

# WARNING THE PUBLIC: A SURVEY ON ATTITUDES, EXPECTATIONS AND USE OF MOBILE CRISIS APPS IN GERMANY

*Research paper*

Kaufhold, Marc-André, Technical University of Darmstadt, Hessen, Darmstadt,  
and University of Siegen, Siegen, [kaufhold@peasec.tu-darmstadt.de](mailto:kaufhold@peasec.tu-darmstadt.de)

Haunschild, Jasmin, Technical University of Darmstadt, Hessen, Darmstadt,  
[haunschild@peasec.tu-darmstadt.de](mailto:haunschild@peasec.tu-darmstadt.de)

Reuter, Christian, Technical University of Darmstadt, Hessen, Darmstadt,  
[reuter@peasec.tu-darmstadt.de](mailto:reuter@peasec.tu-darmstadt.de)

## Abstract

*As part of information systems, the research field of crisis informatics increasingly investigates the potentials and limitations of mobile crisis apps, which constitute a relatively new public service for citizens and are specifically designed for the dissemination of disaster-related information and communication between authorities, organizations and citizens. While existing crisis apps, such as KATWARN or NINA in Germany, focus on preparatory information and warning functionality, there is a need for apps and research on police-related functionality, such as information on cybercrime, fraud offences, or search for missing persons. Based on a workshop with civil protection (N=12) and police officers (N=15), we designed a questionnaire and conducted a representative survey of German citizens (N=1.219) on the past, current and future use, perceived helpfulness, deployment and behavioural preferences, configurability and most important functionality of mobile crisis apps. Our results indicate that in addition to emergency and weather warnings, crime- and health-related warnings are also desired by many, as is the possibility for bidirectional communication. People also want one central app and are resistant to installing more than one crisis app. Furthermore, there are few significant differences between socio-economic groups.*

*Keywords: Crisis apps, disaster communication, crisis informatics, representative survey, Germany.*

## 1 Introduction

In the past two decades, information and communication technology (ICT) has become a relevant part of responding to crises and fostering public safety against bio-medical or chemical emergencies, large-scale traffic accidents, natural disasters and catastrophes, human-made attacks, terrorism and political uprisings (Olteanu, Vieweg and Castillo, 2015; Palen and Anderson, 2016; Stieglitz, Mirbabaie and Milde, 2018). The corresponding multidisciplinary field of crisis informatics, which seeks to combine knowledge from computer science, information systems and social sciences, largely focuses on the utilization of social media technologies, including artificial intelligence and social media analytics, applied to crisis management and response by emergency services (ES), affected citizens and digital volunteers (Alam, Ofli and Imran, 2019; Kaufhold et al., 2019; Kaufhold, Bayer and Reuter, 2020; Soden and Palen, 2018; Stieglitz et al., 2018). However, an increasing body of research examines the development, evaluation, potentials and limitations of so-called crisis apps. These are understood as mobile

smartphone apps specifically designed by public authorities for the distribution of disaster-related information and communication between authorities, organizations and citizens across different phases of the emergency management cycle (EMC) (Grinko, Kaufhold and Reuter, 2019; Helmerichs et al., 2018; Karl, Rother and Nestler, 2015; Tan et al., 2017). Crisis apps nowadays complement existing multichannel warning systems, such as MoWaS (Modular Warning System) in Germany, to increase urban resilience (Klaft, 2013; Weichselgartner et al., 2018).

Despite Germany being frequently struck by severe floods and storms and recently experiencing terrorist attacks, such as the 2016 Munich shooting and 2016 Berlin truck attack, most German citizens have never experience a crisis and do not consider the risk very high (Guha-Sapir, Hargitt and Hoyois, 2004; Höpfe, 2015; Mirbabaie et al., 2019). The lack of preparation enhances the potential damage inflicted by a crisis, which means locals' threat awareness should be raised and according measures for a higher crisis risk should be supported (German Federal Ministry of the Interior, 2015). Accordingly, existing crisis apps in Germany, such as KATWARN or NINA, which support different crisis types, focus on preparatory information and warning functionality, and provide different degrees of configurability (Kotthaus, Ludwig and Pipek, 2016). Although existing representative studies for Germany examined the citizens' adoption and use of crisis apps, they did not include police-related functionality, such as information on cybercrime, fraud offences, or search for missing persons (Grinko, Kaufhold and Reuter, 2019; Reuter et al., 2019). Furthermore, as research indicates that only 16% of German citizens used crisis apps, ways to incentivize their use and continuance of use have to be explored (Reuter et al., 2017). In order to examine the use, perceived helpfulness, deployment and behavioural preferences, desired configurability and functionality of crisis apps, our paper integrates insights from both civil protection and police officers to answer the following research questions:

