

PANDHUB



Grant Agreement No: 607433
Project Acronym: PANDHUB
Project Title: Prevention and Management of High Threat Pathogen Incidents
in Transport Hubs

D5.2 – Communication tools

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Status: Final
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Dissemination level: PU = Public
Date: 30.06.2017



This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 607433



Summary

The movement of large volumes of people is known to be a considerable factor in the spread and emergence of infectious diseases, and the speed, reaches and volume of human travel made possible by current transportation methods makes the issue particularly pertinent. During infectious disease outbreaks the need for effective communication with the public is paramount; without proper risk communication, efforts to increase disease resilience and mitigation are considerably weakened. There is therefore a need to identify effective methods of communicating with members of the public at transport hubs during infectious disease outbreaks; such methods may include the use of Information and Communication Technology (ICT). The current study used a systematic scoping review method to assess the use of ICT tools for communicating health related information during pandemic disease outbreaks, both at transport hubs specifically, and during the outbreak more generally. The research question addressed was: “How have real-time communication tools been used to facilitate effective information dissemination during pandemics or disasters and how can the lessons learned be applied to transport operators?” Results are used to generate recommendations for communicating with members of the public at transport hubs during infectious disease outbreaks.

Findings revealed that in general, real-time communication tools are seen as a positive factor for increasing the effectiveness of communication with the public during outbreaks. This is largely due to the increased ‘speed, reach and transmission’ of these tools’. Social media has been the most heavily studied communication tool during disasters and pandemics, and a number of novel applications for its use have been tested and implemented. Literature relating to the use of real-time communication tools to disseminate information to members of the public at transport hubs specifically during pandemics was very limited. Due to the increased transmission effects and risk potential associated with transport hubs, and the need for better communication with the public, researchers and scientists should focus on addressing this research gap.



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1. Introduction

The movement of large volumes of people is known to be a considerable factor in the spread and emergence of infectious diseases; and the speed, reaches and volume of human travel capable through current transportation methods makes the issue particularly pertinent (Browne, St-Onge Ahmad, Beck, & Nguyen-Van-Tam, 2016; Wilson 1995). Deliverable 3.3 considered a review of mathematical modelling of global disease spread culminating in a scoping review under review with Eurosurveillance (Walters, Mesle and Hall, *in press*). Simulations of historic infectious disease outbreaks, for example a study of the 1968-1969 influenza pandemic; have shown that the inclusion of modern day air travel patterns would significantly increase the spread of global outbreaks over and above the seasonal patterns displayed in specific geographic regions (Grais, Ellis and Glass, 2003). Additionally the use of local area transport (i.e. bus, train and tram) shows significant associations with the onset of infectious respiratory disease symptoms (Troko, Myles, Gibson, Hashim, Enstone, Kingdon, Packham, Amin, Hayward, Nguyen Van-Tam, 2011).

During infectious disease outbreaks the need for effective communication with the public is paramount. Bennett, Calman, Curtis and Fischbacher-Smith (2010) state that many of the health risks faced by the public are 'ill-defined... ill understood and interconnected' (Pg. 2) and state that without proper risk communication, efforts to increase disease resilience and mitigation are considerably weakened. The effects of poor communication between health responders and the public have been highlighted through a number of influenza outbreaks reported by the CDC in the US (Staes, Wuthrich, Gesteland, Allison, Leecaster, Shakib, *et al.* 2011) and calls for improved public communications during outbreaks have been made by a number of health organisations. Indeed the need for effective communication is increased for vulnerable populations based on a wide variety of factors, i.e. socioeconomic, economic, health, psychological and demographic (Vaughan and Tinker 2009). Past research suggests that trust and credibility are key components in creating effective communication and that this is best engendered through: empathy and caring, competence and expertise, honesty and openness, and dedication and commitment (Reynolds and Crouse Quinn, 2008).

The field of risk communication for infectious disease outbreaks is highly related to that in general disaster settings, i.e. Man-made disasters or natural disasters. This field has



received a great deal of attention and has formed its own specific discipline of 'crisis communication' (Ulmer, Sellnow and Seeger 2013; Heath & O'Hair, 2010). Psychological and behavioural science fields have often been used to inform such crisis communication, with well-established psychological theory being used to develop guiding principles for effective implementation (Coombs, 2007; Seeger 2002). Disaster risk communication and risk communication specific to pandemics are highly related, and the development/incorporation of psychological theory current study will extend its interest into public communications for both infectious disease and disaster settings.

Of particular interest for the current study is the ways in which modern day Information and communication Technology (ICT) can be utilised to improve communication from emergency responder organisations to the public. These tools allow for instant and real-time communication and information dissemination via the internet and web 2.0 (O'Reilly 2007). Such tools, including social media, have been used in a number of fields for the wide-spread dissemination of information or as a platform for facilitating collaboration and co-creation. For example, social media was used to connect large and disparate groups of activists during the 2012 Arab spring uprisings (Youmans and York 2012), and for mobilizing political activists during national campaigns in the US (Hara, 2008).

The current study will assess the impact of using ICT tools to communicate health related information during pandemic disease outbreaks and disasters. Due to the risks associated with transport hubs and infectious disease we will have a particular focus on the use of these tools in transport settings. Additionally, we will assess the psychological and communication theories underlying the use of these tools and will produce a set of practical recommendations for their use aimed at transport operators and health responder organisations.

The study will employ a systematic scoping review method to highlight academic research articles related to the topic and two separate thematic qualitative synthesis analyses will be run on: [1] the past use of ICT tools in disaster or pandemic settings to communicate with the public, and [2] the inclusion and discussion of psychological or communication theories highlighted in the papers identified by the literature search. A Scoping literature search has been chosen to allow for an iterative approach to article searches. This iterative search is advantageous and appropriate for the current study as it allows for a more flexible search strategy, appropriate for the current topic.



1.1 Research Question

Our overall research question for this scoping review has been developed using the 'PICO' method of research question development for evidence based decision making (Booth, 2004), and is as follows:

- *How have real-time communication tools been used to facilitate effective information dissemination during pandemics or disasters and how can the lessons learnt be applied to transport operators?*

2. Methods

2.1 Literature search strategy:

Five databases were used for the literature search, these included: Embase (Ovid), Medline (Ovid), Scopus, PsycINFO (NICE HDAS) and Cinhal (Ebsco). Search terms were split into four 'categories' relating to the key aspects of our research questions and included: [1] Transportation terms, [2] Disaster/Pandemic terms, [3] Communication tool terms, and [4] Victim/Population terms. Each category contained 20-40 individual terms, which were combined using 'or' statements. During the final search all chunks were combined using 'AND' statements. The terms were originally created in Embase (Ovid) and were adapted for use within the other databases; see *Appendix 1* for full list of Embase search terms. All searches were run on the 7th of October 2016 and were imported into Endnote X7 (Thomson Reuters, San Francisco, USA).



2.2 Inclusion criteria:

A number of inclusion criteria were developed for the literature search. Initially, only studies written in English and published after January 2000 were included in the review. The year of publication criteria was included as the kind of real-time online communication tool being assessed only became popularly available in the early 2000s with the advent of Web 2.0. Only published and peer reviewed journal articles were included in the review, however the search was not restrictive of studies which did not include original data, i.e. literature reviews.

A set of four research question specific terms were applied to the search results and include: [1] *Included articles should discuss the information dissemination between disaster/medical responders and members of the public, with a particular focus on communications from the former to the latter. In this case, the term 'responders' broadly applies to any persons/organisation involved in the management/coordination/application of incident response or preparedness.* [2] *Articles must discuss real or imagined incidents relating to pandemics/communicable diseases/infectious diseases, or Crises/man-made-disaster/Natural disasters.* [3] *Articles should focus on the discussion or analysis of real-time/wireless/mobile communication tool, or communication strategies which focus on ICT technologies.* [4] [Optional] *Papers should discuss incidents based in transportation or transport hub setting.* The transportation focused inclusion criteria was initially set as a mandatory requirement but was later set as an optional, but desirable one. This was because early attempts at searching and screening revealed very few papers which fulfilled all four criteria, with the transportation criteria being the biggest reason for exclusion.

Selection and screening of papers followed a systematic search method following a PRISMA framework (Moher, Liberati, Tetzlaff, Altman; 2009) and forward and backward citation screening was carried out on the eligible articles after full text screening. Finally, the online critical appraisal tool, 'understanding health research', was used to assess the quality of the included papers. The scoring system in this tool is based on a series of questions about the research, some of which are determined based on earlier answers, and positive and negative scores. A cut off for inclusion was set at 50% positive scores out of the total number of responses (a percentage cut off was used because the number of questions varied based



on the type of research). This tool was suitable for all types of research apart from literature reviews therefore critical appraisal was not applied for these papers.

2.3 Data Organisation and Analysis:

A qualitative synthesis analysis was used to assess the included papers. This analysis was split into two stages. Initially, the articles were split into four categories based on the type of data presented including: [1] Quantitative studies, [2] Qualitative studies, [3] Case studies, [4] Literature reviews/modelling articles. For all papers demographic information was recorded (Authors, title, date of publication etc.) as well as information relating to methodology and tool type/disaster setting assessed in the papers. A more detailed analysis of the papers was conducted which included a range of factors relating to the study's findings and key discussion points. At this stage of the analysis the information extracted contained a high amount of depth and detail. The second stage of the framework analysis reduced the stage one analysis into key findings and broader discussion points. The papers were then organised into papers with either disaster setting or infectious disease setting and into the type of communication tool presented (social media, mobile/applications, communication strategies/response plans, and websites) and a thematic qualitative analysis was conducted. For all categories demographics were recorded and the data was synthesised based on 4 key components in the paper, this included: [1] Study objectives, [2] Methodology, [3] Analysis results, [4] Study conclusions. The notes taken for these components were then developed into initial codes, followed by second level codes in which the initial codes were compared and reviewed across the papers. Finally, themes were developed by assessing relationships within and between second level codes. The paper demographics and the major themes and second level codes are presented in tables in the results section along with a written description of the qualitative synthesis analysis.



3. Results and Discussion

3.1 General search results

The main literature search retrieved a total of 23,627 entries across the five databases, of which 5,813 were duplicates; no papers were included from other sources at the identification stage. 15,457 articles were excluded at the first stage of screening; the vast majority of these entries clearly did not meet the research question inclusion criteria or were excluded for bibliographic reasons. Titles and abstracts were then screened which resulted in 148 articles being selected for full text screening, of which 23 articles met our inclusion criteria. At this stage the 23 selected articles were forward and backward citation screened; this search retrieved 546 and 543 articles respectively, of which 21 articles were included after screening. These articles were added to the 23 articles screened from the primary search resulting in 44 included articles for the qualitative synthesis analysis. See *Figure 2* for PRISMA flow diagram (Moher *et al.* 2009).

Primarily, the literature search retrieved no articles which fully met the study's brief of a discussion of a real-time public communication tool used at transport hubs during pandemic disease outbreaks. The fact that our large and extensive search of literature revealed no articles of this nature shows a significant gap in published literature relating to the topic. Of the 44 articles that met our inclusion criteria the majority of them discussed communication tool use during natural/man-made disasters (n=33); with the remaining articles focusing on infectious disease outbreaks (n=11). These were split between a variety of article types including: eight primarily quantitative articles, 15 primarily qualitative articles, 14 case studies, and seven literature review articles. Critical assessment of the articles highlighted two papers of borderline quality (Schroeder, Pennington-Gray, Donohoe, Kiousis; 2013, Abdullah, Annamalai, M., and Rani, M; 2016) and one of suboptimal quality (Fordis, Alexander, McKeller; 2007), the former will be tentatively included in the synthesis and the latter will be excluded.). A full list of the included studies and their bibliographic information can be seen in *Table 1*.

The remainder of this section will focus on the description and presentation of the qualitative synthesis analysis of the included articles. It will be split into two overarching categories based on the Incident type, [1] natural/man-made disaster vs. [2] infectious



diseases; each will be further divided into four subcategories based on the type of communication tool/strategy adopted, which will include: [a] social media, [b] mobile phones/applications, [c] response plans, and [4] websites. Finally, we will discuss the analysis of the use of psychological/communication theories across the included papers.

