1-2018

The social amplification of haze-related risks on the Internet

Mark CHONG
Singapore Management University, markchong@smu.edu.sg

Murphy CHOY
BigTapp Pte Ltd

The Social Amplification of Haze-Related Risks on the Internet

Mark Chong & Murphy Choy

This is an Author's Accepted Manuscript of an article published in Health Communication, 2016 November 30, Advance Online, copyright Taylor & Francis, available online at: http://doi.org/10.1080/10410236.2016.1242031

Abstract

Abstract: This study explores the implications of the digital network society for public health communication and management through an empirical study on communication related to the transboundary haze crisis in Singapore. Using the Social Amplification of Risk Framework (SARF), the authors applied sentiment and thematic analysis on haze-related posts on an online discussion forum (HardwareZone) and a social networking site (Facebook), and to haze-related articles in *The Straits Times* (a newspaper). The study shows that the medium matters in social amplification of risk: Facebook had an effect on the amplification of emotions, while HardwareZone and *The Straits Times* did not. In addition, the results show that spikes in online risk amplification were strongly influenced by unprecedented events. They also suggest that anger expressed online may be linked to a sense of futility. Implications for practice and recommendations for future research are provided in the conclusion.

The digital network society of the early 21st century is characterized by ubiquitous wireless communication, increasing interactivity, and a plethora of communication channels that enable individuals and organizations to interact virtually "anytime, anywhere" (Castells, 2004). But as socialization and communication increasingly take place in a networked, digitized, and interactive space centered on the Internet, electronic networks have become the commons of society (Castells, 2004), and media have become the public space (Volkmer, 2003). According to Castells (2004),

> The relationship between citizens and politicians, between the represented and the representative, depends essentially on what happens in this media-centered communication space … It is in the media space that political battles of all kinds are fought, won, and lost … Media politics works … as an alternative form of sociopolitical presence, using the input of grassroots power. (pp. 30–31)

In such an environment, individual voices and points of view about issues such as health and environmental risk can be easily amplified.

This study explores the implications of the digital network society for public health management and communication through an empirical study on communication related to the transboundary haze crisis in Singapore. Transboundary haze caused by the large-scale burning of forests and peat land in Indonesia has been an annual problem in Southeast Asia since 1985. In 1997, the haze crisis cost Southeast Asian nations an estimated US$9 billion in health expenses and business impacts such as disruption to air travel (O'Callaghan, 2013). In 2013, the haze caused record high levels of air pollution in Singapore and in several parts of Malaysia. The three-hour Pollution Standards Index (PSI; developed by the United States Environmental Protection Agency to measure the daily levels of air pollution) reached a record high of 401 ("hazardous") in Singapore on June 21, 2013, surpassing the previous record of 226 set during the 1997 haze. Public anxiety in Singapore rocketed, especially on days when the PSI readings hit "very

unhealthy" and "hazardous" levels (Gill & Tan, 2013). Online forums and blogs complicated the issue by perpetuating confusing reports about the availability of N95 masks and the accuracy of PSI readings, including allegations that Singapore's National Environment Agency (NEA) was misreporting PSI readings ("MCI's response to PQs," 2013). Many of the online comments criticized the Singapore government for its perceived slow response to the haze crisis and for its lack of prior planning (Gill & Tan, 2013).

Singaporeans are among the world's most active users of social media, with the world's second highest social penetration rate of 59%, which is more than double the global average of 26% (Aziz, 2014). According to a Google report, the haze was the most-searched topic in Singapore in 2013 ("Haze is Singapore's most-searched subject," 2013). It was also the top-trending topic in Singapore in 2013 on Twitter (Nur, 2014).

Theoretical Background: Social Amplification of Risk

The Social Amplification of Risk Framework (SARF) explains how social context influences perceptions and communication related to risks (Kasperson & Kasperson, 1996). Kasperson et al. (1988) define social amplification of risk as "the phenomenon by which information processes, institutional structures, social-group behavior, and individual responses shape the social experience of risk, thereby contributing to risk consequences" (p. 181). More specifically, hazards may interact with social, psychological, cultural, and institutional processes to amplify or attenuate public responses to risks. Strong public concern and drastic socioeconomic impact may accompany risk events with seemingly minor physical consequences (Kasperson et al., 1988). Indeed, social institutions such as the media may amplify perceived risk to the extent that perceptions of risk occur before or even in the absence of any actually occurring hazards or accidents (Kasperson, 1992).

Social amplification is rooted in the social experience, which includes both direct (personal) and indirect experience (e.g., via media coverage) of the risk (Kasperson et al., 1988). Direct experience "can provide feedback on the nature, extent, and manageability of the hazard, affording better perspective and enhanced capability for avoiding risks" (Kasperson et al., 1988, p. 184).