- RQ1: What is the citizens' past, current and expected future use and the perceived helpfulness of crisis apps in comparison to other media channels?
- RQ2: What are citizens' preferences on the deployment as well as the information and warning behaviour of crisis app?
- RQ3: What are citizens' demands on configurability, required and most important functionality of crisis apps?

The paper is structured as follows: After discussing related work on the characteristics and continuous use of crisis apps, outlining a research gap (section 2), we introduce the overall method of our empirical study (section 3). More specifically, based on a workshop with civil protection (N=12) and police officers (N=15) for the design of the questionnaire, we address these research questions by conducting a quantitative representative survey with German citizens (N=1.219). We then present the descriptive and statistical results of our survey, also comparing some of them to findings of previously published work (section 4). The subsequent section discusses our findings, the limitations of our study and concludes with potential future work (section 5).

## **2 Related Work**

Since September 11<sup>th</sup>, 2001, ICT have played an increasing role in fulfilling information demands in crises and helping concerned parties communicate with each other (Hughes et al., 2008; Reuter and Kaufhold, 2018). Facilitated by the wide distribution of smartphones and mobile apps, crisis and warning apps have been developed to supplement crisis communication and management efforts (Karl, Rother and Nestler, 2015; Tan et al., 2017). Crisis apps refer to mobile smartphone apps which are designed for the purpose of disaster-related information and communication (Appleby-Arnold et al., 2019). Furthermore, the term warning apps is often used to refer to crisis apps which focus on warning functionality (Reuter et al., 2017). These apps are typically used as a direct means of communication between emergency services and citizens and research shows that crisis apps serve a different audience than social media do (Haunschild, Kaufhold and Reuter, 2020), specifically a group that favours direct, privileged information.

## **2.1 Characteristics and Use of Crisis Apps**

Among the most popular existing crisis apps in Germany are KATWARN and NINA, which deliver warning messages based on the users' GPS coordinates or user-defined locations and offer recommendations for actions as well as general tips (BBK, 2015; Fraunhofer FOKUS, 2018). Furthermore, affected people can inform contact points and tell them to what extent they are affected by the crisis or not. Groneberg et al. (2017) have so far conducted one of the broadest international crisis app comparison based on categories of information (e.g., push notifications, maps, news, organisational information), communication (e.g., social media integration, direct 112 emergency calls, contact directory, "I'm safe" notification) and preparation (e.g., emergency planning, behavioural tips, descriptions of dangers, trainings). They found that the most frequent crisis app functionalities in the information category are warnings, followed by maps and general information or news. The first aspect is also the most expected one, while (potential) users also often wish to receive behavioural advice and to help emergency services by providing on-site information (Reuter et al., 2017). However, communication and preparation functions are less widely spread in crisis apps (Groneberg et al., 2017). A review by Tan et al. (2017) revealed 57 crisis apps, whereof 16 had crowdsourcing, 13 collaboration, 13 alerting and information, nine collating, and six notification as primary purpose. In summary, 86% of the examined crisis apps contributed to the EMC's response phase, while only 26% had functionality contributing to each the mitigation, preparedness, and recovery phases.

