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## Content and source analysis of popular tweets following a recent case of diphtheria in Spain

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**Background:** Despite major progress in global vaccination coverage, immunization rates are falling, resulting in outbreaks of vaccine-preventable diseases. This study analyses content and source of the most popular tweets related to a recent case in Spain where an unvaccinated child contracted and later died from diphtheria. Understanding the characteristics of these tweets in the context of vaccination could inform efforts by health promotion professionals to increase their reach and impact. **Methods:** We extracted tweets containing keywords related to the diphtheria case (from 1 May to 15 July 2015). We explored the prevalence of terms relating to policy and misinformation and manually coded the 194 most popular tweets (retweeted 100 or more times) with regard to source, topic, tone and sentiment. **Results:** A total of 722 974 tweets were collected. Prevalence of terms relating to policy and misinformation increased at the onset of the case and after the death of the child. Popular tweets (194) were either pro-vaccination (58%) or neutral, with none classified as anti-vaccination. Popular topics included criticism towards anti-vaccination groups (35%) and effectiveness of immunization (22%). Popular tweets were informative (47%) or opinions (53%), which mainly expressed frustration (24%) or humour/sarcasm (23%). Popular Twitter accounts were newspaper and TV channels (15%), as well as individual journalists and authors of popular science (13.4%). **Conclusions:** Healthcare organizations could collaborate with popular journalists or news outlets and employ authors of popular science to disseminate health information on social media, while addressing public concerns and misinformation in accessible ways.

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## Introduction

Despite major progress in global vaccination coverage, immunization rates are falling in many countries, including in the developed world,<sup>1</sup> resulting in outbreaks of vaccine-preventable diseases. The WHO European Region has reported over 3300 measles cases since June 2016 up to July 2017, resulting in 35 deaths<sup>2</sup>. Objections or concerns about immunizations include perceptions of the disease (e.g. not serious, uncommon), perceptions of the vaccine (e.g. ineffective, unsafe), mistrust in institutions related to vaccination and the belief that there are other methods of disease prevention that are preferable to vaccination.<sup>3,4</sup> A recent survey in 67 countries evaluating trust in vaccines found that safety concerns were highest in Europe<sup>5</sup>. Similarly, a study in US schools showed that immunization exemption rates based on personal belief are rising.<sup>6</sup>

Spain has childhood vaccination coverage (including diphtheria, pertussis and tetanus) above 95%.<sup>7</sup> However, in June 2015, the first case of diphtheria was recorded since 1986. A six-year-old boy whose parents opted not to vaccinate him against the bacterial infection died after a month of illness<sup>8</sup>. This event was discussed heavily in the media and the decision of the parents not to vaccinate the child led to a public debate over the risks of the vaccine and the responsibility of parents to vaccinate their children. The interest raised by this episode provided an opportunity to explore reactions to public health issues, such as vaccination, and investigate the opinions and information that are most shared in this context. Social media, such as Twitter, provides an excellent means to explore these reactions.

Twitter is one of the prominent social networking sites. The micro-blogging service has over 300 million active users sending around 500 million status updates, or *tweets*, per day.<sup>9</sup> It is a popular platform for the informal sharing of health information, opinion, experience and advice that have an impact on patients' health decisions,<sup>10</sup> including vaccination.<sup>11–13</sup> Information deemed important by the community propagates through retweets,<sup>14</sup> a process by which tweets are shared with one's followers. Retweeting is the key mechanism for information diffusion, and this snowballing action of retweets from follower to follower means that a single message can be seen by a vast number of people.<sup>15</sup> Understanding the characteristics of these influential tweets in the context of vaccination may be valuable for health promotion professionals to increase their reach and impact.

A number of studies have analyzed vaccination content in social media, e.g.<sup>16–19</sup> however, there is still a need to understand what characterizes a popular tweet in this context and who disseminates this information, which might help to inform future health promotion and public health education activities on social media. The aim of this study was to analyze the most popular tweets in the context of vaccination, documenting the source, topic, tone and sentiment, using the 2015 diphtheria episode in Spain as a case study.