However, direct experience is not always available. In such a situation, the public learns about the risk indirectly—through "social amplification stations" (e.g., the media and government agencies) that not only transmit the risk information but also interpret and frame the risk issues through the metaphor of risk "signals". As the risk information filters through various social and individual amplification stations, it is processed and modified in ways (e.g., by the volume, dramatization, and symbolic connotations of the risk information) that shape the salience of the risk, which in turn influences individual perceptions of risk. The extent to which the risk is amplified or attenuated through this social process can create social and economic consequences that ripple beyond the immediate impact of the risk event and thus affect markets, demand for regulation, and trust (Kasperson & Kasperson, 1996). Thus, "this framework recognizes that individuals' perceptions of risk are processed through filters at various levels, from individual heuristics to social and political processes that frame risk issues" (Brenkert-Smith, Dickinson, Champ, & Flores, 2013, p. 801). Nonetheless, lay publics are not simply passive recipients of risk messages but may actively express their opinions and get involved in constructing what they see and hear (Chung, 2011).

Risk Communication on Social Media

Social media has made it possible for anyone with Internet connection to access and add to the repository of online information, radically changing how information flows through societies (Neely, 2014). Online information search is more convenient, more accessible, and less expensive than reading traditional literature or communicating with experts (Westerman, Spence, & Van Der Heide, 2011). By making it much easier for millions of people to find risk information and become more involved (e.g., in their own health care), the Internet has become an important source of information for individuals who seek to reduce their uncertainty about various risks (Neely, 2014). Its accessibility and low cost as a medium for public communication also mean that a "small number of people can alert the public to a risk issue and public attention to the issue can expand exponentially through online interactions" (Chung, 2011, p. 1885). For example, even a one-person Web campaign on the Anaheim, CA, landslide attracted strong social attention to the natural disaster and prompted widespread suspicion of government activity and capability for risk management (Rodrigue, 2001).

Equally important, the interactive openness of the Internet allows the general public to become active participants in the discussion of risk (Neely, 2014). For example, Chung (2012) showed how online news providers and Internet forums amplified the risk of mad cow disease associated with U.S. beef imports into South Korea. The Internet-enabled protest was largely made possible by the ubiquity of wireless Internet in Korea and the experiences of "Internet democracy" during the 2002 Korea Presidential election. The same technology has made it possible for users to begin virtual petitions on online forums and personal blogs. This amplification process resulted in a very negative impact on the Korean livestock industry.

Although these features of the Internet environment foster broader participation, they also facilitate the development of fringe ideas and the rapid spread of falsehoods (Neely, 2014). While there is limited control over the veracity and accuracy of information on the Internet (Chung, 2011), audiences are generally aware that falsehoods are commonplace online. Thus, there is hunger for credible information (Stelter, 2008), as well as endorsements from trusted sources (Neely, 2014).

The history of social media has been linked heavily to disasters and emergencies, and a common characteristic of these disasters and emergencies is the remarkably small time gap between the start of the disaster and the onset of "live" social media reporting about the disaster. Often, the victims (or others) form online social networks to share information and provide rapid assistance and relief. These self-organizing efforts can help provide critical risk information and thus reduce uncertainty and save lives and property in the process (Neely, 2014).

The opposite, however, is also true—distrust of authorities and frustration with official channels can lead to dangerous decisions by members of the public (Reynolds, 2011). For example, social media have played a critical role in the antivaccination campaigns in the United States and Europe—the Internet has noticeably more antivaccination messages than other forms of media, and parents who chose not to vaccinate their children were more likely to have gathered information online (Kata, 2010).

Haze-related messages posted on Singapore online forums (e.g., HardWareZone) and social media platforms (e.g., Facebook) may amplify risk perceptions and, in the process, create public uncertainty about the authorities' management of the haze crisis. As negative emotions about a crisis are known to be highly predictive of increased risk perception (Burns, Peters, & Slovic, 2012), it is important to assess whether social and digital media have a tendency to amplify negative emotions related to a particular risk:

Research Question 1 (RQ1):

Do social and digital media amplify particular emotions during a risk event?

Research Question 2 (RQ2):

How do social/digital media compare with the mainstream media as a risk amplification station?

Additionally, it would be useful to know whether the social amplification of risk on the Internet follows a particular "pattern": Research Question 3 (RQ3):

Does the amplification of risk on social and digital media have a pattern?

Method

Data Collection

Data collection took place in two stages. In the first stage, the researchers collected online posts on the ChannelNewsAsia[1] Facebook page and from HardWareZone.com for the period January 2013 through December 2013. Facebook is the number one social media platform and HardWareZone the top online forum in Singapore (http://www.alexa.com/topsites/countries/SG).

In the second stage, the researchers searched the Factiva database for haze-related articles that appeared in *The Straits Times* between June 17 and 24, 2013. Articles that included the word "haze" in the headline or text were included. The search resulted in 161 articles. *The Straits Times* was selected as it is the leading newspaper in Singapore. The search was confined to June 17–24 as the Facebook and HardWareZone posts peaked during this period.

Data Analysis

Two types of analysis—sentiment analysis and thematic analysis—were conducted on the data from HardwareZone, Facebook, and *The Straits Times*.

Sentiment analysis is the task of identifying positive and negative opinions, emotions, and evaluations. It is relevant because "responses to risky situations (including decision-making) result in part from direct (i.e., not cognitively mediated) emotional influences, including feelings such as worry, fear, dread or anxiety" (Loewenstein, Weber, Hsee, & Welch, 2009, p. 118).

Most of the work on sentiment analysis has been done at the document level. However, tasks such as multiperspective question answering and summarization, opinion-oriented information extraction, and product review mining require sentence-level or even phrase-level sentiment analysis (Wilson, Wiebe, & Hoffmann, 2005).

