Diabetes on Twitter:

Influence, activism, and what we can learn from all the food jokes

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<u>Introduction</u>

Governments across the world are increasingly using social media platforms like Twitter to disseminate health information and advice. Growing numbers of health departments and organisations have social media policies, and social media are now used by many as a low-cost tool for addressing so-called 'lifestyle diseases' such as obesity and Type 2 diabetes. The effectiveness of these initiatives is generally measured in terms of the number of subscribers following social media accounts (for example, see Public Health England 2014). Government social media policies tend to focus on legal concerns such as regulating staff use and ensuring privacy protection, rather than citizen health outcomes or experiences (Fast et al. 2015).

Government social media policies seldom acknowledge explicitly that, for citizens, Twitter contains a multitude of messages, with public health messages being posted and read alongside marketing for unhealthy products (Kelly et al. 2015); or that it may be used for a wide range of reasons, including for information seeking or dissemination (Scanfeld et al. 2010), stigmatisation and exclusion, or as a source of emotional support and community acceptance (Pew Research Center 2013). Twitter is also used as a venue for community activism and protests (Beguerisse-Díaz et al. 2014; González-Bailón et al. 2011), as a platform where information (or disinformation) can be shared, and activism-related events organised and coordinated. Government policies rarely consider the experience of social media users and the multitude of ways messages on the platform can be used, read, understood or interpreted; instead, they typically emphasise the importance of self-responsibility (Fast et al. 2015), implying by default that it is citizens' responsibility to responsibly navigate the broader social media landscape for themselves.

Content from social media that appears 'unrelated' to health advice is usually discarded by health researchers as irrelevant to their work. Analysis carried out for studies relating to Twitter and health tends to filter out content such as chatter or jokes – often about food – that the researchers view as 'noise' and 'irrelevant' to health research (for example, Harris et al. 2013; Hawn 2009; Paul & Dredze 2011). However, there is ample evidence that marketing (Kelly et al. 2015), social values (McLennan & Ulijaszek 2015), emotional connection, community (Ferzacca 2004) and humour can all contribute to health outcomes by affecting lifestyle patterns, food choices, stress levels and other physiological changes (McCreaddie & Wiggins 2008; Hayashi et al. 2003).

Unlike typical policy approaches or public health studies, our multidisciplinary approach to understanding the significance of Twitter in public health is not limited to formal health messaging or content that aligns with broader public health aims. Instead, we take a large collection of tweets containing a health term (in this case, 'diabetes'), and employ techniques from network science and information retrieval to determine who are the most influential Twitter users, what are the most common messages, and what is the content that attracts the most attention. We interrogate the significance of patterns in the data using social theory and analysis, and consider how findings fit in the broader public health context. Our collaborative analytic approach, which combines network analysis methods and social theory, is starting to break new ground in using data science to offer insights into our social world (Cihon & Yasseri 2016).

In this chapter, we focus especially on tweets that link food, eating and diabetes, and consider what our results can tell us about the use of Twitter as a platform for food activism. While diabetes management is almost inevitably about diet and nutrition, and diabetes rates worldwide are widely acknowledged to be associated with increasing consumption of 'junk' food, diabetes-related activism on Twitter rarely directly mentions food. A number of the most seemingly authoritative accounts

belong to activists and advocacy groups who use the platform to collectively organise around diabetes advocacy events and campaigns; these largely focus on raising diabetes awareness in the general population, and advocating for greater investment in research. Yet while food is surprisingly absent from tweets relating to diabetes advocacy (bringing about social or political change from *within* a system (Martinsson 2011)) and activism (bringing about social or political change from *outside* a system (Martinsson 2011)), it is not absent from our dataset. Many users talk about food, expressing themselves in updates and jokes about what they are eating. When we look more closely at these messages, we see that some users – in this case, people who tweet about diabetes – perform consumer activism differently to diabetes advocates and activists. As a result, our work calls into question current notions of what consumer-level food activism is and does.

We begin this chapter by introducing Twitter and explaining why its content relating to diabetes and user interactions is the focus for our research. We then ask three questions. First, *who generates the content (messages) with the most impact?* To answer this question we examine the structure of the time-changing network of retweets, and introduce the notion of 'hub' and 'authority' scores from network mathematics to describe different types of influence and impact. Second, *what is the most common content?* Here, we examine the tweets generated by the top authority accounts, and explore the type of messages they disseminate. Food-related jokes and banter stand out as particularly common content. As a result, we ask *why does much of the content involve humour and food?* We look more closely at the content that appears persistently – food-related jokes and banter – and explore what it tells us about health information seeking, community building and activism. As tweets relating to diabetes activism rarely mention food (even though diabetes is fundamentally related to food), this chapter is not directly about digital food activism. Instead, it calls into question what 'counts' as activism on social media, and highlights different forms that user-generated digital food activism might take.

Twitter is more than a news platform for people with diabetes

Twitter is a social media platform with approximately 320 million monthly active users around the world (Desilver 2016). Users can post short public messages or *tweets* of up to 140 characters in length. In addition, users can subscribe (*follow*) to receive the tweets of other users. When users log in, they can see in their *timeline* tweets that have been posted by the people they follow, plus some sponsored tweets, which are algorithmically selected by Twitter and ordered chronologically with the most recent tweets on top. According to Twitter, the microblogging platform is 'like being delivered a newspaper whose headlines you'll always find interesting' (Twitter Inc. 2016). Many users use Twitter exclusively to read messages: over 25% of users have never posted a tweet.

Twitter's marketing material emphasises the platform's importance as a global, real-time public information source; providing information about health management and diet is no exception. Many users of social media perceive health as something that can be modified by encouraging individuals to change their behaviour through education, marketing or messaging. Commercial social media platforms have a large, global user base, significant reach into people's everyday lives, and require very little infrastructure to post messages. As such, they are perceived by users as relatively cheap channels through which to encourage large numbers of individuals to change their behaviour or attitudes. Therefore, it is no surprise that Twitter and other social media have been taken up as platforms through which to seek, share and disseminate advice about a range of diet and health related

conditions that are linked strongly to so-called 'individual choice'; including diabetes, which is the focus of this chapter.

Diabetes is a growing global phenomenon (International Diabetes Federation 2015). It is a chronic clinical condition associated with blood sugar regulation by the hormone insulin and other endocrine factors (World Health Organisation 2010). Type two diabetes (T2D), in which the pancreas produces insufficient insulin, accounts for around 90% of cases worldwide. Type one diabetes (T1D) accounts for the remaining 10% of cases, in which the pancreas produces no insulin at all (International Diabetes Federation 2015; World Health Organisation 2010).

