

Rationalising the Use of Twitter by Official Organisations during Risk Events: Operationalising the Social Amplification of Risk Framework through Causal Loop Diagrams

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Abstract

Communication of health risk events is a complex and challenging task. The advent of information and communication technology along with the following popularisation and widespread uptake of social media are reshaping the field of risk communication. Guided by key tenets of the Social Amplification of Risk Framework, this study developed a causal loop diagram, capturing the perceptions of professionals in health organisations regarding the role of Twitter during risk events. The aim of this paper is to explore the use of the causal loop diagram and its role with rationalising the use of Twitter in risk communication strategies. A key finding of the model is the central role of trust and its inter-relationship with other factors during a risk event. A contribution is made to operational research through the novel use of soft system dynamics in risk communication, to risk communication through the investigation of the new medium Twitter and also to research on the Social Amplification of Risk Framework by providing a means through which to operationalise the framework.

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1. Introduction

The internet is recognised as a participatory environment through which various actors communicate about risks (Chung, 2011). Microblogging site Twitter, with its unique capabilities in a risk event, has set in motion an irreversible change in the way in which information is exchanged among stakeholders. Twitter enables its diverse user base - from lay publics to global organisations - with unprecedented means to share information with an unknown but potentially wide indirect audience. Its almost non-existent barriers to interaction provides unparalleled opportunities for direct engagement with other users. The immediacy and ease of information sharing allows live reporting; there are numerous instances where Twitter has been the first to report news.

Potentially, social media may be harnessed as a platform to implement a number of suggested principles of risk communication (Regan et al., 2016). For example, the above mentioned factors position Twitter better than other social media and social networks to allow the estimation of the public's understanding and perception of a risk (Gaspar et al., 2014) with tweets being easily searched and retrieved; it provides information from the ground and it allows direct engagement with the public. Yet, Twitter has serious disadvantages. Disadvantages include the limited size of the Twitter user base, meaning that messages posted on Twitter by official organisations have a limited reach. Second, the platform is unregulated allowing misinformation to be easily propagated through the network. An aspect that is exacerbated by properties of the site including retweeting. Third, while Twitter is potentially a source of information for official organisations, there are challenges associated with harnessing this information in order to use it effectively during a risk event.

Risk communication is a critical aspect of the risk management of an event. Effective communication of risks by official organisations, such as fire services,

police and health bodies who are privileged to scientific expert information, to the public is a challenging task. The advent of newer communication channels such as Twitter is changing risk communication from one-way, unidirectional channels of communication into complex, multidirectional communication networks. Twitter has gained prominence in recent risk events and while it appears a suitable form of communication to adopt by emergency organisations, to aid with the overall management of risk events, it is noted that the integration of such forms of communication present challenges for many official emergency service organisations (Latonero & Shklovski, 2011). Although important, limited studies investigate the use of Twitter by official emergency organisations.

This research focuses on the role of Twitter by official health organisations and the integration of Twitter. The research gap addressed in this paper is primarily aligned to the limited research on the use of Twitter by health organisations during risk events. A secondary purpose is to contribute to innovative applications of operational research within the context of risk communication. In this research Social Amplification of Risk Framework (SARF) (Kasperson et al., 1988) which is a comprehensive framework available for the study of risk events is used as the theoretical basis. This framework seeks to explain the way in which risk signals are passed between stations and how they are altered during this process to amplify or attenuate the signal, explaining the social response to risk events. Key tenets of SARF are used to inform the selection of modelling choice, which is causal loop diagrams (CLD) and inform the development of the data collection method, namely semi-structured interviews. The CLD developed from the interviews is used to capture and facilitate understanding of professionals in health organisations of the role of Twitter in risk events.

1.1. Outline of paper

The paper is structured as follows. Section 2 is a review of relevant literature and details the theoretical basis of the research. Section 3 provides the method employed in the study. The findings of the CLD are given in Section 4. Finally, Section 5 presents the discussion and conclusions of the research.

2. Review of relevant literature and theoretical framing

We organise our review of previous studies around three bodies of research. First, we review studies carried out by the field of crisis informatics, a distinct field bringing together social sciences and computer sciences, which has contributed a vast amount of empirical research on the use of Twitter and other social media during crisis events. Second, we review disaster OR, a field that has applied a diverse range of tools and techniques to a vast range of problems related to disaster events but with limited applications to risk communication and Twitter. Third, we review studies related to the multidisciplinary SARF. Individually, these three areas offer distinct contributions but together they offer a comprehensive basis and theoretical framing for the research problem.

2.1. Crisis informatics

Crisis informatics has conducted significant empirical research investigating Twitter during crisis events, particularly natural disasters. Investigation into the use of Twitter by the public, including victims, show that Twitter has multiple purposes being used to coordinate humanitarian responses; enable remote individuals to help in disaster responses; locate individuals; seek information; provide information from the ground and share information (see, for example Vieweg et al., 2010; Hughes & Palen, 2009; Starbird & Palen, 2011; Paul et al., 2014). The public have shown to be resourceful and innovative in their use of Twitter during an event. Studies further highlight that depending on the type of crisis event, whether it is a natural or man-made crisis, then the social response to that event on Twitter differs. Limited studies address the use of social media by official emergency organisations (see, for example Latonero & Shklovski, 2011; Hughes & Palen, 2012; Hughes et al., 2014; St. Denis et al., 2014). These studies find individuals drive the use of Twitter but organisational factors prevent it being institutionalised. Organisations are slow to adopt social media but recognise that it may be an opportunity. Other studies have shown the benefits of Twitter for the surveillance and prediction of events, with

Twitter users being used as sensors in events such as earthquakes and also monitoring disease outbreaks (Sakaki et al., 2010; Achrekar et al., 2011; Lampos & Cristianini, 2010). Several specific applications are shown to be highly effective; showing how tweets can be mined for information.

2.2. Disaster and emergency OR

A review of disaster and emergency OR literature demonstrates a diverse and extensive application of OR to a variety of problems (see Altay & Green, 2006; Simpson & Hancock, 2009; Galindo & Batta, 2013, for detailed reviews). With respect to risk communication, there are few studies. Preece et al. (2015) adopt a soft OR approach, applying a Viable System Model (VSM) to investigate challenges of risk communication in dynamic disaster events and Eiselt & Marianov (2012) formulate the problem of loss of cell phone towers as a mixed-integer linear programming problem to provide a model to minimise loss of communication. Fry & Binner (2016) recently addressed the evaluation of information gained from Twitter and developed a model for utilisation of Twitter for the improved management of evacuations.