[1] ChannelNewsAsia is Singapore's English-language, Asian TV news channel.

A typical approach to sentiment analysis is to start with a lexicon of positive and negative words and phrases. In these lexicons, entries are tagged with their a priori polarity (i.e., out of context, does the word evoke something positive or something negative?). However, the contextual polarity of the phrase in which a word appears may be different from the word's a priori polarity. To achieve a good sentiment prediction result, the authors elected to use Janyce Wiebe's subjectivity lexicon to handle phrase-level and document-level sentiments (Wilson et al., 2005). However, sentiment analysis does not attempt to describe or model underlying themes even though it is able to identify sentiments at a phrase level. For a deeper understanding of textual data, text mining is needed.

The most common approach in text mining is to develop a topic model, which represents multivariate count data as multinomial observations parameterized by a weighted sum of latent topics. With each observation x_i ε

$x_i \in \{x_1 \dots x_n\}$, a vector of counts in p categories, given a total count of $m_i = \sum_{j=1}^{p} x_{ij}$, the K-topic model can be formulated as

$$x_i \sim MN(w_{i1}\theta_1 + \dots + w_{i1}\theta_1, m_i)$$

where topics $\theta_k = [\theta_{k1} \dots \theta_{kp}]'$ and the weights w_i are probability vectors. In this context, each x_i is a vector of counts for terms (i.e., words or phrases) in a document with total term-count m_i, and each topic θ_k is a vector of probabilities over words. Documents are thus characterized through a mixed-membership weighting of topic factors and, with K far smaller than p, each w_i is a reduced dimension summary for x_i.

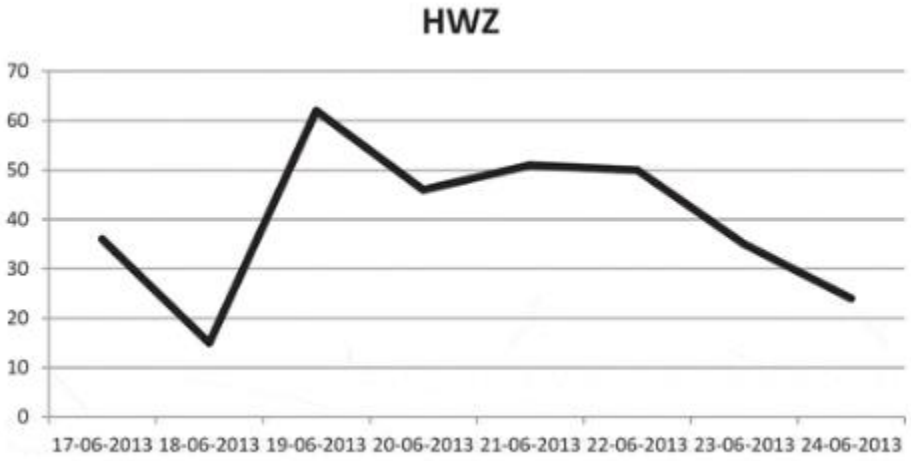
To identify the number of topics from the data, researchers may make use of cross-validation, nonparametric mixture priors, or marginal likelihood. Cross-validation (CV) is by far the most common choice (e.g., Grimmer, 2010; Grün & Hornik, 2011). For a model-based alternative, Teh, Jordan, Beal, and Blei (2006) constructed latent Dirichlet allocation into a hierarchical Dirichlet process, with each document's weighting over topics a probability vector of infinite length. While this removes the need to identify K, the estimation may be sensitive to the level of finite truncation for these prior processes and will require inference about high-dimensional term-topic memberships. Finally, the standard Bayesian solution is to maximize the marginal model posterior.

Results

Number of Posts

Figure 1 shows the number of HardwareZone articles on the haze from June 19 to 24, 2013. The number of comments peaked on June 19.

Figure 1. Number of haze-related posts on HardwareZone.



As shown in Figure 2, there were in total 16,755 Facebook posts on the haze between June 17 and 24, 2013. The number of comments peaked on June 17. It is not surprising that June 17 marked the start of the most significant upswing in the number of haze-related posts on HardwareZone and Facebook in 2013, as the first sightings of the haze started on that day.

Figure 2. Number of haze-related posts on ChannelNewsAsia Facebook page.