Insulin regulates a person's blood sugar levels in response to food consumption or avoidance. Foods that are high in sugar, or which have a high glycaemic index (e.g., foods high in carbohydrates and low in fibre) can cause significant blood sugar fluctuations as the sugars are rapidly absorbed and metabolised, if insulin does not effectively act as a buffer to maintain a constant blood sugar level. If a person's blood sugar becomes too low, their brain will cease to function. Over a person's lifetime, fluctuating and/or consistently high blood sugar levels can cause problems with the heart, blood vessels, eyes, kidneys and nerves (World Health Organisation 2010). People who have diabetes must constantly monitor and adjust their blood sugar levels; administering insulin or being active can reduce blood sugars, while consuming most types of food and drink can raise them.

Americans living with chronic diseases use the internet more for communication than for seeking health information (Fox & Purcell 2010). While they are less likely than those without chronic disease to have access to the internet or to seek health information online, once they are online, people living with chronic disease are more likely than others to access user-generated health content such as blog posts, hospital reviews, doctor reviews, and podcasts (Fox & Purcell 2010). If people seek emotional support when dealing with a health issue, or a quick remedy for an everyday health issue, they more commonly seek information from fellow patients, friends and family than from professional sources (Pew Research Center 2013). Caregivers are also more likely than non-caregivers to seek health information and support online (72% versus 50%) (Pew Research Center 2013).

Twitter is increasingly used as a platform through which to disseminate dietary and health information to people who have been diagnosed with diabetes, or who are considered to be at risk of developing it. Yet in practice, Twitter, like other social media platforms, is more than a news source that facilitates a unidirectional flow of information. It is also a venue for engaging in social interaction, seeking or giving emotional support, stigmatising or ostracising others, and organising collective action (Kwak et al. 2010).

Social media such as Twitter allow users to build community through their interactions. Twitter users can interact with each other in a variety of ways, including *liking* (expressing approval or appreciation of a tweet), *replying* to a tweet, *mentioning* a specific user in a tweet, and *retweeting* (forwarding a tweet posted by someone else to one's own followers). Through retweeting, the flow of messages can create local or global concentrations of a particular type of information at a particular moment in time. For example, revelations of diabetes by celebrities such as film actor Tom Hanks spread rapidly and widely on Twitter in a short amount of time (Beguerisse-Díaz et al. 2017). Twitter users generated a wealth of messages about this news; some messages were supportive while others were critical or sarcastic, some were gossip or jokes, while others mainly reported facts and news headlines. The structure of these interactions lends itself to being investigated using quantitative and computational methods, such as network science: the interactions among users (e.g., retweets, friend/follower relationships) can be represented as a network in which the users are the nodes and the relationships

form the connections between them. In addition, Twitter allows its information to be mined through its application programming interface (API), which facilitates the acquisition of data in digital format.

Twitter has also been used to organise and disseminate information about collective action, from diabetes fundraising and awareness events that are explored further in this chapter, to massive protests and rallies (Beguerisse-Díaz et al. 2014). Two key features contribute to making it a useful tool for advocacy and activism. From a technical perspective, it enables immediate and easy messaging so it requires few specific skills or specialised equipment. From a social perspective, it is used and endorsed by a large global user base; it cannot work as an advocacy tool unless a critical mass of users employ it in a certain way and are not prevented from doing so. Such technical and social features allow Twitter and other social media platforms to enable what is known as 'organisation without organisations' (Shirky 2008). This new form of collective organisation permits collective action, social connectivity, and consensus-formation around personal lifestyle values without group loyalties that characterised pre-digital social movements (Bennett 2012). Individual Twitter users can, for example, pay attention to a selected group of users who match their values and interests, many of whom they may not know offline; they can choose to retweet a particular message in an instant, but they are not committed to continuing to retweet future messages about the same cause or by the same user. They can coalesce around specific issues or events momentarily, but there is not necessarily any longer dialogue or relationship formed before, during or after the digital interaction or collaboration. Other authors have described this as a distinction between 'collective action' (where formal organisations coordinate individuals in common action) and 'connective action' (where action is co-produced and shared based on personal expression) (Bennett & Segerberg 2012).

Methods

This chapter is the result of an iterative process of collaborative research between applied mathematicians and anthropologists. The analysis is based on over 2.5 million English-language tweets that contain the term 'diabetes' posted between March 26 2013 and January 19 2014. The tweets were collected by Sinnia, a data analytics company.[1] Along with the text of the tweets, we collected the following information about the users who produced them:

- Followers: Twitter users that are subscribed to the user's tweets.
- Friends: Users whom the user has followed.
- Retweets: Tweets composed by other users that a user has passed along to his/her followers.
- Biography: A user's self-description, where Twitter allows users to describe themselves in 140 characters, at most.

A *network* (or graph) is an information structure (more precisely, a mathematical object) in which pairs of *nodes* (or vertices) can be connected to each other by *edges* (or arcs) (Newman 2010). From Twitter, one can obtain several networks in which the users are nodes by creating, for example, connections that represent friend/follower relationships, or the event in which one user has retweeted someone else's tweet. In these cases, the edges are *directional,* that is, they distinguish the user who follows (retweets) from the user who is being followed (retweeted). The information (i.e., the content) flows in the opposite direction to the declared direction of interest. In other words, if a user 'follows' another user, the interest goes from the source of the connection to the target, and the target's tweets

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[1] Sinnia is a data analytics company operating from Mexico City. More information can be found at their website: www.sinnia.com

are received by the source. Likewise, in a retweet, the person who retweets is expressing interest in a particular message, which then is transmitted to the retweeter's followers.

We used methods from network science (analysis of centralities in temporal networks, community detection) and information retrieval (topic detection) to identify the main patterns in the content of tweets, and the interactions among the users. Importantly, only 10% of user accounts in our data produced tweets that elicit any form of response (a retweet or reply). Furthermore, the intensity of the response was extremely heterogeneous: relatively few users attained a disproportionally high amount of attention. Technical sketches of our work are briefly described in the following sections.[2]

From an ethical perspective, the data presented in this study are public information (as per Twitter's terms and conditions) and do not pose ethical risks. Our analysis serves the public interest and poses no risk to users, and we do not reproduce tweets with notable amounts of sensitive or private material. Indeed, the most prominent users in our dataset also maintain other online profiles and produce tweets for public consumption. Further, users who wish to restrict access to their tweets to specific users can do so via their privacy settings. However, we do note ongoing debates about the ethical dimensions of research on social media data (Zimmer & Proferes 2014).

Whose content has the greatest influence?

Understanding power dynamics and relationships is essential for understanding activism; activists may, for example, challenge existing powers, while empowerment can enable the success of activism. Anthropologists, sociologists, mathematicians, and computer scientists, among others, have begun to explore how the rise of digital and interactive media reflects, or can change, the power landscape in global society. Some have argued in relation to food that existing power structures are destabilised and democratised as information becomes more widely available (Lien & Nerlich 2004; Blue 2010). In this case, attribution of 'authority' (i.e. power or rights to dominate others, rather than the technical mathematical term used in the context of a directed network) is broadened, when knowledge production becomes more participatory and widely distributed. However, others have found that a specific curatorial process is required to achieve such distributed power, and that the use of participatory platforms in the absence of careful guidelines and principles can limit their capacity to achieve the imagined ideals of open access and information democratisation (Geismar 2012). In this case, digital platforms can just be another channel through which existing power structures are reinforced.

