.who.int/news-room/events/detail/2019/04/24/default-calendar/world-immunization-week-2019

Wolfe, R. M. (2002). Vaccine safety activists on the internet. *Expert Review of Vaccines*, *1*(3), 249–252. https://doi.org/10.1586/14760584.1.3.249

Wolfe, R. M., & Sharp, L. K. (2002, August 24). Anti-vaccinationists past and present. *British Medical Journal*. https://doi.org/10.1136/bmj.325.7361.0

Zhao, D., & Rosson, M. B. (2009). How and why people Twitter. In *Proceedinfs of the ACM 2009 international conference on Supporting group work - GROUP '09* (p. 243). New York, New York, USA: ACM Press. https://doi.org/10.1145/1531674.1531710

Appendix A: Recommended Immunization for Children from Birth Through 6 Years Old

Appendix B: Recommended Immunization for Children from 7 - 18 Years Old

Appendix C: Vaccine-Preventable Diseases and The Vaccines that Prevent Them

Vaccine-Preventable Diseases and the Vaccines that Prevent Them

Disease	Vaccine	Disease spread by	Disease symptoms	Disease complications
Chickenpox	Varicella vaccine protects against chickenpox.	Air, direct contact	Rash, tiredness, headache, fever	Infected blisters, bleeding disorders, encephalitis (brain swelling), pneumonia (infection in the lungs)
Diphtheria	DTaP* vaccine protects against diphtheria.	Air, direct contact	Sore throat, mild fever, weakness, swollen glands in neck	Swelling of the heart muscle, heart failure, coma, paralysis, death
Hib	Hib vaccine protects against *Haemophilus influenzae* type b.	Air, direct contact	May be no symptoms unless bacteria enter the blood	Meningitis (infection of the covering around the brain and spinal cord), intellectual disability, epiglottitis (life-threatening infection that can block the windpipe and lead to serious breathing problems), pneumonia (infection in the lungs), death
Hepatitis A	HepA vaccine protects against hepatitis A.	Direct contact, contaminated food or water	May be no symptoms, fever, stomach pain, loss of appetite, fatigue, vomiting, jaundice (yellowing of skin and eyes), dark urine	Liver failure, arthralgia (joint pain), kidney, pancreatic and blood disorders
Hepatitis B	HepB vaccine protects against hepatitis B.	Contact with blood or body fluids	May be no symptoms, fever, headache, weakness, vomiting, jaundice (yellowing of skin and eyes), joint pain	Chronic liver infection, liver failure, liver cancer
Influenza (Flu)	Flu vaccine protects against influenza.	Air, direct contact	Fever, muscle pain, sore throat, cough, extreme fatigue	Pneumonia (infection in the lungs)
Measles	MMR** vaccine protects against measles.	Air, direct contact	Rash, fever, cough, runny nose, pink eye	Encephalitis (brain swelling), pneumonia (infection in the lungs), death
Mumps	MMR**vaccine protects against mumps.	Air, direct contact	Swollen salivary glands (under the jaw), fever, headache, tiredness, muscle pain	Meningitis (infection of the covering around the brain and spinal cord), encephalitis (brain swelling), inflammation of testicles or ovaries, deafness
Pertussis	DTaP* vaccine protects against pertussis (whooping cough).	Air, direct contact	Severe cough, runny nose, apnea (a pause in breathing in infants)	Pneumonia (infection in the lungs), death
Polio	IPV vaccine protects against polio.	Air, direct contact, through the mouth	May be no symptoms, sore throat, fever, nausea, headache	Paralysis, death
Pneumococcal	PCV13 vaccine protects against pneumococcus.	Air, direct contact	May be no symptoms, pneumonia (infection in the lungs)	Bacteremia (blood infection), meningitis (infection of the covering around the brain and spinal cord), death
Rotavirus	RV vaccine protects against rotavirus.	Through the mouth	Diarrhea, fever, vomiting	Severe diarrhea, dehydration
Rubella	MMR** vaccine protects against rubella.	Air, direct contact	Sometimes rash, fever, swollen lymph nodes	Very serious in pregnant women— can lead to miscarriage, stillbirth, premature delivery, birth defects
Tetanus	DTaP* vaccine protects against tetanus.	Exposure through cuts in skin	Stiffness in neck and abdominal muscles, difficulty swallowing, muscle spasms, fever	Broken bones, breathing difficulty, death

* DTaP combines protection against diphtheria, tetanus, and pertussis.
** MMR combines protection against measles, mumps, and rubella.

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