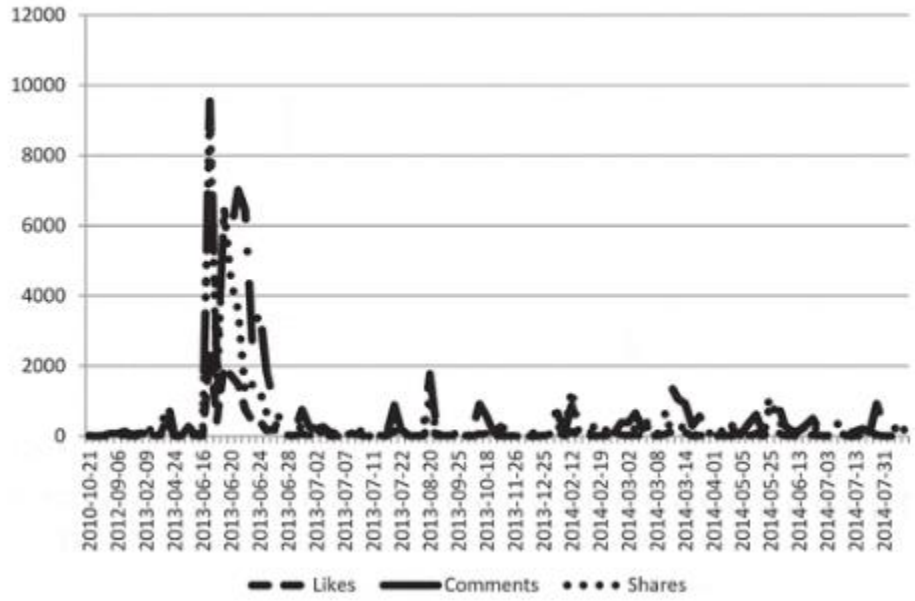
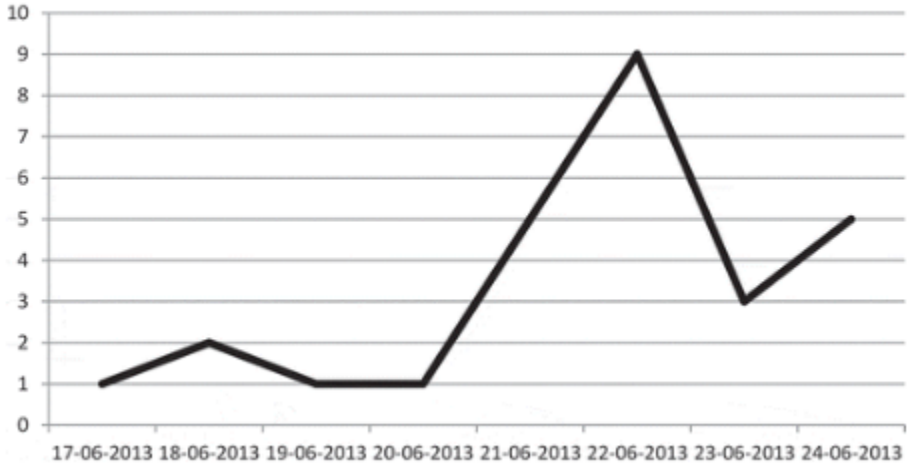


Figure 3 shows the number of *Straits Times* articles on the haze from June 17 to 24, 2013.

Figure 3. Number of haze-related articles in *The Straits Times*.



Themes

The top five thematic word clusters[2] and their corresponding percentages for HardwareZone, Facebook, and *Straits Times* for the period April 17–24, 2013, were as follows.

HardwareZone

1. "Liao," "smell," "now," "leh," "think," "bad," "hazy," "see," "wrote," "down" (20.6%): This theme is about the smell and sight of the haze.

2. "Saysuzu," "likes," "haze," "last," "one," "next," "over," "Singapore," "days," "few" (18%): This theme is about the previous haze and the possibility of haze in the future.

3. "Come," "reading," "still," "very," "back," "year," "ask," "clear," "good," "take" (15%): Similar to theme 2 but with a focus on the PSI readings.

4. "Aircon," "air," "better," "home," "those," "day," "stay," "mask," "use," "need" (12.3%): This theme is about air conditioners and the N95 mask.

5. "Masks," "Indonesia," "stop," "well," "work," "n95," "long," "Singapore," "burning," "never" (11.9%): This theme is about the N95 mask and how long the haze will last.

[2] In the interest of conciseness, only data for the top five thematic clusters have been included. Contact the corresponding author for data on the other thematic clusters.

Facebook

1. "Holiday," "declare," "eyes," "gov," "day," "smell," "same," "very," "lol," "one," "public," "smoke," "wonder," "cause," "serious," "someone," "being," "level," "few," "working" (6.1%): This theme is about whether the government should declare a public holiday, given the high PSI levels.

2. "PSI," "readings," "went," "over," "higher," "out," "level," "yesterday," "few," "days," "lol," "down," "nothing," "someone," "being," "wonder," "look," "100," "instead," "same" (5.5%): This theme is about the increasing PSI levels.

3. "Haze," "people," "indoors," "cause," "such," "being," "few," "down," "went," "level," "away," "serious," "god," "dengue," "working," "first," "nothing," "yesterday," "outdoor," "smoke" (5.4%): This theme is about the imperative to stay indoors and about the aggravation of the crisis by dengue fever.

4. "Free," "hope," "unhealthy," "down," "cause," "few," "really," "come," "make," "year," "level," "away," "went," "smoke," "being," "nothing," "someone," "burn," "instead," "that's" (5.1%): This theme is about hopes that the PSI level will go down.

5. "Don't," "stay," "everyone," "home," "smoke," "nothing," "again," "help," "many," "indoors," "being," "feel," "such," "serious," "yesterday," "cause," "children," "years," "higher," "few" (4.9%): This theme is about pleas to stay indoors, as PSI levels are increasing and will harm children.

6. [3]"Mask," "think," "sure," "doing," "face," "wonder," "look," "god," "cause," "feel," "100," "unhealthy," "dun," "being," "outdoor," "few," "someone," "nothing," "stock," "higher" (4.9%): This theme is about the belief that normal face masks will not work given that the PSI level has exceeded 100.

