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ABSTRACT

On Twitter, people answer the question, “What are you doing right now?” in no more than 140 characters. We investigated the content of Twitter posts meeting search criteria relating to dental pain. A set of 1000 tweets was randomly selected from 4859 tweets over 7 non-consecutive days. The content was coded using pre-established, non-mutually-exclusive categories, including the experience of dental pain, actions taken or contemplated in response to a toothache, impact on daily life, and advice sought from the Twitter community. After excluding ambiguous tweets, spam, and repeat users, we analyzed 772 tweets and calculated frequencies. Of the sample of 772 tweets, 83% (n = 640) were primarily categorized as a general statement of dental pain, 22% (n = 170) as an action taken or contemplated, and 15% (n = 112) as describing an impact on daily activities. Among the actions taken or contemplated, 44% (n = 74) reported seeing a dentist, 43% (n = 73) took an analgesic or antibiotic medication, and 14% (n = 24) actively sought advice from the Twitter community. Twitter users extensively share health information relating to dental pain, including actions taken to relieve pain and the impact of pain. This new medium may provide an opportunity for dental professionals to disseminate health information.

KEY WORDS: Twitter, odontalgia, surveillance, social networking, pain, toothache.

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Public Health Surveillance of Dental Pain via Twitter

INTRODUCTION

In the United States, orofacial pain is a prevalent and debilitating problem that accounts for approximately 40% of an estimated \$80 billion in pain-related health care costs annually (Israel and Scrivani, 2000). The most common acute manifestation of orofacial pain is odontalgia or toothache. It is a stressful and intensely painful experience, often leading to absences from work or school (Cohen *et al.*, 2007, 2009; Pau *et al.*, 2007), and is estimated to affect 12% or more of the population at any given time (Locker and Grushka, 1987; Lipton *et al.*, 1993). In this study, we explored a new way of evaluating individuals' experiences of dental pain using Twitter, an online micro-blogging service.

Twitter is a Web site that allows users to broadcast “tweets”, or short posts of 140 characters or fewer, to answer the question, “What are you doing right now?” (Java *et al.*, 2007). Twitter content is largely public and accessible through its Web site and other applications. Because tweets are limited in length, users post more frequently in real time. A recent study demonstrated a correlation of 72% between an analysis of Twitter user sentiments and both consumer confidence and presidential job approval indices (O'Connor *et al.*, 2010), suggesting that Twitter may be a useful data source, especially for real-time studies. Although it is well-known that patients use online resources to acquire health information, researchers and clinicians are just beginning to evaluate the usefulness of social networking Web sites such as Facebook and Twitter as a source of health information (Fox and Jones, 2009; Scamfeld *et al.*, 2010; Greene *et al.*, 2011).

This study evaluated whether Twitter users broadcast information relating to dental pain and assessed the content of the information being communicated. Persons sharing their experience of dental pain in real time on Twitter may provide a novel vehicle for the study of dental health behavior.

MATERIALS & METHODS

We evaluated the content of a cross-sectional sample of tweets relating to dental pain utilizing publically available data from Twitter. A representative sample of tweets was collected using the search terms “toothache OR tooth ache OR dental pain OR tooth pain”. From this dataset, 1000 tweets were randomly selected for analysis. After excluding un-interpretable tweets and multiple tweets from the same user (see Appendix Methods), we analyzed a set of 772 tweets.

Prior to analysis, a coding system was developed (NH, BG, JG) using a different dataset obtained with the same search criteria. The content of over 300 tweets was systematically categorized until thematic saturation was obtained. This iterative process was repeated until consensus was obtained in defining non-mutually-exclusive categories consisting of 14 primary categories and 46 secondary categories that investigators could use to code data

