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Public expectations of critical infrastructure operators in times of crisis

Introduction

The European Union defines critical infrastructure (CI) as 'an asset, system or part thereof that [is] essential for the health, safety, security, economic or social well-being of people, and its disruption or destruction would likely have a significant impact upon the ability of a Member State to maintain those functions' (Council Directive, 2008). The EU Horizon 2020 IMPROVER (improved risk evaluation and implementation of resilience concepts to critical infrastructure) project has found that an important part of CI resilience is providing a minimum level of service as well as recovering quickly after a shock (Alheib et al., 2016). However, there remains no consensus in relation to what the level of service should consist of or restoration time should be. For actors that meet public needs, such as CI operators, the general public's expectations and tolerance levels should be considered. However, few studies have empirically investigated what members of the public expect in relation to CI during disasters. This paper sets out to address this gap by examining the public's declared capacity to cope with reduced service levels. Since information provision has been found to play a part in expectation management, leading to more reasonable expectations (Bylund & Lille, 1999), it also examines declared expectations of information provision from CI operators. It does so by first presenting a literature review of public expectations of critical sectors as well as of dis- aster related information. After which the methodology of the questionnaires and interviews is revealed, followed by a presentation of the results and then discussion. A number of recommendations for critical infrastructure operators when responding to crisis situations are elaborated in the final section of the paper.

Public expectations of critical sectors

Recent research indicates that there remains an 'expectation gap' between what services the public expect CI operators to provide after a disaster and the CI operators' abilities to do so (Buller, 2015; Iannucci et al., 2013). For example, Charney et al. (2013) found that public expectations of hospital services during disasters were unrealistic and perhaps even 'inappropriate' when compared to the disaster management plans of those organisations. Sperry (2003) found that most people expect telephone lines and electricity to be restored quickly after a disaster event, despite this not usually being the case. These types of expectations were also held by communities affected by Hurricane Sandy in October 2012. Baker et al.'s (2012) survey found that only a very small percentage of residents anticipated that they might be without electricity for a 'sustained period'.

When it comes to critical sectors, expectations appear for there to be a rapid service recovery time. For food and essential goods, people expect to be able to stock up either after receiving a warning or after the disaster event occurs and in general are not prepared in advance (Baker et al., 2012; Sperry, 2003). While it seems that the government and NGOs are the main actors expected by the public to be responsible for the provisioning of essential goods, there also appears to be an expectation that food companies will distribute food free of charge following a disaster (Australian Government Department of Agriculture, Fisheries and Forestry, 2012). Potable water expectations are similar to those for food and essential goods, and in general the public is not prepared to be self-sustaining in the case of water shortages (UK Department for Environment Food & Rural Affairs, 2009; US Environmental Protection Agency, 2011). Regarding transportation, there is an expectation for continued mobility. However, people are willing to use alternative means of travel, such as when NYC subway users walked, biked or carpooled when the subway was closed during Hurricane Sandy (Kaufman et al., 2012). These expectations continue into long term recovery, whereby residents who have lost access to their private vehicles expect there to be an offer of public transportation available, as seen during the 2011 Great East Japan Earthquake and the 2010–11 Queensland Floods (Nakanishi

et al., 2014; Regional Australia Institute, 2013). Overall, the public expect there to be very little disruption to these critical services during disasters, irrespective of the scale of disruption caused by such incidents.

Factors affecting expectations

The expectations about the availability of critical infra- structure services during disasters are subject to be influenced by broadly four factors: previous disaster experience, culture, demographic factors (such as age, gender, education level, or place of residence (rural or city)) and information provision. Public expectations can be directly influenced by previous experience of disasters, leading to a more accurate perception of risk (Helsloot & Ruitenberg, 2004). However, previous disaster experience does not necessarily lead to better preparation in the face of other risks (Helsloot & Ruitenberg, 2004). For example, a study of evacuation behaviours of the public during the 2011 Great East Japan Earthquake found that many were familiar with natural disasters and aware of what to do in the case of tsunamis. However, 'tsunami anecdotes' from older generations led some people to believe that the tsunami wave would be no higher than six metres and arrive no later than 10–15 min after the earthquake. This left them ill prepared for a wave that was an estimated 10–15 metres in height and arrived 30–40 min after the earthquake (Hasegawa, 2013). Disaster events are interpreted through a cultural lens, influencing risk perception, disaster preparedness and response (Furedi, 2007; Hewitt, 2008; Mayhorn & McLaughlin, 2012; The Johns Hopkins & the International Federation of Red Cross & Red Crescent Societies, n.d.). However, the exact role culture plays in public expectations regarding disaster response has yet to be explored empirically. Contradictory findings exist for how demographic factors such as education level and gender affect expectations (Caplan, 2007; Castro Garcia & Reyes Zuniga, 2009; Chamlee-Wright & Storr, 2010). Socio-economic status may affect expectations, with Leitch (2012) finding that people with low incomes often had lower expectations in relation to critical infrastructure than other income groups. Place of residence also plays a part, with rural residents being described as having more realistic expectations than their urban counterparts (Sperry, 2003).