Within the context of social responses to risk, a system dynamics (SD) approach was utilised by Busby & Onggo (2013) to model the responses of the public to zoonotic disease outbreaks; Busby et al. (2016) use agent-based modelling to model social risk beliefs and Kandiah et al. (2017) use agent-based modelling to investigate public adoption of water reuse.

Preece et al. (2015) evaluate that most existing disaster OR literature featured the ‘application of reductionist approaches’, cautioning that these types of approaches can fail to consider the ‘need for holism in risk communication and analysis’ (p.313). With the unstructured, dynamic nature of emergency events, the tools and techniques of soft OR are naturally more suitable, first in the problem structuring with the ability to involve decision-makers in the modelling process and also their ability to deal with complex, ill-structured problems (Simpson & Hancock, 2009).

2.3. Social Amplification of Risk Framework (SARF)

SARF is a comprehensive, multidisciplinary framework positioned to support the study of risk communication; it remains one of the only frameworks to integrate the work of previous studies on risk communication and risk perception (Kasperson et al., 2003; Pidgeon & Henwood, 2010). It is proposed that SARF could be used to advance knowledge of risk communication and ultimately lead to better execution of communication during health risk events (Pidgeon & Henwood, 2010).

There are two main parts of the framework. The first part distinguishes social and individual stations through which risk signals pass as transmitted from source to end receiver. The framework draws upon classical communications theory to explain amplification and attenuation of risks (Duckett & Busby, 2013; Bakir, 2005); SARF states that when a signal is received by a station it is decoded and then encoded as it is passed to the next station or the final end receiver (Kasperson et al., 1988). The central tenet of the framework is that risk signals pass between stations and these include the media, scientific representatives and individuals, and as they do the signals undergo transformations. The framework contends that events related to hazards “interact with psychological, social, institutional, and cultural processes” causing the increase or decrease of individual and social perceptions and also on the associated risk related behaviours (Renn, 2011, p. 154). The processes depicted in this part of the framework can amplify risk events in two ways; “by intensifying or weakening signals of the risk and by filtering the signals with respect to the attributes of risk and their importance” (Kasperson & Kasperson, 1991, p. 22). Although the investigation of the role of the media and more traditional forms of communication is extensively researched (for example Rossmann et al., 2018), research is only beginning to address the context of the internet (Regan et al., 2016; Chung, 2011) and more specifically Chew & Eysenbach (2010) who investigate Twitter and a disease outbreak.

In the second stage, the effects or secondary impacts of the amplification of the risk are identified. It is noted that through amplification of risk signals the

effect of the risk event can cause wide indirect consequences in society (Bennett et al., 2010), examples include loss of confidence in institutions managing the event, change in regulations (Kasperson et al., 1988) and community opposition (Duckett & Busby, 2013). These secondary effects can be felt by future generations.

“SARF itself is not a theory and specifies no unambiguous testable hypotheses” (Breakwell, 2007, p. 237) and thus it cannot be tested to prove or disprove SARF. Instead, studies that use SARF “are illustrations of some of the relationships that SARF considers important” (Breakwell, 2007, p. 237) and that risk signals/messages can be amplified or attenuated. SARF is criticised for being simplistic in nature by Murdock et al. (2003) and Bakir (2005) who propose it should simply be viewed as a framework through which to initialise the investigation of risk communication. SD approaches with SARF are limited, with only two studies identified (Busby & Onggo, 2013; Burns & Slovic, 2007). However, there are compelling arguments for the suitability of SD and SARF to further explore risk events. First, both focus on the system; within SARF there is an implicit assumption of the importance of the totality of the system and likewise in SD. Second, feedback, can be likened to risk amplification and risk attenuation. Positive feedback loops, reinforcing the original change, can be likened to risk amplification and negative feedback loops, which resist change, can be likened to risk attenuation. Third, both deal with dynamic, complex systems, allowing the consideration of behaviour over a period of time. Although previous studies related to SARF have focussed on the media, emergency organisations are also a station for the transmission of information.

2.4. Theoretical framing

To summarise, crisis informatics has developed a diverse body of research investigating the use of Twitter during crisis events by bringing together computer science and social sciences. Altay & Green (2006), Simpson & Hancock (2009) and Galindo & Batta (2013) on review of disaster and emergency OR identify a lack of soft OR in their respective reviews in the context of disaster

operations management. Preece et al. (2015) identify there are very few studies of OR, risk communication and disasters with the exception of their study as well as Eiselt & Marianov (2012) and they argue soft OR is well-suited to this problem area. With respect to risk communication the suitability of soft OR is clear and yet, to date, has limited applications.

We identify that risk communication and the role of newer channels of communication such as Twitter pose difficulties for official organisations. SARF is a comprehensive framework, well suited to the problem identified and puts forth a framework for investigating communication, yet research has not explored means for it to be operationalised. To model the role of Twitter a method that allows the consideration of a system, the incorporation of perspectives of multiple stakeholders and the study of the system over time is required. We propose that SD is a suitable means to operationalise SARF to investigate the role of Twitter during health risk events. We focus on the identification and support of decision problems related to Twitter.

3. Method & model development

Two case studies, geographically bounded, were conducted, these are Nova Scotia and Scotland. Nova Scotia is one of ten provinces in Canada and is one of four Atlantic provinces. The population of Nova Scotia is approximately 921,727. Health is the responsibility of the Nova Scotian provincial government. Scotland is one of four countries in the United Kingdom and is located in the north of Great Britain. The population of Scotland is 5.2 million. Health is one of the powers of the devolved government in Scotland. In Nova Scotia, the delivery of health services is provided by nine district health authorities¹ and similarly in Scotland 14 regional health boards are responsible for the protection of the population's health and the delivery of health services. Prior to investigation in the two regions, there was a varying degree of Twitter usage

¹Since conducting the interviews these district health authorities have been brought together to become the Nova Scotia Health Authority.

in both daily and risk events. A review of the Twitter accounts prior to beginning research revealed that Twitter was used sporadically between regions and districts. It suggested that individuals were driving the use of Twitter as opposed to formal policies in the health organisation. It was seen that typically the Twitter accounts associated with the more densely/cosmopolitan populated areas had, comparatively, successful Twitter accounts (in terms of number of followers and frequency of posting). Areas serving a more rural population had little use of Twitter. The similarity of the two allows these areas to form an appropriate level to bind the two cases.