## Methods

### Data extraction

We extracted all tweets written in Spanish from 1 May to 15 July 2015 containing keywords related to the diphtheria case: 'difteria' (diphtheria), 'Olot' (the town where the case occurred), 'antivacunas' (anti-vaccination) and 'vacuna' (variations of the term vaccination/vaccine). We tracked data starting one month before the incident (which was publicly released by newspapers and TV on 1 June) until two weeks after the report that the child had died (26 June). To extract the tweets, we used the public Application Programming Interface of an online service designed for this purpose (Topsy).

We explored prevalence of keywords relating to policy and misinformation. Specifically, we searched the dataset for *Policy* keywords

('escuela'/'colegio'=school, kindergarten 'escolarización'=schooling, 'colonias'=summer schools, 'calendario'=calendar, 'voluntario'=voluntary, 'obligatorio'=compulsory, 'regulación'=regulation) which could relate to the debate about whether vaccinations should be compulsory or voluntary and whether children should be allowed to attend public schools if they are not vaccinated.<sup>20</sup> We also searched for *Vaccination misinformation* keywords ('autismo'=autism, 'mercurio'=mercury, and 'aluminio'=aluminium) which could relate to the discredited link between the mumps-measles-rubella (MMR) childhood vaccine and autism reported in a misperformed and retracted study published in the UK in 1998,<sup>21</sup> and a more generalized discredited link between childhood vaccines containing aluminium or mercury compounds and autism.<sup>22</sup> We focused on these areas since they are popular topics discussed in traditional media and parents' forums, indicating they are of interest and concern among parents and the general population.

Furthermore, we examined the correlation between the number of tweets collected during this period and the number of news articles in the online mainstream media. For this purpose, we selected the Spanish newspapers with the highest sales rates in Spain in 2015 according to the Spanish Dissemination Justification Office ([www.ojd.es](http://www.ojd.es)), and searched for articles including the keywords 'diphtheria', 'Olot' or 'vaccination'.

To analyze content and source of the most popular tweets relating to the diphtheria case, we extracted from the dataset messages that were retweeted 100 or more times and we coded them manually following the protocol summarized below in the Results section.