Lastly, information plays a key role in setting expectations, where providing the public with information leads to more realistic expectations (Buller, 2015; Sperry, 2003). When the public is provided with regular updates, their expectations become more in line with operators' capabilities. For example, Bylund and Lille (1999) found that Swedish communities were willing to go without water service for longer periods of time when informed ahead of time.

Public expectations of disaster-related information

Knowing that information provision affects expectations, one must also examine expectations for information during crisis. Indeed, information is required during every stage of the disaster cycle and intensified information-seeking is a normal response to a disaster event (Perko et al., 2013; Tierney, 2009). Due to the speed of modern telecommunication systems and the Internet, the public expect to find real-time information relating to disasters from both traditional and social media sources (Lacey, 2014; The American Red Cross, 2009). Research suggests that people use a combination of communication channels to find information during disasters, as was the case during Hurricane Sandy and the 2011 Great East Japan Earthquake (Burger et al., 2013; Mitomo et al., 2013). Social media generally encourages interaction and dialogue between users (Giroux et al., 2013). This means that certain members of the public may expect to be able to share information, as was the case during the Boston Marathon bombings and Hurricane Sandy (Burger et al., 2013; Fine Maron, 2013). The public also expect a response from emergency services if they post on social media platforms such as Facebook and Twitter (Reuter & Spielhofer, 2017; The American Red Cross, 2009). Another way the public is accessing disaster related information is via emergency and alert smartphone applications; examples include 'Tsunami Alert,' 'Hurricane Pro,' 'Firerisk,' 'LastQuake,' and the French national

government's warning app 'SAIP' (Fallou, 2017). These types of apps meet people's need for timely information, alerts and safety tips and have multiplied over the past 5 years (Bachmann et al., 2015). However, as people tend to use the same media during a crisis as in normal times (Fire Services Commissioner Victoria, 2013; Steelman et al., 2014), alert apps face a challenge that social media does not, as alert apps are useful only in case of disaster, which is hopefully rare.

When it comes to critical infrastructure, citizens are likely to expect CI operators to provide frequent updates on progress related to the restoration of services. During Hurricane Sandy, for instance, customers became increasingly frustrated when power companies refused or were unwilling to give them an accurate timeline for resto- ration of electricity and other key utilities in affected areas (Pramaggiore, 2014). Hence, power companies are expected to provide information to customers in the wake of extreme weather events (Lacey, 2014). A similar finding emerged from a study conducted by Reuter (2015), which suggested that citizens expected information relating to the cause of a power outage and the expected duration of the 'blackout' to be shared. Reuter (2015) concluded that CI operators should make this critical information available for smartphones. Some operators are currently meeting information needs by making use of social media, which is often accessed via smartphone. After Hurricane Sandy, New York's Metropolitan Transportation Authority (MTA) regularly updated its service map to show only which routes were functional on their website, Twitter and Facebook and PSE&G used Twitter to update the public about the daily locations of their tents and generators (Fine Maron, 2013; Kaufman et al., 2012). Since 2015, ERDF, the top French electricity provider, has a smartphone application that provides updates to the user when a power outage occurs.

Methodology

Research questions

Specifically, three Research Questions emerged from the literature reviewed above:

(1) What do European citizens think is an acceptable level of disruption to critical infrastructure during a disaster?

(2) What do these citizens expect of CI operators in regards to information provision during such an incident?

(3) How do these expectations compare to the current practices of European CI operators?

In order to investigate these questions, the IMPROVER project designed an online questionnaire and inter- view-based study. Ethics approval was sought and obtained from the respective authorities prior to data being collected.

Questionnaire

The target population for the questionnaire was adults aged 18 years and over who were familiar with, but not the operators of, the four IMPROVER Living Labs. Living Labs are clustered regions of different types of infrastructure which provide specific services to a city or region. These were: Barreiro Municipal Water Network, Oresund Region, Oslo Harbour, and French transportation net- works (roadways). Convenience sampling was used. In order to maximise the response rate, the questionnaire was translated into the six languages spoken around the Living Labs (English, French, Danish, Swedish, Norwegian, and Portuguese). For the purposes of this questionnaire, respondents were presented with the following definition of a disaster: 'an event which has catastrophic

consequences and significantly affects the quality, quantity, or availability of the service provided by the critical infrastructure.' Respondents were asked questions regarding the immediate post-disaster phase.