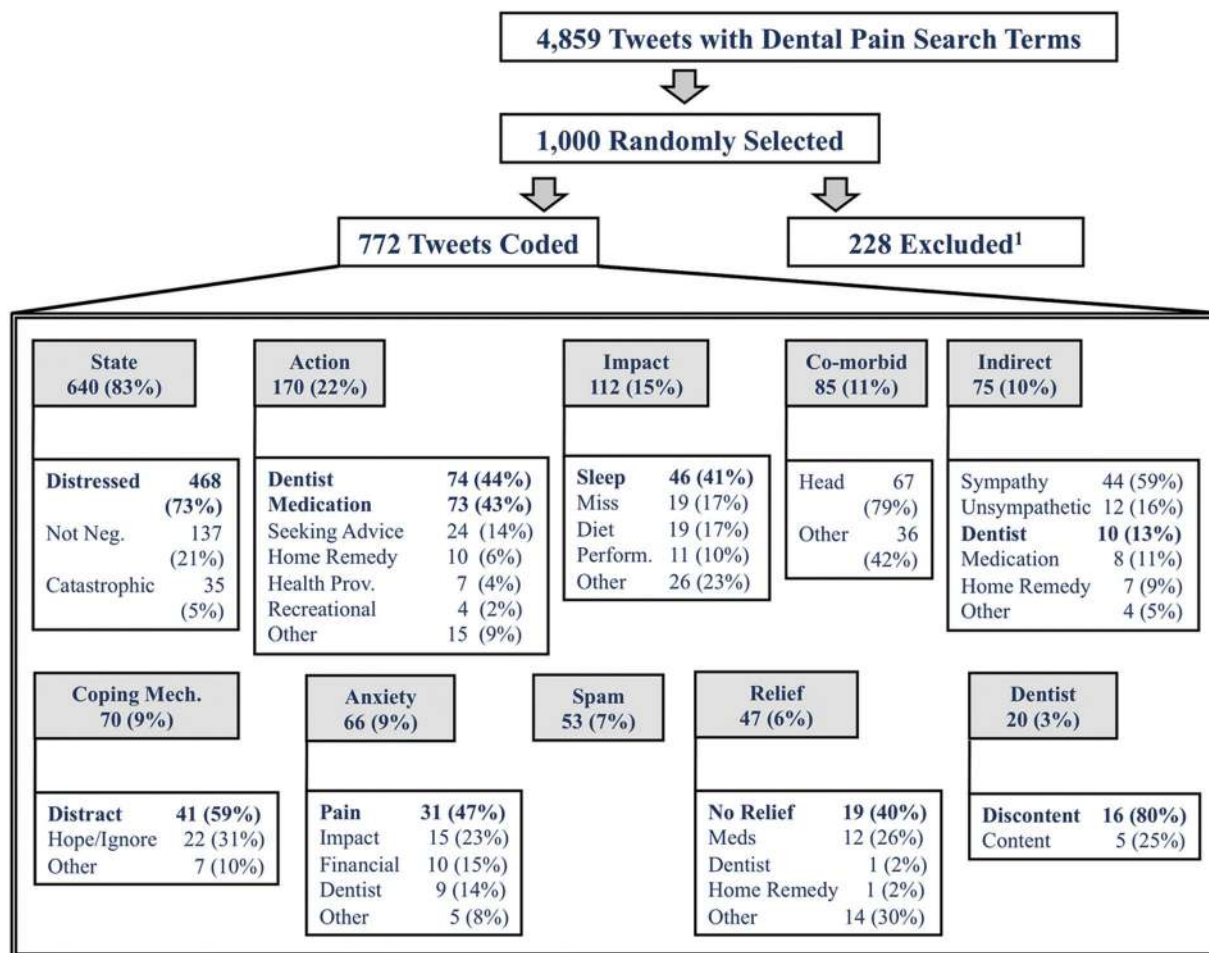


Figure 1. Frequencies of primary categories (PC) and secondary categories (SC), n (%). Gray-shaded boxes contain PCs, while non-shaded boxes contain SCs. The PCs are ordered from most frequent to least frequent. The categories are not mutually exclusive, and therefore the percentages of PCs may not total 100% and the percentages of SCs may not total 100%. The denominator used for PC was the sample size following the removal of tweets that met exclusion criteria (PC denominator n = 772). The denominator used for SC was the number of tweets coded in the respective PC [e.g., SC denominator for all SC under Statement = 640, for SC under Action = 170, for SC under Impact = 112, etc.]. Re-tweets, unrelated or ambiguous tweets, tweets from repeat users, and any uninterpretable tweets were excluded from the sample (n = 228).