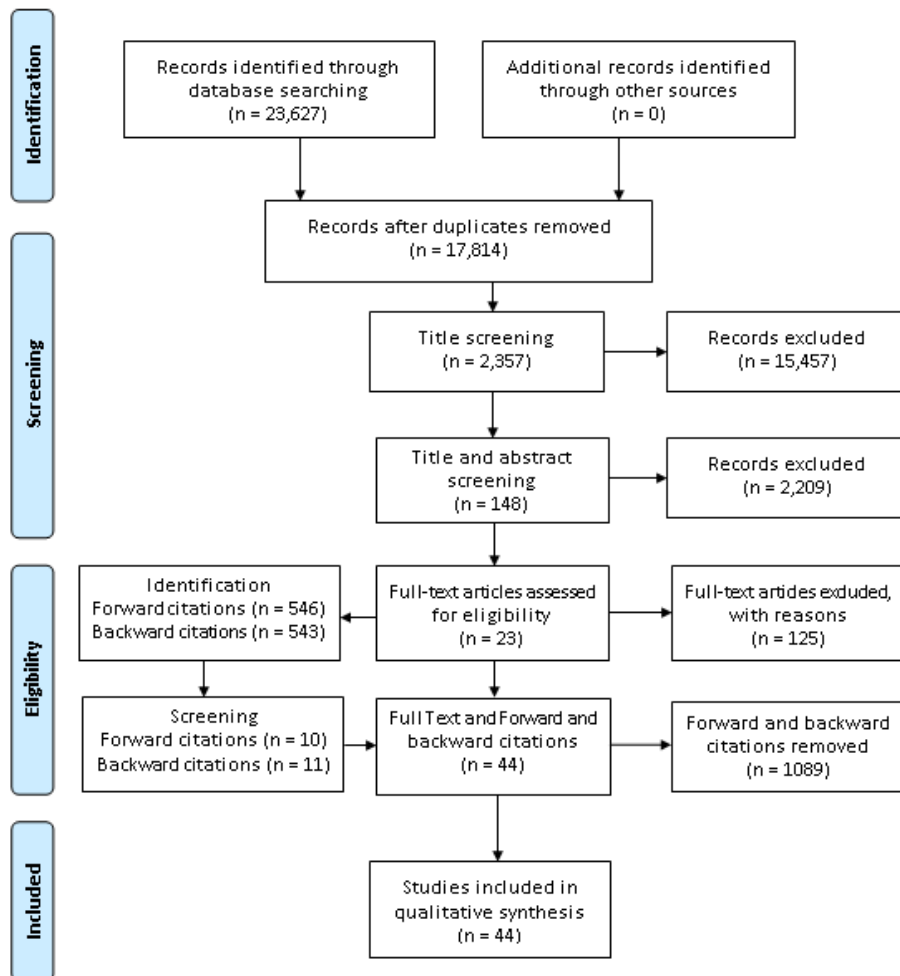


Figure 1: PRISMA flowchart of search strategy



3.2. Disasters

3.2.1. Social media

The most commonly discussed topic was ‘the use of social media as a communication tool during disasters’, with a total of 20 papers focusing on the topic (6 case studies, 5 reviews, 5 qualitative studies, and 4 quantitative studies), see *Table 1* summary of articles. A number of key themes were highlighted during the analysis of the papers including: [1] speed, reach and transmission, [2] two-way communication and public engagement, [3] Organisational factors, [4] novel applications of social media.

Disaster Social Media						
Author Name	Year	Study Type	Incident type	Transport Setting	Responder type	Tool type
Dabner, N	2012	Case Study	Hurricane	None	University Management	Facebook groups
Chatfield, A et al.	2013	Qualitative	Earthquake	None	Government Responders	Twitter
Cooper, A. et al.[a]	2015	Conceptual framework	Earthquake	None	Disaster management	Twitter triangulation
Cooper, G. et al.[b]	2015	Case study	Earthquake	None	Disaster management	Twitter triangulation
Cooper, G. et al.[c]	2015	Quantitative	Earthquake	None	Disaster management	Twitter triangulation
Yeager et al.	2015	Conceptual framework	Disaster (General)	None	Disaster management	Twitter
Leykin et al.	2016	Review	Disaster (General)	None	Disaster Management	Social media (General)
Simon et al.	2014	Case study	Mass Shooting	None	Disaster Management	Twitter & Facebook
Starbird et al. 2010	2010	Qualitative	Floods & Wild-fire	None	Disaster Management	Twitter
Sutton et al.	2014	Quantitative	Wild-fire	None	Government Responders	Twitter
Latonero & Skylovski	2011	Case study	Disaster (General)	None	Fire service (L.A., USA)	Twitter
Haataja et al.	2016	Qualitative	Disaster (General)	None	Disaster management	Social media (General)
Kent & Ellis	2015	Review	Disaster (General)	None	Social media developers & Disaster management	Social media (General)



Pender <i>et al.</i>	2014	Review	Disaster (General)	Railway	Transport operators	Social media (General)
Wybo <i>et al.</i>	2015	Review	Disaster (General)	None	Disaster management	Twitter & Social Network analysis
Hagar	2013	Review	Disaster (General)	None	Disaster management + citizen journalists	Social Media (General)
Schroeder & Pennington-Gray	2015	Quantitative	Disaster (General)	International air-travel	Disaster management	Twitter
Schroeder <i>et al.</i>	2013	Quantitative	Disaster (General)	International air-travel	Disaster management	Social media (General) & Smart phones
Bird <i>et al.</i>	2012	Quantitative	Flooding	Travellers/ Tourists	Local government	Facebook
Alshareef & Grigoras	2016	Quantitative	Disaster (General)	None	Disaster management	Emergency notification system (Twitter cloud service)
Palen <i>et al.</i>	2009	Case study	School Shooting	None	First Responders	Social Media (General) & ICTs
Howe <i>et al.</i>	2011	Case study	Disaster (General)	None	Disaster management + net-savvy citizens	Social media (General) & ICTs

Table 1: Bibliographic information for included texts related to the use of social media as a communication tool during disasters.

The first major theme discussed across a number of papers was the speed, reach and transmission of social media communication (Dabner 2012; Chatfield, Scholl, Brajawidagda; 2013; Simon, Goldberg, Aharonson-Daniel, Leykin, Adini 2014; Haataja Laajalahti, and Hyvarinen 2016; Pender, Vieweg, Liu; Hughes 2014; Hager 2013; Bird Ling, and Haynes, 2012; Alshareef and Grigoras, 2016). Across the highlighted articles an acknowledgement of the speed of social media communication was ubiquitous, as was an acknowledgement of its potential reach in times of disaster. For example, in a survey assessing public use of Facebook following widespread flooding, respondents highlighted Facebook's timeliness as one of the most appealing features of its use (Bird *et al.* 2012); it's highly reactive, *rapid and direct channel of communication* was seen as highly advantageous during interviews with



emergency responder organisation as opposed to 3rd party conventional media information dissemination (Haataja *et al.* 2016). One of the key functions of social media platforms that contribute to their reach and speed is *transmission*, or *serial transmission*, which is embodied by 'retweets' on twitter and 'likes' and 'group invitations' on Facebook. A number of the papers focused on methods of increasing serial transmission rates and highlighted it as crucial to widespread information dissemination. Its successful use is best exemplified in a case study of an twitter early warning system in which ~350,000 of the system's followers were notified within 5 minutes and transmissions spread the message to a further 4 million people (Chatfield *et al.* 2013). Predictors of successful disaster related tweet serial transmission have also been assessed and included: the user's follower count, user 'klout' (a numerical measure of 'social influence' on twitter), and hashtag use (particularly disaster relevant hashtag) (Cooper *et al.* 2015).

Another key factor related to the speed, reach and transmission of social media was that of *widespread public use* with a number of studies noting that social media is already highly integrated in people's lives and that it is considered to have strong growth potential (Dabner *et al.* 2012; Pender *et al.* 2014; Chatfield *et al.* 2013). Although this rapid growth and popular use is a positive factor, one of the included papers did note that social media had large accessibility issues for vulnerable groups such as the elderly and disabled (Kent and Ellis 2015). In this article the authors describe a 'social media mash-up' in which various integrated platforms are operating in a state of constant beta testing. Whilst this approach is a suitable approach for experienced internet users, it creates difficulties for those vulnerable groups not considered in the design processes. Indeed, in empirical surveys, the largest predictor of social media use during a disaster was shown to be past experience and use of social media (Schroeder *et al.* 2013). This raises the possibility that social media, as a disaster alert tool, may only be beneficial to experienced individuals and may exclude other subsets of society.

The second major theme highlighted during the analysis of disaster social media was the potential for *two-way communication and public engagement* with a large number of the included studies focusing on interacting with, and engaging with, members of the public during disasters (Dabner *et al.* 2012; Chatfield *et al.* 2013; Simon *et al.* 2014; Starbird *et al.* 2010; Latonero and Shklovski 2011; Haataja 2016; Pender *et al.* 2014; Wybo *et al.* 2015; Hagar *et al.* 2013; Cooper, Yeager, Burkle, Subbaro 2015c; Palen *et al.* 2009). One of the key methods



for two way communication was the *use of crowdsourcing and citizen journalists/sensors*. In an analysis of twitter communications during a US Tornado, researchers showed that the most effective disseminators of information for locals (measured by reach and transmission of their messages) were local influential individuals rather than disaster response organisations (Cooper *et al.* 2015c). Additionally, in fast moving disaster situations, such as the Virginia Tech School shooting of 2007, social media communication responded more quickly than organisation communications and was attributed with aiding in the evacuation of students and tracking of events for emergency responders (Palen *et al.* 2009). Local emergency responder groups have also employed social media strategies based on monitoring and listening to social media channels for emergency information (Latonero and Shklovski, 2011). This approach was attributed with improving response times and with providing responders with increased information depth.

Finally, the X24 projects in the US and Europe showed that large numbers of people, locally and internationally, can be effectively utilised to aide in disaster responses and that they are most effective in quickly disseminating information through social media networks (Howe *et al.* 2011) These studies show the effectiveness of involving members of the public during disaster response for both effective dissemination and collection of information. Indeed, the previously discussed social media transmission functions are based upon effectively involving individuals in the dissemination of time-critical information (Chatfield Scholl, Brajawidagda, 2014). Crowdsourcing is thought to bring a number of benefits to the disaster response, ranging from the psychological, such as empowering the public, to more tangible logistic benefits, by delegating certain tasks to crowd sourced individuals and reducing the load on responder groups (Pender *et al.* 2014). However, it does come with a number of challenges. It is very difficult to process large amounts of incoming user generated content and it is difficult to ensure the reliability and accuracy of this information (Pender *et al.* 2014; Wybo *et al.* 2015). Additionally, whilst crowdsourcing has proved effective in information dissemination and transmission, it has proved less successful in engaging citizens in the practical, on the ground response (Chatfield *et al.* 2014). Crowdsourcing of information can be an extremely useful tool for emergency responses, particularly in the dissemination and transmission of information to local populations. However, crowdsourcing does raise



challenges that need to be planned for by responder groups and is less effective in prompting the public to practically engage in response activities during disasters.

Another key concept in two way communication and public engagement is that of *community resilience*. The ability to form and coordinate groups of individuals using tools such as Facebook can provide a platform for engagement and support with, and by, the public during the course of a disaster. Facebook groups set up following an earthquake in New Zealand were shown to be an effective tool for psychological relief in the aftermath of the disaster (Dabner *et al.* 2012); and Facebook groups set up during flooding in Queensland showed that many people used the groups to gather information about loved ones and that they appreciated the community support offered by the tool (Bird *et al.* 2012). These kind of soft support factors are vitally important during times of crisis and are difficult for responder groups to provide resources for. Indeed, Facebook, has been highlighted as particularly useful for the provision of these soft support factors whereas Twitter is more useful for widespread and immediate information dissemination (Dabner *et al.* 2012).

The third theme to emerge from the analysis of this section was Organisational factors surrounding the use of social media by disaster responders. These methods largely centred on the techniques used, and issues faced, by responder groups during the implementation of social media communication strategies. Interviews and surveys of emergency responder groups have shown that views of social media strategies in disaster settings are generally positive, with its direct and rapid communication channels and ability to build and foster relationships and situational awareness being cited as particular strengths (Haataja *et al.* 2016). A number of key disadvantages were also covered in this paper, many of which were also discussed in the other papers in the review. One of the key issues cited was that of loss of *informational authority* and the *potential for rumour spreading*. High levels of public engagement may challenge the authority and monopoly of information disseminated by emergency responders via conventional media sources (Haataja *et al.* 2016; Dabner *et al.* 2012). In the survey associated with flooding in Victoria, 39% of users reported a number of information inaccuracies with regard to user generated information, indicating a problem with democratised information (Bird *et al.* 2012). Furthermore, one of the key issues faced during the implementation of a social media response system at a local fire department was the control of misinformation and rumour (Latonero and Shklovski 2011). In response to these



issues responder organisations need to foster trust by building positive relationships between the responder organisations and affected populations (Hagar *et al.* 2013). Responder organisations can also maintain informational accuracy by engaging in rumour control (fact checking and suppression of inaccurate information), as has been implemented by large responder organisations such as FEMA; indeed, Wybo *et al.* (2015) suggests that this is a responsibility of responders once they commit to engaging in social media platforms. A number of articles also suggest that social media should be used as a secondary communication tool run in parallel with more established conventional media sources in a multichannel approach (Haataja *et al.* 2016; Bird *et al.* 2012; Latonero and Shklovski 2011). This approach aims to maintain the authority and reputation associated with conventional media as well as the benefits provided by social media.

Another organisational issue related to social media is the *slow and inflexible uptake* of the tool by responders. In Haataja *et al.* (2016) emergency managers note that there is a general lack of knowledge and inflexibility about social media amongst management structures in responder organisations. In Latonero and Shklovski (2011) (Local fire department social media strategy) the prime interviewee stated that the social media strategy was often overlooked by senior management and resources were slow to come in. This problem is heightened by the rapidly changing nature of social media systems and the large operational resources required to control for the large noisy data generated by users (Wybo *et al.* 2015; Pender *et al.* 2014). Research into the use of social media by disaster managers during a mass shooting has shown large variability in the quality and organisational uptake of the tool (Simon *et al.* 2014). One of the key issues cited by this research was the lack of uniformity in its use and its complexity; specifically, both organisations and end users complained that there were too many different kinds of twitter hashtags used during the event. The authors suggest that the field would benefit from the development of 'standard operating procedures' (SOPs) or code of practice. This approach is thought to have a twofold benefit of providing a clearer and easier route for social media uptake as well as establishing social media as a more established official communication tool.