It was structured as follows: first, a brief description of the project was provided and participants were informed of their right to withdraw from the project at any time, as well as how all data would be handled during the project. Regarding the minimum acceptable level of service, questions were asked for the three sectors most relevant to the Living Labs: essential goods, potable water and transportation. Respondents were presented with four below normal service level scenarios (for example, for drinking water: Bottled drinking water provided), which they had to state whether they were willing to accept the given reduction in service. After which, they then had to choose the maximum amount of time they would be willing to tolerate said disruption (from 'hours,' 'days,' 'weeks,' 'months,' to 'years,' or 'not at all'). Likert scale systems were used for the information provision questions. The questionnaire also asked about the participants' demographics. While the literature review found that place of residence (rural or city) does play a part in influencing expectations, due to requirements from the project's ethics board, this factor was not asked of respondents and as such could not be studied here. The same is true for income level. The full questionnaire is available in the Appendix. Data from the questionnaire were collected between 28 March 2016 and 30 April 2016. The questionnaires were translated back into English at the data entry stage. The questionnaire was disseminated through the project's consortium partners' contacts as well as through the Living Labs.

Questionnaire sample characteristics

A total of 403 participants completed the online questionnaire. Due to the dissemination method, this self-selected sample was not broadly representative (at least by age, sex or education level) of the European population, nor of the Living Lab populations. Sample characteristics showed that 57% of the respondents were men, 41% were women and 2% chose not to answer that question. Most were highly educated, with 77% reporting that they have a university degree or higher qualification. Both young and old people appeared to be underrepresented in the study. Respondents aged 18–24 accounted for only 8% of the total sample, with 16% identifying themselves as aged 55 years and above. While 26 nationalities were rep- resented, 88% of the questionnaire sample is made up of French, Norwegian, Portuguese or Swedish respondents. However, due to the limitations in the sampling method no generalisations about the attitudes of citizens in these countries should be made. Social media users makeup 90% of the respondents. Regarding previous disaster experience, 50% of the respondents have experienced a disaster.

Interviews

The findings were then compared to the current practices of CI operators based on 22 semi-structured interviews with CI operators and other relevant stakeholders. Interviewees came from France, Sweden, Norway, Denmark and Italy. An in-person interview took place with actors from all four Living Labs. Experts were selected for interviews based on their experience in working with disaster management, disaster risk reduction, and/or resilience. Experts were interviewed in person as well as via telephone. The findings were then analysed using critical thematic analysis (Braun & Clarke, 2006). The interview guide is available in the Appendix. Data from the interviews was collected between January and May 2016.

Questionnaire results

Minimum level of acceptable service

Findings suggest that the public are willing to tolerate at least some reductions in the level of service for the three sectors studied (essential goods, water and transportation). When presented with the scenarios for each sector, 2% or fewer respondents declared they would not tolerate any reduction in service. Similarly, when asked about how long they would be willing to tolerate a given service disruption, very few respondents (6% or less) selected 'not at all.' The public is in general willing to tolerate disruptions for either 'days,' 'weeks' or 'months,' depending on the disruption, as will be demonstrated in the following paragraphs. This section will first examine the results by sector (acceptability of scenario followed by acceptable duration), and then look at demographic factors affecting tolerance levels. Indeed, tolerance levels were found to vary depending on age, education level, nationality, and previous disaster experience.

Essential goods

For essential goods, respondents were asked about the following four service disruption scenarios: International aid/food drops required; Rationing; Essentials only; and Limited supply of fresh produce. When asked if they are willing to tolerate the disruptions, all scenarios appear to be well accepted, as all are tolerated by 62% or more of respondents. Differences among the acceptable length of time for each disruption are apparent (see Figure 1). International aid is mainly accepted on the short-term, as most respondents believe they could tolerate this reduction for only days (31%). For Essentials only, Rationing, and Limited supply of fresh produce, weeks was selected by the most respondents (35, 34 and 36%, respectively).