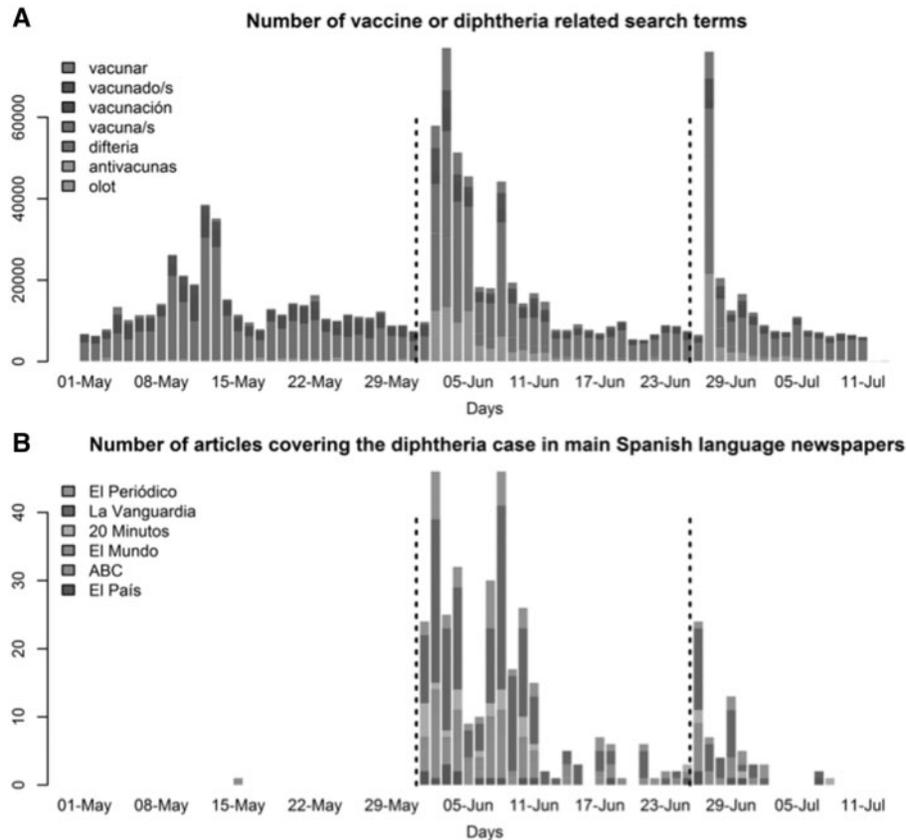
## Results

### Frequency of vaccination, anti-vaccination and diphtheria terms

The data collection resulted in a total of 722 974 tweets: 577 822 tweets containing 'vaccination' terms; 39 662 containing the term 'anti-vaccination'; 70 906 containing the term 'diphtheria' and 34 584 containing the term 'Olot'. Figure 1A (and in colour in Supplementary figure S1A) shows the number of tweets collected using each search term (in Spanish in the legend). As can be seen, tweets mentioning vaccination were already present in our sample before June 2015, suggesting that this was already a popular topic of discussion on Twitter. However, there was a sudden increase in the prevalence of these search terms over the days immediately following 1 June, when the first news of the diphtheria case was published in the media and on 26 June, when the first report on the child's death was published. 'Diphtheria' and 'anti-vaccination' were also mentioned frequently at this stage. Figure 1B (and in colour in Supplementary figure S1B) shows the number of news articles covering this episode published in the main Spanish newspapers during the same timeframe. There was a significant correlation (Pearson's  $r = 0.55$ ,  $P < 0.001$ ) between the number of tweets collected each day with our search terms and the publication of related news in the mainstream media (Figure 1A and B).

### Frequency of policy and misinformation terms

Daily frequencies of tweets referring to policy (schooling, regulation, voluntary, obligatory, calendar) and vaccination misinformation (autism, aluminium, mercury) are depicted in Supplementary figure S1C. In total, our key terms appeared 25 476 times within the complete dataset: 19 122 relating to policy terms (presented in different shades of blue and green) and 6354 relating to vaccination misinformation (presented in different shades of red/pink). There was a sudden increase in the number of tweets containing these key terms at the onset of the diphtheria case and after the death of the child. The prevalence of the terms 'autismo' and 'calendario' during those two time-frames is particularly prominent.



**Figure 1** (A) Number of tweets found with vaccine or diphtheria related search terms on Twitter. (B) Number of news articles covering the diphtheria case in the main Spanish language newspapers. The dotted black lines mark the first report on the diphtheria case (June 1) and the report on the child's death (June 26)

## Content analysis of popular messages

### Coding procedure

Overall, 562 tweets in our dataset were retweeted 100 or more times. To select only the ones relating to the episode, three of the authors (P.G., M.F., M.A.V.), all native Spanish speakers, manually coded whether each tweet was relevant or not, ensuring that each tweet was classified by at least two coders. There was high consensus among all coders, with a Cohen's Kappa of 0.86. When coders disagreed, the tweet was removed from the analyses. Following this procedure, 194 popular Twitter messages were identified.

These tweets were then manually coded separately by two authors (M.F., M.A.V.) for key variables, including number of retweets, source (user who posted the message), topic, content type, tone (i.e. positive, negative, neutral) and sentiment of tweet (how the messages were expressed, e.g. frustration). We used thematic analysis<sup>23</sup> to identify the topics, which were inductive in nature. Initial topic categories were defined by three authors (T.P., M.F., M.A.V.) based on inductive analysis of 20 tweets. Two authors (M.F., M.A.V.) then analyzed 20 additional tweets and a discussion took place among the three authors (T.P., M.F., M.A.V.) on the problems encountered during the trial coding, and changes were made to the initial categories. Based on the new defined topic categories, two authors (M.F., M.A.V.) coded all the tweets separately, including content type, tone and sentiment. There was high consensus between the coders, with good inter-rater reliability: Cohen's kappa of 0.88 for topic, 0.97 for content type, 0.89 for tone of tweet and 0.72 for sentiment. Statistical analysis was conducted using *SPSS v22 for MAC*. Table 1 describes the topics that were identified with tweet examples. Sentiments of the tweets were based on the tweet analysis methods in previous studies,<sup>16,24</sup> which included frustration,

humour/sarcasm, concern and information. Table 2 describes the different sentiments with tweet examples.