Quantitative approaches to investigating Twitter offer a different perspective on influence, power and authority. Using techniques from network science, researchers can find which users are more 'central' (i.e., important and/or potentially seen as important) in a network of interactions. There are many different notions of centrality that range from the simple (number of connections) to the sophisticated (using the properties of random walks on networks) (Newman 2010; Masuda et al. 2016).[3] The 'hub'

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[2] For a detailed technical explanation of the mathematics and algorithms, we refer readers to Beguerisse-Díaz et al. 2017.

[3] Random walks are useful processes to study networks. In a nutshell, a random walk consists of one 'walker' or an ensemble of 'walkers' that navigate the network. When a walker arrives at a particular node it decides where to go next by choosing one of the node's connections at random. There is a long history of using the properties of random walks to investigate the properties of systems in the life, social and physical sciences. For a review of random walks on networks see Masuda et al. (2016).

and 'authority' score of a Twitter user (or node) are two examples of node centrality that are defined recursively (Kleinberg 1999):

- A good 'authority' is a node that receives many connections from many 'hubs' (defined in the next point); i.e. authorities are users who produce tweets that attract the most attention (in the form of retweets). For example, in the worldwide web (in which web pages are nodes and hyperlinks are directed connections between them) an example of an authority would be a site such as Wikipedia, which contains content that many web users seek.
- A good 'hub' is one that points to good 'authorities'; i.e. passes information from authorities to other users. In the worldwide web, an example of a hub would be Google, which contains links to other sites but which itself may not host any content.

We have extracted the 'hub' and 'authority' score of all users (a number between 0 and 1) in the weekly retweet networks in our data. In each weekly network, the sum of the authority scores of all users is equal to 1 (likewise for hub scores); the magnitude of scores can be interpreted as 'how good is this node as a hub (or authority) compared to the rest of the nodes?' (or 'how big is their share of the hub (authority) pie?').[4]

Authorities send the messages with the biggest influence

The top ten authorities in our dataset are a mixture of bloggers, advocacy groups, companies and a health information firm (Figure 1). The top authorities tend to have a relatively sustained presence over the data observation period (i.e., their authority score is usually not zero for most weeks). Four of the top ten authorities are directly linked to T1D. The onset of T1D is typically much earlier than T2D and tends to affect people much more severely than T2D, as it is related to inability of the pancreas to produce insulin rather than a reduction in the pancreas' capacity to produce insulin.

Top 10 users by aggregate authority score

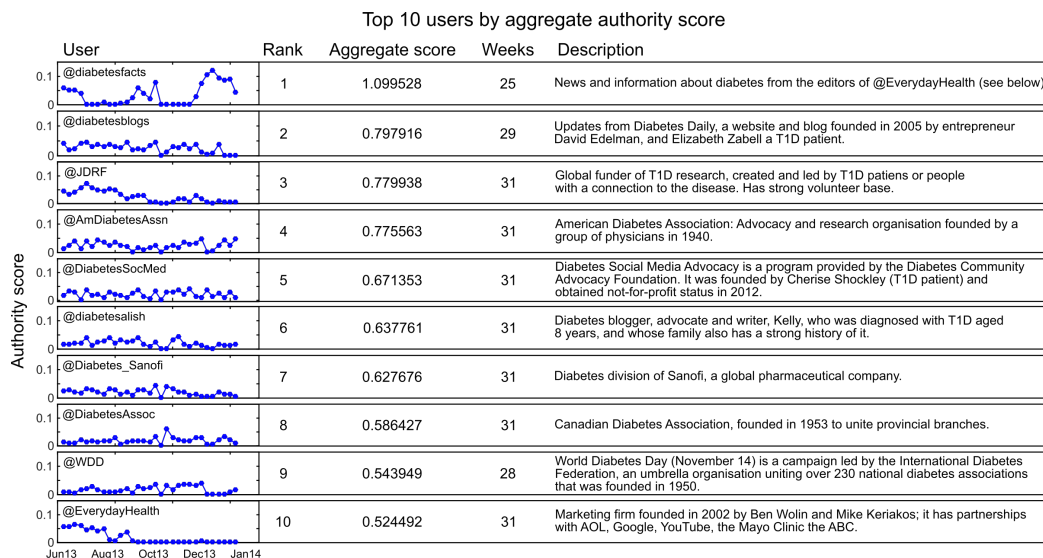| User	Rank	Aggregate score	Weeks	Description
@diabetesfacts	1	1.099528	25	News and information about diabetes from the editors of @EverydayHealth (see below).
@diabetesblogs	2	0.797916	29	Updates from Diabetes Daily, a website and blog founded in 2005 by entrepreneur David Edelman, and Elizabeth Zabell a T1D patient.
@JDRF	3	0.779938	31	Global funder of T1D research, created and led by T1D patiens or people with a connection to the disease. Has strong volunteer base.
@AmDiabetesAssn	4	0.775563	31	American Diabetes Association: Advocacy and research organisation founded by a group of physicians in 1940.
@DiabetesSocMed	5	0.671353	31	Diabetes Social Media Advocacy is a program provided by the Diabetes Community Advocacy Foundation. It was founded by Cherise Shockley (T1D patient) and obtained not-for-profit status in 2012.
@diabetesalish	6	0.637761	31	Diabetes blogger, advocate and writer, Kelly, who was diagnosed with T1D aged 8 years, and whose family also has a strong history of it.
@Diabetes_Sanofi	7	0.627676	31	Diabetes division of Sanofi, a global pharmaceutical company.
@DiabetesAssoc	8	0.586427	31	Canadian Diabetes Association, founded in 1953 to unite provincial branches.
@WDD	9	0.543949	28	World Diabetes Day (November 14) is a campaign led by the International Diabetes Federation, an umbrella organisation uniting over 230 national diabetes associations that was founded in 1950.
@EverydayHealth	10	0.524492	31	Marketing firm founded in 2002 by Ben Wolin and Mike Keriakos; it has partnerships with AOL, Google, YouTube, the Mayo Clinic the ABC.

Figure 1: Top ten users by aggregate authority score, number of weeks with non-zero authority score, and brief description (Beguerisse-Díaz et al. 2017).

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[4] See Beguerisse-Díaz et al. (2017) for a precise mathematical formulation and implementation of the problem.