Water

For water, respondents were asked about the following four service disruption scenarios: drinking water from tanks provided (need to boil before drinking); bottled drinking water provided; water still in tap, but restrictions on water usage (need to boil before drinking); and reduced pressure. When asked if they are willing to tolerate the disruptions, all respondents agreed that they would tolerate a disruption. Bottled drinking water; drinking water from tanks; and water still on tap were selected by over 40% of respondents, while only 33% chose reduced pressure. Once again differences in acceptable length were found (see Figure 2). Drinking water from tanks is mostly accepted in the short term with 42% of respondents selecting days. On the contrary, reduced pressure appears to be well accepted on the long term, as 40% of respondents selected months. Water still in tap and bottled drinking water have similar levels of acceptance among the respondents; they are quite well accepted for weeks (34% and 28%, respectively) and months (27% and 26%, respectively).

Figure 1 here

Figure 2 here

Transportation

For transportation, respondents were asked about the following four service disruption scenarios: transportation for emergency services only; alternative means (for example, trains as opposed to private car, ferry instead of bridge); local diversion; or reduced capacity or frequency of service (for example, trains going every half hour instead of every 10 min). When asked if they are willing to tolerate the disruptions, Transportation for emergency services only was the least chosen option at 65%. The other three disruptions were selected by 80% or more of respondents. When asked for how long respondents would be willing to tolerate the reduction in service, differences appeared (see

Figure 3). Most respondents are only willing to tolerate transportation for emergency services only for hours or days (25% and 37%, respectively). On the contrary, for reduced capacity, local diversion and alternative means most respondents selected months (40, 36 and 30%, respectively).

Factors affecting expectations

Another finding from the questionnaire is that tolerance of reduction in service may vary across age groups, education level, previous disaster experience and gen- der, however not all of the time. On average, younger respondents are either equally or more accepting of service reductions and are willing to wait equally or longer before services are restored than older respondents. For example, International aid/food drops required disruption in the availability of Essential goods is accepted by 87% of 18–24-year-old respondents compared to 45% of respondents 55 years or older. Most 18 to 24 year old respondents (42%) chose months as the maximum duration of a transportation diversion, whereas respondents 55 years or older mostly chose weeks (40%) (Figure 4).

Previous disaster experience appears to make respondents more willing to tolerate a Limited supply of fresh produce (79% compared to 68% of people without previous experience) as well as more willing to have Drinking water

Figure 3 here

Figure 4 here

from tanks (at 60% with previous experience compared to 47%). The questionnaire results show no clear gender differences in terms of expectations between men and women, except for water. For each water disruption, there are proportionally less women who say they will accept it than men (the difference goes from four to eight points). Education level seems to influence heavily the acceptability of the minimum level drinkable water service that would be tolerated during a crisis (for Bottled drinking water, going from 55% for university level or higher to 20% for other) (Figure 5).

Nationality also appears to contribute to expectation levels. In general the Portuguese respondents have the highest expectations and are the least likely to tolerate a reduction in service (when compared to French, Swedish or Norwegian respondents, the other nationalities studied). For example, Portuguese respondents feel that they can tolerate Rationing as a short-term solution only, selecting weeks (41%), whereas French, Norwegian and Swedish respondents feel it is a more long-term solution, selecting months (31, 37, 39%) (Figure 6).

Public expectations of disaster-related information provided by critical infrastructure operators

The questionnaire found that every respondent expected CI operators to provide information during the crisis via at least one media channel (telephone hotline, social media, website or traditional media). Respondents clearly expected to be able to find information from CI operators through traditional media, as 78% of them strongly agree with this statement (Figure 7). Still more than half (57%) strongly agreed that they expect to be able to find information on the CI website. Forty-nine per cent of respondents strongly agreed that social media should be used. The least chosen option was via calling a telephone hotline, with only 30% of respondents strongly agreeing.

Figure 5 here

Figure 6 here

Figure 7 here

The study also found that expectations of information provided by CI operators during crisis situations varied according to different age groups, previous experience of social media use, and nationality. Social media are proportionally more selected by the youngest respondents. Seventy per cent of 18–24 year old respondents strongly agreed that they expect to be informed through social media, against for example only 37% of 55 years old and older. Similar correlation has been found for information on the website, with 94% of 18–24 year old respondents strongly agreeing against only 38% of 55 years and older. Those who declared that they were regular social media users were the most likely to expect to receive information from CI operators on these platforms. Indeed, 78% agreed or strongly agreed with this proposition, in comparison to only 29% of those who do not use social media sites.

Figure 8 here

Social media non-users mostly (47%) declared that they are unsure or neutral. No difference was found between these two groups regarding expectations to be able to get information via the other media channels. Lastly, there were no observable differences in terms of expectations of the media channels used by CI operators during crisis situations based on gender or education.