A key organisational approach discussed in the included papers was the use of *social media evangelists* (Latonero and Shklovski 2011; Wybo *et al.* 2015; Howe *et al.* 2011; Chatfield *et al.* 2014). Social media evangelists are key actors within responder organisations



who drive the use of social media communications. Wybo *et al.* (2015) sees this role being taken up by public information officers (PIOs) with the hope of evolving the role of these communication specialists to incorporate the increasingly important field of social media. Research into information dissemination by PIOs has shown that the quality of disaster information is significantly heightened when they are used, meaning that these individuals can have an important role in maintaining informational authority during disasters. In Latonero and Shklovshi's (2011) case study the social media strategy described is driven by a single individual within the department who is described as a social media evangelist. Here, an ad-hoc, self-taught approach was adopted in order to achieve change within the organisation. The authors claim that this is an example of how small groups of visionaries are at the heart of organisational change and innovations. In the X24 exercise (Howe *et al.* 2011) and Istanbul earthquake response program social media evangelists refer more to members of the public with technical skills who are brought into the disaster management response in order to alleviate some of the resource demands on organisations. In X24 knowledgeable members of the public are recruited on an ad-hoc basis as the disaster unfolds and aide in the propagation of information through social networks as well as performing disaster response activities based on their specialities, i.e. analytics. For Istanbul's earthquake response, members of the public are trained by response organisations to provide assistance on a range of disaster response tasks if and when required (Chatfield *et al.* 2014). These approaches provide a great deal of flexibility for response organisations and promote co-creation and collaboration between responders and the public.

The final major theme highlighted in the assessment of social media in disaster settings was the use of novel applications of social media (Cooper, Yeager, Burkle, Subbarao, 2015a; Cooper, Yeager, Burkle, Subbarao 2015b; Chatfield *et al.* 2014; Leykin *et al.* 2016; Wybo *et al.* 2015; Alshareef *et al.* 2016). One of the key issues in the use of social media for disaster communication is how to properly target at-risk audiences; this is especially true of twitter in which all messages are only viewable to a user's followers or when retweeted. Cooper *et al.* (2015a) propose a *twitter triangulation system* based on processing a user's: biographical metadata, twitter posts, and retweets/links. This system was later validated by analysing tweets posted during the course of a tornado in the USA and was shown to be effective at using the posts to highlight users in the geographic area affected without relying on GPS



functions, which only 2% of users choose to activate (Cooper *et al.*2015b). The authors suggest that this tool can be used to quickly and cheaply highlight at risk groups so that twitter posts can be specifically designed to ensure their accessibility. Twitter has also been used as the basis of *emergency notification and response applications* which include both an 'end user' and 'rescuer' environment (Alshareef *et al.*2016). Using this application, end users can send notifications directly to responder organisations in emergencies/disasters; these notifications are automatically classified by the system and can include information rich items (i.e. photographs/GPS coordinates) which are then processed and stored. The items can then be viewed and acted on by responders in the rescuer interface. This system allows for rapid sharing of information from end user to responder with more dynamic and rich information than that provided in a 9-1-1/9-9-9 emergency call. Twitter's incorporation into Istanbul's earthquake response system also represents an interesting approach to disaster communication (Chatfield *et al.* 2014). It is a fully automated system which receives information from geological sensor equipment before disseminating to twitter within 5 minutes of the earthquake. This system provides rapid emergency information to a large number of users without relying on individuals or organisations to perform communication tasks.

The three previous articles focus on the quick and effective transmission of information on social media; however the development of *targeted content* is also critically important when disseminating information. Social network analysis techniques have been used to understand the impact of message content on communication in the aftermath of an event in case studies relating to man-made and natural disasters (Simon *et al.* 2014; Cooper *et al.* 2015c). These analyses highlight the factors of twitter messages that lead to the greatest retransmission rates, which can then be used in the development of messaging protocols for future events. Leykin *et al.* (2016) present a framework for using naturalistic language processing tools such as text mining and recommender systems to produce personalised and targeted messages based on the content of users messages, as well as their 'like'/'retweet' behaviour. Although these tools have not yet been developed for these purposes they present a promising future direction for disaster communication.



Disaster Mobile Social Media			
No.	Major themes	Sub Themes	Cited articles
1	Speed, reach and transmission	Rapid and Direct	Dabner <i>et al.</i> 2012; Chatfield <i>et al.</i> 2013; Simon <i>et al.</i> 2014; Haataja <i>et al.</i> 2016; Pender <i>et al.</i> 2014; Hager 2013; Bird <i>et al.</i> 2012; Alshareef <i>et al.</i> 2016
		Serial Transmission	Cooper <i>et al.</i> (2012a) Chatfield <i>et al.</i> (2013) Haataja <i>et al.</i> (2016) Bird <i>et al.</i> (2012)
		Widespread public use	Schroeder <i>et al.</i> (2013) Kent <i>et al.</i> (2012) Dabner <i>et al.</i> (2012) Pender <i>et al.</i> (2014) Chatfield <i>et al.</i> (2013)
2	Two-way communication and public engagement	Crowdsourcing and citizen journalists/sensors	Chatfield <i>et al.</i> (2014) Pender <i>et al.</i> (2014) Wybo <i>et al.</i> (2015) Howe <i>et al.</i> (2011) Latonero and Shklovski, (2011) Palen <i>et al.</i> 2009 Cooper <i>et al.</i> (2015b)
		Community resilience	Dabner <i>et al.</i> (2014) Bird <i>et al.</i> (2012)
3	Organisation Factors	informational authority and Potential for rumour spreading	Haataja <i>et al.</i> (2016) Howe <i>et al.</i> (2012) Dabner <i>et al.</i> (2012) Bird <i>et al.</i> (2012) Latonero and Shklovski (2011) Hagar <i>et al.</i> (2013) Wybo <i>et al.</i> (2015)
		The Slow and inflexible uptake	Haataja <i>et al.</i> (2015) Latonero and Shklovski (2011) Wybo <i>et al.</i> (2015) Pender <i>et al.</i> (2014) Simon <i>et al.</i> (2014)
		Social media evangelists	Latonero and Shklovski (2011) Wybo <i>et al.</i> 2015; Howe <i>et al.</i> 2011 Chatfield <i>et al.</i> 2014
4	Novel applications	Twitter triangulation system	Cooper <i>et al.</i> 2015a Cooper <i>et al.</i> 2015b Cooper <i>et al.</i> 2015c



	Emergency notification and response applications	Chatfield <i>et al.</i> (2014) Alshareef <i>et al.</i> (2016)
	Targeted content	Simon <i>et al.</i> (2014) Cooper <i>et al.</i> (2015c) Leykin <i>et al.</i> (2016)

Table 2: Major themes and second-level themes highlighted during the qualitative analysis of the use of Social media as a communication tool during disasters.

3.2.2 Mobile Applications

Five of the included papers discussed ‘the use of mobile phone applications in disaster communication settings’ which included: two case studies, one modelling paper and two review articles. See *Table 2* for the basic summaries of these texts. The major themes highlighted in this section included: [1] *The Impact and efficacy of mobile phones/mobile applications on disaster response;* and [2] *Novel mobile application tools and their functionality.*

Disaster Mobile Applications						
Author Name	Year	Study Type	Incident type	Transport Setting	Responder type	Tool type
Buzzelli <i>et al.</i>	2014	Review	Disasters (General)	None	Disaster management	ICT tools
Mesmer & Bloebaum	2012	Modelling	Terrorist attacks	None	Disaster management	Personal communication tool (PCD)
Onorati <i>et al.</i>	2014	Case study	Disaster (General)	None	Disaster management	EmergencSYS crisis toolbox & Andriod and iOS
Romano <i>et al.</i>	2016	Case report	Earthquake	None	Disaster management	Smart phone application
Rubin <i>et al.</i>	2014	Review article	Disasters General	None	Government responders	Mobile Applications

Table 3: Bibliographic information for included texts related to the use of mobile phone application as a communication tool during disasters.

The first key theme related to the use of mobile phones/mobile applications in disaster response was the *impact and effectiveness* of the tools on past and or hypothetical disaster environments (Buzzelli, Morgan, Muschek, Macgregor-Skinner, 2014; Rubin, Bouri, Jolani, Minton 2014; Mesmer and Bloebaum 2012). All included papers generally advocated for the



increased use of these tools in disaster response and cited a number of advantages which were similar to those highlighted during the analysis of social media tools. These included: *The abundance of available tools* (Buzzelli *et al.* 2014), *high levels of tool uptake amongst the public* (Buzzelli *et al.* 2014; Rubin *et al.* 2014), and the *reach, speed and real-time communication abilities* of the tools (Buzzelli *et al.* 2014; Mesmer *et al.* 2012).

One of the key issues faced during the past implementation of these tools was a *lack of engagement/implementation* despite the abundance of available tools and audience. In an assessment of local emergency department's use of mHealth tools (internet based tools used on mobile applications and social media platforms) researchers showed that only a fraction used a proper strategy (Rubin *et al.* 2014) citing diminishing funding for preparedness programs and a lack of direction from policy makers and the research community (Rubin *et al.* 2014). This paper advocated for: the development of an information exchange database, guidance for local emergency departments (under the executive direction of the 'National association of county & city health officials (NACCHO)), the use of 'mHealth' tools, and the development of legislation for its use. Similar findings were presented in a case study/literature review of the use of mobile tools in key historical case studies (i.e. the London bombings, Boston Bombings, Japanese tsunami). A lack of consistency in the strategic use of mobile tools by different responders was cited as a key reason for the limited success of past tools. They suggest the development of 'nomenclature', or standard language development for the industry, i.e. designated names, websites and hashtags for communications as well as the designation of specialist 'master' ICT outlets which act as an executive hub for designing and developing protocols for mobile application use.

The practical implications of mobile tools were also discussed across a number of papers. Buzzelli *et al.* (2014) also note that inclusion of user generated content in disaster response caused problems because of the noisy data and non-conventional language used by the public during disasters and Mesmer *et al.* (2012) discuss issues relating to the longevity of products and pace of change in the mobile technology industry as well as the efforts needed to train and educate organisations in the use of tools. These papers highlight the need for a *standardised approach to the use of* mobile communication tools which provide organisations with a blueprint for the use of mobile tools.



The second key theme of this section focused on the testing or description of novel mobile phone/mobile application tools and their functionality which included two papers describing the same mobile application. Onorati, Aedo, Romano, Diaz (2014) describes an application known as EmergencSYS which aimed to improve communication flows between emergency workers and members of the public. The system had two functions: [1] to notify emergency responders of an incident, and [2] to provide users with relevant information and alerts about the incident. 'EmergencSYS' includes a number of interesting tools to aide responders and users including: the transfer multimedia tools, a GPS function and a panic button for particularly dangerous situations. The system was later tested using qualitative and quantitative procedures which included: a controlled experiment, a questionnaire of end users and a series of interviews with emergency managers (Romano, Onorati, Aedo, Diaz 2016); all of which aimed to validate the effectiveness, usability and resilience of the system.

The controlled experiment showed that the system didn't need much training with differences in the time taken to run an operation and the number of errors being small between trained and untrained participants. Both participants in the experiment and survey respondents showed high acceptability of the system in disasters with >90% saying they would use the system in times of disaster. Finally, findings from focus groups with emergency responders suggested that the use of multimedia functions was particularly useful as it provided respondents with rich, detailed and reliable information, thereby providing situational awareness during disasters. This kind of tool could be applied to cases of infectious disease in a transportation setting as it provides effective two-way communication using non-noisy data which is centrally controlled. The main issue with this kind of system is that participants have to actively sign-up with and install the application to their devices and one can also imagine that these kinds of applications will have a number of competitors. Therefore emergency responder organisations need to make considerations for the marketing and dissemination of these kinds of applications to try to produce the highest possible uptake. Additionally, attempting to produce uniformity and consistency of the mobile applications used across responder organisations may be useful to increase uptake of these systems. If this is not possible these tools can still be useful as a supplementary/parallel tool with other kinds of information dissemination, i.e. social media, conventional media.



Disaster Mobile applications			
No.	Major themes	Sub Themes	Cited articles
1	Impact and efficacy	The abundance of available tools	Buzzelli <i>et al.</i> (2014)
		High levels of mobile phone use	Buzzelli <i>et al.</i> (2014) Rubin <i>et al.</i> (2014)
		Reach, speed and real-time	Buzzelli <i>et al.</i> (2014) Mesmer and Bloebaum (2012)
		Lack of engagement/implementation	Rubin <i>et al.</i> (2014)
		Standardised approach to the use	Buzzelli <i>et al.</i> (2014) Mesmer and Bloebaum (2012)
2	Novel mobile phone/mobile application tools	Emergency notifications and communication tools	Onorati <i>et al.</i> (2014) Romano <i>et al.</i> (2016)

Table 4: Major themes and second-level themes highlighted during the qualitative analysis of the use of Mobile applications as a communication tool during disasters.

3.2.3. Response Strategies

Five of the included papers discussed 'the use of mobile phone applications in disaster communication settings' which included: three case studies, one modelling paper and one review article. See *Table 3* for the basic summaries of these texts. The major themes highlighted in this section included: [1] *Large scale a priori response plans*, [2] *small scale ad-hoc response plans*, [3] *impact and issues related to the of ICT tools in existing disaster response plans*.