We then created the follower network of the top 1,000 authorities in our data: in this network the nodes are the 1,000 top authorities, and the connections correspond to who follows whom from within this group. This network offers a different view of the relationship between these users. In a retweet network the interactions of the users is the context of a topic in a given time interval, in this case tweets about diabetes during the data collection period. On the other hand, a follower network indicates a more 'stable' interest that need not be restricted to a specific topic: users are subscribed to receive all tweets from the users they follow, regardless of whether the tweets contain the word diabetes or not. In this follower network the users can be divided into six distinct communities using the Markov Stability community detection framework (Delvenne et al. 2013). A 'community' in this context is a group of nodes that are more tightly coupled with nodes in the group than with the rest of the network (Beguerisse-Díaz et al. 2014; Porter et al. 2009):

C0. Health and medicine related accounts.
C1. A diabetes-related group of advocates, patients and families.
C2. Accounts related to lifestyle and wellbeing.
C3. Accounts related to news and media.
C4. Celebrities.
C5. A group of accounts specifically related to retailer Tesco.
C6. Humour and parody accounts.

The biographies of the members of each community show a remarkable consistency in the vocabulary used (Figure 2); the exception is the community of humoristic and parody accounts whose members do not use the same vocabulary to describe themselves. Despite Tesco's location in the UK, it has a large presence on the global Twitter platform (in English). Aside from Tesco, food industry representatives and lobbies, which are extremely influential actors in debates in relation to food policy and legislation, are notably absent from Twitter debates about diabetes.

The top authority nodes represent a variety of advocacy positions – health advocates tweet about different lifestyle choices, the wellbeing group promotes new diets and fads, and the pharmaceutical industry advocates for pharmaceutical intervention rather than dietary change. However, not all users give a clear signal of what underpins their position; Tesco's interest in diabetes, for instance, in addition to generating awareness, can be to promote its brand and generate opportunities to promote its products, such as health insurance and food. In practice, there is an unclear distinction between marketing, sponsorship and advocacy on Twitter. This lack of clarity is a characteristic of many electronic media: anyone can establish a presence, and there is little scrutiny of their objectives and their effects on the broader population. Users may be expected to be discerning and responsible, but it is unclear on what they should base their judgement, given that many user profiles appear equally credible and the information equally 'authoritative'. A similar observation has also been made by other authors in this volume.

Figure 2: A: The follower network of the top authority account. Nodes are coloured according to the community to which they belong. B: The follower network coarse-grained by communities. The word clouds contain the words that most frequently appear in the members' self-descriptions. The greatest number of users overwhelmingly pays attention to the health and medical advice community (C0), some pay attention to the diabetes community (C1, which includes funding agencies and patients) (Beguerisse-Díaz et al. 2017).

Hubs connect users to the most important messages

The top hub accounts in our dataset change from week to week, and tend to be a mixture of bloggers, automated accounts, users with no specific or declared interest in health, and accounts which have since been closed. Hubs, unlike authorities, do not have a sustained high presence over time (Figure 3). This means that there is no account that is routinely and consistently linking users with sources of information. Instead, hubs tend to have a flash of 'brilliance' (i.e. importance) and then dissipate. Our data do not allow any inference about why this is the case.

The top hubs in our dataset are predominantly bloggers and users who have experienced diabetes. It makes sense that they point to many authoritative sources of information, as this is their declared interest both on Twitter and on the blogs they administrate. However, the intention of the top hub – *@1Medical2News* – is less clear. It appears to be a medical doctor named Dr Richard Billiard, and the account appears credible at first glance. However, this doctor has no other online presence, s/he retweets a large amount of messages per day at regular intervals (an average of 50 tweets per day since 2013), and s/he has never produced an original tweet. It is unclear who might be behind the profile or what they are attempting to achieve.
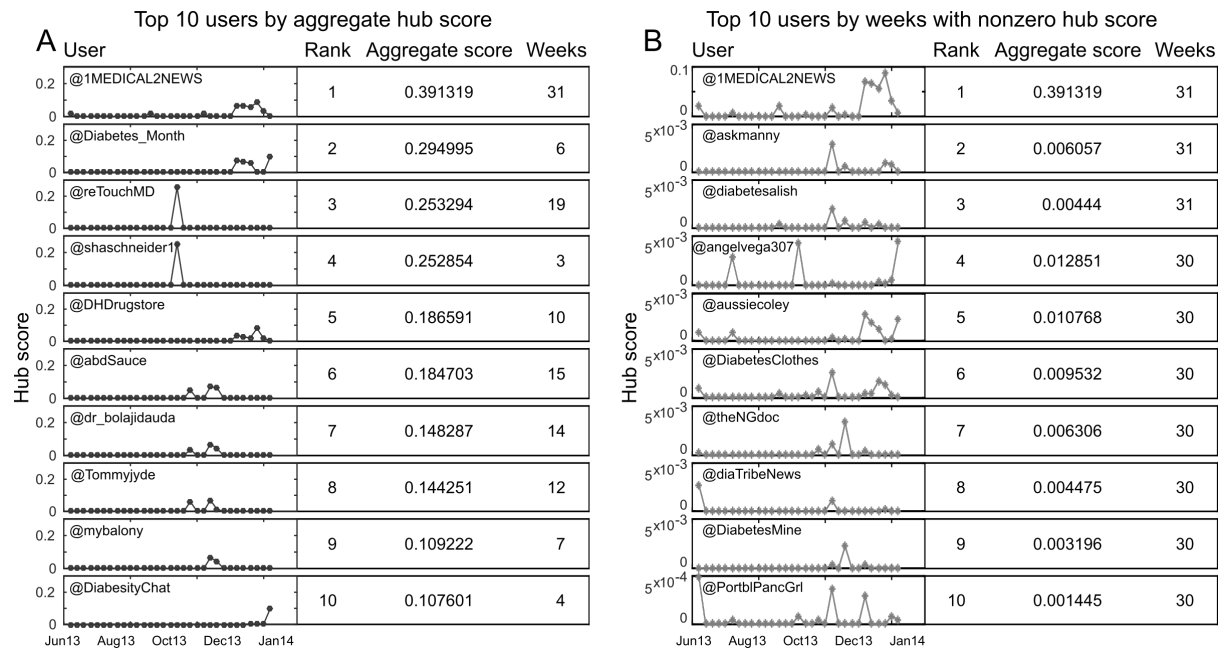

Figure 3: A: Top ten hub accounts by aggregate hub score score. B: Top hub accounts by number of weeks with non-zero authority score (Beguerisse-Díaz et al. 2017).

It is difficult to be a top authority and hub simultaneously

There are a number of advocates and activists in our dataset who aim to bring about social or political change. Most appear to try to do so by posting messages of their own, rather than amplifying other similar messages coming from a variety of places.

Of the two percent of the most central users in our dataset (by joint hub and authority scores) – users who are frequently retweeted by other users – none are at the very top of the authority and hub ranking simultaneously. Authorities tend to push out information of their own, but they retweet

messages by other authoritative sources of information far less frequently. Hubs tend to retweet authorities' messages but seldom produce tweets with wide impact themselves.

