Dissemination of health information through social networks: Twitter and antibiotics

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Abstract

Background—This study reviewed Twitter status updates mentioning "antibiotic(s)" to determine overarching categories and explore evidence of misunderstanding or misuse of antibiotics.

Methods—One thousand Twitter status updates mentioning antibiotic(s) were randomly selected for content analysis and categorization. To explore cases of potential misunderstanding or misuse, these status updates were mined for co-occurrence of the following terms: "cold + antibiotic(s)," "extra antibiotic(s)," "flu + antibiotic(s)," "leftover antibiotic(s)," and "share antibiotic(s)" and reviewed to confirm evidence of misuse or misunderstanding.

Results—Of the 1,000 status updates, 971 were categorized into 11 groups: General Use (n=289), Advice/Information (n=157), Side Effects/Negative Reactions (n=113), Diagnosis (n=102), Resistance (n=92), Misunderstanding and/or Misuse (n=55), Positive Reactions (n=48), Animals (n=46), Other (n=42), Wanting/Needing (n=19), and Cost (n=8). Cases of misunderstanding or abuse were identified for the following combinations: "flu + antibiotic(s)" (n=345), "cold + antibiotic(s)" (n=302), "leftover antibiotic(s)" (n=23), "share antibiotic(s)" (n=10), and "extra antibiotic(s)" (n=7).

Conclusions—Social media sites offer means of health information sharing. Further study is warranted to explore how such networks may provide a venue to identify misuse or misunderstanding of antibiotics, promote positive behavior change, disseminate valid information, and explore how such tools can be used to gather real-time health data.

INTRODUCTION

First coined in 2004, "web 2.0" describes a change in the way people interact with information online, moving from passive consumption to active creation of content. Web 2.0 software harnesses network effects and knowledge in an open, interactive manner [1]. It is now common to participate in social networking communities (e.g. Facebook), social rating websites (e.g. Digg), customer review websites (e.g. Yelp), photo and video sharing networks (e.g. Flickr and YouTube), blogs (e.g. Huffington Post), and information aggregators (e.g. Wikipedia). These platforms enable people to share their knowledge and experience, creating a rich array of user-generated content [2]. Within this new construct, one's peers are an important source of information, with 47% of respondents in one survey reporting the information they receive from "a person like me" to be extremely or very credible, on par with their trust of industry experts [3]. See Table 1: Social Media Tools, Definitions & Examples.

Not surprisingly, web 2.0 trends have extended to the health care arena, as those seeking health information online began disseminating their experiences and knowledge [4]. Collectively referred to as "medicine 2.0" or "health 2.0," these trends are broadly defined as "the use of a specific set of Web tools (blogs, Podcasts, tagging, search, wikis, etc.) by actors in health care including doctors, patients, and scientists, using principles of open source and generation of content by users, and the power of networks in order to personalize health care, collaborate, and promote health education" [1]. A Pew study recently reported that 61% of American adults seek health information online and 37% have accessed user-generated health information online. Sixty percent of e-patients (internet users that have looked online for health information) reported that online inquiries had an impact on their health decisions. Forty-two percent of all adults say that they or someone they know has been helped by following medical advice or health information found on the internet, a 43% increase since 2006; only 3% of all adults report that they or someone they know has been harmed [5].

The purpose of this paper is to report a content analysis of the large microblog, Twitter, to determine the main categories of content contained in Twitter users' status updates mentioning antibiotics and to explore cases of misunderstanding and misuse of antibiotics that might inform potential interventions and information campaigns.

METHODS

Design

We conducted a cross-sectional survey using content analysis of Twitter status updates between March 13, 2009 and July 31, 2009.

Study Setting

The observational study applied content analysis to publicly available Twitter Web pages using the Web site www.Twitter.com. Twitter updates may be public, meaning content is viewable to any Web site visitor, or protected, meaning updates are not available on a public search and can only be viewed by approved users. Individuals can optionally identify their location, a one-line biography, and language. Twitter also tracks and makes publicly available the number of people following the user; the number of people the user is following; and the number of status updates ("tweets") the person has posted. Only publicly available data were used in this analysis. As of August 2009, approximately 94% of Twitter accounts were public, with that number trending upward [6]. See Table 2: Dictionary of Twitter-related terms.