For both cases, semi-structured interviews were conducted with professionals from multiple health organisations in the two areas including governmental organisations, district health authorities, regional health boards and supporting health and emergency management organisations. The range of participants allowed the incorporation of differing viewpoints within the CLD, developing a detailed representation of the use of Twitter during health risks. Interviewees had varying roles in their organisations including emergency planners; communications officers; public engagement; medical officer; chief medical officer; deputy chief medical officer. In both cases, participants were chosen purposefully to ensure similar participants. The same interview questions were asked to participants in both cases.

Semi-structured interviews are recognised as an effective method of data collection to develop CLDs (Serman, 2000). The interview protocol was informed by key aspects of SARF, this included the role of social and individual stations; trust in official organisations; public perception of risk; information provided by official and public stations; Twitter's role within wider communications strategies; public panic and the role of misinformation. Interviews lasted between 60 and 90 minutes. The interview data was used to develop a single CLD. The interviews were reviewed and coding was developed based on the transcripts. Themes were developed and interview scripts were re-organised such that all parts of the interview addressing a theme were collected together. Variables and the causal links between variables were identified from the transcripts. Us-

ing the participants' terms and through several iterations, the CLD was formed. Causal links were denoted with a + or - sign to show whether the causal link reinforced the original change (a positive link) or whether the causal link opposed the original change (a negative link). Loops were identified as positive or negative based on the overall behaviour of the variables in the loop. Two feedback sessions of the CLD were conducted to verify the model and to identify its use in discussions related to the use of Twitter. Since the feedback session, the CLD was updated based on review of the participants. Naturally, a key limitation of this approach is that the model developed may have missing links and variables as the model is the perceptions of the participants.

As identified, Twitter is a new means of communication, yet lacking research focus in the context of its role by official organisation during risk events. We utilised SARF (Kasperson et al., 1988) and the key tenets of the framework as the theoretical basis and starting point to inform the development of the study. Several aspects of the framework, including the totality of the system, the dynamic nature of events and feedback were key for the selection of the modelling approach. These aspects as well as stations of amplification and attenuation, amplification and attenuation of risk signals, issues of control and secondary effects informed the development of the interview protocol.

4. Findings from practical application of the methodology

The CLD (see Fig. 1) explicates the structure of the causal relationships among variables during a health risk event as perceived by the health care professional participants. The CLD developed is complex, aggregating the perspectives of participants from a variety of roles in the organisations. The model includes both short-term and long-term term aspects and provides an explicit, detailed representation of the perceived role of Twitter by health care professionals during a risk event. We structure the following around a number of decision problems that emerged from the CLD. Quotes of the participants support the CLD, demonstrating their interaction with the modelling.

4.1. How to manage misinformation

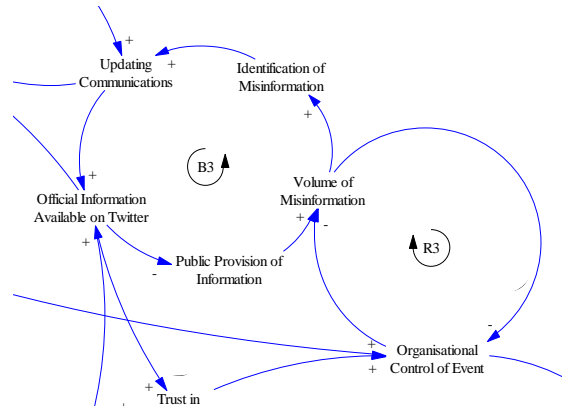


Figure 2: Loop R3 and Loop B3.

Loop R3 (see Fig. 2), which explains the role of misinformation in Twitter, is a reinforcing loop where the causality between the two variables is shown by the direction of the arrow and the negative sign is taken to mean a change in the variable at the tail of the arrow causes an opposite change in the variable at the head of the arrow. A decrease (increase) in the first would cause an increase (decrease) in the second. Loop R3 shows as misinformation increases it causes a decrease in the organisational control of the event, which then leads to an increase in misinformation. The change in the first variable is the same as the first change, thus it is a reinforcing cycle. Misinformation is a key part of the use of Twitter and considering misinformation and rumours a risk identified was: “I think the risk for us is they spin out of control very rapidly on social media”. The participant was concerned that not being in the realm of social media is dangerous as there is no way to intervene in discussions. Therefore, they need to have some sort of presence to take part in conversations and to keep up with the changing preferences of information consumption of the public. Key here is that they need to be present on social media to help shape the discussions and that if they have no presence then shaping discussions is very difficult without them acting as a source of credible information. However, this lack of control of

the event can be managed through provision of information by the organisation.

Loop B3 (see Fig. 2), which captures the management of information, shows that an increase in the variable ‘Information Available’ which represents official information causes a decrease in ‘Public Provision of Information’. Importantly, this aspect of the model highlights that if the organisation fails to provide information it causes the public to provide information. As the public provide unofficial information this causes an increase in the volume of misinformation. The more misinformation causes an increase in updating communication by the organisation as they have to respond to these incorrect tweets. The loop is brought in to balance as they respond and provide information. This highlights that the organisations can manage an event by providing information first, as opposed to reacting to incorrect information. A worry regarding Twitter was the diffusion of misinformation. They noted that timing was key in releasing messages: “If you aren’t out there quick enough the public will make up their own version [of the event] and you’ll try to recover it...and now you have to change that perception and it’s very difficult to do if you are not in that realm at that time. So that’s what we’ve found, you have to be there to see what’s being said. Or even getting out in front of them at some point, so that your perception of what’s going on is the public’s perception and they don’t make it up on their own, which is often what can happen.” Therefore, the organisation has “to get in early to set the tone of how the public are going to see you in that emergency ... the idea is to get out in front and make sure people understand all the dynamics of what’s going on and then at least if somebody tries to steer it in the wrong direction people have a choice to make and that can work in your favour”. They identify that there is a resistance in the system to changing thinking and that if there is a reinforcing loop, reinforcing the volume of misinformation in the system, it may be challenging to change its direction.