There are at least three reasons why this might occur. First, authorities may all be advocating slightly different things: with no complete overlap of agendas, one organisation may not opt to pass to its followers messages from a different source. Second, it is relatively more time-consuming to read, select and retweet information from other sources; guaranteeing the reliability of every single piece of information posted by others, when the provenance cannot always be traced, can be risky for users and their reputations. This may make retweeting content an unsustainable activity, especially for established authorities that must check and verify content before retweeting it. To get around this, some users will state in their bio that a retweet 'does not mean endorsement', but this is not a realistic work-around for those running official Twitter accounts on behalf of governments or other organisations. Third, it may suggest that organisations in the public health landscape situate themselves as atomised units which together create a cacophony of messages (Lang & Rayner 2007), rather than part of a broader network of advocates for common objectives.

What is the most common content?

In addition to knowing who the most influential users on Twitter are, it is useful to understand the content of the messages being posted. Content in tweets can be aggregated into topics using methods from information retrieval and natural language processing, and then qualitatively analysed to interrogate and explain themes and patterns (Beguerisse-Díaz et al. 2017). We employ a variant of the Latent Dirichlet Allocation method which computes the probability that a document (tweet) belongs to a topic based on the words it contains, and the words in the other documents (Blei et al. 2003). We then use an inductive grounded theory approach to manually classify the topics of the tweets into four broad thematic groups (see also: Beguerisse-Díaz et al. 2017; Braun & Clarke 2006; Bowen 2008): health information (e.g. health advice), news (e.g. headlines about a latest breaking story, described in more detail in the following section), social interaction, and commercial. One anomalous cluster of recurrent tweets is discussed further in the following section. The word clouds of the top 200 word roots in each thematic group (for example the word root 'obe' stands for 'obese', 'obesity', and so on) in each theme are shown in Figure 4. Word clouds were created using script in Python, where the size of the word in the cloud is roughly proportional to how frequently the word appears in tweets that belong to each group.

Content can be split into four main thematic groups

Through iterative thematic coding, four thematic groups clearly emerge – health information, news, social interaction and commercial. In the first group, health information, research findings, recommendations, advice and warnings, are abundantly tweeted and retweeted by a range of users. The top 10 terms in this thematic group are: *risk, type2, disease, heart, research, month, obesity, fruit, news* and *aware*. Tweets in this group include:

- Public health messages.
- Links to articles, blogs and studies about risks, treatment and cure of diabetes.
- Population health fears.
- Publicity about outreach and awareness events and activities.
- Advice about diabetes management and diagnosis.

- Lifestyle, diet and cookery tips, news and links.
- Life stories and experiences (some for marketing purposes).
- Dangers of sugar, sugar replacements and/or soda.

The advice in these tweets generally appears authoritative in tone and language, with confident and impersonal 'statements of fact', making it difficult to distinguish less-credible advice from more credible advice. For example:

@Achieveclinical: 8 Tips for Eating Out With Diabetes - Type 2 Diabetes Center-Everyday Health http://t.co/u5nIZ4cg5E #diabetes #health #diettips

@down2earthindia: Fighting flab? Think before u reach out 4 sugar substitute #Sugar #Sucralose #Diabetes http://t.co/cfeYURK7r3

@pinkdrinkladysr: Diabetes is a disease that can strike when you don't take care of your body. Check out these eye-opening statistics. http://t.co/zwpfTPgbtu

Credibility might be discerned from an examination of the original source of the tweet; however, user accounts are not always forthcoming with information and legitimacy is difficult to discern (Beguerisse-Díaz et al. 2017). In general, there is a high turnover in the content that each user is exposed to, even though many messages (for example, those from newspapers and online media) are posted multiple times. Put another way, a 'hot topic' in one week will not necessarily appear in subsequent weeks.

The second group contains news-related content. News tweets in the dataset list a headline of a news article and sometimes the first line of the story, and often provide a link to the complete story. For example:

@wwhitworthmw: AstraZeneca could buy Bristol stake in diabetes JV: analyst: LONDON (Reuters) – AstraZeneca may seek to increa... http://t.co/rcZQPIIZxo

@DietitianInNYC: Fish Oil Pills Might Cut Diabetes Risk, Researchers Say http://t.co/fvsIMXFKGR

@KatieBaby4587: Thief steals family car with daughters #diabetes medicine insidehttp://youtu.be/juPZtMmzL2s via @youtube @tmz http://t.co/agDquGWmUL

The top 10 terms in this group are: *type2, risk, fruit, type1, eat, people, blueberry, cut, research* and *juice*. Some news-related tweets communicate research breakthrough studies or technologies, which may be reported with messages of hope for those who have diabetes, in particular T2D. Tweets in this group include:

- Headline links to particular 'breakthrough' studies or technologies.
- Celebrity news.
- General news articles about diabetic people or pets.
- News relating to the pharmaceutical industry and the economy.

The third group corresponds to social interaction. These tweets use language differently than the other thematic groups: they are typically informal and conversational in tone, their attention to spelling and grammar is limited, and they often use exclamation marks and other punctuation (e.g., smiley faces) to express fun, laughter, exasperation, and abuse. The top 10 terms in this group are: *give, health, food, die, think, fat, year, diet, disease* and *cause*. Tweets typically include:

- Users who joke about how what they have eaten is likely to give them diabetes.

- Chatter and everyday social interchanges that include mentions of diabetes.
- Everyday experiences of diabetes.
- Stigmatising comments.
- Banter, sexual innuendo and humour relating to sweetness and diabetes.

These tweets indicate a baseline level of awareness of dietary guidelines and diabetes aetiology. Users have conversations and interact about a diversity of topics in chatter that is not necessarily directly related to diabetes but may include references to it. People who have diabetes – particularly T1D – also talk about the daily experiences of their bodies, sugar management, and social acceptance or stigma; such tweets may elicit retweets or messages of support from other users. Some users also talk in terms of a division between 'us' (people with diabetes, especially T1D) and 'them' (people without diabetes). For example, a user talks about T1D as being a feature he/she looks for in a romantic partner:

> I haven't stopped thinking about this girl for seriously like...a month. AND she has diabetes! #diabetesperks.

Such content often receives retweets and replies, including messages of support, or appreciation of a joke.

On the other hand, stigmatising comments, especially tweets that blame diabetic people for bringing the disease on themselves through, for example, poor diet or lack of physical activity, are abundant in the dataset. Faced with such messages, users with T1D diabetes point out that it is important to differentiate between T1D and T2D, insinuating that while T1D diabetes is not a person's 'fault', T2D may be. Other tweets include calling other people 'diabetic' as an insult and wishing diabetes upon a person a user does not like.

A distinct theme in this category consists of tweets with sexual innuendo. At their mildest, such tweets refer to boy-band members or other (e.g., celebrity) infatuations, where the person is said to be 'so sweet' they are diabetes-inducing. At their most extreme, such tweets joke that others' bodily fluids and genitals are so sweet they are diabetes-inducing, and these tweets contain links to pornography websites or other explicit material. Like the jokes discussed earlier, these tweets reflect a baseline awareness of the links between sugar and diabetes amongst people who do not appear to have diabetes themselves.