When asked if they expect CI operators to respond to their questions and comments on social media, 56% of respondents agreed or strongly agreed (Figure 8). Again, social media non users mostly responded that they were unsure or neutral on this topic (44%) and agreed less than social media users. Moreover, we also found that more than 50% of respondents who expect CI operators to provide information on social media also expect them to respond to their questions and comments. No significant differences linked to sex, age or education were found in the responses to this particular question. However, these results were probably due to the convenience sampling methods and no generalisations should be made based on these findings.

Interviews: current practices of CI operators

Operators are aware that the public expect fast service restoration

Most operators expressed the opinion that the main public expectation is for services to be restored as quickly as possible. Operators also said the public expect to see that the operator is doing the best they can. As one interviewee put it, '[the] public expect that we are hands on and do our best to minimize downtime.' When asked if operators meet public expectations, only one said that they believe they currently meet expectations compared to four who stated that they do not.

Some CI operators have a strategy to increase disaster preparedness amongst members of the public. The Oslo Harbour Living Lab actors mentioned the Harbour Exercise as a means to increase preparedness. The Oslo Harbour Authority also has outreach programs to the local schools, and even receives the 7th graders for a week to educate them about disaster preparedness. Barreiro Municipal Water Network Living Lab actors also stated that they have undertaken exercises which included local schools and emergency management personnel. Oresund Region Living Lab actors mentioned that they have lots of online publications to help people prepare for disasters. However, all acknowledged the difficulty in getting the public interested in disaster preparedness.

Internet is an underutilised communication tool

Regarding information provision, operators referenced the fact that there is an expectation for the operator to provide the public with information. A Norwegian water sector operator said that

'informing the public about when the services will be restored is just as important as restoring the services quickly.' Despite this, very few CI operators said that they share information with the public during a disaster and instead have put into place communication strategies to inform the authorities and traditional media, either by responding to journalists' questions or by press releases. While six operators mentioned using social media to communicate with the public generally, only two said they use it to communicate about disasters. Another operator mentioned, 'in the future we think social media will be more important.' This is similar to communication via websites, whereby nine said they have a publically accessible website; only three said that they provide disaster related information online. Only one operator mentioned having a smart phone application.

Factors that affect expectations according to operators

Operators mentioned two factors affecting expectations: place of residence and information provision. A Norwegian electrical power production and distribution operator said their experience has shown that there are higher expectations in big cities compared to more decentralised locations, and that people in rural areas adapt better in crises. It would seem that interviewees are divided about whether communicating about disaster can affect public expectations. Five interviewees mentioned that by providing information expectations change, with one interviewee stating, 'open communication is a key for achieving resilient operation.' However, three interviewees were not sure if their communication strategies could affect public expectations. French transportation agents said that when they provide information, users of the infrastructure are more willing to accept increased journey times, and that these same users demand to be informed about any incidents. Another example came from two big storms in Denmark in 2013, which both affected the railway net- work. During the first storm, only limited information was provided to the public. Consequently, it was seen as a 'big mess' and expectations were not met. During the second storm, however, the train operator did provide the public with information, letting them know about reduction in service ability, and the public responded 'very positively,' adjusting their plans and expectations accordingly. Lastly, a Swedish resilience expert discussed the fact that in the 1970s and 1980s there was a defence initiative with local communities that focused on informing them about the capabilities of critical infrastructure during crisis and that this led to more realistic expectations from the public, and how today, 'the situation just isn't as good anymore.'

Discussion

Public appear willing to tolerate service disruptions

The results indicate that the public is willing to tolerate service disruption in times of crisis. This suggests that the expectation gap evoked in the literature is not as wide as previously thought. Few respondents were willing to tolerate reductions for a duration of 'years' however. This is reflective of the fact that as time since the disaster event increases, the desire to return to normalcy also increases. The willingness to tolerate a disruption appears to be linked to the amount of inconvenience a given disruption would inpart on the respondent. Take for example the transportation sector. As was found in the literature review, people expect a mini- mum of mobility, which only allowing emergency services to use transportation infrastructure (the least chosen option with 65%) clearly does not permit. The respondents seem to be willing to seek out new ways of getting around and accepting of increased journey times (80% or higher), again reinforcing the findings from the literature.