Search Strategy

Twitter features a search function to filter status updates that meet particular search criteria. Each individual search returns results from a variable timeframe (approximately one week), depending on the storage capacity of Twitter's database. We included publicly available updates on Twitter that mentioned antibiotic(s) in English. No restrictions were placed on location or age. Twitter does not track age, but registrants to the service must certify that they are 13 years of age or older. We conducted two searches, one for "antibiotic" and one for "antibiotics," on a weekly basis from March 13 to July 31, 2009. The combined results yielded a list of 52,153 status updates mentioning at least one of the search terms.

Determining Categories

We applied Q-methodology [7], to categorize the status updates. We downloaded an initial set of updates that mentioned 'antibiotic' or 'antibiotics' and then generated a list of 100 random updates intended to be sufficiently representative of the universe of antibiotic-related content expressed on Twitter [8]. Three researchers separately evaluated the updates and inductively classified them into broad categories. The categories were then discussed to reach consensus and 11 categories were initially determined: Advertisements, Advice/ Information, Animals, Cost, Diagnosis, General Use, Other, Positive Feedback, Resistance, Side Effects/Negative Reactions, and Wanting/Needing. This process was then repeated, applying the 11 categories to two new sets of 100 randomly selected status updates to ensure that the categories were sufficient and to further clarify category definitions.

Based on this process, another category, labeled "Misunderstanding and/or Misuse," was added to replace and subsume "Advertisements," given that all examples of advertisements were from illegitimate sources. With this new categorization, legitimate advertisements would have been categorized as "Advice/Information." The "Misunderstanding and/or Abuse" category was utilized in the following specific cases: (1) references to using antibiotics to treat a virus, cold, or flu; (2) attempts to access or sell antibiotics without a prescription; (3) incorrect use; and (4) refusal to take antibiotics under any circumstances. Therefore, when a status update provided advice or information, a specific subset of those updates was categorized as "Misunderstanding and/or Abuse." The rest were categorized as "Advice/Information," including cases when the advice might be incorrect.

Data Collection

Once categories were established, 1,000 status updates were selected from the complete list of 52,153 status updates mentioning antibiotic(s) using the RC4 method for randomization [9]. Each status update was grouped into a single category by two researchers, with each reviewing one half of the data set. Areas of ambiguity were discussed and agreed upon by consensus. Status updates that used the term "antibiotic(s)" metaphorically (e.g., "Turning benign symbiotes into vicious, antibiotic resistant bacteria dedicated to film industry destruction") were removed. Some status updates included links; for cases in which content was ambiguous, the link was checked to clarify the user's intent. To assess inter-rater reliability, we re-categorized a random sample of 10% of the status updates. The Cohen's κ statistic was used to measure the extent to which there was agreement in the categorization of status updates and determined a value of 0.73.

We further mined the total list of 52,153 for updates that included the following phrases: "cold + antibiotic(s)," "extra antibiotic(s)," "flu + antibiotic(s)," "leftover antibiotic(s)," and "share antibiotic(s)." Each update was reviewed for indication of misunderstanding and/or misuse of antibiotics. Updates that resulted from the search but which did not indicate misunderstanding or misuse were not included.

We also recorded the number of followers for each Twitter user, the number of people the user was following, and the number of status updates the user had submitted, all standard information on a Twitter page. No attempts were made to contact individuals or obtain access to information set as private.

RESULTS

Of the 1000 status updates, 29 were removed because they treated the word "antibiotic(s)" as a metaphor. For an overview of the resulting categorization, see Table 3: Antibiotic-Related Categories, Definitions, Examples, and Frequencies from Twitter Status Updates.

The most common category was "general use," including a range of updates about taking antibiotics, often simply mentioning the number of days remaining on a prescription and a desire that the antibiotics begin helping soon. The second most common category was "advice and information." While some updates simply included the transfer of personal advice or information, such as "get antibiotics if its [*sic*] serious" or "Garlic generally good, but not specific to strep. Walmart pharmacy will have antibiotics…," many referenced news articles about antibiotics and included a link, such as this: "Antibiotic delayed aging in mice: http://tiny.cc/C17Bp. Why do mice have all the fun?"

The third most prevalent category was "side effects/negative reactions," which included a variety of complaints and side effects from taking the medication. Examples of side effects ranged from the general, such as, "those antibiotics made me want to die," to the more specific, "I am on antibiotics that make me want to vomit." Negative reactions generally revolved around inconveniences, such as not being able to drink alcohol or sensitivity to the sun.