Disaster Response Strategies						
Author Name	Year	Study Type	Incident type	Transport Setting	Responder type	Tool type
Stephens <i>et al.</i>	2015	Review	Disasters (General)	Car and Road	Disaster management & First responders	SMS, Social media (Twitter) & Broadcast media
Langdon & Hosking	2010	Modelling	Flooding & Terrorist attacks	None	Government Responders	Wireless technologies
Lu <i>et al.</i>	2015	Case study	Disaster (General)	None	Government responders	Beidou emergency communication system



Ulgen	2005	Case study	Earthquake	Road bus networks	Government responders	GIS tools and wireless technologies
Howe <i>et al.</i>	2011	Case study	Disaster (General)	None	Disaster management + net-savvy citizens	Social media (General) & ICTs
Palen <i>et al.</i>	2009	Case study	School Shooting	None	First Responders	Social Media (General) & ICTs

Table 5: Bibliographic information for included texts related to the use of response strategies when communicating during a disaster.

Two of the included papers review frameworks and case studies of large scale communication plans/networks which are set up by government organisations in anticipation of a specific disaster (Lu, Liao, Li, Deng, 2015; Ülgen 2005). Different approaches are used by the two systems based on the type of disaster they focus on. In Lu *et al.* (2015) an *automated early warning system* is adopted to respond to tsunamis and is highly suitable because they have a period of time between the first indication of their presence and their impact. Using this system, all actors in the disaster response, including the public, receive automated text messages about the disaster. These convey standardised information about the disaster risk and effects via mobile applications for responder groups, and SMS messages for members of the public. The system is based on a series of satellites and sensory tools to detect early warning signs for the disaster. This approach delivers time critical emergency information in a highly streamlined and efficient approach designed to minimise the impact of an upcoming disaster. In the case of Istanbul's Earthquake response system, the impact of the disaster is much less predictable therefore the system is focused on *facilitating an effective response* (Ülgen *et al.* 2005). A series of communication applications were designed for this task and include: Geographic information systems, which provide the public with information about neighbourhood specific resources/response plans; and a transit rerouting system for the city's bus network. This response system also includes the training of emergency volunteers whose communication and coordination are facilitated by the communication system.

Both systems use a *wide spread and multi-layered* approach which aims to provide a number of communication channels including: responder to public, responder to responder



and public to public, in the case of the Istanbul response system. This capacity allows for increased control and coordination of communication channels which is highly desirable from an emergency manager's perspective (Lu *et al.* 2015). Both papers note that the systems are *highly resource intensive* and require significant investment to develop. This is largely due to their wide-spread communication efforts, reliance on expensive technologies and development of bespoke communication applications/devices. Additionally, these systems are designed to be effective only for very specific disaster types meaning that they *lack flexibility* and may only be worth the investment in geographic regions which are highly susceptible to particular disasters. This specificity makes it difficult to apply to the field of infectious diseases in transport hubs because of the variety of responses required to deal with these incidents. These systems are more suited to large scale and high impact incidents and may therefore not apply to most infectious disease outbreaks, which happen over protracted time periods.

Another focus was on the use of communication tools in more *small scale and reactive/ad hoc* responses (Palen, Vieweg, Liu, Hughes, 2009; Howe, Jennex, Bressler, Frost 2011). The articles display coordinated communication efforts which arise, either spontaneously or through semi-structured platforms, in response to disasters by involving members of the public through crowdsourcing and information sharing. Palen *et al.* (2009) conducted an in depth descriptive case study of the communications surrounding the Virginia Tech school shooting which included a series of interviews, artefact collection and social media and discussion forum data collection. The data assessed in this paper included: emergency responders communication channels, public communication channels and information needs, and the communication response of the online community. Howe *et al.* (2011) present a report discussing the viability of ICT tools and social media as a democratised global communication in an international disaster response exercise for a hypothetical disaster, known as X24. One of the key strengths of these response systems was their *dynamic and flexible* capabilities. Rather than involving a specific pre-arranged response to a disaster these responses allowed for 'socially distributed problem solving' to be applied to complex and evolving scenarios (Palen *et al.* 2009). It was also noted that the wider online community was very quick to fill the gaps in situational knowledge when it was not provided by emergency responders. Critically, the accessibility inherent in the online response allowed for the *inclusion of experts and organisations that would not usually be included in the official*



response. Similarly the X24 exercise allowed for integrated communications between a number of organisations and stakeholders (i.e. NGOs, government officials) in a rapid and cost effective manner, thereby providing more dynamic communications between these groups and members of the public.

One of the key disadvantages of this approach is the *complexity and noise of unregulated communications*. In the X24 exercises many of the responders reported feeling confused and overwhelmed by the discussions during the response, and the online activity in the Virginia response produced information which was difficult for authorities to track, police and respond to. The same issue was noted during the analysis of social media communications and is similarly linked to a loss of informational authority. Palen *et al.* also note that these communications responses are *more suited to short term, high impact scenarios* as it is difficult to maintain the attention and interest of a large social network over a protracted period of time. Whilst suited to disasters they may not apply to infectious disease outbreaks, as these tend to happen over long periods of time with a relatively lower impact level.

The remainder of studies in this section assessed the *addition of ICT tools in existing disaster response plans* (Langdon and Hosking 2010; Stephens, Jafari, Boyles, Ford, Zhu, 2015). In a modelling study of the inclusion of ICT tools in an evacuation response from a small US city Stephens *et al.* showed that the increased awareness and communication delivered via ICT tools (relative to conventional broadcast media) resulted in faster evacuations by residents; however, the collective increase in fast evacuations resulted in a much higher level of road congestion meaning that overall evacuation times were similar in scenarios in which ICT were included vs when they weren't. This is not so much a criticism of ICT tools as the authors acknowledge that fast evacuation times are desirable; instead it highlights *the need for responder organisations to understand the impact of more quickly disseminated information and strategically plan their responses accordingly*. Whilst this scenario is vastly different to infectious disease outbreaks, parallels can be made with increased communication meaning more people may visit clinicians or attempt to gather information from responder organisations.



Similar to the previous social media analysis, the issue of *accessibility for vulnerable groups* was raised as an important consideration for disaster response plans in Langdon and Hosking (2010), with a focus on the elderly. They report a series of case studies in which a reliance on ICT tools during disaster responses had negative, and sometimes life threatening, effects on elderly populations who had poorer knowledge and access to these forms of communication. It is therefore crucial that responder groups consider the needs of different demographics and make accommodations for vulnerable groups who may not be able to receive information through ICT communication channels. This may help in the prioritisation of the development of these technologies for the provision of emergency alerts, information and instructions to elderly and vulnerable individuals during the course of incidents.

Disaster Response strategies			
No.	Major themes	Sub Themes	Cited articles
1	Pre-planned communication systems	Automated early warning systems	Lu <i>et al.</i> (2015) Ulgen <i>et al.</i> (2005)
		Facilitates effective response	Ulgen (2005)
		Wide-spread multi-layered	Lu <i>et al.</i> (2015) Chatfield <i>et al.</i> (2012)
		Highly Resource intensive	Lu <i>et al.</i> (2015) Chatfield <i>et al.</i> (2012)
		Lack of flexibility	Lu <i>et al.</i> (2015)
2	Ad-hoc response system	Dynamic and Flexible	Palen <i>et al.</i> (2009) Howe <i>et al.</i> (2011)
		High public/experts/responder organisations engagement	Howe <i>et al.</i> (2011)
		Complex and noisy	Palen <i>et al.</i> (2009) Howe <i>et al.</i> (2011)
		Suited for short term high impact scenarios	Howe <i>et al.</i> (2011) Palen <i>et al.</i> (2003)
3	Addition of ICT tools in existing disaster response plans	Impact of more quickly disseminated information and strategically plan their responses accordingly	Langdon and Hosking (2010) Stephens <i>et al.</i> (2015)
		Accessibility for vulnerable groups	Langdon and Hoskings (2010)

Table 6: Major themes and second-level themes highlighted during the qualitative analysis of the use of ICT response strategies during disasters.



3.2.4. Websites

Two of the included papers discussed 'the use of mobile phone applications in disaster communication settings' which included: one case study, and one qualitative study. See *Table 4* for the basic summaries of these texts. The major themes highlighted in this section included: [1] *website implementation in disaster settings*; and [2] *Website content*.

Disaster Websites						
Author Name	Year	Study Type	Incident type	Transport Setting	Responder type	Tool type
Fordis <i>et al.</i>	2007	Case Study	Hurricane	None	University management	Database driven website
Friedman <i>et al.</i>	2008	Qualitative	Disaster (General)	None	Public health authorities	Disaster information websites

Table 7: *Bibliographic information for included texts related to the use of websites to communication disaster information.*

The implementation of a website in disaster response was one of the key themes discussed in this section. Fordis, Alexander, McKellar (2007) discussed the ad hoc implementation of a disaster recovery website in the aftermath of a hurricane by a medical university's administration. The site provided official communications for staff or students at the university and provided a web forum communication platform to facilitate communication within the university community. The authors largely attributed the website's success to the pre-existing audience and community, and its existing reputation as a reliable information source to students. The use of *pre-existing communities* and *organisational reputation* can ensure that information disseminated will be received by a large audience and can increase conformity with and trust in the information disseminated. This approach can be applied to the efforts of public health organisations, which can foster relationships with their communities and build their reputations outside of crisis periods so that the information they disseminate is more effective during crises. Whilst the university did use the website for the delivery of time critical emergency information, the authors note that it was *most* useful during the disaster's recovery stage and aftermath (Fordis *et al.* 2007). In addition, Friedmann, Tanwar and Ritcher's (2008) review of disaster websites claimed that these tools are useful for the *delivery of health information outside of times of disaster*. Unlike social media which relies on swells and surges of interest and participation, websites are used as a platform to facilitate



communication between groups and as a method for delivering non time critical information during the slow recovery period of a disaster.

The second key theme discussed was related to the website content and was primarily covered in Friedmann *et al* (2008). This study reviewed 50 of the most popular disaster information sites (mostly government and international public health websites) and assessed them for suitability (the extent to which the website provides high quality and relevant information to readers) and readability (the reading level required to understand the websites content and advice). Generally this paper showed that the *readability* of disaster websites was too high to be universally understood, meaning that large parts of the population may have poor access to disaster information online. It was also shown that readability differs drastically depending on the type of disaster discussed, with radiological, chemical and nuclear websites possessing the lowest readability. This paper also showed that *quality of information* varied significantly across the websites. In general, government agencies and NGOs had the highest quality of information and news websites contained the poorest information. Across all papers the representation of ethnic minorities was low. Readability and suitability (quality) also displayed a negative correlation meaning that more high quality information resources were the most difficult to read, and that the most valuable information may therefore be inaccessible for many people. When designing communication tools designers must maintain high quality of information whilst ensuring their resources are highly readable to ensure the effective delivery of information to the largest pool of individuals.

Disaster Websites			
No.	Major themes	Sub Themes	Cited articles
1	Implementation and Effectiveness	Pre-existing communities	Fordis <i>et al.</i> (2007) Friedmann <i>et al.</i> (2008)
		Organisational reputation	Fordis <i>et al.</i> (2007)
		Disseminations of health information outside of crisis period	Fordis <i>et al.</i> (2007) Friedmann <i>et al.</i> (2008)
2	Website content	Readability	Friedmann <i>et al.</i> (2008)
		Information quality/suitability	Friedmann <i>et al.</i> (2008)

Table 8: Major themes and second-level themes highlighted during the qualitative analysis of the use of Websites as a communication tool during disasters.



3.3. Infectious disease outbreaks

3.3.1. Social media

One of the most commonly discussed topics was ‘the use of social media as a communication tool during infectious disease outbreaks’, with three papers focusing on the topic, including two qualitative articles and one quantitative study (See *Table 5* for basic summary of articles). A number of key themes were highlighted during the analysis of the papers including: [1] public engagement and perception monitoring and [2] surveillance and early warning systems.

Infectious disease Social media						
Author Name	Year	Study Type	Incident type	Transport Setting	Responder type	Tool type
Lazard <i>et al.</i>	2015	Qualitative	Ebola	None	Centre for Disease control	Twitter
Glowacki <i>et al.</i>	2016	Qualitative	Zika virus	None	Centre for Disease control	Twitter
Kostkova <i>et al.</i>	2014	Qualitative	Swine flu	None	Disaster management	Twitter

Table 9: Bibliographic information for included texts related to the use of social media as a communication tool during infectious disease outbreaks.

Two of the included papers discuss the use of twitter as a tool for engagement and perception monitoring during disease outbreaks. These articles were based on US Centre for disease control (CDC) twitter live chat projects during the 2014 Ebola outbreak (Lazard, Scheinfeld, Bernhardt, Wilcox, Suran, 2015) and 2016 Zika Virus outbreak (Glowacki, Lazard, Wilcox, Mackert, Bernhardt, 2016). In both of these projects the CDC hosted a live chat to address public concerns about the two diseases. Both papers highlighted the tool as a unique forum for *quickly and dynamically* addressing public concerns, as questions could be raised and answered directly and immediately. The functions are far more difficult, or impossible, to achieve with conventional media. In addition, the posts made during the chat could be disseminated to individuals live and had the potential to be disseminated more widely across the twitter-verse through a process of *serial transmission* (i.e. retweeting). This transmission allows for widespread information dissemination in an organic and democratised manner. Kostkova and Szomszor (2014) also analysed the extent to which twitter users disseminated



and engaged with public health information sources during diseases. They showed that the twitter verse is highly reactive and effective during outbreaks at sharing and transmitting information sources. The CDC's live chats focused on addressing public concerns and, as a result, acted as a way of *alleviating anxiety* about the disease by displaying the organisation's active and public facing participation in the response to the outbreaks (Lazard *et al.* 2015). One of the organisational drawbacks of this approach is that the live chat sessions were quite short and a relatively small number of people were directly involved. For these systems to run on a permanent basis and with a large number of directly involved participants, a large number of qualified communicators would have to be employed, making this system *highly resource intensive* compared with traditional one way communication strategies (Glowacki *et al.* 2016).