One advantage of crisis apps lies in resilience against infrastructure breakdowns such as power outages, providing an additional channel for crisis communication, allowing for ubiquitous usage, utilizing their battery life and providing recommendations for action even offline (Nestler, 2017). In a study of Markwart et al. (2019), people who received warning messages reached a safe spot faster than the control group, showing the apps' positive impact. Furthermore, crisis apps with formalized bidirectional communication functions enhance trust by giving users the impression that they are appreciated contributors (Appleby-Arnold et al., 2019). However, concerning their usage, low familiarity with such apps and their benefits is currently the greatest barrier: As found in a representative survey, only 16% of Europeans have been using crisis apps (Reuter et al., 2017). A following study by Reuter et al. (2019) also shows that risk culture is an important aspect for peoples' expectations in crises and that strong national differences exist in terms of crisis apps: while 28% of the Dutch population reported to have downloaded and used a crisis app, 16% in Germany and Italy, and only 7% in the UK had done so. Despite the findings that many people perceive a civic duty to stay informed and follow authorities' instructions (Appleby-Arnold et al., 2019), retention of such apps appear to be low. This may be due to the limited awareness of their availability, to their infrequent use, or the inadequacy of their design, which results in users' dissatisfaction and deletion of the app. By exploring peoples' wishes and needs, we can induce how an app should be designed to increase their continuous use.

## **2.2 Artefacts Mediating Citizen-Agency Interactions**

Since many aspects of emergency interventions are a government service, the use of crisis apps can be regarded as an element of e-government. E-government means the use of ICT to improve government services and requires organizational change. Digitization is changing the ways in which citizens and agencies interact (Lindgren et al., 2019) and crisis apps are changing crisis communication, data transfer and processing and visualization of information (Tan et al., 2017). As Tan et al. (2017) show, about a third of crisis apps mainly support traditional one-way (one-to-one and one-to-many) interactions, regarding the public as a victim of disasters and as information receivers. About two thirds have followed the trend to (also) support the public's role as in-situ sensors and offsite volunteers, employing many-to-many interactions and/or many-to-one-to-many interactions. In this process, the skills required by citizens to access services or information and to participate can change. But agencies' tasks can also shift from case work towards educating people how to access digital resources (Pors, 2015) or move towards collating of content, alerting and informing, facilitating collaboration and crowdsourcing (Tan et al., 2017). In addition, while general-purpose apps are being used in crises because of peoples' familiarity with these apps, these may not be designed for the special requirements relevant in crises. In

contrast, crisis apps are often less relevant to citizens' day-to-day life but designed to fulfil certain functions specifically in emergencies. While initiatives have already been taken to adjust emergency response to social media activity, for example by Virtual Operations Support Teams (VOST) (VOSG, 2019), this has so far been unexplored regarding crisis apps. This leaves the question open whether citizens' preferences in emergencies are best served by familiar general-purpose apps – requiring emergency services to adapt their organization and processes to these tools – or by designing specific crisis apps, which can be more geared towards emergency services' structures and needs. So far, citizens' expectations have not been analysed with this perspective of required organizational adaption.

However, there is a risk that authority-centred apps will not be highly used by citizens. Tarute et al. (2017) find that continuous use of apps is mainly promoted by design and information quality. Information given by the app must be timely, relevant (Nikou and Mezei, 2013) and necessary (Tarute, Nikou and Gatautis, 2017), while unnecessary information can lead to confusion and dissatisfaction. Other factors affecting user's satisfaction can be the ease of use (mental effort put into handling), privacy aspects, battery drainage (Olubusola, 2015) and ease of access and download (Kim, Kim and Wachter, 2013). While there are many studies on retaining users on health and educational mobile apps, only few studies have explored factors that influence citizens' use of government-related apps. Their findings suggest that trust, performance expectancy and ease of use are the primary factors influencing whether or not such apps are engaged with (Sharma et al., 2018; Susanto, Diani and Hafidz, 2017). Research specifically on crisis apps shows that utility, dependability and output are significantly positive related to continuance, while graphics and input can negatively affect it (Tan et al., 2018). Requirements and perceptions of IT and security are culturally influenced (Sturm and Nestler, 2018), therefore determining such requirements in a representative manner is crucial to designing usable systems. In addition, since crisis apps can help emergency services spread and receive important information, exploring what features are important to potential and current users is paramount to identifying which aspects would make such an app more useful to citizens and whether features could be added that avoid unnecessary information, yet provide value to users despite the infrequent nature of emergencies.