consistently (Appendix Table). The coding system was used to analyze the content of the random set of 772 tweets, which was primarily accomplished by one investigator (NH). Frequencies were determined for each category. Data were compiled in an Excel spreadsheet that was used to calculate basic descriptive statistics. A subset of 100 tweets was coded to measure interrater reliability, which had high agreement (Cohen’s kappa = 0.96) (see Appendix Methods).

RESULTS

Using the search terms, we collected a total of 4859 tweets over a seven-day period (Appendix Fig.). These search terms resulted in an average of 694 tweets collected *per day* (standard deviation = 58, max = 761, min = 606, median = 692). The terms “toothache” and “tooth ache” were the most frequent matches in the queries, accounting for over 80% of updates collected. (Appendix Fig.).

Of the 1000 status updates selected, 228 were excluded from the analysis because they were not related to dental pain, the meaning was ambiguous, or because they included “re-tweeted” content (Fig. 1). Further, so that heavy Twitter users did not bias our findings, we included only the first tweet from each unique user in the dataset. This left 772 tweets for analysis from 772 unique users. An analysis of user characteristics revealed that 62% were female, 27% male, and we were unable to determine the gender of 11% of the user population (Table 1). We also evaluated the geographic location of the user when possible and found that most of the users in our study were from the USA and Canada (47%), the UK (18%), and Asia (12%) (Table 1).

Since the codes used were not mutually exclusive, we found an average of 2 items coded *per tweet*, with each code having a primary category (PC) and a secondary category (SC) (for examples, see Table 2). The majority of tweets were statements suggesting that the users were experiencing a toothache [PC = Statement n = 640, 83%_(640/772) of tweets], and the vast majority

Table 1. Demographic Characteristics of Unique Twitter Users in Sample

User Characteristics (n = 772 Unique Users)	Frequency, n (%)
Gender*	
Female	479 (62)
Male	209 (27)
Uncertain	84 (11)
Geographic Location	
USA and Canada	362 (47)
UK	137 (18)
Asia	91 (12)
Africa	16 (2)
Other	37 (5)
Unknown	127 (16)
Number of Status Updates	Max: 128,150 Min: 1 Median: 2208
Number of Followers	Max: 17,502 Min: 0 Median: 136

*Gender of unique users determined by investigator based on profile name and picture, when provided.

of these statements connoted some negative or even catastrophic association with the experience [SC = Distressed + Catastrophic n = 468+35 = 503, 79%_(503/640) of Statement codes] (Fig. 1 and Appendix Table for sample tweets). An example of this kind of post is: “ugh!! my toothache is killing me!! PAIN GO AWAY!!” The second most common type of content observed was the user stating an action he/she takes as a result of a toothache [PC = Action n = 170, 22%_(170/772) of tweets]. The most frequent actions reported were going to the dentist, taking medications including analgesics and antibiotics, and seeking advice from the Twitter community [SC = Dentist + Dentist Specific Root Canal + Dentist Specific Extraction n = 46+2+26 = 74, 44%_(74/170) of Action codes; SC = Medication n = 73, 43%_(73/170) of Action codes; SC = Seeking Advice n = 24, 14%_(24/170) of Action Codes]. The third most common type of content related how the dental pain was having an impact on a basic activity of daily living [PC = Impact n = 112, 15%_(112/772) of tweets]. By far the most frequently reported impact was on missing sleep because of dental pain [SC = Sleep n = 46, 41%_(46/112) of Impact codes].