The second key aim of these two studies was to conduct a *text mining content analysis of the live twitter chats*. This qualitative approach allowed the researchers to organise the data into major themes of public concern about the disease, i.e. Symptomology, person to person transmission and travel advice for Ebola (Lazard *et al.* 2015), and education/training, consequences for pregnant women, protective measures for Zika (Glowacki *et al.* 2016). This analysis of social media data can provide responder organisations with *useful and easy to interpret insights* about public fears and trending topics. These analyses output easy to interpret topics which can be incorporated into future disaster responses. Additionally, the analysis of public perceptions allows responders to gain insights into how the public perceives their actions and can therefore act as a useful self-evaluative tool for these organisations. Whilst this analysis cannot provide instantaneous results it can provide *retrospective evaluation* about the needs and wants of the public during disease outbreaks, which has the potential to improve an organisation's response to future incidents.

The main focus of Kostkova *et al.*'s (2014) study was to investigate the extent to which twitter can be used as a *surveillance and early warning system*. Instead of actively engaging with the public to answer queries and stimulate discussion the goal of this system was to monitor the content of user's messages for self-report influenza symptoms or information in order to make predictions about flu outbreaks. This system was based in the UK, and again used a text mining approach to highlight when twitter users made mentions of flu symptoms or transmitted information sources relating to influenza. The researchers found that the twitter surveillance system was able to make accurate flu outbreak predications 1-2 weeks faster



than official channels. The authors suggest that this sort of tool can be used to *complement traditional surveillance techniques* and that it can be easily applied to other disease outbreaks. Additionally, it is stated that the effectiveness of these systems is likely to increase in the future with the adoption of new tools on twitter, i.e. GPS tracking software, and the increased uptake and increased normalisation of social media amongst the public.

Infectious disease social media			
No.	Major themes	Sub Themes	Cited articles
1	Live chat engagement and perception monitoring tools	Quickly and dynamic	Glowacki <i>et al.</i> (2016) Lazard <i>et al.</i> (2015)
		Serial Transmission	Kostkova <i>et al.</i> (2014)
		Alleviating Anxiety	Lazard <i>et al.</i> (2015)
		Highly resources intensive	Glowacki <i>et al.</i> (2016) Lazard <i>et al.</i> (2014)
2	Text mining and content analysis	Useful and easy to interpret insights	Glowacki <i>et al.</i> (2016) Lazard <i>et al.</i> (2014)
		Retrospective evaluation	Glowacki <i>et al.</i> (2016) Lazard <i>et al.</i> (2014)
3	Surveillance and early warning system	Complement traditional surveillance techniques	Kostkova <i>et al.</i> (2014)
		Rapid response	Kostkova <i>et al.</i> (2014)

Table 10: Major themes and second-level themes highlighted during the qualitative analysis of the use of Social media as a communication tool during Infectious disease outbreaks.



3.3.2. Mobile Applications

Two of the included papers discussed ‘the use of mobile phone applications during infectious disease outbreaks’ which included: a qualitative study and a quantitative study. See *Table 6* for the basic summaries of these texts. Only a single major theme was highlighted in this section: [1] *the use of mobile applications for self-triaging.*

Infectious disease Mobile Applications						
Author Name	Year	Study Type	Incident type	Transport Setting	Responder type	Tool type
Kellerman <i>et al.</i>	2010	Qualitative	Influenza	None	Medical Professionals & Public health officials	Strategy for Off-site Rapid Triage (SQRT)
Abdullah <i>et al.</i>	2016	Quantitative	Infectious disease (General)	None	Disaster management organisations	Mobile applications

Table 11: *Bibliographic information for included texts related to the use of mobile phone application as a communication tool during Infectious disease outbreaks.*

Kellerman, Isakov, Parker, Handrigan and Foldy (2010) discuss the rapid development and implementation of an offsite self-triaging algorithm and online tool (SORT) which helps lay people make judgements about care seeking decisions. The tool was based on CPCR guidelines and was tested using a hypothetical influenza pandemic. The application involved a 3 step process: [1] Screening for flu symptoms, [2] Assessment of illness severity, [3] Questionnaire to determine pre-existing conditions. The application then determines flu risk, the data is stored for use by responder organisations, and health advice is provided to the user. This kind of application therefore has a dual purpose of *providing health advice to the public* as well as *providing large amounts of health data to responders and epidemiologists.* The advice provided to public by SORT was dependent on the responses to the questions on the mobile application and the influenza risk level given to them. This function provides users with *tailored health advice* in a manner that is not possible with the broad communications tools such as conventional media or social media. The tool was validated with two hypothetical tests and was shown to incorrectly classify respondents at a relatively low rate and the tool was used approximately 1.6 million times, thus indicating a low error rate for the tool and relatively high user uptake rate. Preliminary analysis indicates that 37% of these visitors



provided answers that categorized them as high risk. The authors argue that information technology has progressed at a high pace but that it has not been fully exploited by public health authorities; SORT is an example of how the Web may be used to inform and empower the public to make prudent health care decisions. They also state that SORT-like algorithms for selected public health threats could be prepared and evaluated in advance. One of the main concerns with these tools is that users have to actively sign up to the system and have to take time to complete the questionnaire, meaning that they will have a *smaller audience* compared with more established and integrated communication systems such as social media or conventional media.

The focus of Abdullah, Annamalai and Rani's (2016) controlled experiment was on *optimising the user interfaces* of mobile communication tools for infectious disease self-triaging applications. Abdullah et al. assessed two factors in their experiment: [1] the use of Scrolling vs Paging navigations methods, and [2] opening vs closed answer questions; completion time and user preference were the dependant variables in the study. The results showed that paging was preferred to scrolling and that a combination of closed and open answer questions was preferred to other questioning methods. The preference results also showed that a paging and a combination of question types was the most optimal question type/navigation method pairing. The completion time results show that closed answer questions were always fastest, slightly more so in the paging condition. Open answer questions were the slowest with little time difference being observed between paging and scrolling methodologies. In the combined question type condition the completion time was significantly faster in the paging condition indicating that this question methodology was only effective in the scrolling condition. This kind of detailed experiment shows the importance of considering *the user preferences and usability* of mobile applications for self-triaging. Research in this area can ensure that applications are easier to use thereby increasing the likely uptake of the tool and user's accuracy when filling in questions (Abdullah *et al.*2016).



Infectious disease Mobile Application			
No.	Major themes	Sub Themes	Cited articles
1	Self-Triaging tools	Health advice to the public	Kellerman et al. (2010)
		Health data to responders and epidemiologist	Kellerman et al. (2010) Abdullah et al. (2016)
		Tailored health advice	Kellerman et al. (2010) Abdullah et al. (2016)
		Small audience	Kellerman et al. (2010)
2	Optimising the user interfaces	User preferences	Abdullah et al. (2016) Kellerman et al. (2010)
		Usability	Abdullah et al. (2016)

Table 12: Major themes and second-level themes highlighted during the qualitative analysis of the use of Mobile applications as a communication tool during Infectious disease outbreaks.

3.3.3. Response Strategies

The most commonly discussed topic in this section was ‘the use of mobile phone applications during infectious disease outbreaks’ with a total of three articles, including: two qualitative papers, and an article with both qualitative and quantitative components. See *Table 13* for the basic summaries of these texts. The major themes highlighted in this section included: [1] *Telemedicine*, [2] *the use of public health officials*.

Infectious Disease Response Strategies						
Author Name	Year	Study Type	Incident type	Transport Setting	Responder type	Tool type
Norum et al.	2002	Qualitative	Infectious disease (General)	Ships and maritime	Disaster management & First responders	Telemedicine communication tools
Pribble et al.	2010	Qualitative	West Nile virus	None	Public health officials	Local Broadcast networks
Westlund	2011	Quantitative & Qualitative	Infectious disease (General)	Ships and maritime	Swedish telemedical advise service	Wireless telemedicine tools

Table 13: Bibliographic information for included texts related to the use of response strategies when communicating during an Infectious disease outbreak.



Two of the papers in this section reviewed the use of *Telemedicine* initiatives in the Scandinavian maritime industry (Norum, Moksness and Larsen 2002; Westlund 2011). In these papers telemedicine settings referred to a range of wireless and real-time communication systems that allowed people on-board ships to contact a physician (administered by government organisations) on-land who could provide immediate medical advice should a medical incident occur. Whilst these systems respond to any kind of medical incident the authors note that the majority of incidents in which telemedicine is used are related to infectious diseases. The authors of both papers note that these systems are highly effective in *communicating with remote groups of users who do not have direct medical access*. When employing a full time medical professional is too resource intensive, the ability to have access to advice is crucial. However the one to one communication channels used by these systems make them highly *resource intensive* meaning that they could not feasibly be applied to large populations, i.e. those that pass through international transport hubs. Norum *et al.* (2002) conducted a series of interviews with leaders within the maritime industry during the early 2000s. At this point the Telemedicine services were mainly based on telephone and radio systems and were not utilised at a high rate; however, the Norwegian government had begun the development of guidelines for the use of wireless technologies on ships which were positively anticipated by participants in the study. Westlund's (2010) longitudinal study, 2001-2009, shows greater development of wireless telemedicine and a much larger utilisation of the tools during medical incidents. This indicates an *increased popularity* of these tools as the technical capabilities and policy guidelines develop.

Pribble, Fowler, Kamat, Wikerson, Goldstein and Hargarten (2010) focused on the impact of *expert public health officials* on the quality of health information provided in the media during disease outbreaks. In this case media communications about the West Nile virus in 2010 were analysed for quality of information, inclusions of public health officials, and degree of coverage. The results showed that stories relating to WNV were the second most common stories during the data collection period (12%) with most stories contained local authority 'public health officials' (PHOs). Critically there was a strong positive *association between PHO inclusion and quality of health stories*. Optimizing the interactions and availability between PHOs and media sources may offer an opportunity to provide the public with accurate, timely, and useful public health emergency information. As a result the authors highlight an *increased*



need for media training for PHOs to improve the public health emergency communication process. Training PHOs to use methods of communication may help contextualize their media interviews and allow them to disseminate a more appropriate message to the public.

Infectious disease Response strategies			
No.	Major themes	Sub Themes	Cited articles
1	Telemedicine	Communicating with remote groups of users	Norum <i>et al.</i> (2002) Westlund (2011)
		Resource intensive	Norum <i>et al.</i> (2002) Westlund (2011)
		Increased popularity	Norum <i>et al.</i> (2002) Westlund (2011)
2	Expert public health officials (PHO)	Association between PHO inclusion and quality of health stories	Pribble <i>et al.</i> (2010)
		Need for media training for PHOs	Pribble <i>et al.</i> (2010)

Table 14: Major themes and second-level themes highlighted during the qualitative analysis of the use of ICT response strategies during Infectious disease outbreaks.

3.3.4. Websites

Finally, two papers discussed ‘the use of mobile phone applications during infectious disease outbreaks’ which included: a case study and a review article. See *Table 8* for the basic summaries of these texts. The major themes highlighted in this section included: [1] *Epidemiological tools* [2] *Commercial travel websites*.

Infectious disease Websites						
Author Name	Search terms	Study Type	Incident type	Transport Setting	Responder type	Tool type
Licciardone	2002	Case study	Infectious disease	International air travel	Public health authorities	Travel health Website
Madoff & Woodall	2005	Review	Infectious disease (General)	None	Health professionals	Pro-MED mailing list and website

Table 15: Bibliographic information for included texts related to the use of websites to communication infectious disease outbreak information.



Madoff and Woodall's (2005) case study describes the development and use of ProMed's mailing list and website during the late 1990s and early 2000s. The development of this online tool highlights the potential for websites and a platform for international Epidemiological tools. ProMed began as a mailing list between leading epidemiologists and was aimed at being a communication platform between health professionals to highlight infectious disease outbreaks around the world. The successes of the mailing list lead to the development of a website and a series of interactive online map tools which pooled the work of local epidemiologists into one place and acted as an *early warning system* for the health profession. This also allowed information to be directly disseminated to the public and international health organisations such as the World Health Organisation. Indeed, the authors note that the tool has been used by such organisations in a number of global health incidents which were later confirmed and acted on by thorough investigations. This interactive unofficial reporting of outbreaks can result in much faster warning systems than official channels and highlights the use of these tools for *collaboration on global health issues*. This collaboration is particularly relevant to transport operators who may not be about to invest in disease monitoring functions and who are at high risk of incoming infectious diseases. The tool is maintained by health professionals and its support from international public health organisations brings significant *legitimacy* to the tool and its membership and access patterns over the study period show continuous growth and popularity of the tool.

Licciardone (2002) utilised a descriptive case study approach to assess the implementation of a commercial travel website and popularity and effectiveness of its use by the public. The study assessed user patterns for a USA travel health website between 2000 and 2001; the website offered three categories of health information: [1] health promotion and disease prevention topics, [2] vaccine information, and [3] health hazards according to geographic destination. The access patterns of the website show that the site was relatively popular when considering the rates of internet use in the early 2000s. Additionally, people mostly used the site to access protective information for infectious diseases and searches for health promoting behaviours were least common. The authors note that websites are a particularly *good source of information outside of disaster periods*, when people are planning travel. This study was conducted in the early days of the internet and the full scale of its impact or technical advances had not been revealed. It is therefore difficult to apply the findings of



this research to current times. Regardless, the authors do note the huge potential that the internet holds as a communication tool.