The differences in the length of time respondents are willing to tolerate a given disruption demonstrate that inconvenience also determines whether a solution is seen as short term or long

term. For example, the least imposing solution for essential goods is Limited supply of fresh produce, and it is the most accepted on the long term. International aid is seen as a short term solution, which could be due to the added limitations it imposes on the public. For water, it seems that the acceptability of service reduction can also be linked to the perceived efficacy of the measures. For instance in the first hours or days of a crisis, providing water from tanks might be more efficient than reducing pressure. But it is also a more restrictive measure so it is less tolerated on the long term. This could also explain why respondents with previous disaster experience were more willing to tolerate Drinking water from tanks.

Demographic factors appear to affect expectation levels

Nationality seems to be a key factor when it comes to tolerance and expectation levels, however further research would be needed to confirm this. For example, one rea- son that Portuguese respondents seem unlikely to tolerate reductions in the provision of essential goods could be linked to the wheat and bread crisis Portugal faced in 1915–1917 (Wheeler, 1978). Collective memory of this incident might be a factor in the apparent unwillingness to tolerate such disruption but further work (perhaps involving interviews/focus groups with citizens in Portugal) would be needed to verify this. Another factor could be the way in which the Portuguese questionnaire was disseminated (via the Barreiro municipality's Facebook Page), as it was able to reach a greater number of the general public (i.e., people who are not already aware of these issues) than the other language questionnaires, which were mostly disseminated via IMPROVER consortium partners' networks.

Expectations were found to be influenced by previous disaster experience and demographic factors such as gender, age or education level. Differences were found between respondents based on gender only for water. Literature suggests that women are often more responsible for water provision, which may explain this difference (Drolet et al., 2015). However, in general Europe has high equality between men and women and as such more research should examine why there is this difference. Overall, younger respondents seem more willing to accept service disruptions and seem more patient when it comes to service restoration than older respondents. Education level seems to influence the acceptability of the minimum level of service for drinkable water. This may confirm Caplan's (2007) argument that less educated members of the public (i.e., those without university degree) are likely to hold high expectations during disasters. However, as the literature review found contradictory results regarding how education level affects expectations, this difference may have more to do with socio-economic status as in general people with higher levels of education tend to have higher incomes. Furthermore, the lack of such differences for the other two sectors studied may indicate that something other than education is at play. While more research is needed to explore whether these findings are generalizable, these demographic differences are why it is especially important that CI operators are aware of who their public stakeholders are and directly ask them their expectations. This is particularly true in a European context, where the public served by a given CI operator may be made up of neighbouring nationalities and/or cultures.

Crisis information should be provided by CI operators

Results indicate that members of the public expect CI operators to provide relevant disaster related information via both traditional and social media. That all four media channels were chosen by over 50% of respondents demonstrates the demand that the public has for CI operators to provide them with information during crises. Traditional media was the most chosen option (96%), demonstrating its continued importance in crisis communication. CI operators appear to meet this expectation.

Both websites and social media were heavily chosen, demonstrating a desire for information to be pushed directly to citizens. Communication expectations were found to be influenced by age and

social media use. Younger respondents have higher expectations, despite the fact that older respondents are all Internet users and 81% of respondents 45 years or older use social media. It is important to keep in mind that Internet communication is meant to compliment traditional crisis communication methods and not replace them. Furthermore, servers may be affected by the disaster and communication strategies relying exclusively on the Internet are therefore not a robust solution. Literature demonstrates that individuals turn to media platforms that they are already familiar with (Fire Services Commissioner Victoria, 2013; Steelman et al., 2014), and unsurprisingly, social media users had higher expectations for social media use by CI operators than social media non-users. With overall expectations high, communicating via these channels (website, social media) presents CI operators with a chance to increase social resilience and meet public expectations. During interviews, several operators mentioned these expectations. However, very few CI operators said that they share information directly with the public during a disaster, instead prefer- ring to communicate with the authorities or respond to press questions. This indicates that if CI operators change their communication policies accordingly, they could have a big impact in increasing social resilience.

Limitations

This method is not without limitations, however. As dis- cussed earlier, this was a self-selecting sample that was not representative of the demographics in neither the four respective Living Labs nor the European population. The international aspect of the survey may also affect the findings, as social and cultural backgrounds may create different meanings for the scales (Boulan, 2015). Furthermore, people often respond to surveys by providing snap judgments based on available information and may be influenced by emotional or contextual factors (Schwarz & Strack, 1999). Also, respondents may choose to answer in