Despite the recognition of the benefits of quick responses, it was noted that to have someone on call to respond to social media is difficult: “But that’s harder than it looks because you’ve actually got to have somebody you trust, are you really going to let them respond in a timely manner, give them the

authority to respond?” There is a clear indication that there are organisational factors slowing the progression of Twitter as the devolution of power to the communications persons is difficult.

4.2. Institutionalising Twitter

A critical aspect of the model concerns the variable ‘Organisational Twitter Usage’. The variable was identified to be central in the model. With increased use of Twitter it causes an increase in many other favourable aspects, as well as some negative effects. Participants identified that it was dependent on ‘Organisational Desire to Use Twitter’ and ‘Personal Knowledge’. These key links highlight that Twitter usage is driven by individuals, organisations or both.

One participant stated: “a first principle in emergency management is that you don’t want to first implement processes when you go into an event, it has to be part of the social norm during daily routine business [...] Twitter has to be part of our common day to day business so that when we ramp up proportional to an event that it is part of the emergency response.” In response, another stated: “I think X has made a really important point, you know the topic is the use of Twitter during a risk event, and the underlying principle for our organisation is that’s not the time to start to use Twitter.” Therefore, Twitter must be institutionalised well ahead of any critical need to use it: “this is one other tool we have to add to our tool box and then we have to ask: how do we institutionalise it so that we are not relying on any individual, what’s the right level of institutionalising it? So, especially during an emergency event, where everything is about back-up ... so it’s not one person that has to sit through the whole seven days on Twitter, right? That’s not manageable.”

Yet, in terms of institutionalising Twitter, the culture of the department was identified as a key issue: “Our department, being in a conservative organisation that they are, tend to be late adopters and struggle with how to use social media channels to their most effective use. I mean we are slowly getting there ... We still struggle with it because partly it’s resourcing and partly it’s our comfort level with risk.” Critically, there is a real risk of relying on one person driving

Twitter and reliance on one person exposes the organisation to risk.

The CLD highlights that there are two ways of increasing Twitter knowledge. First, support of training in the organisation and second, personal knowledge from experience. The diagram shows that personal knowledge is an exogenous variable in the system. However, staff training is under the control of the organisation. The limitations on budgets as well as the culture in the organisation potentially limit staff training.

4.3. How to manage direct communication with the public

Consideration was also made to the role of Twitter as a communication medium and the way in which it allowed direct communication to the end receiver. One participant noted: “previously you always [had to] apply a media filter to everything going out, we would put out something that is positive and the media would take that press release and turn it around and say ‘well actually that’s a terrible thing that you are doing’ and we would have no influence on how that appeared in the paper”. It was identified that they were able to use Twitter to bypass this. Furthermore, there appeared a changing dynamic with the media: “So rather than social media following the mainstream media, it’s the other way around now; [mainstream] media follows social media and I found that interesting how it’s all turned on its head”. Regarding Twitter in the communication strategy, one noted: “in a time of crisis [Twitter] should be the first thing that should be a priority instead of the last thing”. Another interviewee stated: “the way in which we interact directly is absolutely here to stay; something that none of our forefathers would ever have recognised or even taken into account”. They state: “we have to use [Twitter] and for me as a communications professional it’s ideal because it allows you to communicate directly with the audience”.

4.4. What information can be gained?

One part of the model highlights that as public interest in the event increases it causes an increase in public Twitter activity, meaning the number of tweets

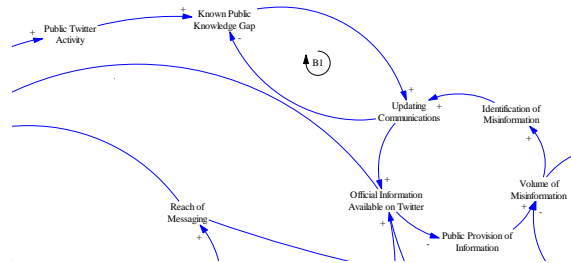


Figure 3: Loop B1.

related to the event increases. As this increases it provides information to the organisation of the public’s perception of the event (see Loop B1 in Fig. 3) and therefore identification of the knowledge gap. This part of the model shows that Twitter can be used to inform communication strategies to reduce the gap between the public understanding and what the official organisations want the public to know by monitoring Twitter and responding.

One noted that there is a clear advantage from the monitoring of Twitter for information: “I think we would be foolish not to be on Twitter just to observe because there are events happening that’ll be talked about very quickly”. It was noted by participants that Twitter could be used to gain insight into what the public were thinking, although currently it was not done, one participant reflected for future: “another reason for us to be monitoring the social media sites because it at least gives us a sense of where at least a proportion of the public are at but also anticipating where we may get questions or opposition or whatever”. Another stated, regarding Twitter, from their experience of using Twitter during a health risk event: “sometimes we got information that was correct that we didn’t know. Maybe once or twice and there was a couple of things that came out and we were like ‘Hang on, is that a thing?’ and we went and checked it. And, it was, in some ways, an early warning system and we do use it that way in terms of trying to anticipate”. They identified that they could move to a more proactive usage of Twitter to gain information quicker and be better placed to respond to the event. Throughout the mapping, the need for

decision making on how to use Twitter as a mechanism to gain feedback from the public through monitoring of social media was identified. Generally, they identified that Twitter was an opportunity to better understand the public’s knowledge. While some information was being gained from Twitter there was no formalised strategy and this was more so done in an ad hoc way, resulting from the sessions, participants recognised Twitter as an opportunity to gain a better sense of what the public are thinking.

It was noted that although information can be gained from Twitter, there was a query raised: “how do you capture all of that information so you can make sense of it?” and this is a critical point about using Twitter during a risk event, how can these organisations make sense of live information and translate that into their decision making? There is a clear lack of knowledge in these organisations regarding how to feasibly incorporate the use of Twitter. Furthermore, in terms of person resources: “you have to have someone specifically dedicated to moderating these sites and if you are in the middle of an emergency situation it’s a lot of work”.

4.5. How can credibility be maintained?

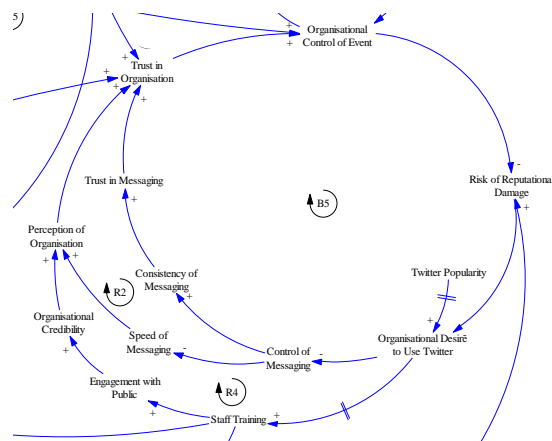


Figure 4: Loop B5, Loop R2 and Loop R4.