The Straits Times[4]

1. "Session," "seven," "full," "spent," "fall," "2011," "hong," "cent," "left," "return" (38.5%): This theme is about the return of the haze.

2. "Exposure," "24 hours," "PM25," "NEA," "API," "unhealthy," "coast," "mask," "masks," "readings" (31.2%): This theme focuses on the N95 mask and the PM25 haze reading.

3. "Solve," "enforcement," "aircraft," "culprits," "agreement," "named," "Pekanbaru," "causing," "forestry," "laws" (30.3%): This theme is about haze-related problems in Indonesia.

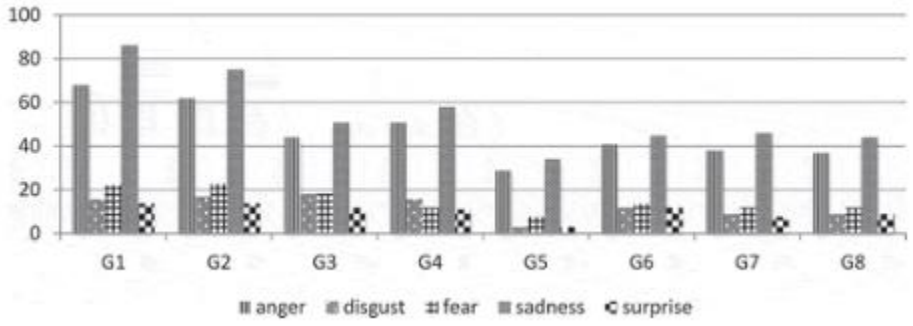
Emotions

HardwareZone

Between June 17, 2013, and June 24, 2013, the three most prominent emotions were sadness (134 posts), anger (88 posts), and disgust (27 posts). The researchers also overlaid emotions against themes and found that while sadness and anger loomed large for all eight themes, they loomed largest for themes 1, 2, and 4 (see Figure 4).

[3] There is a tie between thematic clusters 5 and 6.
[4] There are only three thematic clusters for The Straits Times.

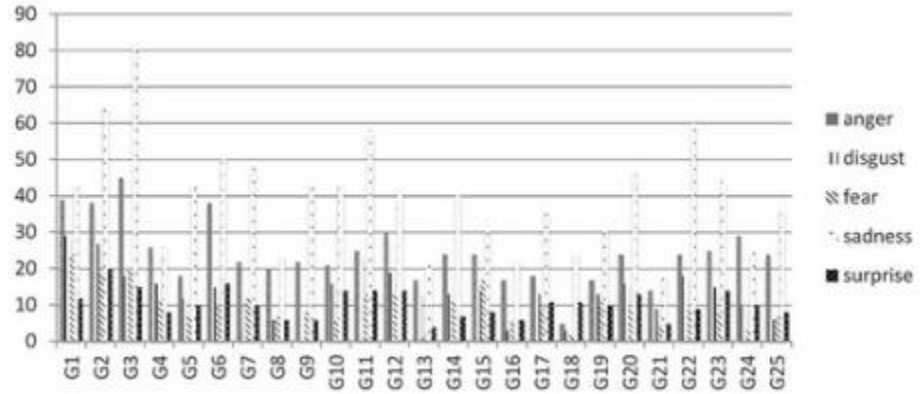
Figure 4. Prominence of emotions (overlaid against themes) in haze-related posts on HardwareZone.



Facebook

The three most prominent emotions were sadness (1266 posts), anger (732 posts), and disgust (450 posts). The researchers also overlaid emotions against the themes and found that sadness loomed largest for themes 3, 2, and 22, while anger loomed largest for themes 3, 1, and 2. Disgust loomed largest for themes 1, 2, and 11 (see Figure 5).

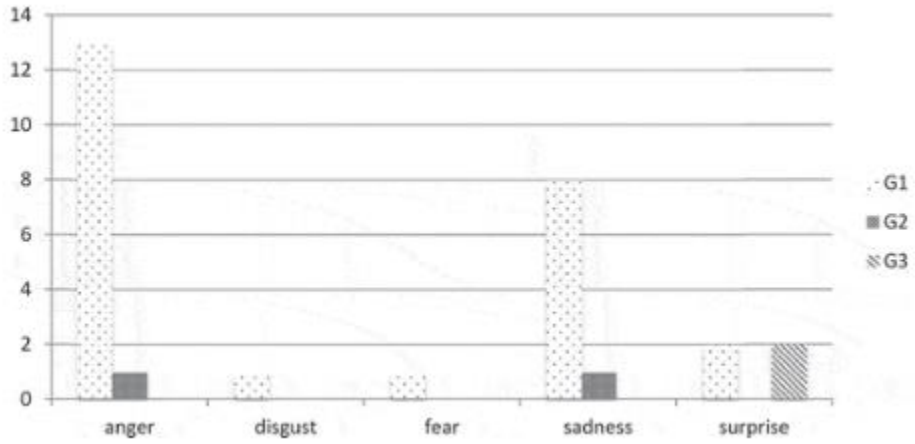
Figure 5. Prominence of emotions (overlaid against themes) on ChannelNewsAsia Facebook page.