### Measures—final codebook

The final codebook included the following categories: Tweet ID; URL; Number of retweets; User name; Topic; Content type; Tone, and Sentiment. *Topic* categories included: (i) efficacy of immunization/saves lives, (ii) vaccine safety concerns, (iii) regulation/policy issue, (iv) criticism of parents not vaccinating their children or of anti-vaccination movements, (v) severity and susceptibility of the diphtheria disease and (vi) other—general comments about vaccination. *Content type* categories included: (i) news article, (ii) blog post, (iii) image, (iv) other, (v) no link and (vi) no access (we could not access the link). *Tone* categories included: (i) pro-vaccination, (ii) anti-vaccination, (iii) neutral/unclear. *Sentiment* categories included: (i) information, (ii) frustration, (iii) humour/sarcasm, (iv) concern and (v) other. All categories were mutually exclusive.

### Content analysis

The most common topic was *Criticism of parents not vaccinating their children or of anti-vaccination movements* (35%). Comments mainly emphasized the dangers in not vaccinating children and that it is an irresponsible behaviour with risks that affect wider society. The second most common topic was *Efficacy of immunization/saves lives* (22%), highlighting the importance and effect of vaccinations in preventing different types of diseases. Six tweets in this category (3%) commented that, contrary to popular belief, there is no scientific debate about the safety of vaccines. *Severity and susceptibility of the diphtheria disease* (14%) included news items regarding the state of the child and information about

**Table 1** Topics of the popular tweets

Topic	Description	Example tweet
Criticism of parents not vaccinating their children or of anti-vaccination movements	Messages emphasizing the dangers in not vaccinating children and that it is an irresponsible behaviour with risk affecting wider society	'Anti-vaxxers boast that their children are healthy, when they are taking advantage of the existing collective immunity.'
Efficacy of immunization/saves lives	Messages highlighting the importance and effect of vaccinations in preventing different types of diseases	'If not for the vaccine, today we would have eight children suffering from diphtheria. In a week they could be 64. In a month, more than 4000.'
Regulation/policy issues	Messages addressing the debate about compulsory childhood vaccination and recommendations preventing unvaccinated children from attending school	'For me, the phrase of the day: "To vaccinate should be the right of children, not parents" #difteria.'
Severity of the diphtheria disease	Included mainly news articles describing the state of the child with diphtheria	'The six-year-old boy with diphtheria who was admitted to a hospital in Barcelona died.'
Vaccine safety concerns	Included messages raising concerns about the safety of vaccines	'Let's not deny that those who oppose the vaccination of children have firm arguments.'
Other	Included mainly compliments about the Spanish medical system and links to campaigns in favour of vaccinations	'At the request of the Catalan doctors' college, I have gladly collaborated in the next vaccination campaign.'

**Table 2** Sentiments of the popular tweets

Sentiment	Description	Example tweet
Information	Messages containing information and/or sources about vaccination or diphtheria	'Smallpox killed between 300 and 500 million people worldwide in the 20th century. The disease has now been completely eradicated due to vaccination.'
Frustration	Messages containing anger, irritation, contempt, criticism	Eight healthy and vaccinated children need to be medicated and stay at home to protect NON-vaccinated children. Why don't the unvaccinated children stay at home.'
Humour/sarcasm	Funny or sarcastic messages	'Spain, the country where it is mandatory to vaccinate your dog and optional to vaccinate your child.'
Concern	Messages containing fear, anxiety, worry or sadness about themselves or others. May also express scepticism	'The worrisome trend of the antivaxxers...'
Other	Messages that did not relate to the above sentiments	'Proud of the paediatrician who thought of diphtheria, although had not seen a case in decades. Great public health system, a treasure to take care of.'

diphtheria. Popular *Regulation/policy issues* (10%) included the debate about compulsory childhood vaccination and recommendations to prevent unvaccinated children from attending school. *Other* comments (18%) included mainly compliments about the Spanish medical system and links to campaigns in favour of vaccination. A small number of tweets raised *vaccine safety concerns* (2%). Supplementary table S3 shows the coding of the 20 most popular tweets.