Infectious disease Websites			
No.	Major themes	Sub Themes	Cited articles
1	Epidemiological Tools	Early warning system	Madoff and Woodall (2005)
		Collaboration of global health issues	Madoff and Woodall (2005)
		Legitimacy	Madoff and Woodall (2005)
2	Commercial Travel Websites	good source of information outside of disaster periods	Licciardone 2002

Table 16: Major themes and second-level themes highlighted during the qualitative analysis of the use of Websites as a communication tool during Infectious disease outbreaks.

3.4. Psychological & Communication Theories:

Of the 42 included texts, 11 explicitly discussed and/or implemented psychological or communication theories into their work. Although there was a small degree of overlap in the theories discussed from paper to paper, the majority of papers discussed different theories with little or no relation to the other studies in the review. This indicates that the field does not have a theoretical consensus as far as psychology/communication is concerned. Due to the lack of overlap between papers it is not possible to conduct a qualitative synthesis on these theories. Instead the following section will provide a short description of each of the theories discussed and an explanation of how the concepts from these theories were applied to the articles in which they were discussed.



Psychological & Communication Theories					
Author Name	Year	Study Type	Incident type	Tool type	Psych/Comms theories
Kent & Ellis	2015	Case Study	Hurricane	Facebook groups	Universal Design
Stephens <i>et al.</i>	2015	Qualitative	Earthquake	Twitter	Information theory
Leykin <i>et al.</i>	2016	Conceptual framework	Earthquake	Twitter triangulation	Communication accommodation theory
Wybo <i>et al.</i>	2015	Case study	Earthquake	Twitter triangulation	Social media evangelists
Hagar	2013	Quantitative	Earthquake	Twitter triangulation	Trust
Yeager <i>et al.</i>	2015	Conceptual framework	Disaster (General)	Twitter	Community engagement through super-spreaders
Chatfield <i>et al.</i>	2013	Review	Disaster (General)	Social media (General)	Information theory
Haataja <i>et al.</i>	2016	Qualitative	Floods & Wild-fire	Twitter	Attribution theory
Schroeder & Pennington-Gray	2015	Quantitative	Wild-fire	Twitter	Protection motivation theory
Schroeder <i>et al.</i> 2013	2013	Case study	Disaster (General)	Twitter	Prospect theory
Howe <i>et al.</i>	2011	Qualitative	Disaster (General)	Social media (General)	Democratisation of the Internet

Table 17: Bibliographic information for all papers which discuss psychological or communication theories substantially and the names of those theories.

Universal Design: This theory sets out the design principals which originate from the early developers of the internet (Berners-Lee, 1997) and govern the basic principles of ergonomic design on the internet, particularly with regards to web 2.0. Purports of this theory seek to provide accessibility for the greatest range of potential users on web 2.0 platforms. These principals should be incorporated very early on in the design process so as to avoid ad hoc accommodation for these groups. When technology is designed in such a way that it enables use by people with a wide range of different impairments it often benefits the broader population as well. Kent and Ellis (2015) is based on the principles of Universal design and specifically discusses it with regards to the ‘mash-up’ of social media and its inaccessibility for those with disabilities. Many component networks of the social media mash up specifically lock information in a particular format as part of a process of commercialising the information.



In perpetual beta mode (in a constant state of develop) of the social media mash-up these choices can limit the accessibility of the whole network. This lack of accessibility can have costly effects for those vulnerable groups who may be left out of time critical communications, especially in disaster settings. It is not possible for responder organisations to adapt the mechanisms behind social media for universal design principles; this is only possible for developers. However responder organisations can make certain accommodations for vulnerable groups, including using multiplatform communication methods and pressuring developers to incorporate accessibility in their systems.

Information Theory: This psychological theory posits that people actively look to confirm emergency information, and most often, that confirmation is from other people (Egnoto, Svetieva, Vishwanath and Ortega, 2013). In a disaster, a common way to validate the legitimacy is to send multiple messages from different trusted users. This message repetition or redundancy is a fundamental part of the theory as it produces informational consistency and consensus. Stephens' *et al.* (2015) create a model which shows that by using multiple ICT tools to create redundancy, agents had a higher sense of urgency and evacuated much more quickly than agents who only received face-to-face messages. Furthermore, by using ICTs, a higher percentage of agents evacuated, especially in the advance notice condition; a finding that also supports information theory. In accordance with this theory, responder organisations should seek to achieve redundancy of information dissemination by using multiplatform communications from a number of organisations.

Information theory has a number of principles which must be fulfilled in order to achieve effective information dissemination, including: [1] Speed of communication, [2] Reach, [3] Information quality. Chatfield *et al.* (2013) state that social media effectively fulfils the first two criteria extremely well as was exemplified by their use of social media in a city wide early warning system for earthquakes. The authors claim that resilient information infrastructures are needed to maintain communication quality. They can act as the backbone for response and must focus on delivering trustworthy, accurate, complete, and timely information in order to meet with information quality criteria of the framework.

Communication accommodation theory: This theory of interpersonal communication provides a framework for understanding how and why people adapt their communication



toward and away from others and the social consequences of doing so. The theory holds that people tend to perform accommodative and non-accommodative moves, to reduce or increase significant social distances between the speakers. Leykin *et al.* (2016) present the best practices in crisis communication for introducing general principles of communication, such as strategic planning, proactive strategies and strategic response, and each include sub categories related to public communication. Since speakers' verbal style also influences how messages are perceived, crisis managers should employ certain linguistic styles accommodated language which considers the language used by members of the public they are targeting.

Social Media Evangelists: This is the concept that organisational change in social media or ICT communication is driven by dedicated individuals or groups of individuals who are uniquely focused on implementing technical innovations at an organisational level. Wybo *et al.* (2015) discuss and promote the use of Public Information Officers (PIOs) as social media evangelists. This position adopts the role of the "gate keeper" or "listener" for public facing communications, and the driver for organisational change. Langdon and Hosking (2004) discuss the work conducted by a social media evangelist at a local fire department in the US. This paper claims that the approach effectively developed the use of social media by the organisation which resulted in both positive changes for organisational practices and 'soft' communications. Social media evangelists can also include the use of net savvy members of the public who aid disaster and disease outbreak communications. Wybo *et al.* (2015) focus on the use of VOSTs (virtual operations support teams), teams of 'voluntweeters' who act as 'trusted agents' by aiding authorities during crises with information dissemination and monitoring, and Howe *et al.* discuss the use of an international network of social media users for coordination and communication functions. This concept reminds responder organisations that employing social media experts is central to driving change for this communication platform.

Community engagement through super-users: This organisation concept is highly related to the previous point and posits that public health organisations should recruit social media users with large klout and follower bases in the local region of a disaster to target and disseminate information on social media platforms which rely on serial transmission in order to disseminate information. This can include: community leaders, local news organisations,



celebrities etc. So long as responder organisations are able to utilise these groups or individuals as nodes for reaching large or more focused populations they can be useful for disaster communication strategies. In Yeager *et al.* (2015) the authors suggest the development of training and education for net-savvy citizens to aide responder groups in the use of social media. They also suggest a framework for identifying these individuals and utilising them to aide in the propagation and transmission of information through the twitterverse.

Trust: A key component of effective communication, the salience of which is heightened during disasters. It is rooted in the uncertainty experienced during a disaster and is important for people's decision making. The amount of trust people have for organisations affects the level of information they gain. This level of trust is influenced by their existing relationship with the organisation. Hagar (2013) note that social media tools have the capacity and power to inform, to provide real-time information, facilitate recovery efforts, and save lives, but they also have the potential to spread misinformation and rumour, and to create panic. Establishing trust is important in dispelling rumours and controlling user generated content. Maintaining trust is vital to maintaining effective communication as untrusted information is unlikely to be followed by the public and without it rumours will be very difficult to control for.

Attribution Theory: This theory is interested in how and why people explain events and reasons for events in their lives and the actions of others and themselves. Explanations for why an event is occurring and why people behave as they do differ based on: whether the cause of an event is attributed to an internal or external characteristic (Locus), whether it is seen as stable or changing over time, and whether or not it is viewed as controllable. Haataja *et al.* (2016) suggest that understanding the locus, stability, and controllability can provide useful ideas about incentives for and barriers to certain behaviours and actions, in this case the use of ICT technologies in infectious disease outbreak incidents. It is also used to assess what needs to be done in order to promote or discourage particular behaviours through a framework approach of the different factors. Responder organisations can consider these psychological framework approaches when designing and implementing public communications tools in order to increase their effectiveness.



Protection motivation theory: In the context of disaster response this theory states that an individual evaluates the perceived severity of, and their vulnerability to, the risk. This is heavily influenced by their ability to manage the risk. If the risk is perceived to be relevant and manageable, the likelihood of response behaviour increases accordingly. Further, information-seeking behaviours increase when an individual receives information about the severity of the threat. Once a risk is perceived to be relevant, an individual will likely cope with the threat by engaging in information search. A study carried out by Schroeder and Pennington-Grey (2015) sought to examine whether tourists with high levels of perceived risk are likely to use social media to seek information in the event of a crisis during travel, as suggested by protection motivation theory.

Prospect theory: This theory suggests that during the risky decision-making process, prospective decisions (prospects) are reduced to substitutes. Prospects are subsequently appraised and those that are considered to be undesirable are not chosen. The evaluation of prospective destinations can be influenced by various factors including a tourist's risk perceptions. Schroeder *et al.*'s (2013) development of the conceptual framework of this study was informed by prospect theory and based on consumer, tourist oriented, and risky decision-making frameworks and theories. This study specifically posits that internal and demographic factors may potentially affect international tourists' use of social media as an information source during a crisis while traveling.

Democratisation of the Internet: This is the principles underlying to and resulting from web 2.0 technologies. Web 2.0 allows for the populations as a whole to have access to information and have the ability to disseminate it. Howe *et al.* (2011) state that the concept relies on a number of key principles including: [1] Universal connectivity, [2] Open access, [3] Reliability, [4] Interoperability and user choice, [5] Data security, [6] Privacy, [7] Economic value, and [8] Sustainability. The X24 exercise utilized the principles to bring about an open and inexpensive cloud computing technology which gave individuals caught in the midst of an emergency situation the ability to decide their own course of action through crowdsourcing readily available information. This concept can be very useful for responders' disaster communication as it can allow for the recruitment of the public in disaster response which can reduce the resource intensity of disaster response and can aid significantly in collaboration.



However, this democratisation can lead to the loss of informational authority if measures are not taken to prevent it.

4. General Discussion

The current study aimed to review and analyse the literature relating to the use of real-time communication tools to disseminate information to the public during pandemics and infectious disease outbreaks in transport hub settings. One of the key findings of this research was that there existed a very limited literature on the use of the specific incidents and settings we primarily aimed to assess. This finding demonstrates a clear gap in the research and has implications for transport operators and public health organisations, as it is indicative of a limited evidence base for decision making by such industries. Due to the increased transmission effects and risk potential associated with transport hubs and the need for better communication with the public, researchers and scientists should focus specifically on the special needs and requirements of the field.

In general, our results suggest that real-time communication tools are seen as a positive factor for increasing the effectiveness of communication with the public during outbreaks. This is largely due to the increased 'speed, reach and transmission' of these tools. Our review also shows that social media has been the most heavily studied communication tool during disasters and pandemics, and a number of novel applications for its use have been tested and implemented. These tools are not resource intensive to set up as the infrastructure and audience for their use is already in place. Additionally these tools, and others such as mobile applications, allow for effective two way communication. This adds a layer of flexibility, meaning that these tools can be utilised for information collection and community engagement as well as information dissemination. Our review also highlights a number of factors that contribute to the success of these tools as well as some of the issues and risks that can arise because of their use, i.e. loss of informational authority, poor accessibility for vulnerable groups. The review also highlights a number of organisational considerations related to the use of communication tools.



Our review also shows that whilst some of the identified articles include a discussion of psychological or communication theories, there is very little consensus across the research, and no driving theories appear to exist. Instead the field is mainly focused on the coverage of practical and technical research. Whilst practical research is vital in this field, psychological and communication theories are also important when developing communication strategies. A lack of consensus around these theories indicates a lack of development amongst the psychological research community within this field. Researchers should focus on developing studies in which these theories are more centrally incorporated in their design.

Although this review did not identify any studies which focus specifically on transport hubs, the studies included have many applications for the sector. They cover the use of communication tools in a high risk public health setting and many lessons can be taken from them. The next section of this review will focus on the development of a set of practical recommendations for the transport hub sector, generated from our analysis of the literature.

4.2 Recommendations

This set of recommendations is designed to be practically applied to transport hub operators and is based on the key themes from our qualitative synthesis analysis. The recommendations will be split into recommendations on the use of: *Social media tools (1-5)*, *Mobile applications, websites and other tools (5-9)*, *Organisational recommendations (9-12)*.

1. Transport hub operators should consider the use of social media platforms (e.g. Twitter) to rapidly disseminate information to, and obtain information from, members of the public during an infectious disease outbreak.
2. Social media early warning systems may be developed for use in transport hubs, to ensure that those at-risk can be reached rapidly and directly.
3. Consider the development of SOPs for social media use during infectious disease outbreaks, for example SOPs around monitoring of hashtag use. This will provide a



clearer and easier route for social media uptake, as well as establishing social media as an official communication tool.