The Straits Times

The vast majority of the articles in *Straits Times* scored "neutral" on emotion. This is not surprising, as the press's standards of professionalism, its self-correcting nature, and the threat of lawsuits tend to decrease deliberate journalistic bias and distorted news reporting (Gans, 1985). Nonetheless, the three most prominent emotions in the *Straits Times* coverage of the haze were anger (14), sadness (9), and surprise (2) (see Figure 6).

Figure 6. Prominence of emotions (overlaid against themes) in *The Straits Times.*



To determine whether a specific medium (e.g., social media, online forum) amplified emotions during the haze, the Pearson's chi-squared test was used. The researchers found that the difference between the expected and observed chi-squared scores for each of the five emotions expressed on HardwareZone was insignificant (*p* value = .18), indicating that the online forum did not amplify emotions during the haze (see Table 1). The researchers conducted the same test on Facebook and found that the medium did have an effect on the type of emotion expressed on the platform (*p* value = .01) (see Table 2).

Table 1. Pearson's chi-squared test (*The Straits Times*/HardwareZone).

	Observed		Expected	
Emotions	*Straits Times*	HardwareZone	*Straits Times*	HardwareZone
Anger	14	102	9	107
Disgust, fear	2	56	5	53
Sadness	9	134	11	132
Surprise	2	27	2	27

Table 2. Pearson's chi-squared test (*The Straits Times*/ChannelNewsAsia Facebook page).

	Observed		Expected	
Emotions	*Straits Times*	Facebook	*Straits Times*	Facebook
Anger	14	732	7	739
Disgust, fear	2	775	7	770
Sadness	9	1,226	11	1,224
Surprise	2	307	3	306

Discussion

At first glance, the number of haze-related articles in *The Straits Times*—161—is remarkable for an 8-day period. The number of haze-related comments on Facebook (43,415 posts) in the same period is similarly notable. However, the number of posts on HardwareZone and Facebook declined substantially after June 24, 2014, and June 26, 2014, respectively—even though the haze continued to plague Singapore for another few weeks. The very early peaks in the number of comments on both HardwareZone (on June 19) and Facebook (on June 17) coincided with two significant events: Jun 17 marked the first time in 16 years

that the PSI level hit a record high of 155, while June 19 marked the first time ever that the 3-hour PSI reading (321) reached the hazardous zone (Wikipedia, n.d.). This suggests two things: One, spikes in online risk amplification appear to be strongly influenced by unprecedented, newsworthy events. Two, the rapid drop in online amplification may be explained by the absence of subsequent unprecedented events, and by a sense of resignation and "fatigue" setting in among Singapore residents. For example, the posts indicate that residents seemed to believe their response to the hazardous haze levels was limited to the option of staying indoors.

The absence of any relationship between the online forum and mainstream newspaper, on the one hand, and emotions on the other may be explained by the very nature of the risk event: The haze is immediately palpable to virtually all Singapore residents, so everyone had "equal access" to, and direct experience of, the hazard—that is, everyone could very quickly see and smell the haze and ascertain for himself or herself the seriousness of it. As people's emotional reactions to risks are influenced by personal exposure to risk outcomes or personal experience with those outcomes (Loewenstein et al., 2009), the authors postulate that the ubiquity of the experience (and the amount of mainstream newspaper coverage devoted to it) significantly reduced the knowledge gap (Tichenor,P, Dohonue, & Olien, 1970) among individuals and groups and, thus, the opportunity for risk amplification.

On the other hand, the fact that Facebook had an effect on emotions (while HardwareZone did not) may be attributed to the very nature of a forum: A forum tends to encourage longer, more thoughtful posts and thus more balanced—and less emotional—viewpoints.

The prominence of sadness on Facebook and HardwareZone may be accounted for by Singaporean society's passivity (see Wee, 2007). Moreover, as the haze had been an annual occurrence since the 1990s, many residents were likely resigned to the futility of measures aimed at stopping it.

Anger was the second most prominent emotion on Facebook and HardwareZone. In the case of HardwareZone, anger was partly linked to the fact that N95 masks were sold out early in major drugstores and other retailers. Online commentators blamed the Singapore authorities for their "failure" to anticipate the haze crisis and for having insufficient stock of the masks. Anger was also associated with the PSI readings—not just that they were high, but also that they were not useful in helping citizens to assess the level of hazard posed by the haze. Similarly, the anger expressed in the Facebook comments was partly directed at the Singapore authorities for not declaring a public "holiday," especially as the PSI levels were high.

The coexistence and co-prominence of sadness and anger for all themes on both HardwareZone and Facebook (except for theme 14) suggest that anger may be linked to a sense of futility. In other words, it is possible that a sense of futility may—under certain conditions—breed anger. For example, Facebook users felt both sadness and anger about the aggravation of the haze crisis by the outbreak of dengue fever (a "double whammy").

The eminence of anger in the *Straits Times* may, at first glance, seem surprising: After all, Singapore is widely acknowledged to practice development journalism (Cenite, Chong, Han, Lim, & Tan, 2008), which translates into the press playing a nonadversarial, national development role in partnership with the government (Gunaratne, 1999; Massey & Chang, 2002). Nonetheless, most of the anger is expressed in the *Straits Times' Forum* page, which acts as a controlled platform for the expression of differing views by the public. For example, a few of the *Forum* page letters challenged the National Environment Agency's (NEA) wisdom of using the PSI as the sole barometer and suggested that particulate matter (PM) readings were in fact more revealing of the hazard level. As Singapore's strategic relationship with Indonesia makes it very difficult for the Singapore government to publicly criticize the Indonesian government for its handling of the haze crisis, the *Forum* page in the state-controlled *Straits Times* acted

as a "diplomatic" conduit for national anger, as the anger was expressed in the voices of ordinary Singapore citizens instead of government officials.