Other interesting results included the frequent reporting of co-morbidities of other pain or illness [PC = Co-morbidity n = 85, 11%_(85/772) of tweets], the most common of which were other head and neck pains, most commonly including headache [SC = Head and Neck n = 67, 79%_(67/85) of Co-morbidity codes]. Some tweets conveyed anxiety about the potential future impact of the toothache [PC = Anxiety n = 66, 9%_(66/772) of tweets], as in the following example, where the user is worried about having to see the dentist as a result of recent pain: “Oh no. . . I got tooth ache :(don't want to go to the dentists. Think its a wisdom tooth trying to get through.” Interestingly, anxiety was observed most frequently relating to the experience of pain itself [SC = Pain n = 31, 47%_(31/66) of Anxiety codes], and relatively less frequently about visiting the dentist [SC = Dentist n = 9, 14%_(9/66) of Anxiety codes]. Another interesting result was obtained regarding

Table 2. Examples of Tweets Extracted from Twitter Using the Designated Search Terms and Their Classifications into a Primary category and a Secondary Category (classifications not mutually exclusive)

Tweet	Primary Category (PC)	Secondary Category (SC)
“I think I’m dying. Headache, toothache plus it’s hot >_< <-- DEAD”	1. Statement 2. Co-morbidity	1.1. Catastrophic 2.1. Head & Neck
“Just bit into a chocolate biscuit and a tooth fell out. Just had to take a 2 paracetamol to kill the pain. Visit to the dentist tomorrow”	1. Action	1.1. Medication 1.2. Dentist
“@username Great. Now it’s like a song that I can’t get out of my mind. But at least it will take my mind off my toothache. . . .” *	1. Coping mechanism	1.1. Distraction
“I cannot wait to get this wisdom tooth pulled . . .my body is immune to every pain medicine . . .and I have taken EVERYTHING”	1. Relief Status 2. Action 3. Wisdom	1.1. No Relief 2.1. Dentist
“Ugh! The pain is unbearable. . .This dentist needs to hurry up. . .I feel like yanking the tooth out myself! Lol”	1. Dentist 2. Action	1.1. Discontent 2.1. Dentist

*Username removed to maintain privacy of Twitter user.

reported user satisfaction upon visiting the dentist [PC = Dentist n = 20, 3%_(20/772) of tweets]. The majority of these tweets expressed discontent regarding the dental visit [SC = Discontent n = 16, 80%_(16/20) of Dentist codes], whereas only 25%_(5/20) (SC = Content n = 5) conveyed a positive impression.

Finally, we created a word cloud on <http://www.wordle.net/> using the content from the 772 randomly collected tweets. In the word cloud, the larger the font size of the word, the more frequently the word was used in tweets related to dental pain (Fig. 2).

DISCUSSION

The high prevalence of orofacial pain and its association with significant reduction in quality of life support the need to pursue new ways to communicate with patients. We found that a large volume of content relating to dental pain is generated daily on Twitter and is readily retrievable using simple search terms. The majority of users express distress or negative feelings when experiencing a toothache. Additionally, users provide multiple dimensions for their experience of dental pain despite the limiting character constraint of Twitter. These findings demonstrate that the public uses Twitter to communicate experiences of dental pain, including specific dimensions such as actions taken



Figure 2. Word cloud created from tweet content for the 772 randomly collected tweets (<http://www.wordle.net/>). Font size correlates with the greater frequency of the word used in tweets related to dental pain.

to address the pain, descriptions of the impact on daily life, and many others.

It is of great interest that the impacts on daily living and common actions taken to manage toothache-associated pain we observed in Twitter users are similar to previous reports using other methods. For example, a telephone survey study found that the most frequently reported behavioral effects of toothache are mood changes, difficulty eating, worry, and disruptions in sleep (Cohen *et al.*, 2009). Although we did not attempt to infer mood from tweets, we did find that most users expressed various levels of distress in response to a toothache, as in the following example: *“This toothache is preventin [sic] me from my happiness :(”*. Also, similar to the phone survey, we found that users would frequently post about disruptions in sleep, eating, and working (PC = Impact). Another similarity found was that users would tweet about their worries regarding the toothache, and the most frequent worry was related to how much pain the toothache would cause (PC = Anxiety). These similarities suggest that the toothache experience shared in an unsolicited manner by Twitter users is similar to what was obtained using more traditional survey strategies, supporting the potential validity of Twitter as a data source.