Bringing Twitter into a communications strategy related to providing infor-

mation in a suitable form and this related to the credibility and confidence of the organisation. On consideration of the use of Twitter, it was reasoned that if the official organisations are ineffective at providing information in the form needed (i.e. not using popular mediums), it may lead to a lack of trust in the official organisations. With less trust the management of events is more difficult (see Loops B5, R2, R4 in Fig. 4). One participant noted: “we run the real risk of being or appearing to be out of touch and very slow and ponderous in our response which then greatly affects our public confidence and our credibility”. From the discussion it was identified that, as an organisation, their choices in communication have impacts upon trust in them. One participant stated: “if we are not using the best communication vehicle or media, then that affects our credibility too, because people may say ‘where are they?’, ‘they’re not there’ or ‘they’re late’ or whatever and you just - that affects your credibility as well.” Thus, utilising Twitter may be a signal to show that the health organisations are listening to the preferences of the public. Existing literature states that trust of an information source impacts on the way in which information is internalised (Frewer, 2003) thus, the importance of trust in an information source is paramount to the way in which the information is processed. One participant also noted that prior risk events were different to a risk event at present in terms of communication and social media: “it wasn’t the same social media presence in 2009 for H1N1 but if we had a H1N1 tomorrow, we wouldn’t be able to have nearly enough effective public communications responses without having a robust social media ... because it will be all over social media”. Another stated: “In today’s world, we could not deal with H1N1 without a robust social media”. There is clearly an understanding of the need for social media: “it’s more about your ability to influence the people who have the most weight” but it was also noted: “we have most of the media [here] following us, so we know that if there is a risk event they are going to come to us to look for information and it is just a matter of saying ... I don’t know right now, I commit to getting back to you in so much time or, you know, we are working on finding out what the reality is, however you phrase it, and to me that’s how you keep your position as one

of the trusted sources of information.”

4.6. How to allow real-time messaging?

What was also considered was that these organisations are part of a wider communications team on these matters as health often involves a multi-party response. Then, “you have to make sure that your local messages aren’t in direct conflict to messages coming out at the national level”. With longer approvals it could ensure that they are consistent across the messaging but then Twitter messages require to be fast. “[I]t is very important to have consistent messaging ... I would suggest that centralised control would ensure consistent and appropriate messaging”. Another considered the credibility of the organisation: “My sense would be that if you had these big gaps, it would be that you become irrelevant, right? It is that the speed of information is much faster in that so it’s one of the issues that if you are gonna get in this game, then how do you do it 24/7 or close to 24/7?”. One other participant followed this with: “I would say it, a couple of things, one is to do it effectively you need strong policies or guidelines in place to - for government communications in a crisis event to work you need strong policies or guidelines to guide the staff who are using the tools so they can communicate effectively, know the parameters in which they can communicate and they have to, the more they know the better but to your point, probably the great thing about Twitter and social media is that you can rebound quickly as well, you can lose it but you can also rebound”. It was recognised that there was a trade-off between speed and consistency of messaging (see Loops R4 and R2 in Fig. 4) and there requires a balance to be achieved between the two so that they were quick in messaging but were not contradictory.

Emerging from the modelling was the autonomy of those who are tweeting. The level of checks within the organisation means that there is a strict process in place before releasing a message. The alternative is to have a structure, where those in charge of the Twitter accounts are given the decision-making of what to tweet. From the following discussion, the participants reasoned that “[Twitter]

is not something that has to go through 40 stages of approval before it can be sent out, because if you do that there's no point". The interviewee stated that if there was a long approval process, tweets could not be sent out fast enough, noting that the aim of Twitter was to provide up-to-date information. However, they noted that this is in direct opposition with current procedures which tend to require several stages of approval prior to being released. Throughout the feedback discussion, they recognised that within their organisation, there is actually a need to build in adaptive capacity so that individuals in the communications team could work as is appropriate in a crisis event.

4.7. How to allocate resources to Twitter?

The limiting factor of time resources was evident throughout the interviews and is shown in the CLD. The discussion highlighted that these are clearly a finite resource tasked with dealing with a number of aspects during a risk event. Those in the communications teams are tasked with coordinating and executing communication in a variety of forms liaising with experts in the organisation, the media and the public. A key aspect identified is the balance between the time apportioned to the media and that given to the public. With the huge demands of the media, one stated that during an event "there is a constant barrage of phone calls from the press saying latest update, latest update, latest update" they questioned: "should we be doing that?". How best to split these resources is key, as shown in the CLD is a crucial point of the model; one participant identified this as a critical variable. They recognised these were new problems, these new channels of information and the changing preferences of the public are evolving communication and expectations. The media demand so much attention but should these get the undivided attention of these organisations?

Alternatively, one participant viewed the role of information seeking and the potential demand on resources: "I want to talk about the information seeking because I think this is what this part of the model is demonstrating...I see Twitter as an enabler not as a restriction and so if your demand on resources increases it's like cutting the Gordian knot, if you can get just one tweet that

resonates with people then you can cut a dragon’s head off and put the issue to rest, in so I see Twitter as an enabler as there is going to be all this chatter there and you get factual information out there from a [governmental] source it could decrease the demand on resources.”