This study has several implications for communication managers, particularly those working for government agencies. First, the emotionally intense and time-compressed nature of online posts gives communicators an extremely small window of opportunity for intervention. Hence, they need to have an issue management and crisis response plan in place that is tailored for the 24/7 online environment.

Second, even though the Singapore authorities provided assurances to the public—through the mainstream media—that sufficient N95 masks were available for every single citizen, they did not attempt to address the groundswell of anger online. Left unaddressed, the anger could undermine—in a matter of hours—public trust in government bodies at precisely a time when it is most critical (i.e., during a crisis). The online debate surrounding the relative utility of PSI versus PM2.5 readings also shows that authorities no longer have a "stranglehold" on risk information—their expertise is open to contestation and even ridicule in the online world. Therefore, the authorities should make a more concerted effort to foster conditions for public participation during a health or environmental crisis. According to Webler (2014):

> Theory and evidence suggest that people will find decision outcomes more acceptable if they feel that all voices, in any way relevant, were heard, that the best arguments available were brought to bear, and that the unforced force of better argument determined the results. (p. 137)

Conclusion

This is possibly one of the first studies on the amplification of health-related environmental risk on the Internet to incorporate sentiment and thematic analytics. Moreover, it is based on a data set that spans two Internet platforms and a mainstream newspaper. Classical SARF studies have largely neglected the role of the medium and mainly focus on the portrayal of the risk event by social amplification stations. This study contributes to the literature by studying and showing that the medium matters: A social networking site (i.e., Facebook) had an effect on the amplification of emotions, while an online discussion forum (i.e., HardwareZone) and a mainstream newspaper (i.e., *Straits Times*) did not. Last but not least, the study shows that spikes in online risk amplification are strongly influenced by unprecedented events.

Nonetheless, the study has a few limitations. First, natural language processing (NLP) cannot accurately measure the intensity of emotions—the literature suggests that the accuracy of human emotion detectors is around 80% (Wilson et al., 2005). In addition, the study did not account for joy, as there is a tendency for the software program used to conflate sarcasm with joy, and many Facebook users tend to have psycholinguistic styles that bias scoring in the direction of "joyful" posts.

Future studies could empirically investigate whether knowledge gaps influence the social amplification of risk. Moreover, health communication researchers could study whether efforts to address a sense of resignation or futility may help to attenuate social amplification of risk, and thus, public outrage.

Acknowledgments

The authors thank Dr. Jeong-Nam Kim for his helpful comments on an earlier draft of this article.

References

1. Aziz, M. S. (2014, January 10). Singapore among the most active on social media: Report. *TodayOnline*. Retrieved from http://www.todayonline.com/tech/singapore-among-most-active-social-media-report
2. Brenkert-Smith, H., Dickinson, K. L., Champ, P. A., & Flores, N. (2013). Social amplification of wildfire risk: The role of social interactions and information sources. *Risk Analysis*, 33, 800–817. doi:10.1111/j.1539-6924.2012.01917.x
3. Burns, W. J., Peters, P., & Slovic, P. (2012). Risk perception and the economic crisis: A longitudinal study of the trajectory of perceived risk. *Risk Analysis*, 32, 659–677. doi:10.1111/j.1539-6924.2011.01733.x
4. Castells, M. (2004). Informationalism, networks, and the network society: A theoretical blueprint. In M. Castells (Ed.), *The network society: A cross-cultural perspective* (pp. 3–45). Cheltenham, UK: Edward Elgar.
5. Cenite, M., Chong, S. Y., Han, T. J., Lim, L. Q., & Tan, X. L. (2008). Perpetual development journalism? Balance and framing in the 2006 Singapore election coverage. *Asian Journal of Communication*, 18, 280–295. doi:10.1080/01292980802239416
6. Chung, I. J. (2011). Social amplification of risk in the Internet environment. *Risk Analysis*, 31, 1883–1896. doi:10.1111/j.1539-6924.2011.01623.x
7. Chung, J. B. (2012). *Social amplification of risk - learning lessons from the U.S. beef crisis in Korea*. Retrieved from http://www.kent.ac.uk/scarr/events/beijingpapers/Ji%20Bum%20Chungppr.pdf
8. Gans, H. J. (1985). Are U.S. journalists dangerously liberal? *Columbia Journalism Review*, 24, 29–33.
9. Gill, A., & Tan, S. B. (2013). *Transboundary haze: How might the Singapore government minimize its occurrence?* Retrieved from http://lkyspp.nus.edu.sg/wp-content/uploads/2014/01/Transboundary-Haze.pdf
10. Grimmer, J. (2010). A Bayesian hierarchical topic model for political texts: Measuring expressed agendas in senate press releases. *Political Analysis*, 18, 1–35. doi:10.1093/pan/mpp034
11. Grün, B., & Hornik, K. (2011). Topic models: An R package for fitting topic models. *Journal of Statistical Software*, 40, 1–30. doi:10.18637/jss.v040.i13
12. Gunaratne, S. A. (1999). The media in Asia: An overview. *International Communication Gazette*, 61, 197–223. doi:10.1177/0016549299061003002
13. Haze is Singapore's most-searched subject, says Google. (2013, December 18). *TodayOnline*. Retrieved from http://www.todayonline.com/tech/haze-singapores-most-searched-subject-says-google
14. Hofstede Centre. (n.d.). *What about Singapore?* Retrieved from http://geert-hofstede.com/singapore.html
15. Kasperson, R. E. (1992). Social amplification of risk: Progress in developing an integrative framework. In S. Krimsky & D. Golding (Eds.), *Social theories of risk* (pp. 153–178). Westport, CT: Praeger.
16. Kasperson, R. E., & Kasperson, J. X. (1996). The social amplification and attenuation of risk. *The ANNALS of the American Academy of Political and Social Science*, 545, 95–105. doi:10.1177/0002716296545001010
17. Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., … Ratick, C. (1988). The social amplification of risk: A conceptual framework. *Risk Analysis*, 8, 177–187. doi:10.1111/j.1539-6924.1988.tb01168.x
18. Kata, A. (2010). A postmodern Pandora's box: Anti-vaccination misinformation on the Internet. *Vaccine*, 28, 1709–1716. doi:10.1016/j.vaccine.2009.12.022
19. Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2009). Risk as feelings. In R. E. Lofstedt & A. Boholm (Eds.), *The Earthscan reader on risk* (pp. 113–150). London, UK: Earthscan.
20. Massey, B. L., & Chang, L. A. (2002). Locating Asian values in Asian journalism: A content analysis of web newspapers. *Journal of Communication*, 52, 987–1003. doi:10.1111/j.1460-2466.2002.tb02585.x