Finally, commercial tweets advertise products, jobs and pharmaceuticals. For example,

> @vernhenderson99: American-Diabetes-Wholesale : $12 Off Order of $100 or More! Code: ADW12100 http://t.co/e5K20ptIhH

> @4londonjob: #jobs,#ukjobs Clinical Nurse Specialist Diabetes http://t.co/QtnCwYK6WR #jobs4u

> @AmatoOrganogold: Caffeine stimulates elevated of Cortisol = arthritis, obesity, diabetes, and depression. Try healthy coffee: - http://t.co/4paSPZ0mrc

The top 10 terms in this group are: *type2, drug, job, manage, care, health, marijuana, sale, test,* and *for sale*. Common tweets include:

- Advertisements for jobs in the pharmaceutical and care industries.
- Marketing for a specific product, app, treatment, event or service.
- Pharmaceutical, health industry and stockmarket updates and FDA approvals.
- Sales of diabetes drugs, diets or treatment products online.

Diabetes treatment and management is a lucrative industry because diabetes is a chronic condition that requires regular and life-long treatment (rather than cure), and so the demand for pharmaceutical products and lifestyle aids is inelastic (Simonsen et al. 2015). People with diabetes depend on different technologies, consumables, health services, and pharmaceutical products. Furthermore, the number of people with T2D is projected to increase dramatically in the future as a result of population ageing and obesity (International Diabetes Federation 2015), which will further expand the market. This commercial dimension of diabetes is reflected in many Twitter messages similar to the examples above.

Who contributes which content, and what do users advocate for?

Overall, tweets are posted by users with different claims to expertise: individuals who have first-hand experience of diabetes; personal trainers advertising their services; companies selling lifestyle products or services; other users with an apparent interest in diabetes, cookery and 'healthy' eating; marketing agencies trying to sell a particular food, supplement or device; or hospitals and health agencies attempting to communicate a specific health message. Home remedies and 'miracle cures' appear alongside health tips and recommendations. Other health-related messages include publicity about outreach and awareness events, activities and information.

The topics in which the highest numbers of top ten authorities converge are related to diabetes advocacy and awareness. For example, a topic about Diabetes Blog Week in May 2013 gathered 6 of the top ten authorities: *@diabetesalish, @diabetesblogs, @DiabetesSocMed, @Diabetes_Sanofi, @diabetesfacts,* and *@EverydayHealth*. In other weeks, the top ten authorities appear together in topics related to promotion of blogs by diabetics (using the hashtag *#dblogs*, which appears in 15,901 tweets in the dataset), and diabetes social media awareness (using the hashtag *#dsma*, which is promoted by @DiabetesSocMed and appears in 10,945 tweets).

All of the top ten authorities post messages relating to health information frequently and consistently. Some also feature news-related tweets, although these are less common. Two accounts, *@Diabetes_Sanofi* and *@diabetesblogs*, post a broad range of health information tweets. Two other accounts, *@WDD* and *@AmDiabetesAssn* primarily contribute tweets related to outreach and advocacy activities, events and news. The not-for-profit organisation and research funding body *@JDRF* produces tweets that contain life stories and experiences of diabetes sufferers more than any other top-ten authority. Importantly this is not interactive or interpersonal in any way, but appears to be just a different framing of news and information. In these users' tweets, the boundaries between health information, health promotion, research and advocacy are blurred.

Two accounts, *@diabetesfacts* and *@EverydayHealth* (both owned by Everyday Health, Inc.) focus predominantly on lifestyle and diet-related tips, hints and advice. Unlike the other authorities, these do not produce the same outreach or advocacy messages in which users advocate for the rights and wellbeing of a group of people with diabetes. Instead, the majority of the tweets from these two accounts provide a link back to the company's website, which offers articles containing health and lifestyle advice. This illustrates the often blurred distinction between advocacy and advertising when using this digital medium.

The messages posted by the accounts *@diabetesalish*, a blogger and diabetes advocate who has had diabetes for over 30 years, and *@DiabetesSocMed*, a diabetes social media advocacy group founded by a T1 diabetic, are dominated by a mix of social interactions, banter and advocacy. They post

content relating to health information and news headlines, but to a lesser degree than the other top-ten authorities. Their tone is different to the others: it is informal and conversational rather than authoritative or informational. For example:

@DiabetesSocMed: Happy Mother's (aunts, fur baby moms, god moms, etc.) to all the women in the diabetes community! Have a great day!

or

Banging My Head Over Hubby's Clueless Doc http://t.co/2EfKqA2qZZ #diabetes #dblog.

Two other users, *@diabetesblogs* and *@DiabetesAssoc*, also tweet some social and interpersonal messages.

Two accounts, *@diabetesblogs* and *@diabetesalish,* occasionally feature marketing or product promotion messages. This is common practise among bloggers, who often both advocate for a particular issue and generate income by advertising goods and services. Indeed, marketing on Twitter is not necessarily as straightforward as having a user profile representing a company posting advertising messages. Firms can advertise, lobby or seek to influence on the platform in much less direct ways, for example, by being posted on bloggers' sites, sponsoring organisations, events or individuals, or by posting and retweeting messages through accounts appearing to be unrelated to the company in question. This may reflect loopholes in regulatory practices in many countries: while company advertising and marketing are often regulated by state authorities, company sponsorship of bloggers is not regulated, and nor is the commercial content that bloggers post.

Figure 4: Word clouds of the four thematic groups and recurrent content. The clouds on the left column are formed by the most frequently used terms in the thematic group (larger words appear more frequently). The clouds on the right column are formed by the names of the users whose tweets appear more frequently in the thematic group (users who appear more in the group appear larger) (Beguerisse-Díaz et al. 2017).

Why does so much of the content involve food jokes?

Humorous tweets, jokes and memes generate substantial and sustained interest over time, something that other types of tweets, and often other forms of advocacy, seldom achieve. They also mention food and drink more than any other type of tweet.

The intensity of collective activity (e.g., number of tweets, book sales, internet searches) can follow a pattern of spikes of interest followed by a relaxation, driven by either external (exogenous) events, or internal activity (endogenous) (Sornette et al. 2004). For example, tweets about Tom Hanks in our dataset began to appear rapidly after Hanks revealed he had T2D on a talk show on 8 October 2013, but interest subsequently waned (Figure 5, dashed line). However, several tweets in our dataset have an activity profile that is strikingly distinct from what we would expect to see; they have a high, sustained occurrence rate over a long period of time. For example, a joke about mathematics and diabetes appears consistently (Figure 5, dotted line). The top 10 terms in this group of recurrent tweets are: *sugar, eat, blood, sweet, risk, type2, drink, high, reduce,* and *health*.