Figure 1: Word Cloud is a visual representation of word content commonly used to represent user-generated content. This word cloud includes the 1000 status updates analyzed for this study. It depicts the 150 most frequently utilized words, with each word's frequency correlated with font size.

We further explored the data by mining the 52,153 status updates for terms likely to be correlated with misunderstanding or misuse and then reviewing them to confirm evidence confusion or mishandling. The most popular word combination in this category was "flu + antibiotics," with 345 status updates including misinformation reaching a total of 172,571 followers. The next most popular word combination was "cold + antibiotics," with 302 status updates reaching a total of 850,375 followers. The remaining combinations, "leftover + antibiotic(s)," "extra + antibiotic(s)," and "share + antibiotic(s)" were determined to indicate misuse in 40 cases, with a total reach of 23,016 followers. See Table 4: Misuse and Misunderstanding: Categories, Examples, Frequencies, and Reach of Twitter Status Updates.

DISCUSSION

Launched publicly in July 2006, Twitter is a social networking and micro-blogging service that allows users to post frequent updates. An update is limited to 140 characters and can be posted through three methods: web form, instant message online, or text message via mobile phone [10]. Twitter users follow one another's updates and can search all updates for keywords of interest. Twitter has been used to disseminate information and news, solicit feedback, communicate with companies, share ideas, document events, and provide personal updates [11]. Notably, Twitter has been employed by NASA to provide updates on the status of space shuttle flights [12], by a student journalist to get himself out of an Egyptian jail by

"tweeting" a single word to his Twitter network: "Arrested" [13], and to disseminate information during protests after a contested election in Iran in June 2009 [14, 15].

Use of Twitter has grown rapidly, with a 1,460% increase in global audience between June 2008 and June 2009. The site had an estimated 44.5 million visitors worldwide as of June 2009 (which only includes traffic to Twitter.com, not usage on desktop and mobile clients, which is also common) [16]. Twitter reached one billion tweets in November 2008 [17] and served over 3.7 billion tweets as of September 4, 2009 [18].

With a median age of 31 years, Twitter attracts 19% of online adults ages 18–24, 20% of online adults ages 25–34, and 10% of online adults ages 35–44 years old. Twitter users are disproportionately from lower-income households and are more ethnically and racially diverse than the full U.S. population due to the skewed age distribution toward a younger population. Twitter users are also more likely to live in urban areas (35%, compared with 29%, of all internet users). Use of Twitter is correlated with utilization of other social media, with 23% of social network users saying they have used Twitter or a similar service, compared with just 4% of those who do not use social services [11].

According to a Pew Internet & American Life survey, 12% of e-patients use Twitter or another service to share health-related updates about themselves or to see others' health-related updates [5]. One survey by Jupiter, a company which researches and analyzes the impact of Internet and consumer technologies, provides insight into why people look for and share information online; 36% of respondents use the internet to see what other consumers say about a medication or treatment, 31% use the internet to research other consumers' knowledge and experiences, 27% use the internet to learn skills or get education that help to manage a condition, and 17% use it for emotional support [19]. People who feel they have a lot at stake, such as people living with a disability or chronic disease, are more likely to engage intensely with online resources [20].

This study confirmed that Twitter is a space for the informal sharing of health information and advice. The dissemination of information on Twitter through networks of followers and a culture of "retweeting" demonstrate the potential reach of this medium for the dissemination of both valid and invalid information. It is therefore important for health care professionals to have a basic understanding of such services and the nature of the health-related information that is shared on them. Given the immense popularity of such sites, they have become an integral way in which people gather and disseminate information [21].

Twitter and similar services may provide a venue to identify potential misuse or misunderstanding of antibiotics, to promote positive behavior change, and to disseminate valid information. For instance, an organization can enable people taking medications to sign up to receive Twitter updates reminding them to take their medication at proper intervals to avoid missing doses or failing to complete a prescription. Research on behavior change interventions delivered by mobile telephone short-message service can be used as a model for such Twitter-based reminders, including prevention of sexually transmitted diseases [22], smoking cessation [23], improving travel vaccination rates [24], and supporting insulin therapy [25]. One recent paper reviewed 14 studies and reported positive behavior change outcomes in 13 of them [26]. To disseminate information to those exhibiting confusion or sharing misinformation, online services are available to monitor and auto-respond to trigger word combinations, such as "flu + antibiotics" [27].