21. *MCI's response to PQs on misinformation during the haze episode and role of Media Literacy Council* [press release]. (2013, July 8). Retrieved from http://www.mci.gov.sg/mobile/news/media/mcis-response-to-pqs-on-misinfromation-during-the-haze-episode-and-the-role-of-mlc
22. Neely, L. (2014). Risk communication social media. In J. Arvai & L. Rivers III (Eds.), *Effective risk communication* (pp. 143–164). Oxford, UK: Routledge.
23. Nur, N. M. (2014, January 2). Haze was a top trending topic in Singapore in 2013 on Twitter. *CIO Asia*. Retrieved from http://cio-asia.com/tech/internet/haze-was-a-top-trending-topic-in-singapore-in-2013-on-twitter/
24. O'Callaghan, J. (2013, June 24). Singapore, Malaysia face economic hit from prolonged smog. *Reuters*. Retrieved from http://www.reuters.com/article/2013/06/24/us-southeastasia-haze-impact-idUSBRE95N0BS20130624
25. Reynolds, B. J. (2011). When the facts are just not enough: Credibly communicating about risk is risker when emotions run high and time is short. *Toxicology and Applied Pharmocology*, 254, 206–214. doi:10.1016/j.taap.2010.10.023
26. Rodrigue, C. M. (2001). Impact of Internet media in risk debates: The controversies over the Cassini–Huygens mission at the Anaheim Hills, California, landslide. *Australian Journal of Emergency Management*, 16, 53–61.
27. Stelter, B. (2008, March 27). Finding political news online, young viewers pass it along. *New York Times*. Retrieved from http://www.nytimes.com/2008/03/27/us/politics/27voters.html?_r=0
28. Teh, Y. W., Jordan, M. I., Beal, M. J., & Blei, D. M. (2006). Hierarchical Dirichlet processes. *Journal of the American Statistical Association*, 101, 1566–1581. doi:10.1198/016214506000000302
29. Tichenor,P, J., Dohonue, G. A., & Olien, C. N. (1970). Mass media flow and differential growth in knowledge. *Public Opinion Quarterly*, 34, 159–170. doi:10.1086/267786
30. Volkmer, I. (2003). The global network society and the global public sphere. *Journal of Development*, 46, 9–16. doi:10.1177/1011637003046001566
31. Webler, T. (2014). Why risk communicators should care about the fairness and competence of their public engagement process. In J. Arvai & L. Rivers III (Eds.), *Effective risk communication* (pp. 124–142). London, UK: Earthscan.
32. Wee, C. J. W. (2007). *The Asian modern: Culture, capitalist development, Singapore*. Hong Kong: Hong Kong University Press.
33. Westerman, D., Spence, P. R., & Van Der Heide, B. (2011). A social network as information: The effect of system generated reports of connectedness on credibility on Twitter. *Computers in Human Behavior*, 28, 199–206. doi:10.1016/j.chb.2011.09.001
34. Wikipedia. (n.d.). *2013 Southeast Asian haze*. Retrieved from https://en.wikipedia.org/wiki/2013_Southeast_Asian_haze
35. Wilson, T., Wiebe, J., & Hoffmann, P. (2005). Recognizing contextual polarity in phrase-level sentiment analysis. *Proceedings of the Conference on Human Language Technology and Empirical Methods in Natural Language Processing*, 347–354. doi:10.3115/1220575.1220619