their own self-interest, claiming to tolerate less so as to not give the CI operators an excuse to perform any lower than absolutely necessary. The opposite may be true, reporting that they are willing to tolerate more than they actually could handle in order to appear heroic. Question wording may also play a part in stated expectations. Research has shown that if you ask someone how concerned they are or even if they are concerned, they are more likely to state that they are very concerned than if the question is asked after asking if the respondent has heard of the issue (Herrmann et al., 1994). Even still, respondents will state concern about issues that do not even exist (idem). Therefore, it would seem reasonable to think that in asking if the respondent expects something, they would be more likely to say yes. This is furthered by the fact that research has also shown that disaster victims rarely passively wait around for someone else to take care of their needs (Quarantelli, 1998), and having high expectations towards CI operators to act in a disaster may indicate a gap between expectations and the ability of citizens to respond to crisis situations. Therefore, additional research including focus groups, interviews, or a representative sample questionnaire should be conducted to provide further insight into the generalisability of the results from this study.

Recommendations for critical infrastructure operators when responding to crisis situations

As previously discussed, no consensus currently exists in relation to the definitions of minimum level or quick recovery when it comes to critical infrastructure resilience. Inputs by the general public were often dismissed with claims of an 'expectation gap'. However, the empirical findings of this study demonstrate that the public is indeed willing to tolerate service disruptions in the case of a disaster. As such, based on the results of the survey and the literature review, the following recommendations are made for CI operators to better meet and manage public expectations and thus, better respond to crisis situations.

Know the public stakeholders and their expectations

One finding is that demographic factors and culture appear to influence expectations, especially between nationalities. This implies that CI operators should know who their public stakeholders are and what their unique expectations might be.

Use their expectations to set appropriate targets for implementation of CI resilience

Once known, public expectations could be used to set appropriate targets for implementation of CI resilience. Furthermore, going beyond basic needs and meeting expectations helps to maintain a good reputation in times of crisis (Barker, 2013).

Share CI specific disaster-related information with the public

If expectations remain unrealistic and outside the capacity of the operator, providing information will lead to more reasonable expectations. Operators should use both traditional and social media. Communicating via the Internet (website, social media) presents CI operators with a chance to increase social resilience and meet public expectations. A communication strategy, encompassing both digital and traditional media platforms, will be developed in the IMPROVER project for CI operators to deploy during each stage of the incident.

Public expectations are dynamic and subject to change. As such, it is important to remember that this is a continuing process and expectations should be reviewed regularly.

Conclusion

After examining public expectations of the different critical sectors studied (food and essential goods, water, and transportation), our findings suggest that expectations are less high than previously imagined. The public does seem willing to tolerate a reduction in service during dis- asters, demonstrating their resilience. The willingness to tolerate a disruption seems to be linked to the amount of inconvenience a given disruption would inpart. There is also an expectation for CI operators to be information providers via traditional media, websites and social media. Expectations were found to be influenced by previous disaster experience and demographic factors such as age, education level, or nationality. For this reason, it is especially important that CI operators are aware of who their public stakeholders are and directly ask them their expectations. Nevertheless, it should be acknowledged that this was a self-selecting sample that was not representative of the demographics in the populations studied. Further work is needed to explore the perspectives of citizens who were not represented or who are unable or unwilling to use the Internet.

Based on these findings, the project developed three recommendations for critical infrastructure operators when responding to crisis situations: know the public stakeholders and know their expectations; use their expectations to set appropriate targets for implementation of CI resilience; and share disaster-related information with the public. Future work will consider the implications of these findings for CI operators and efforts to build community disaster resilience within these Living Labs.

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Appendix
Questionnaire: public expectations for critical infrastructure during and after disasters

1. What is your gender?
    a. Select M/F
2. Please select a country to describe your nationality
    a. Drop down menu of countries
3. Your age
    a. Drop down menu of ages:
        i. 18-24 years old
        ii. 25-34 years old
        iii. 35-44 years old
        iv. 45-54 years old
        v. 55-64 years old
        vi. 65-74 years old
        vii. 75 years or older
4. What is the highest level of education you have completed?
    a. university or college or equivalent
    b. intermediate between secondary level and university (e.g. technical training)

  c. secondary school

  d. primary school only (or less)

5. Do you have an account with a social media site such as Facebook or Twitter?

  a. Yes/No

  b. If Yes, please list a maximum of three sites that you use most frequently

6. In order to establish your familiarity with the living labs, please indicate if you live near…?

  a. Oslo Harbour

  b. Öresund region

  c. Barreiro, Portugal

  d. A4 highway between Paris and Strasbourg

  e. I do not live near a living lab

7. Have you ever experienced a disaster which did not cause any damage, e.g. experienced a hurricane but suffered no personal loss?

  a. Yes/No

8. Have you ever experienced damage from a disaster, e.g. flood damage to your place of residence?

  a. Yes/No

9. If Yes, did you have any assistance during the disaster?

  a. Yes/No

  b. From whom? (select all that apply)

    i. First responders, emergency management personnel, neighbours, volunteers, firemen, police, critical infrastructure operators, others.