## **2.3 Research Gap**

In crisis informatics, an increasing body of research examines the functionality, evaluation, potentials and limitations of crisis apps (Tan et al., 2017). Published representative surveys based on the Germany population investigated the citizens' adoption and use of mobile apps for civil protection (Grinko, Kaufhold and Reuter, 2019; Reuter et al., 2019). However, they did not provide insights on police-related functionality, which was requested by workshop participants (section 3). In addition, a risk perception paradox has been identified, which shows that a high perception of being at risk regarding natural hazards does not mean that precautions are being taken by citizens (Wachinger et al., 2013). Being reminded of previous experiences as well as trust in authorities' and experts' advice have been shown to increase citizen preparedness. Despite manifold potentials of crisis apps (Markwart et al., 2019), research indicates that only 16% of German citizens have used crisis apps, and ways to incentivize their use, desired configurability and functionality as well as continuance of use have to be explored (Reuter et al., 2017). In addition, while e-government is often regarded as the use of technology for delivering services to largely passive citizens, crisis research suggests that citizens are capable of participation and self-organization (Wachinger et al., 2013; Kaufhold and Reuter, 2016) and that ICT may promote such active roles (Palen et al., 2010). In studying citizens' demands and preferences, we can deduce which organizational aspects may have to be changed to accommodate participation, different use patterns, to meet citizens' requirements and to be inclusive. Thus, our study seeks to contribute to the knowledge base by examining the citizens' past, current and expected future use and the perceived helpfulness of crisis apps in comparison to other media channels (RQ1), preferences on the deployment as well as the information and warning behaviour of crisis app (RQ2), and demands on configurability, required and most important functionality of crisis apps (RQ3). In addition to including questions that are particularly relevant to practitioners identified through a workshop, the analysis is based on a representative sample of the German population, which allows identifying usage patterns and the effect of socio-demographic factors and attitudes towards trust on the use and preferences towards crisis apps.

### 3 Empirical Study: Representative German Survey

#### 3.1 Survey Design

On the 13<sup>th</sup> of February 2019, we conducted a workshop at a German central federal police agency that dealt with the use of mobile apps in crises, comprising civil protection (N=12) and police (N=15) officers. At the start we introduced the procedure for conducting a representative survey and the aim of this workshop to generate a questionnaire. Examples of closed and open-ended questions were introduced. After the presentation, the workshop comprised of three phases: In the reflection phase (10 minutes), based on their individual creativity, participants were instructed to note their ideas or questions on moderation tasks. In the presentation phase (20 minutes), participants presented their ideas and we subsequently arranged them thematically on a flip chart. The participants were encouraged to write down further ideas during the presentation phase. Finally, in the discussion phase (60 minutes), based on the group's collective creativity, participants discussed existing moderation cards, generated new ones and reflected upon their thematic grouping. In an integration phase, the workshop results were combined with a previously published survey (Grinko, Kaufhold and Reuter, 2019), whereof two questions (Q1, Q3) were re-integrated and extended to compare two datasets, resulting into seven distinct questions:

- **Helpfulness and Use of Crisis Apps.** Firstly, we designed two questions since officers were interested in the past, current and future use of crisis apps (Q1) and the perceived helpfulness of media channels in previous crises (Q2), which could impact the depth and breadth of their analysis and communication strategies.
- **Attitudes and Sharing Behaviour regarding Crisis Apps.** Secondly, we designed two additional questions since officers were interested in the citizens' attitude (Q3) and sharing behaviour (Q4) using crisis apps as a more detailed picture on motivations and fears would help them to feasibly adapt their communication strategy.
- **Configurability and Functionality of Crisis Apps.** Lastly, to further improve their analysis and communication strategies, emergency services were interested in citizens' expectations towards the configurability and functionality of crisis apps. Thus, we integrated three questions on the overall configurability (Q5), desired (Q6) and most important (Q7) functionality of crisis apps.