Finally, such tools can potentially be used to gather important real-time health data by creating a "mashup," which combines health status updates with location-based information [28]. To track outbreaks, for example, it would be relatively easy for a health organization to enable people to submit Twitter status updates with symptoms and location data using a

predefined format so that the updates are machine readable and easily mapped [29, 30]. A good model for such an initiative is the Twitter Vote Report project, which aggregated and mapped voter reports regarding long lines, broken machines, and problems with registration rolls in real time [31]. The project used a range of hashtag metadata to track these reports, including #votereport (added to all reports), #[zip code] to track where the individual was voting, #machine to report problems with a voting machine, and wait:[minutes] to report the length of the line [32]. Such updates can be submitted proactively by participants for the sake of generating a data pool, as with the Twitter Vote Report, or passively, like the antibiotics-related data we explored for this paper. In either case, such information could be integrated with existing disease surveillance systems to supplement the information already being aggregated from different sources [33, 34].

This study has limitations that warrant discussion. First, the validity of the content and self reported behaviors in Twitter status updates is unknown. This study used status updates as an indicator of what people think, believe, or understand; it is possible, however, that some status updates are embellished or exaggerated for effect and thus cannot be taken at face value. In addition, the extent to which findings are generalizable to other micro-blogging platforms is unknown. We may have experienced a seasonal bias; the study did not take place during the traditional influenza season, but an outbreak of H1N1 increased the frequency with which Twitter users discussed the flu and, likely, the co-occurrence of the terms "flu + antibiotics." This effect, however, would not necessarily affect the relative level of accurate or inaccurate information being discussed. It is possible, however, that the novel nature of the H1N1 strain, in combination with amplified news coverage, may have led to an increase in misinformation. Finally, there may have been measurement biases, as choosing categories was subjective and a different group of researchers might have determined a different set, though Q sort methodology was used to reduce this effect. Also, categorization required a series of individual judgments, and a portion of the status updates could have been reasonably placed into multiple categories, resulting in lower inter-rater reliability. The study team worked to reduce this effect by categorizing ambiguous cases by consensus.

Despite these limitations, this study offers valuable findings. First, given that health information is shared extensively on such networks, it is important for health care professionals to have a basic familiarity with social networking media services, such as Twitter. Second, such services can potentially be used to gather important real-time health data and may provide a venue to identify potential misuse or misunderstanding of antibiotics, promote positive behavior change, and disseminate valid information.

Research focusing on microblogs and social networking services is still at an early stage. Further study is needed to assess how to promote healthy behaviors and to collect and disseminate trustworthy information using these tools.

Acknowledgments

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Figure 1. Word Cloud
This word cloud depicts the 150 most frequently utilized words within the 1000 status
updates analyzed for this study. Each word's frequency is correlated with font size.
Source: http://www.wordle.net. Licensed under a Creative Commons Attribution 3.0 United
States License.

Table 1

Social Media Tools, Definitions & Examples

Term	Definition	Example
Blog ("weblog")	A website that contains regularly updated entries displayed in reverse chronological order. [34]	General: Huffington Post, TechCrunch Health: WebMD Blogs, HealthLine.com Blogs [35], Biography of Breast Cancer [36]
Microblog	A form of blogging that allows users to send brief text updates or micromedia to be viewed by the public or a restricted group. These messages can be submitted by a variety of means, including mobile text messaging, online instant messaging, email, digital audio, or the web [37].	General: Twitter
Social Network Website	Online communities that share interests and/or activities.	General: Facebook, MySpace Health: PatientsLikeMe, DailyStrength [4]
Wiki	A website that enables the easy creation and editing of interlinking web pages. [38]	General: Wikipedia Health: AskDrWiki, Ganfyd, [4] WikiSurgery [36]
Social News & Bookmarking	Social bookmarking enables users to save and share links to web pages organized by metadata (e.g., "tags," or keywords). Social news sites often enable voting on links to news, to bring the most popular stories to the top. [39]	General: Del.icio.us, Digg Health: Digg.com/Health
User Reviews	A website where people can post opinions about people, businesses, products, or services.	General: Epinions, Yelp Health: RateMDs [29]
Photo/Video Sharing	A website that enables the publishing of a user's digital photos or video clips online, facilitating sharing with others.	General: YouTube, Flickr Health: ICYou [4]

Table 2

Dictionary of Twitter-related terms

Term	Definition
@reply	A public message directed at another person, sent regardless of follow-ship.
DM (Direct Message)	A private message that only the author and recipient can view, which can only be sent when the recipient follows the author.
Follow	When someone posts a new message, it appears in his/her followers' Twitter home page in real time. Updates can also be received by mobile phone.
Hashtag	Hashtags are a community-driven convention for adding groupings on Twitter by including metadata within tweets. A hashtag is created by prefixing a word with a hash symbol: "#."
RT (Retweet)	"RT" is added to a tweet to indicate that it includes text from another person's tweet, optionally adding original content.
Tweet	A Twitter update.