The majority of the popular tweets were pro-vaccination (58%) and the remaining tweets were neutral. None of the popular tweets were anti-vaccination. Of the 62% of tweets that contained hyperlinks, the most popular linked content type was news articles (35%).

Popular tweets were informative messages (47%), which included links to news articles and statements about the importance of immunization, while the remaining tweets were classified as expressing opinions (53%). The leading opinions expressed were frustration (24%) regarding parents who do not vaccinate their children and humour/sarcasm (23%) regarding vaccination policy and anti-vaccination groups. Vaccine safety concerns (5%) were rarely expressed.

### *Influential users disseminating information*

To gain information about the source of the most popular tweets, we explored the profiles of the users who published them. These Twitter profiles were most commonly newspapers and TV channels (15%), including: El País (8%), El Mundo (4%), ABC (2%) and A3 Noticias (1%). In addition, some groups of individuals were particularly influential, including individual journalists (2.6%) and well-known authors involved in dissemination and popularization of science

(10.8%). While the well-known newspapers tweeted only links to news articles about the case, the journalists and popular science authors tweeted mainly personal and opinionated messages. None of the popular tweets were posted by healthcare organizations.

## Discussion

Our findings show that vaccination is an important issue discussed on Twitter and that specific episodes, like the diphtheria case in Spain, may provide a valuable means to explore the information shared by users. The number and content of the tweets tracked during this period fits the 'medium's nature as a timely communication channel for breaking news and a place to debate and make sense of complicated health issues'.<sup>18</sup> Twitter and the most popular Spanish newspapers show a high correlation in the number of related news stories published during the case, which is in line with previous studies.<sup>24,25</sup>

The most popular Twitter accounts disseminating information were mainstream media outlets, individual journalists and authors of popular science. While major newspapers and TV channels such as El País, El Mundo, ABC and the news channel A3 Noticias tweeted links to their news articles, individual journalists tweeted mainly personal and opinionated messages, which is in line with those reported in a study that analyzed the Twitter output of prominent journalists.<sup>26</sup> The authors found that journalists on Twitter are modifying and negotiating traditional reporting norms of neutral and unbiased information to more non-traditional elements, such as: sharing their opinions and personal lives; and engaging actively with followers, leading journalists and the public to be more interconnected in real time. They also found that

journalists working for national newspapers or TV were less inclined in their tweets to share their personal opinion or personal lives than their counterparts working at less 'elite' news outlets. This suggests that both objective news articles from mainstream media and personal opinions from individual journalists have a substantial impact on the social media discussion.

Identifying the most popular sources for disseminating vaccination information is important, as they can be a channel for providing information and addressing common misinformation and concerns in understandable and accessible ways. The importance of news articles on health issues to the general public has been highlighted before<sup>27</sup> and also recently in social media.<sup>28</sup> The finding that health organizations did not publish any of the popular tweets in response to the diphtheria case stands in contrast with previous research.<sup>18</sup> However, a recent study<sup>28</sup> has found that stories by news organizations had a higher impact compared to direct tweets by health organizations in communicating health-related information.

Looking at the prevalence of terms at the onset of the diphtheria case and after the death of the child, we found the terms 'autism' and 'calendario' to be particularly prominent. The term 'autism' was especially remarkable given that it was hardly ever mentioned before the episode. Although the MMR vaccine had been (wrongly) linked to autism, there has never been any similar reported association between diphtheria vaccine and autism. This suggests that many of these tweets were not specifically focused on the diphtheria case but on the more general issue of vaccination and vaccination misinformation. The term 'calendario' had a particularly high prevalence during June 2015. In Spain, the vaccination schedule for the administration of different vaccines is established by regional governments and, therefore, there are some inconsistencies in the policies followed in different parts of the country. The prevalence of this term suggests that many tweets were focused on the regulation and policy aspects of vaccination.