4.8. How to use Twitter in the long-term?

The model highlights that an increase in followers will occur when risk events occur. The exogenous variable ‘Time Elapsed’ which represents the time elapsed from a risk event or sub-risk event, the model shows that an increase in this variable causes a decrease in ‘Proximity to Event’. An increase in ‘Proximity to Event’ causes an increase in ‘Public Interest’. The increase in ‘Public Interest’ causes an increase in ‘Information Seeking Rate’. This part of the model captures an important aspect of a risk event. The CLD reflects the way in which there will be impacts to the rate at which the Twitter accounts gain new followers. The CLD depicts that official organisations can expect a risk event to be a catalyst for their followers to increase as compared to that in typical daily activities. Although an organisation may have a small following on Twitter, risk events provide the motivation for Twitter users to begin following as individuals become interested in the event and identify relevant sources of information on Twitter. Therefore, it is anticipated that followers will increase and the audience on Twitter will also increase. The model highlights that the increase in followers is driven by the time elapsed since the risk event. Therefore, it can be argued that in risk events Twitter users seek out sources of information and begin following appropriate sources. In the context of health risk events, clearly health related organisations are likely to be the official source that the public will follow. It is expected that the organisational Twitter accounts will see a large spike in new followers (per day) in the early stages of a risk event as Twitter users seek and identify relevant information sources. Over time, interest will decrease and the rate of new followers will decrease. Some followers may also ‘unfollow’ after the risk event. One participant stated that during a risk event: “The number of people subscribing to social media goes through the ceiling.

And so you just have to be in the position where you have processes already in place”. They stated, thinking more widely about building Twitter: “So I think as we develop perhaps more of an online presence on a day to day basis we get more credibility and it’s easier to flip the switch if there’s a big event.” Therefore, the organisations can pre-empt the demand for information via Twitter during a risk event. Knowing this, as a proactive action, the organisations should develop a strategy with this considered.

4.9. Reflections from participants

In two sessions participants were presented the model resulting in revision and discussion of the model. The presentation of the model clearly provoked thought and discussion around the use of Twitter. Participants found the explicit visualisation of the role of Twitter, which effectively demonstrated the complexity of Twitter, to be valuable. The model was used as a basis for participants to identify variables which they had direct control and how these could be leveraged to produced desired outcomes. The model allowed dialogue between different levels in the organisation particularly between seniors in the organisation and those in communication roles and helped resolve some of the disparities between perceptions of the use of Twitter. In Nova Scotia it was recognised that there required an adaptive capacity in the organisation to allow communications professionals to use Twitter faster and that lengthy approval processes may limit the use of Twitter. In Scotland the feedback session provided understanding of the complexity of the use of Twitter helping facilitate the understanding of the wider implications of Twitter use. Participants identified there required a decision to be made regarding the allocation of resources, namely is the allocation of resources to deal with requests of the media too much, do these resources need to be allocated so that more resources can be invested into Twitter? In both Nova Scotian and Scottish sessions, participants commented that the presentation of the model had increased understanding of the wider complexities of Twitter use, resulting in the understanding of the potential importance of it as a communication channel and realisation that it requires more attention

in the risk communication strategies. Following on from the feedback session, participants in Nova Scotia subsequently updated their social media policy.

Participants in the research identified that if they were not operating in that realm then they were unable to correct misinformation and therefore were unable to manage the information on Twitter. They concluded that they needed to be integrating newer channels of communication as if this is where their public want the information, then they should also be using it. It was also acknowledged that Twitter is a valuable source of information and if their organisation could use it optimally, they could gain information at a pace unparalleled by any other means.

There is a key limiting factor in all organisations and this was the organisational desire to use Twitter, they acknowledged that as an organisation they were not comfortable in using such a communication channel. An important realisation for the participants was the identification of key variables. In both cases they were able to identify that the organisational desire to use Twitter was the key point in the CLD. Increased desire in the organisation leads to training, incorporation and support of the use of Twitter and by increasing this and subsequently Twitter usage there were many impacts within the model, such as accessibility, trust in organisation and management of misinformation. Critically, this is a variable which they can control, yet shifting the organisations perspective on Twitter use, opening it up to allow staff to reply on behalf of the organisation was challenging. The CLD was able to capture this issue and therefore support dialogue between levels in the organisation as they were able to point to the model and help communicate issues from the communications teams to seniors in the organisation. Without the dedication of resources to the use of Twitter and trust in communications team members, they were able to identify that it would continue to be used in a limited form as opposed to how it could be used.

To conclude, one participant's statement resonates with the overall state of the participants:

“it’s interesting that the conversation is no longer about is Twitter something that is going to be here? It’s how to we adapt to it, it’s a social norm. I think what you are hearing is us being challenged by that and understanding where do we go and where don’t we go.”

5. Discussion and conclusions

The underutilisation of soft OR in disaster research and specifically risk communication is well established in the literature (see Altay & Green, 2006; Simpson & Hancock, 2009; Galindo & Batta, 2013; Preece et al., 2015); this research contributes to addressing this gap and provides a unique insight into the perception of health professionals regarding the role and integration of Twitter. In terms of contributions, this research 1) demonstrates the challenges and benefits of Twitter in the management of risk events within a communication strategy, 2) demonstrates an innovative means of operationalising SARF through CLDs and 3) is a step towards increasing the prominence and availability of soft OR.

5.1. Reflections on modelling choice

The choice of causal loop diagramming, on reflection, appears to have been a suitable one. There is a necessity to have a modelling approach capable of dealing with feedback and dynamic behaviour. As shown, there is a lack of knowledge regarding Twitter and the contribution of various perspectives broadened thinking and allowed understanding of the current and potential role of Twitter. Formalising mental models allowed insight of others’ perspectives which provided a shared starting point for discussions. Importantly, this led to discussions across levels of management and departments. In addition, the presentation of the CLD provoked thought related to potential outcomes (intended and unintended) of their current actions and inactions; forced consideration of current practices; enabled identification of alternative system structures to achieve desired outcomes and identification of areas for leverage to provide lasting benefits in the system.

5.2. Contributions to risk communication

The research demonstrates that Twitter provides official organisations a means to bypass traditional intermediate stations of communication, allowing direct communication with end-users. Thus, limiting amplification and attenuation of risk messages. The tradition to refer to communication as two-way understates the current complexity of communication and fails to adequately capture the dynamics. We propose that communication in a risk event is best described as multidirectional. Multidirectional communication epitomises the current state of risk communication and this provides new challenges and increasing complexity of risk responses. Although Twitter brings benefits, such as timely information; visibility of public opinion and knowledge and direct interaction, it also has challenges and risks, such as the spread of misinformation; challenges of adoption of such forms of communication by hierarchical organisations; limitations of user bases; lack of training; lack of resources; timely extraction and use of relevant information. Twitter usage is in the early stages of development for many health organisations who mainly use it as a one-way means of communication; progression to using it as a multidirectional, fast communication tool poses huge challenges and requires a complete change in mind-set for many of these organisations. With trust and perception of the organisation a key aspect, Twitter presents ways to maintain and increase these but also poses risks if organisations utilise it within their communications strategies. To abstain from such newer forms of communication may pose problems in themselves.