4. Transport operators should invest in novel applications for social media. For example: Twitter triangulation systems can be used at transport hubs, in order to target those at-risk. Such triangulation systems have been effective for targeting people in a specific geographical area, and so could be used to ensure that relevant information is disseminated to members of the public at transport hubs in the case of an infectious disease outbreak.
5. Mobile applications may be developed for use in transport hubs. Such applications provide effective two-way communication, but will require successful marketing in order to ensure the highest possible uptake.
6. Responder organisations should carefully consider message development and user interface design using communication accommodation theories and pilot tested designs.
7. Websites are effective in periods of low-risk to act as a centralised information hub for transport users. When high risk periods arise, transport operators can also direct people to these sources using hyperlinks during time critical communication efforts.
8. Transport hub operators should seek collaborations with large public health information sources which provide tracking of disease epidemiology such as 'ProMed' or the World Health Organisation. Such collaborations can increase awareness of international disease threats which may affect transport hubs.
9. While social media and mobile applications represent potentially effective means of communicating with members of the public at transport hubs during infectious disease outbreaks, hub operators should be aware that communicating via these technologies may not be effective for members of some vulnerable groups, and should prepare accordingly.



10. When using social media platforms and ICT tools for information dissemination and collection, transport hub operators should be aware that information will be shared rapidly not only from transport hub operators to members of the public, but also from members of the public to members of the public. While this has the advantage of increasing the speed of information dissemination, it also leads to loss of informational authority, and the potential for rumour-spreading.
11. To maintain the reliability of information, transport hubs should consider appointing a 'social media evangelist', who will be a communication expert designated to ensuring rapid and reliable information dissemination. This person will maintain and monitor social media communications, and will be responsible for fact-checking and suppression of inaccurate information.
12. Hub operators should also be aware of the potential impact of increased speed of information dissemination on public responses during pandemics, and should consider this in their planning.

4.3 Conclusion

This study aimed to report on the state of play in ICT-based public communications efforts in transport hub settings. Although we found no articles which focused specifically on this application of the tools a number of articles focused on the use of ICT tools in disaster and infectious disease settings. An in-depth qualitative analysis was conducted in order to assess the major themes, and these were then developed into practical recommendations which can be applied directly to the transport hub sector. Overall, the research supports the use of these tools in public health settings because of the increased speed, reach and transmission potential as well as the established infrastructure and audience that already exists, particularly in the use of social media tools. Despite these strengths, our review highlights the need to consider a range of organisational factors which are influential in determining the effective use of these tools.



5. References

- Abdullah, N., Annamalai, M., and Rani, M, K, A, A., (2016). "Paging vs. Scrolling: Navigation styles for Self-Triage of epidemic diseases." Journal of Theoretical and Applied Information Technology **88**(2): 262-272.
- Alshareef, H. N. and D. Grigoras (2016). "Using social media and the mobile cloud to enhance emergency and risk management." Parallel and Distributed Computing (ISPDC). DOI: 10.1109/ISPDC.2016.21
- Bennett, P, K. Calman, S, C, and Fischbacher-Smith, D. "Understanding public responses to risk: Issues around policy and practice." (2010): 3-22.
- Berners-Lee. "World-Wide Computer." Communications of the ACM. 40(2) Feb. 1997
- Bird, D., Ling, Megan,. and Haynes, K,. (2012). "Flooding Facebook-the use of social media during the Queensland and Victorian floods." Australian Journal of Emergency Management, **27**(1): 27-33.
- Booth, A. (2004) "Formulating answerable questions" in Booth, A. and Brice, A. Evidence-based practice for information professionals: a handbook. Facet Publishing. pp. 61-70
- Browne, A., St-Onge Ahmad, S., Beck, C. R., & Nguyen-Van-Tam, J. S. (2016). The roles of transportation and transportation hubs in the propagation of influenza and coronaviruses: a systematic review. *Journal of travel medicine*, 23(1). DOI: <https://doi.org/10.1093/jtm/tav002>
- Buzzelli, M. M., Morgan, P., Muschek, A, G., and Macgregor-Skinner, G. (2014). "Information and communication technology: Connecting the public and first responders during disasters." Journal of Emergency Management **12**(6): 441-447. DOI: [10.5055/jem.2014.0207](https://doi.org/10.5055/jem.2014.0207)
- Chatfield, A. T., Scholl, H, J, H., and Brajawidagda, U. (2013). "Tsunami early warnings via Twitter in government: Net-savvy citizens' co-production of time-critical public information services." Government Information Quarterly **30**(4): 377-386. DOI: <https://doi.org/10.1016/j.giq.2013.05.021>
- Coombs, W. T. (2007). Protecting organization reputations during a crisis: The development and application of situational crisis communication theory. *Corporate reputation review*, 10(3), 163-176.
- Cooper, G. P., Yeager, V., Burkle, F, M., Subbarao, I. (2015). "Twitter as a Potential Disaster Risk Reduction Tool. Part I: Introduction, Terminology, Research and Operational Applications." PLoS Currents **7**. DOI: [10.1371/currents.dis.a7657429d6f25f02bb5253e551015f0f](https://doi.org/10.1371/currents.dis.a7657429d6f25f02bb5253e551015f0f)
- Cooper, G. P., Yeager, V., Burkle, F, M., Subbarao, I, (2015). "Twitter as a Potential Disaster Risk Reduction Tool. Part II: Descriptive Analysis of Identified Twitter Activity during the



2013 Hattiesburg F4 Tornado." PLoS Currents **7**: DOI:
[10.1371/currents.dis.f2e5b9e979af6174d2f97c1f0349be5c](https://doi.org/10.1371/currents.dis.f2e5b9e979af6174d2f97c1f0349be5c)

Cooper, G. P., Yeager, V., Burkle, F. M., Subbarao, I. (2015). "Twitter as a Potential Disaster Risk Reduction Tool. Part III: Evaluating Variables that Promoted Regional Twitter Use for At-risk Populations During the 2013 Hattiesburg F4 Tornado." PLoS Currents **7**. DOI:
[10.1371/currents.dis.b305fe1b479528fda724c6f84f546471](https://doi.org/10.1371/currents.dis.b305fe1b479528fda724c6f84f546471)

Dabner, N. (2012). "'Breaking Ground' in the use of social media: A case study of a university earthquake response to inform educational design with Facebook." The Internet and Higher Education **15**(1): 69-78. DOI: <https://doi.org/10.1016/j.iheduc.2011.06.001>

Egnoto, M.J., Svetieva, E., Vishwanath, A., & Ortega, C.R. (2013). Emergency Communication during a crisis within a University: Analysis of an active shooter scenario. Journal of Homeland Security and Emergency Management **10**: 1-21.

Fordis, M., Alexander, J. D., McKellar, J., (2007). "Role of a database-driven web site in the immediate disaster response and recovery of Academic Health Center: the Katrina experience." Academic Medicine : Journal of the Association of American Medical Colleges **82**(8): 769-772. DOI: [10.1097/ACM.0b013e3180cc2b5c](https://doi.org/10.1097/ACM.0b013e3180cc2b5c)

Friedman, D. B., Tanwar, M., and Richter, J. V.,(2008). "Evaluation of online disaster and emergency preparedness resources." Prehospital and Disaster Medicine **23**(5): 438-446. DOI: <https://doi.org/10.1017/S1049023X00006178>

Glowacki, E. M., Lazard, A. J., Wilcox, G. B., Mackert, M., Bernhardt, J. M., (2016). "Identifying the public's concerns and the Centers for Disease Control and Prevention's reactions during a health crisis: An analysis of a Zika live Twitter chat." American Journal of Infection Control. **44**: 1709-11 DOI:
<https://doi.org/10.1016/j.ajic.2016.05.025>

Grais, R. F., Ellis J.H, and Glass G.E, . "Assessing the impact of airline travel on the geographic spread of pandemic influenza." European journal of epidemiology **18**.11 (2003): 1065-1072.

Haataja, M., Laajalahti, A., and Hyvarinen, J., (2016). "Expert views on current and future use of social media among crisis and emergency management organizations: Incentives and barriers." Human Technology. **12** (2), 135-164. DOI:10.17011/ht/urn.201611174653

Hagar, C. (2013). "Crisis informatics: Perspectives of trust—is social media a mixed blessing?" SLKS Student Research Journal **2**(2). DOI:
<http://scholarworks.sjsu.edu/slissrj/vol2/iss2/2>

Hara, N. "Internet use for political mobilization: Voices of participants". First Monday, [S.l.], June 2008. ISSN 13960466. Available at:
<<http://firstmonday.org/ojs/index.php/fm/article/view/2123/1976>>.



Howe, A. W., Jennex, M, E., Bressler, G, H., and Frost, E. (2011). "Exercise 24: Using social media for crisis response." International Journal of Information Systems for Crisis Response and Management (IJISCRAM) **3**(4): 36-54. DOI: 10.4018/978-1-4666-4707-7.ch072

Kellermann, A. L., Isakov, A, P., Parker, R., Handrigan, M, T., Foldy, S., (2010). "Web-based self-triage of influenza-like illness during the 2009 H1N1 influenza pandemic." Annals of Emergency Medicine **56**(3): 288-294. DOI: [10.1016/j.annemergmed.2010.04.005](https://doi.org/10.1016/j.annemergmed.2010.04.005)

Kent, M. and Ellis, K. (2015). "People with disability and new disaster communications: access and the social media mash-up." Disability and Society **30**(3): 419-431. DOI: <http://dx.doi.org/10.1080/09687599.2015.1021756>

Kostkova, P., Fowler, D., Wiseman, S., and Weinberg, J, R., (2013). "Major infection events over 5 years: how is media coverage influencing online information needs of health care professionals and the public?" Journal of medical Internet research **15**(7). DOI: [10.2196/jmir.2146](https://doi.org/10.2196/jmir.2146)

Kostkova, P., Szomazor, M., St Luis, C., (2014). "Swineflu: The use of twitter as an early warning and risk communication tool in the 2009 Swine Flu Pandemic." ACM Transactions on Management Information Systems. **5**(2). DOI: 10.1145/2597892

Lachlan, K. A. (2010). "Handbook of risk and crisis communication" - Edited by Robert L. Heath & H. Dan O'Hair (Eds.). Journal of Communication, 60: E8–E11. doi:10.1111/j.1460-2466.2010.01501.x

Langdon, P. and I. Hosking (2010). "Inclusive wireless technology for emergency communications in the UK." International Journal of Emergency Management **7**(1): 47-58. DOI: <http://dx.doi.org/10.1504/IJEM.2010.032044>

Latonero, M. and Shklovski, I.(2011). "Emergency management, Twitter, & Social Media Evangelism". International Journal of Information Systems for Crisis Response and Management **3**(4): 67-86. DOI: 10.4018/jiscrm.2011100101

Lazard, A. J., Scheinfeld, E., Bernhardt, J , M., Wilcox, G, B., Suran, M.(2015). "Detecting themes of public concern: A text mining analysis of the Centers for Disease Control and Prevention's Ebola live Twitter chat." American Journal of Infection Control **43**(10): 1109-1111. DOI:[10.1016/j.ajic.2015.05.025](https://doi.org/10.1016/j.ajic.2015.05.025)

Leykin, D., Aharonson-Daniel., and Lahad, M., (2016). "Leveraging social computing for personalized crisis communication using social media." PLoS Currents **8**. DOI: [10.1371/currents.dis.b2c5870adf1b7a77af82e7d5552aabe7](https://doi.org/10.1371/currents.dis.b2c5870adf1b7a77af82e7d5552aabe7)

Licciardone, J. C. (2002). "Access patterns of a clinic-based health information web site for international travelers." Journal of Travel Medicine **9**(6): 315-317. DOI: 10.2310/7060.2002.30033



Lu, X., Liao, Y., Li, B., Deng, L., (2015). "BeiDou integrated disaster reduction application platform." China Communications **12**(8): 169-182. DOI: [10.1109/CC.2015.7224699](https://doi.org/10.1109/CC.2015.7224699)

Madoff, L. C. and J. P. Woodall (2005). "The internet and the global monitoring of emerging diseases: Lessons from the first 10 years of ProMED-mail." Archives of Medical Research **36**(6): 724-730. DOI: [10.1016/j.arcmed.2005.06.005](https://doi.org/10.1016/j.arcmed.2005.06.005)

Mesmer, B. L. and C. L. Bloebaum (2012). "Importance of incorporation of personal communication devices in evacuation simulators." Safety Science **50**(5): 1313-1318. DOI: <https://doi.org/10.1016/j.ssci.2011.04.020>

Moher, D., Liberati, A., Tetzlaff, J., Douglas, A, G. The PRISMA Group (2009) "Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA statement." Plos Medicine **6**(7) DOI: <https://doi.org/10.1371/journal.pmed.1000097>

Norum, J., Moksness, S, G., Larsen, E., (2002). "A Norwegian study of seafarers' and rescuers' recommendations for maritime telemedicine services." Journal of Telemedicine and Telecare **8**(5): 264-269. DOI: [10.1177/1357633X0200800504](https://doi.org/10.1177/1357633X0200800504)

Onorati, T., Aedo, I., Romano, M., Diaz, P., (2014). "EmergenSYS: mobile technologies as support for emergency management." Smart Organizations and Smart Artifacts, Springer: 37-45. DOI: [10.1007/978-3-319-07040-7_5](https://doi.org/10.1007/978-3-319-07040-7_5)

O'Reilly, T. (2007). *What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software*.