Our findings related to the frequent report of self-management strategies for toothache are also consistent with previous studies. People will often use prescription and non-prescription medications as well as home remedies to self-manage the pain of a toothache (Gilbert *et al.*, 2000). In fact, most low-income patients will utilize a self-care method before attempting to visit a dentist (Riley *et al.*, 2004; Cohen *et al.*, 2009). In our study, we found similar frequencies of users reporting going to the dentist (44% of Actions reported) or taking medication (43% of Actions reported) as a result of their toothache, suggesting a high rate of utilization of self-management strategies.

There are several potential advantages to the use of Twitter as a data source. One is the abundance of real-time data. The user is typically describing a personal account of a toothache as it is being experienced. Most traditional studies rely on patients’ ability to recall their toothache experience, potentially producing recall bias

or an observer-expectancy effect (Kikuchi *et al.*, 2006; Stone and Broderick, 2007). The use of real-time updates avoids retrospective reports and thereby creates greater accuracy and sensitivity in the measurement of behavioral responses to pain (Gendreau *et al.*, 2003). Another advantage of Twitter is that users can use applications on smartphones or tablets, which greatly increase the frequency of posting (Krishnamurthy *et al.*, 2008). Another potential advantage of Twitter as a data source is that the users represent a global community. As of January 2010, approximately 50% of unique Twitter users were located in the USA (Evans, 2010). The trends over time, however, suggest that users in Asia and Africa are increasing their proportion of Twitter uses, while the

proportions in North America and Europe are decreasing, suggesting a tremendous potential for the study of and access to diverse global populations (Guyot, 2010).

There are several important limitations to this study. First, our observations are not made from a random population sample but from a sample of Twitter users, and therefore are relevant only to that population. Web site use analytics suggest that there are more than 60 million Twitter users visiting the Web site *per* month in the US alone, and the US Twitter population is rich in persons of female gender (55%), persons aged 18-34 yrs (45%), persons of African American (16%) and Hispanic (11%) race, persons making over \$100K *per* yr (30%), and persons with no college (49%) relative to the demographics of average US Internet users (Quantcast, 2010). Since Twitter use fluctuates day to day, we do not know how many unique users were posting to Twitter when our dataset was extracted, which prohibits us from discussing incidence or prevalence of dental pain in this population. Further, the population posting content to Twitter may even differ from the population using Twitter (Wu *et al.*, 2011). In other words, there may be specific qualities that make someone more or less likely to share information in public forums, which could further affect the representativeness of the study population. Further study is necessary to determine the validity of Twitter as a data source.

One of the major findings of this study is that people extensively share information relating their experiences of a toothache in real time. This observation begs the obvious next question of why people turn to social networking sites when they are experiencing pain. Perhaps the answer is contained in the following tweet: *“There’re a lot of people twittering suffering from toothache all around the world, including me.”* People may find comfort in the fact that others are simultaneously facing the challenge of dental pain. It is also clear that people are using the Twitter community to seek advice for managing the pain of toothache. Although in this study we utilized Twitter only to obtain observational data, it is critical to point out that Twitter is designed to be a means of communication among individuals. For example, persons experiencing a toothache

could be referred to evidence-based Web sites that will help them determine the need for professional evaluation or treatment, or, further, directed to a nearby dental office, community clinic, or dental school for care. In the course of our study, we found that many professional and non-professional entities are already targeting persons suffering from toothache, often for the purpose of selling some type of product (7% of tweets were spam in this study).

Twitter is an example of a new means for the public to communicate health concerns and could afford health care professionals new ways to communicate with patients. With the growing ubiquity of user-generated online content *via* Web sites such as Twitter, Facebook, and Yelp, it is clear that we are experiencing a revolution in communication and information-sharing. In this study, we demonstrated that Twitter users are already extensively sharing their experiences of toothache and seeking advice from other users. As dental professionals, we will need to act quickly to ensure that we are part of the conversation.

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