The reach for a layperson's tweet is potentially high and previously such exposure was limited to only the media and other key stakeholders. Risk communication strategies should try to harness such information and make preparations for its use during an event. Dedication of resources is a key factor but organisational culture may limit the integration of such approaches. There is need for research to identify how this information can be rapidly processed to better inform real-time decision making, as well as long term strategies. The research shows the need to institutionalise Twitter as opposed to being reliant

on individuals in the organisation.

Previous research related to SARF highlights that typically risk signals must pass through intermediate stations (Machlis & Rosa, 1990) and related to this it is noted that official information sources have little control over the way in which risk information is communicated through unofficial information sources (McComas, 2006). However, this research identifies that Twitter is a platform which facilitates direct communication between information source and the end receiver and this is recognised by health professionals. This direct communication also extends to distribution and correction of misinformation. As Twitter is an open platform it allows information sources to directly interact with those spreading misinformation and correct this information.

5.3. Contributions to SARF

Considering SARF, the research demonstrates a method which can be used to operationalise the framework and add the necessary additional complexities to rebuttal arguments of the simplistic nature of the framework (Bakir, 2005).

The CLD was able to capture the perceptions of the participants of the role of Twitter during health risk events. The model developed effectively captured softer aspects which are difficult to quantify. The conglomeration of perspectives within one model develops a rich model for understanding the role of Twitter and this application of SD modelling risk communication is clearly of significant impact to health organisations.

SARF shows a number of levels and distinguishes between individual, profession and senses. From the research it appears that the framework could be extended to include shared social networks. Information posted on Twitter is increasingly being used by the media, extending the reach of a tweet far beyond Twitter's site. It provides an opportunity for the public to post information which is accessible to all. Twitter is also being used by prominent individuals and organisations to allow control of the message and provide information to both the public and the media. To date, the media have been identified as a station in the amplification and attenuation of risks, yet there is clearly a changing

dynamic as individuals and organisations access and share information in new ways. In addition, it is identified that social media are changing the dynamics of risk communication, with media following emergency organisations on Twitter and lay publics being able to broadcast, it appears that this traditional notion of the media having the control may be changing. It is unclear how the new dynamics will impact on the long-term role of the media in the amplification and attenuation of risks and provides an opportunity for future investigation.

In the original framework, trust was not included although Kaspersen has since suggested it should be. The framework, at present, shows that secondary effects may lead to loss of trust in information sources and so on, however, the framework does not show dependencies during a risk event. It could be imagined that trust will change over time and the impact of the information source will vary over the course of a risk event, further research could seek to explicate these relationships. In this research the trust of the official organisations is a key variable of the CLD and it could be suggested that it is integral in the amplification and attenuation of risk, albeit a latent one. The relationship of the use of Twitter by official organisations and interaction of these organisations with the public is key. Lastly, Breakwell (2007) suggests a layering method, which proposes a dynamic model, monitoring various elements over time. Naturally, an expansion of the CLD into a quantitative SD model would allow such observations of changing levels over time and this research indicates a first stage in contributions towards furthering the research in this area to allow insight into a challenging framework to model.

5.4. Final conclusions

To conclude, the aim of this paper was to explore the use of the CLD and its role with rationalising the use of Twitter in risk communication strategies. The research brings together existing research to address a relatively new, difficult and relevant area. The research adopted SARF as a theoretical basis, informing the modelling approach and bounding the scope of empirical data collection. Research on operationalising SARF is limited and this research makes a con-

tribution to SARF related research by providing a means through which to operationalise the framework. A contribution is made to operational research through the novel use of CLDs in risk communication and the novel application. Finally, to risk communication through the investigation of the new medium Twitter which is driving changes in the communication during risk events.

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References

- Achrekar, H., Gandhe, A., Lazarus, R., Yu, S.-H., & Liu, B. (2011). Predicting flu trends using Twitter data. In *2011 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS)* (pp. 702–707). doi:10.1109/INFCOMW.2011.5928903.
- Altay, N., & Green, W. G. (2006). OR/MS research in disaster operations management. *European Journal of Operational Research*, *175*, 475–493.
- Bakir, V. (2005). Greenpeace v. Shell: media exploitation and the Social Amplification of Risk Framework (SARF). *Journal of Risk Research*, *8*, 679–691. doi:10.1080/13669870500166898.
- Bennett, P., Calman, K., Curtis, S., & Fischbacher-Smith, D. (2010). Understanding public responses to risk: policy and practice. In P. Bennett, K. Calman, S. Curtis, & D. Fischbacher-Smith (Eds.), *Risk communication and public health* (pp. 3–22). Oxford: Oxford University Press. (2nd ed.).
- Breakwell, G. M. (2007). *The psychology of risk*. Cambridge: Cambridge University Press. doi:10.1017/CB09780511819315.

- Burns, W. J., & Slovic, P. (2007). The diffusion of fear: modeling community response to a terrorist strike. *The Journal of Defense Modeling and Simulation: Applications, Methodology, Technology*, *4*, 298–317.
- Busby, J. S., Onggo, B. S. S., & Liu, Y. (2016). Agent-based computational modelling of social risk responses. *European Journal of Operational Research*, *251*, 1029–1042.
- Busby, J. S., & Onggo, S. (2013). Managing the social amplification of risk: a simulation of interacting actors. *Journal of the Operational Research Society*, *64*, 638–653.
- Chew, C., & Eysenbach, G. (2010). Pandemics in the age of Twitter: content analysis of tweets during the 2009 H1N1 outbreak. *PloS ONE*, *5*, e14118. doi:10.1371/journal.pone.0014118.
- Chung, I. J. (2011). Social amplification of risk in the internet environment. *Risk Analysis*, *31*, 1883–1896. doi:10.1111/j.1539-6924.2011.01623.x.
- Duckett, D., & Busby, J. (2013). Risk amplification as social attribution. *Risk Management*, *15*, 132–153. doi:10.1057/rm.2013.2.
- Eiselt, H. A., & Marianov, V. (2012). Mobile phone tower location for survival after natural disasters. *European Journal of Operational Research*, *216*, 563–572.
- Frewer, L. J. (2003). Trust, transparency, and social context: implications for social amplification of risk. In N. Pidgeon, R. E. Kasperson, & P. Slovic (Eds.), *The social amplification of risk* (pp. 123–137). Cambridge: Cambridge University Press.
- Fry, J., & Binner, J. M. (2016). Elementary modelling and behavioural analysis for emergency evacuations using social media. *European Journal of Operational Research*, *249*, 1014–1023. doi:http://dx.doi.org/10.1016/j.ejor.2015.05.049.