10. After a damaging disaster, my minimum tolerance in terms of potable water service is…? check all that apply:

  a. Drinking water from tanks provided (need to boil before drinking)

  b. Bottled drinking water provided

  c. Water still in tap, but restrictions on water usage (need to boil before drinking)

  d. Reduced Pressure

  e. I would not tolerate any change in service

11. After a damaging disaster, I'm willing to tolerate this reduced service of potable water for…? check all that apply:

	Years	Months	Weeks	Days	Hours	Not at all
Drinking water from tanks provided (need to boil before drinking)						
Bottled drinking water provided						
Water still in tap, but restrictions on water usage (e.g. need to boil before drinking)						
Reduced pressure						

12. After a damaging disaster, I would tolerate the following disruption(s) to the availability of essential goods e.g. food (check all that apply):

  a. International aid / food drops required

  b. Rationing

  c. Essentials only

  d. Limited supply of fresh produce

      e.   I would not tolerate any disruption

13. After a damaging disaster, I'm willing to tolerate this reduced service for…? check all that apply:

	Years	Months	Weeks	Days	Hours	Not at all
International aid / food drops required						
Rationing						
Essentials only						
Limited supply of fresh produce						

14. After a damaging disaster, I would tolerate the following disruption(s) to the usability of transportation (check all that apply):
    a.   Transportation for emergency services only
    b.   Alternative means (e.g. train as opposed to private car, ferry instead of bridge)
    c.   Local diversion
    d.   Reduced capacity or frequency of service (e.g. trains going every half hour instead of every 10 minutes)
    e.   I would not tolerate any disruption

15. After a damaging disaster, I'm willing to tolerate a reduced service of transportation for…? check all that apply:

	Years	Months	Weeks	Days	Hours	Not at all
Transportation for emergency services only						
Alternative means (e.g. train as opposed to private car, ferry instead of bridge)						
Local diversion						
Reduced capacity or frequency of service (e.g. trains going every half hour instead of every 10 minutes)						

16. During and immediately after a disaster, I expect critical infrastructure operators to provide me with information:

	Strongly agree	Agree	Unsure, neutral	Disagree	Strongly disagree
Via calling their telephone number					

On their website				
On their social media sites (Facebook, Twitter)				
Through traditional media e.g. interviews with television networks or the radio, press releases				

17. During and immediately after a disaster, I expect critical infrastructure operators to respond to my questions and comments on their social media sites e.g. Twitter.
    a. Strongly agree/agree/neutral/disagree/strongly disagree
18. During and immediately after a disaster, I expect critical infrastructure operators to provide means of evacuation for the local population e.g. providing free buses to safe areas.
    b. Strongly agree/agree/neutral/disagree/strongly disagree
19. During and immediately after a disaster, I expect critical infrastructure operators to open up their facilities for emergency sheltering if needed.
    c. Strongly agree/agree/neutral/disagree/strongly disagree
20. After a damaging disaster, I expect aid from (check all that apply):
    d. Neighbours, volunteers, first responders, emergency management personnel, firemen, police, critical infrastructure operators, others, I do not expect aid.
21. Following a disaster, I expect critical infrastructure operators to aid in my long term recovery.
    e. Strongly agree/agree/neutral/disagree/strongly disagree

Living lab interview schedule

*(1)*Tell me more about your position within _____ (enter name of CI provider).

(2)Who do you consider as your public stakeholders?

(3) How do you communicate with public stakeholders? How often?

(4) Which of these communication channels do you think is most effective? Why?

(5) Do you have a communication strategy in place to communicate with the public during disasters? If so, please give a brief overview of this i.e., when was it introduced, name, organisational structure.

(6) Do you have a plan/strategy to increase disaster preparedness amongst members of the public? If so, please give a brief overview of this i.e., when was it introduced, name, organisational structure.

(7)From your perspective, what do you think the public's expectations are in relation to critical infrastructure during disasters?

(8) What influence, if any, do you think your communication strategies have had upon these expectations? How would you like to influence them in the future?

Relevant questions from expert and operator interview schedule

(1)From your perspective, what do you think the public's expectations are in relations to critical infrastructures during disasters?

(2)Do you have a communication strategy for the public? If yes, how efficient do you think it is? How would you like it to be in the future?