Humorous tweets not only generate sustained interest, they also maintain similar phrasing across the duration of the dataset. Examples of these tweets include:

- Jokes about the relative healthiness or unhealthiness of a particular food or activity, relative to widely published public health standards.
- Lyrics from two specific rap songs (one making a joke about sex, sugar and diabetes; the other an inspirational song by a rap artist with T1D).
- Viral 'fun facts' or trivia such as tasting urine as a test for diabetes, or moderate consumption of alcohol being linked to reduced diabetes.

One of the most prominent instances of recurrent content in our data corresponds to various versions of a mathematics joke:

Math Problems: If Jim has 50 chocolate bars, and eats 45, what does he have? Diabetes. Jim has diabetes...

This joke appears consistently in our dataset, more than any other specific tweet (44,130 times including retweets). Other common jokes are exclamations that a user's latest meal or snack (typically food products, from soda to cookies to ice cream) was tasty but will likely cause them diabetes:

2 bowls of yogurt, a bowl of oreos, hersheys, chips, cheese and a shitload of mints. My diet consists of diabetes.

Bother! Burger King has arrived. Hello obesity, diabetes, poor nutrition. McD's is bad enough. Grumble Grumble????

The coca cola Christmas advert, because nothing says Christmas quite like diabetes and capitalism. LOL

It would be easy to disregard these tweets as 'noise' distracting from more important messages; indeed, one anonymous reviewer of our initial manuscript that reported this finding asked why we were writing about such material (Beguerisse-Díaz et al. 2017). It could also be the case that the format of Twitter (with short messages only) lends itself to short, light statements only, rather than other types of communication, although this does not necessarily explain the jokes and humour in particular.

However, there are several reasons why it is important to examine these tweets further. First, the striking consistency and volume of these messages, especially compared to other tweets in the dataset, must be important in some way. Second, just because these tweets contain content that does not fit

into the narrow biomedical definition of health and nutrition, does not mean the content is unrelated to it. Indeed, these tweets represent how a large proportion of Twitter users engage in conversations about diabetes. They also discuss food –which is fundamentally related to diabetes, but not frequently mentioned in other Tweets about diabetes in our dataset. For this reason in the following pages, we look further at humour, and food jokes in particular.
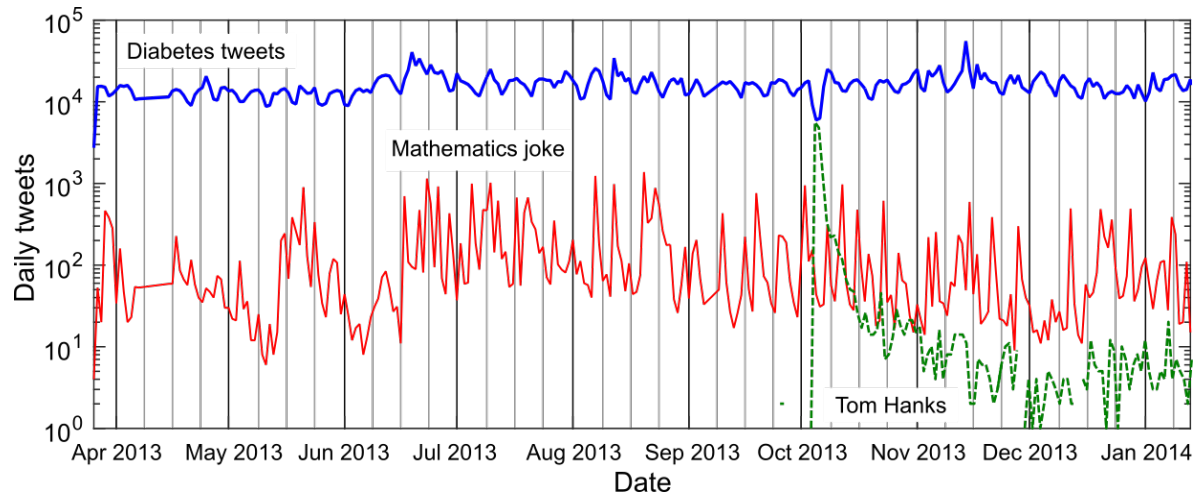

Figure 5: The number of daily tweets in English containing the term 'diabetes' (solid line), the number of tweets containing some version of the 'mathematics joke' (dotted line, appears in a total of 44,130 tweets in our dataset), and the number of tweets mentioning the actor Tom Hanks, who disclosed that he had diabetes in October 2013 (dashed line, appears in a total of 13,454 tweets in our dataset) (Beguerisse-Díaz et al. 2017).

Humour is not a well-studied topic in anthropology and the social sciences (Wasilewska 2013). Some anthropologists have written about it, predominantly because jokes or humour inevitably arise in the course of fieldwork and so ethnographers talk about them briefly (Carty & Musharbash 2008). Sustained enquiry on the topic has been much less common.

The investigations that have been carried out suggest that humour largely appears to relate to social inclusion and exclusion, where laughing *with* some people inevitably leads to others being excluded from the joke or even being laughed *at*. Digital platforms permit users to create their own categories, and jokes can illuminate what those categories are.

A number of other common themes arise in research relating to humour and jokes (Carty & Musharbash 2008). In particular:

- Laughter and humour are often used to express unease about discrimination, domination and power imbalances.
- Laughter often appears to have a role in mediating social rupture.
- Laughter and humour often only make sense in a particular context (time, place and/or social context).

These anthropological insights highlight just how significant the relatively high and enduring popularity of diabetes-related jokes on Twitter might be for understanding the success – or failure – of health messaging and advocacy.

Joking on Twitter is set in a global context, at a time where there is good public awareness about rising diabetes levels, and the links between diet and diabetes. Jokes are also set in a context of rising neoliberal forms of governance that emphasise free markets, consumerism and self-responsibility. Individuals are expected to navigate markets responsibly and to avoid doing things that might harm them, and at the same time to be consumers of products and services. We have discussed this consumer-citizen tension elsewhere (Ulijaszek & McLennan 2016).

The majority of diabetes jokes on Twitter point to a sense of powerlessness among users in this neoliberal, globally-connected context. The chocolate bar joke, for example, and the multitude of other jokes about what people have eaten that is likely to give them diabetes, makes a subtle protest, a mockery of official dietary advice, as consumers at once acknowledge what they 'should' be eating, jest that they have capitulated again in the face of the ubiquity of unhealthy food, and ironically resign themselves to developing the inevitable – diabetes. Excluded by these jokes are health agencies and their scientific advice, perhaps purposefully. Included are everyday people, who demonstrate that they understand the scientific advice but also recognise the cultural dominance of the foods they invoke in their everyday lives (soft drinks, cookies, ice cream, chocolate, junk food and so on). Medical and scientific advice is quickly shown to be almost ridiculous when placed in the context of a world in which food products entice us at every turn. Jokes in this case appear to represent critique or unease due to power imbalances.