Almost half of the popular messages were informative, containing information about the diphtheria case and the efficiency of vaccination, either by links to news articles or informative messages. The other half were personal opinions expressing frustration, mainly regarding parents who do not vaccinate their children and humour/sarcasm, regarding vaccination policy and anti-vaccination groups. People shared their frustration about this preventable death of an unvaccinated boy. A similar finding was reported in a study analyzing content in social media and online newspapers during the measles outbreak in the Netherlands.<sup>23</sup> There too, the most common sentiment expressed was frustration after a girl who for religious reasons was not vaccinated against measles had died. Literature on commercial advertising suggests that appeals to humour and sarcasm capture more attention, especially online,<sup>29</sup> are easier for people to recall,<sup>30</sup> and reach more people than serious appeals. Moreover, done well, humorous appeals increase advertisement liking, which positively influences advertisement persuasiveness.<sup>31</sup> An example in the health domain is the video of actor Ryan Reynolds teaching men how to check for testicular cancer wearing a superhero costume, with over 2.4 million views.<sup>32</sup> On Twitter, humorous tweets were also found to be popular in health-related contexts, such as during the H1N1 swine flu outbreak<sup>16</sup> and in discussions about obesity.<sup>33</sup> A study examining the extent to which the most-followed journalists on Twitter are using humour,<sup>34</sup> found that humour is closely associated with sharing opinions and engaging in interpersonal discussion, and that journalists from less elite news organizations use humour more frequently.

We cannot conclude from our findings which content is more effective in changing beliefs and attitudes towards vaccination, such as convincing people that vaccines are safe. Existing messaging interventions demonstrate short-term success. However, some attempts to correct misperceptions about vaccines can easily backfire, increasing the perceived risks of vaccination and reducing intention to vaccinate.<sup>35</sup> Previous research has suggested

recommendations for effective messaging which include: reducing the impact of misinformation relating to vaccination, such as by emphasizing the facts and not the myth;<sup>36</sup> or appealing to values (namely 'purity' and 'liberty') associated with vaccine hesitancy, to appeal to core morality and influence the attitudes individuals have on vaccination.<sup>37</sup> Future research should address whether these features also increase impact of messages posted on social networking websites.

We captured tweets at a specific time when an unvaccinated child in Spain became ill and died from diphtheria. This context is important when analyzing the content and tone of popular tweets which were, perhaps unsurprisingly, mainly pro-vaccination. This pro-vaccination response to a tragic death is not unique to Spain. In 2016, there was a huge pro-vaccination social media response to a meningitis B death in the UK.<sup>38</sup> This incident sparked a powerful social media campaign in which more than 820 000 people signed a petition about changing the NHS meningitis B vaccination programme.

These pro-vaccination responses may have an effect on injunctive social norms (i.e. perceptions of which behaviours are approved or disapproved by others) in support of vaccination. There is some evidence that consensus messages on vaccine safety and efficacy could improve parents' perceptions of vaccine safety.<sup>39</sup> Thus, encouraging vaccination as the responsible and 'right' thing to do, versus not vaccinating one's child, which may be perceived as irresponsible and bad parenting.<sup>40</sup>

This study highlights the continuing power of traditional news outlets, journalists and science communicators to reach large audiences and amplify public health messages. Healthcare organizations could do more to collaborate with popular journalists or news outlets and employ authors of popular science to disseminate health information and personal opinions on social media, while addressing public concerns and misinformation in accessible ways. Future research, using machine learning algorithms could automatically analyze tweet content and users' characteristics, which could provide a fuller picture of attitudes and opinions of different users towards vaccination.

## Supplementary data

Supplementary data are available at *EURPUB* online.

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*Conflicts of interest:* None declared.

## Key points

- The most popular Twitter accounts were newspapers and TV channels as well as individual journalists and authors of popular science.
- The vast majority of popular tweets were either informative or personal opinions expressing frustration or humour/sarcasm.
- Healthcare organizations could collaborate with popular journalists or news outlets and employ authors of popular science to disseminate health information on social media.

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