- Galindo, G., & Batta, R. (2013). Review of recent developments in OR/MS research in disaster operations management. *European Journal of Operational Research*, 230, 201–211. doi:<http://dx.doi.org/10.1016/j.ejor.2013.01.039>.
- Gaspar, R., Gorjão, S., Seibt, B., Lima, L., Barnett, J., Moss, A., & Wills, J. (2014). Tweeting during food crises: a psychosocial analysis of threat coping expressions in Spain, during the 2011 European EHEC outbreak. *International Journal of Human-Computer Studies*, 72, 239–254.
- Hughes, A. L., & Palen, L. (2009). Twitter adoption and use in mass convergence and emergency events. *International Journal of Emergency Management*, 6, 248–260.
- Hughes, A. L., & Palen, L. (2012). The evolving role of the public information officer: an examination of social media in emergency management. *Journal of Homeland Security and Emergency Management*, 9.
- Hughes, A. L., St. Denis, L. A., Palen, L., & Anderson, K. M. (2014). Online public communications by police & fire services during the 2012 Hurricane Sandy. In *Proceedings of the 32nd Annual ACM Conference on Human Factors in Computing Systems* (pp. 1505–1514). ACM.
- Kandiah, V., Binder, A. R., & Berglund, E. Z. (2017). An empirical agentbased model to simulate the adoption of water reuse using the social amplification of risk framework. *Risk Analysis*, 37, 2005–2022. doi:10.1111/risa.12760.
- Kasperson, J. X., Kasperson, R. E., Pidgeon, N., & Slovic, P. (2003). The social amplification of risk: assessing fifteen years of research and theory. In N. Pidgeon, R. E. Kasperson, & P. Slovic (Eds.), *The social amplification of risk* (pp. 13–46). Cambridge: Cambridge University Press.
- Kasperson, R. E., & Kasperson, J. X. (1991). Hidden hazards. In D. G. Mayo, & R. D. Hollander (Eds.), *Acceptable evidence: science and values in hazard management* (pp. 9–28). New York: Oxford University Press.

- Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., Kasperson, J. X., & Ratick, S. (1988). The social amplification of risk: a conceptual framework. *Risk Analysis*, *8*, 177–187. doi:10.1111/j.1539-6924.1988.tb01168.x.
- Lamos, V., & Cristianini, N. (2010). Tracking the flu pandemic by monitoring the social web. In *2010 2nd International Workshop on Cognitive Information Processing* (pp. 411–416). doi:10.1109/CIP.2010.5604088.
- Latonero, M., & Shklovski, I. (2011). Emergency management, Twitter, and social media evangelism. *International Journal of Information Systems for Crisis Response and Management*, *3*, 1–16.
- Machlis, G. E., & Rosa, E. A. (1990). Desired risk: broadening the Social Amplification of Risk Framework. *Risk Analysis*, *10*, 161–168.
- McComas, K. A. (2006). Defining moments in risk communication research: 1996–2005. *Journal of Health Communication*, *11*, 75–91.
- Murdock, G., Petts, J., & Horlick-Jones, T. (2003). After amplification: rethinking the role of the media in risk communication. In N. Pidgeon, R. E. Kasperson, & P. Slovic (Eds.), *The social amplification of risk* (pp. 156–178). Cambridge: Cambridge University Press.
- Paul, M. J., Dredze, M., & Broniatowski, D. (2014). Twitter improves influenza forecasting. *PLoS Currents Outbreaks*, *6*. doi:10.1371/currents.outbreaks.90b9ed0f59bae4ccaa683a39865d9117.
- Pidgeon, N., & Henwood, K. (2010). The social amplification of risk framework (SARF): theory, critiques, and policy implications. In P. Bennett, K. Calman, S. Curtis, & D. Fischbacher-Smith (Eds.), *Risk communication and public health* (pp. 53–67). Oxford: Oxford University Press. (2nd ed.).
- Preece, G., Shaw, D., & Hayashi, H. (2015). Application of the Viable System Model to analyse communications structures: a case study of disaster response in Japan. *European Journal of Operational Research*, *243*, 312–322.

- Regan, Á., Raats, M., Shan, L. C., Wall, P. G., & McConnon, Á. (2016). Risk communication and social media during food safety crises: a study of stakeholders' opinions in Ireland. *Journal of Risk Research*, *19*, 119–133.
- Remn, O. (2011). The social amplification/attenuation of risk framework: application to climate change. *Wiley Interdisciplinary Reviews: Climate Change*, *2*, 154–169. doi:10.1002/wcc.99.
- Rossmann, C., Meyer, L., & Schulz, P. J. (2018). The mediated amplification of a crisis: Communicating the A/H1N1 pandemic in press releases and press coverage in Europe. *Risk Analysis*, *38*, 357–375. doi:10.1111/risa.12841.
- Sakaki, T., Okazaki, M., & Matsuo, Y. (2010). Earthquake shakes Twitter users: real-time event detection by social sensors. In *Proceedings of the 19th International Conference on World Wide Web 2010* (pp. 851–860). ACM.
- Simpson, N. C., & Hancock, P. G. (2009). Fifty years of operational research and emergency response. *The Journal of the Operational Research Society*, *60*, S126–S139.
- St. Denis, L. A., Palen, L., & Anderson, K. M. (2014). Mastering social media: an analysis of Jefferson County's communications during the 2013 Colorado floods. In *Proceedings of the Information Systems for Crisis Response and Management Conference (ISCRAM 2014)*.
- Starbird, K., & Palen, L. (2011). Voluntweeters: self-organizing by digital volunteers in times of crisis. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1071–1080). ACM.
- Sterman, J. D. (2000). *Business dynamics: systems thinking and modeling for a complex world*. Boston: Irwin/McGraw-Hill.
- Vieweg, S., Hughes, A. L., Starbird, K., & Palen, L. (2010). Microblogging during two natural hazards events: what Twitter may contribute to situational awareness. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1079–1088). ACM.