Some jokes are specific to diabetic patients: humour helps to build camaraderie between diabetes sufferers, who bond by joking about what they have to go through on a daily basis to survive. Irony and sarcasm, in particular, are used in this case as people who have diabetes build a community through shared experience. The importance of social support and inclusion for healing has been noted elsewhere (Holt-Lunstad et al. 2010; Kawachi & Berkman 2000), although it is unclear whether this form of collective or connective action might be considered a deliberate or explicit activist practice.

Some jokes advocate for a different type of justice: a justice based on the view that individuals should each benefit from public funds and health services proportionately, and that those with chronic diseases such as diabetes 'unfairly' use significantly more resources than others. Further, when diabetes is framed as resulting from individual choices (a common view in neoliberal societies in particular), advocates for this position argue that the individual should therefore have to pay for the consequences themselves rather than be supported by society. This view is typically expressed through stigmatisation and abuse. Stigmatisation of obesity is well-documented (Brewis 2014), and although it is not as common as jokes about food and diabetes in general, there is evidence of similar stigmatisation of people with diabetes in our dataset. In these instances, people with T1D were quick to highlight that theirs was not a form of diabetes caused by being irresponsible consumer-citizens. More broadly, instances of this form of humour are used to advocate for tighter reprimands for people who are perceived to self-impose themselves as burdens on society.

Conclusion

The collaborative, multidisciplinary approach we are developing has the potential to break new ground in understanding sociocultural patterns in today's digitally-enabled global society (Cihon & Yasseri 2016). Our investigation of diabetes on Twitter clearly illustrates that this social media platform is much more than a news source. It is a site for social interaction and support. It is a site through which collective action and advocacy are organised and coordinated, especially around raising awareness about a particular cause or event. It is also a site where 'connective action' (Bennett

& Segerberg 2012) occurs. This dynamic organisation around a particular idea – such as using humour to highlight consumers' sense of powerlessness – brings to light shared values but does not necessarily connect to action in the non-virtual world.

Digital platforms are commonly assumed to make disruption of the social order possible, and to democratise knowledge and power. For example, digital platforms arguably permit users to choose where to direct their attention, and to collectively give more authority to some voices over others. However, science and technology studies (STS) and media scholars have commonly called this utopian view of social media and user agency into question (e.g., Ruppert 2015; van Dijck 2009). Several findings in our analysis contribute to this problematisation.

In the digital environment, it is difficult to tell where the real powers lie, especially in relation to health and wellbeing. Health agencies often invoke numbers of followers as an indicator of influence, but this does not consider the impact of content posted, nor the complex structure of the digital environment (e.g., the structure of the underlying networks of interest and interaction). Calculating authority and hub scores using data science represents a more sophisticated approach that acknowledges and exploits network structure. While this gives more information about users who have most influence, it does not necessarily reveal what positions the most influential users are advocating, or why.

A hub's role of bridging content between users or distributing information can be an important one, especially when it comes to seeking to elicit widespread political or social change. However, it does not appear to be a sustained activity by any one user on Twitter in relation to diabetes. It may be worth considering whether this represents an opportunity for improving public health information. This could be capitalised on if large organisations focus not only on publishing their own information, but also on pointing at relevant *and reliable* information from other sources, and engaging more widely with other Twitter users. In other words, leading authorities could become more hub-like to maximise their influence.

Overall, the users who are most influential on Twitter when it comes to diabetes are a diverse group. This challenges the notion that the domain of health is a discrete category: social media content relating to diabetes on Twitter is connected with a diverse range of sectors, organisations, interests and perspectives. Biomedicine and public health must look beyond their boundaries to identify important influencers of people, their opinions and their behaviours.

The top 1,000 authority users extracted from our analysis are similar to many of the authorities that we would expect to see based on observations in the non-virtual world, including health authorities, lifestyle coaches, pharmaceutical firms and celebrity chefs (Beguerisse-Díaz et al. 2017). However, there is a notable exception: aside from retailer Tesco, the food industry is poorly represented. The absence of the food industry may be related to our use of hub and authority scores for this analysis. Both of these rely on a response from the wider public (i.e., retweets) in order to achieve a high authority score. The absence of the food industry in this case could be interpreted as users choosing to direct their attention elsewhere and to ignore organisations considered to be powerful in the non-virtual world. Superficially, this might support the claims that digital platforms like Twitter can democratise knowledge and power.

However, this interpretation assumes that influence is primarily exerted in direct and obvious ways. Looking more closely, the food industry is present in our data in other ways. Some advertising appears in the blogger profiles that we investigate, some authorities receive funding and sponsorship

from companies (for example, Tesco sponsors Diabetes UK (Tesco PLC 2014) and soda companies sponsor health organisations (Aaron & Siegel 2016)). Sponsorship, corporate philanthropy, advocacy and lobbying expenditures are largely undocumented and unregulated by nation states (Aaron & Siegel 2016), so the extent to which corporate powers also exert power in the landscape of social media and health is unknown.

Food brands appear frequently in many users' tweets, especially jokes about foods being likely to give them diabetes. Coca Cola, Hershey's, McDonalds, Burger King and Oreos are mentioned, to name a few. Users' jokes about these brands imply a sense of powerlessness in the real world food environment. Humorous tweets that tend to be considered irrelevant to public health researchers and policy makers suggest a public resigned to the dominance of certain food products in everyday life. Users appear to jokingly set their everyday food environment against health advice about how to avoid diabetes. The humorous and flippant quips simultaneously convey a deeper ironic observation about the disjuncture between the food environment and dietary advice.

George Orwell observed that "*a thing is funny when – in some way that is not actually offensive or frightening – it upsets the established order. Every joke is a tiny revolution*" (Orwell 1945). Orwell pointed out that jokes can highlight the relative weakness of established powers, and use of humour can disrupt the established hierarchy. He also observed, that "*whatever destroys dignity, and brings down the mighty from their seats, preferably with a bump, is funny. And the bigger they fall, the bigger the joke*" (Orwell 1945). If the size of a joke is crudely measured by the amount of times it is posted, or the number of retweets it obtains, then the biggest jokes on Twitter where diabetes is concerned bring down the mighty health authorities, admit powerlessness in the face of omnipresent big-brand food products, and remind them that the world of food and health is much bigger than their narrow interpretations of it. Governments and researchers position themselves as authorities in this space, often downplaying or ignoring the effect of corporate lobbies, so they are the easy target of these jokes. At the same time, users ironically point to where they feel the real power lies – a power that creeps into their daily lives in myriad ways, but which demonstrates its authority in its pervasive actions rather than through statements or proclamations. Everyday citizens joke about which foods are going to give them diabetes, and in doing so, highlight an uneven balance of power between citizens, governments and organisations that advocate for healthy diets, and the world around us.

Acknowledgements

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