Table 3

Antibiotic-Related Categories, Definitions, Examples, and Frequencies from Twitter Status Updates

Category	Definition	Example	Frequency
General Use	Commenting generally on taking antibiotics	"Got more antibiotics from doc. hope these ones finally get rid of this cough"	289 updates
Advice & Information	Offering or seeking advice, information, or explanations regarding antibiotic use	"Absolutely it could mess up your stomach. A good rule of thumb with antibiotics is to ear [sic] a yogurt every time you take your dose"	157 updates
Side Effects/ Negative Reactions	Claiming or mentionin side effects from antibiotics, negative reactions, complaints	"The antibiotic I took a while ago is killing my stomach… ugh!"	113 updates
Diagnosis	Mentioning the reason for taking antibiotics	"A dying tooth. Painkillers. Antibiotics. Root canal scheduled. Ahhh … the sweet curves life throws."	102 updates
Resistance	Discussing resistance, including reference to antibiotics in farm animals	"Dangers from overuse of antibiotic use in animal feed leading to MRSA outbreaks http://tinyurl.com/cqj638"	92 updates
Misunderstanding and/or Misuse	Referencing viruses, cold, flu; attempts to access or sell antibiotics without a prescription; incorrect use; refusal to take antibiotics under any circumstances.	"Go get a shot, babe. Or some Murine ear drops from Walgreens. I can also mail out my leftover antibiotics."	55 updates
Positive Reactions	Expressing a positive reaction to or result from taking antibiotics	"I promise this is my last sickness tweet (bored with me yet?) But I could literally FEEL the antibiotic start to work. Amazing."	48 updates
Animals	Referencing an animal, not including antibiotics in farm animals	"Cat has antibiotics. doesn't like traveling when it means there might be peroxide at the end. is currently being bathed. not happy. is loud."	46 updates
Other	Miscellaneous mention of antibiotics that fails to fit into any other category.	"From the pharmacy frontier: Does the world really need 20 flavor options to make medicine go down easier? Cotton-candy antibiotic, anyone?"	42 updates
Wanting/Needing	Expressing a desire for antibiotics, but not having received them yet	"Needs antibiotics right now !!"	19 updates
Cost	Discussing cost or pricing	"Turns out I can still take my antibiotic if I take an anti-histamine for the reactions :/ Total bill for illness? $165 thus far."	8 updates

Table 4

Misuse and Misunderstanding: Categories, Examples, Frequencies, and Reach of Twitter Status Updates

Category	Example	Frequency	Reach
Cold + antibiotics	"Finally over my cold. Summer colds suck. Thank-you Z-pack antibiotics."	302 updates	Unique users: 277 # followers: 1 to 759,127 Median followers: 66 Total followers: 850,375
Flu + antibiotics	"Starting to feel better from the terrible flu. One antibiotic to go."	345 updates	Unique users: 317 # followers: 0 to 34,721 Median followers: 78 Total followers: 172,571
Leftover + antibiotics	"Trying to find out how to get healthcare card for my uninsured urinary tract needing antibiotics.If you have any leftover,ill pay u!"	23 updates	Unique users: 21 # followers: 6 to 2,337 Median followers: 62 Total followers: 5,860
Share + antibiotics	"Hella productive.. haha! feel better homie. If I need to share my remaining antibiotics I will."	10 updates	Unique users: 10 # followers: 7 to 3,574 Median followers: 164 Total followers: 6,216
Extra + antibiotics	"Well, looks like I have strep throat. anyone have some extra antibiotics I could snag?"	7 updates	Unique users: 5 # followers: 11 to 10,750 Median followers: 71 Total followers: 10,940

Note: "Unique users" refers to the number of people who posted a status update demonstrating evidence of misunderstanding or misuse. In some cases, status updates were associated with users that lacked data on number of followers. In those cases, the user was not included as a unique user, and their followers were not included in the follower count.