Palen, L., Vieweg, S., Liu, S, B., Hughes, A, L.,(2009). "Crisis in a networked world features of computer-mediated communication in the April 16, 2007, Virginia Tech Event." Social Science Computer Review **27**(4): 467-480. DOI: [10.1177/0894439309332302](https://doi.org/10.1177/0894439309332302)

Pender, B., Currie, G., Delbosc, A., Shiwakoti, N., (2014). "Social Media Use during Unplanned Transit Network Disruptions: A Review of Literature." Transport Reviews **34**(4): 501-521. DOI: <http://dx.doi.org/10.1080/01441647.2014.915442>

Pribble, J. M., Fowler, J, M., Kamat, S, V., Wilkerson, W, M., Goldstein, K, M., Hargarten, S, W., (2010). "Communicating emerging infectious disease outbreaks to the public through local television news: public health officials as potential spokespeople." Disaster Medicine and Public Health Preparedness **4**(3): 220-225.

Reynolds, B., & Quinn, S. C. (2008). Effective communication during an influenza pandemic: the value of using a crisis and emergency risk communication framework. *Health Promotion Practice*, **9**(4_suppl), 13S-17S.

Romano, M., Onorati, T., Ignacio, A., Diaz, Paloma, D., (2016). "Designing mobile applications for emergency response: Citizens acting as human sensors." Sensors (Switzerland) **16**(3). DOI: [10.3390/s16030406](https://doi.org/10.3390/s16030406)



Rubin, S., Bouri, N., Jolani, N., Minton, K., (2014). "The adoption of social media and mobile health technologies for emergency preparedness by local health departments: a joint perspective from NACCHO and the UPMC center for health security." Journal of Public Health Management and Practice **20**(2): 259-263. DOI: [10.1097/PHH.0000000000000056](https://doi.org/10.1097/PHH.0000000000000056)

Schroeder, A. and L. Pennington-Gray (2015). "The Role of Social Media in International Tourist's Decision Making." Journal of Travel Research **54**(5): 584-595. DOI: [10.1177/0047287514528284](https://doi.org/10.1177/0047287514528284)

Schroeder, A., Pennington-Gray, L., Donohoe, H., Kiouisis, S., (2013). "Using Social Media in Times of Crisis." Journal of Travel and Tourism Marketing **30**(1-2): 126-143. DOI: <http://dx.doi.org/10.1080/10548408.2013.751271>

Seeger, M. W. (2006). Best practices in crisis communication: An expert panel process. Journal of Applied Communication Research, **34**(3), 232-244.

Simon, T., Goldberg, A., Aharonson-Daniel, L., Leykin, D, Adini, B., (2014). "Twitter in the cross fire—the use of social media in the westgate mall terror attack in Kenya." PLoS ONE **9**(8): e104136. DOI: <https://doi.org/10.1371/journal.pone.0104136>

Staes, C. J., Wuthrich, A., Gesteland, P., Allison, M. A., Leecaster, M., Shakib, J. H., ... & Pavia, A. T. (2011). Public health communication with frontline clinicians during the first wave of the 2009 influenza pandemic. Journal of public health management and practice: JPHMP, **17**(1), 36.

Starbird, K. and L. Palen (2010). "Pass it on?: Retweeting in mass emergency", International Community on Information Systems for Crisis Response and Management.

Stephens, K. K., Ehsan, J., Boyles, S., Zhu, Y., (2015). "Increasing Evacuation Communication Through ICTs: An Agent-based Model Demonstrating Evacuation Practices and the Resulting Traffic Congestion in the Rush to the Road." Journal of Homeland Security and Emergency Management **12**(3): 497-528. DOI: 10.1515/jhsem-2014-0075

Sutton, J., Spiro, E, S., Johnson, B., Fitzhugh, S., Gibson, B., and Carter, C.,(2014). "Warning tweets: Serial transmission of messages during the warning phase of a disaster event." Information, Communication & Society **17**(6): 765-787. DOI: 10.1080/1369118X.2013.862561

Troko, J., Myles, P., Gibson, J., Hashim, A., Enstone, J., Kingdon, S., ... & Van-Tam, J. N. (2011). Is public transport a risk factor for acute respiratory infection?. BMC infectious diseases, **11**(1), 16.

Ülgen, S. (2005). "Public participation geographic information sharing systems for community based urban disaster mitigation". Geo-information for Disaster Management, Springer Berlin Heidelberg: 1427-1434. DOI: 10.1007/3-540-27468-5_98



Ulmer, R. R., Sellnow, T. L., & Seeger, M. W. (2013). "Effective crisis communication: Moving from crisis to opportunity". Sage Publications.

Vaughan, E., & Tinker, T. (2009). "Effective health risk communication about pandemic influenza for vulnerable populations". American Journal of Public Health, 99(S2), S324-S332.

Walters, C. E., Mesle, M., Hall, I. (*in press*). "Modelling the global spread of diseases: a review of current practice and capability". Eurosurveillance. PANDHUB Consortium.

Westlund, K. (2011). "Infections onboard ship--analysis of 1290 advice calls to the Radio Medical (RM) doctor in Sweden. Results from 1997, 2002, 2007, and 2009." International maritime health 62(3): 191-195.

Wilson, Mary E. "Travel and the emergence of infectious diseases." *Emerging infectious diseases* 1.2 (1995): 39.

Wybo, J. L., Goelman-Soulié, F., Gouttas, C., Freyssinet, E., Lions, P.,(2015). "Impact of social media in security and crisis management: A review." International Journal of Emergency Management 11(2): 105-128. DOI: <http://dx.doi.org/10.1504/IJEM.2015.071045>

Yeager, V., et al. (2015). "Twitter as a Potential Disaster Risk Reduction Tool. Part IV: Competency-based Education and Training Guidelines to Promote Community Resiliency." PLoS Currents 7: DOI: [10.1371/currents.dis.ce3fad537bd666770a649a076ee71ba4](https://doi.org/10.1371/currents.dis.ce3fad537bd666770a649a076ee71ba4)

Youmans, W. L., & York, J. C. (2012). Social media and the activist toolkit: User agreements, corporate interests, and the information infrastructure of modern social movements. *Journal of Communication*, 62(2), 315-329.



6. Appendices

Appendix 1: Literature Search Terms

Search number	Search terms
Transport terms	
1	traffic and transport/
2	transport*.ab,ti.
3	Travel/
4	Travel*.ab,ti.
5	Aviation.ab,ti.
6	Aircraft/
7	Aircrafts*.ab,ti.
8	Airport*.ab,ti.
9	Airplane.ab,ti.
10	Aeroplane*ab,ti.
11	Airline.ab,ti.
12	Flight.ab,ti.
13	Flying.ab,ti.
14	Ship/
15	Shipping/
16	Ship*.ab,ti.
17	Cruis*.ab,ti.
18	Boat*.ab,ti.
19	Ferry.ab,ti.
20	Ferries.ab,ti.
21	Naval medicine/
22	Maritime.ab,ti.
23	Ocean liner.ab,ti.
24	Railway/
25	Railway*.ab,ti.
26	Railroad*.ab,ti,kw.
27	Rail*.ab,ti.
28	Train*.ab,ti.
29	station adj3 (rail* or bus* or transport or underground or coach*).ab,ti.
30	Subway*.ab,ti.
31	underground* adj10 (train* or tube* or rail* or travel* or transport* or transit* or people or passeng*).ab,ti.
32	Automobile*.ab,ti.
33	Car*.ab,ti.



34	Tram.ab,ti.
35	Trams.ab,ti.
36	Motor vehicles/
37	Bus.ab,ti.
38	Buses.ab,ti.
39	coach* adj3 (travel or transport).ab,ti.
40	transit adj3 (hub or mass).ab,ti.
41	port adj3 (ship* or travel or sea).ab,ti.
42	hub adj5 (travel* or transport* or transit*).ab,ti.
43	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42
Disaster/Pandemic terms	
44	Disaster/
45	"Disaster planning".ab,ti.
46	Mass disaster/
47	Emergency/
48	Terrorism/
49	Terrori*.ab,ti.
50	Disaster*.ab,ti.
51	Emergenc*.ab,ti.
52	Terror adj3 (attack* or disaster*).ab,ti.
53	Diseases/
54	Disease*.ab,ti.
55	Pandemic/
56	"pandemic*".ab,ti.
57	Epidemic/
58	Epidemic*.ab,ti.
59	Disease transmission/
60	transmission adj3 (disease* or infect* or viral*).ab,ti.
61	Communicable disease/
62	Communicable disease*.ab,ti.
63	Disease outbreak*.ab,ti.
64	outbreak adj3 (disease* or Infect* or "Virus").ab,ti.
65	Bioterrorism/
66	"Bioterrori*".ab,ti.
67	Ebola hemorrhagic fever/
68	Ebola*.ab,ti.
69	Ebolavirus.ab,ti.
70	Influenza.ab,ti.
71	Flu.ab,ti.



72	SARS.ab,ti,kw.
73	Plague/
74	Pneumonic plague.ab,ti.
75	Plague.ab,ti.
76	Anthrax/
77	Bacillus anthracis.ab,ti.
78	Attack rate*.ab,ti.
79	Infection/
80	"infection control".ab,ti.
81	Infecti*.ab,ti.
82	Accident/
83	Casualt*.ab,ti.
84	Accede*.ab,ti.
85	Fatalit*.ab,ti.
86	"person to person".ab,ti.
87	"human to human".ab,ti.
88	"deliberate release".ab,ti.
89	44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 88
Communication Terms	
90	Interpersonal communication/
91	Communication/
92	information/
93	communica*.ab,ti.
94	informa*.ab,ti
95	sign* adj5 (communica* or inform* or technolo*).ab,ti
96	internet/
97	"Web browser".ab,ti,kw
98	internet.ab,ti
99	Web.ab,ti.
100	Web-based.ab,ti.
101	updat* adj5 ("informa*" or communica*)
102	smartphone/
103	smartphone.ab,ti
104	"Smart phone".ab,ti
105	Iphone.ab,ti
106	Android.ab,ti.
107	Real-time adj3 (informa* or Communica* or Warn*).ab,ti
108	mobile phone/
109	Mobile application/



110	"mobile phone".ab.ti
111	media.ab,ti.
112	telecommunication/
113	broadcast*.ab.ti.
114	telecommun*.ab.ti
115	social media/
116	wireless communication/
117	wireless communica*.ab,ti.
118	"wireless technology".ab,ti,kw.
119	"Local area network".ab,ti,kw.
120	cell* adj3 (communica* or informa* or media*).ab.ti
121	interact* adj3 (communic* or media or applica* or tool*).ab.ti
122	social* adj5 (media or market* or informa* or technolo*).ab.ti
123	"social media".ab,ti.
124	digital.ab.ti
125	"world wide web".ab,ti.
126	network* adj3 (communica* or system* or informa*).ab,ti.
127	risk communica*.ab,ti.
128	satellite adj5 (Communic* or informa* or technol* or social*).ab,ti
129	computer network*.ab,ti.
130	wifi.ab,ti.
131	wi-fi.ab,ti.
132	bluetooth.ab,ti.
133	radio.ab,ti
134	radio/
135	mass communication/
136	Mass Media.ab,ti,kw.
137	Mass adj3 (comunica* or media*).ab,ti.
138	telephone/
139	phone.ab,ti.
140	pager adj3 (communica* or messag* or alert*).ab,ti.
141	tablet* adj5 (device* or communica* or informa* or apple* or comput*).ab,ti.
142	connect* adj3 (communic* or informa* or internet* or wire*).ab,ti.
143	text* adj3 (mobile or communic* or messag*).ab,ti.
144	SMS.ab,ti.
145	tool* adj5 (mobile or communic* or web-based or internet or *phone or messag*).ab,ti.
146	app* adj5 (mobile or communic* or web-based or internet or *phone or messag*).ab,ti.
147	telemedicine.ab,ti.
148	90 or 91 or 92 or 92 or 93 or 94 or 95 or 96 or 97 or 98 or 99 or 100 or 101 or 102 or 103 or 104 or 105 or 106 or 107 or 108 or 019 or 110 or 111 or 112 or 113 or



	114 or 115 or 116 or 116 or 117 or 118 or 119 or 120 or 121 or 122 or 123 or 124 or 125 or 126 or 127 or 128 or 129 or 130 or 131 or 132 or 133 or 134 or 135 or 136 or 137 or 138 or 139 or 140 or 141 or 142 or 143 or 144 or 145 or 146 or 147
Victim/Population terms	
149	public health/
150	disaster victim*.ab,ti,kw.
151	public*.ab,ti.
152	"Public health".ab,ti.
153	Public policy/
154	"evacu* ".ab,ti.
155	victim/
156	victim*.ab,ti.
157	population/
158	urban population/
159	popula*.ab,ti.
160	resident/
161	residen*.ab,ti,kw.
162	commuter*.ab,ti,kw.
163	people*.ab,ti.
164	travel?er*.ab,ti.
165	passenger*.ab,ti.
166	casualt*.ab,ti.
167	touris*.ab,ti
168	customer*.ab,ti
169	crowding/
170	crowd*.ab,ti
171	community/
172	communit*.ab,ti.
173	user* adj3 (Transport* or Travel* or rail* or bus*).ab,ti.
174	inhabita*.ab,ti.
175	Local adj3 (popula* or people* or transport*).ab,ti.
176	occupan*.ab,ti.
177	Personnel.ab,ti.
178	Civilian*.ab,ti.
179	Patient* adj3 (disaster* or emergenc* or pandemic* or epidemic* or diseas*).ab,ti.
180	149 or 150 or 151 or 152 or 153 or 154 or 155 or 156 or 157 or 158 or 159 or 160 or 161 or 162 or 163 or 164 or 165 or 166 or 167 or 168 or 169 or 170 or 171 or 172 or 173 or 174 or 175 or 176 or 177 or 178 or 179 or 180
Final search	
181	43 and 89 and 148 and 180