#### 3.2 Data Collection and Analysis

After two rounds of feedback from the central federal police agency, the finalized questionnaire was self-hosted through LimeSurvey, then sent to the commercial and ISO-certificated panel provider GapFish in May 2019, which ensures random sampling and representativeness according to age, gender, regional distribution and education. The survey covered the above dimensions which translated into seven closed and four socio-demographic questions about age (continuous 14-87 years), education (5-point ordinal scale "no school diploma" to "university degree"), urbanization (4-point ordinal scale "less than 5.000 inhabitants" to "more than 100.000 inhabitants"), gender (3 categories, "male", "female" "other"<sup>1</sup>, "no answer"). The definition of emergencies as unforeseeable events (such as epidemics, earthquakes, fires, big accidents, or floods) that impact several people and require immediate action to minimize negative consequences was given before the relevant questions. Information and warning apps were defined as smartphone applications that can provide information on how to behave before, during and after an emergency, and that can warn about imminent emergencies such as an attack, a bomb discovery, multiple vehicle collision, or storms. For all generated items, we followed guidelines for valid item design, including phrasing positively, clearly, short, concisely, and understandably, limited to one statement per item and avoiding leading questions (Moosbrugger and Kelava, 2012). Though items should be related to the present (Mummendey and Grau, 2014), due to the infrequent nature of emergencies, we resorted to previous experiences, so potential effects of remembering should be taken in account in interpreting the results. Questions are either on a 5-point interval Likert scale (allowing for

---

<sup>1</sup> Since only one respondent identified as "other", the category could not be used for analysis due to the small group size.

“no response”) to evaluate the degree of agreement with a statement or the judgement of relevance of functions and design features. One categorical variable reveals the respondents’ experience (16,5% were currently using an app, 26% had previous or current experience) and awareness of different warning and emergency apps. After elimination of incomplete answers, N=1.219 reliable answers resulted representing the German population in age, gender, geography, urbanization and education (Statista, 2018), of whom 68% had been in an emergency (N=827). An approximation of normal distribution of the data can be assumed due to the sample size (Leonhart, 2008).

We analyse the data using Chi Square tests, Cramer’s V, Kendall’s tau-b, ANOVA, Spearman’s rho and Pearson’s r, depending on the scale of the dependent and independent variables. For the categorical variable “gender”, we applied the t-test for independent samples, paying attention to the assumption of homogeneity of variance through a Levene test. We judge effect sizes of Pearson’s r of  $|0,10|$  as a small, of  $|0,30|$  as a moderate, and of  $|0,50|$  as a strong correlation (Cohen, 1988). For the statistical analysis we use IBM SPSS Statistics Version 26. For each analysis, we chose the test that is most robust and allows for the most fine-grained scale. An exception is made when testing for non-linear correlations, for which data are recoded into categories to test group effects, such as binary categories for those under 25, over 45 and those over 60-years old. We test city size and age for collinearity and find no multicollinearity (VIF = 1). In Q1 and Q3, we furthermore compare the studies of 2017 (N=1.069) and 2019 to see if and how crisis app use patterns and expectations have changed over recent time. The comparison data come from a 2017 survey conducted in Germany (Grinko, Kaufhold and Reuter, 2019).

## 4 Empirical Findings

### 4.1 Awareness, Use and Helpfulness of Crisis Apps (Q1, Q2)

Awareness of crisis apps is currently not widespread in Germany (Figure 1). The German Red Cross’ (DRK) app is the only app that more than 50% of respondents were aware of, followed by Facebook’s Safety Check, KATWARN (of the Fraunhofer Institute for Open Communication Systems) and NINA (of the Federal Office of Civil Protection and Disaster Assistance), which are known only to about a third of the population. Other apps are unknown to about 80% of respondents. But awareness does not equate to usage: Despite being well-known, the DRK’s app is used by only 4% of the population, while the most actively used app, NINA, is used by 12%. Current or former usage varies between 16% (NINA) and only 2% (Safeture). Numbers on future use show a slightly better picture. Here, between 14% (DRK) and 4% (Cell Broadcast) of participants indicate that they would use a certain crisis app in the future. For most apps, the percentages of approximate future use are as high or even higher than those of current or former use. However, there is also a substantial group of respondents (10% - 27%) who are aware of crisis apps, and despite never having used them are not planning on using them in the future.

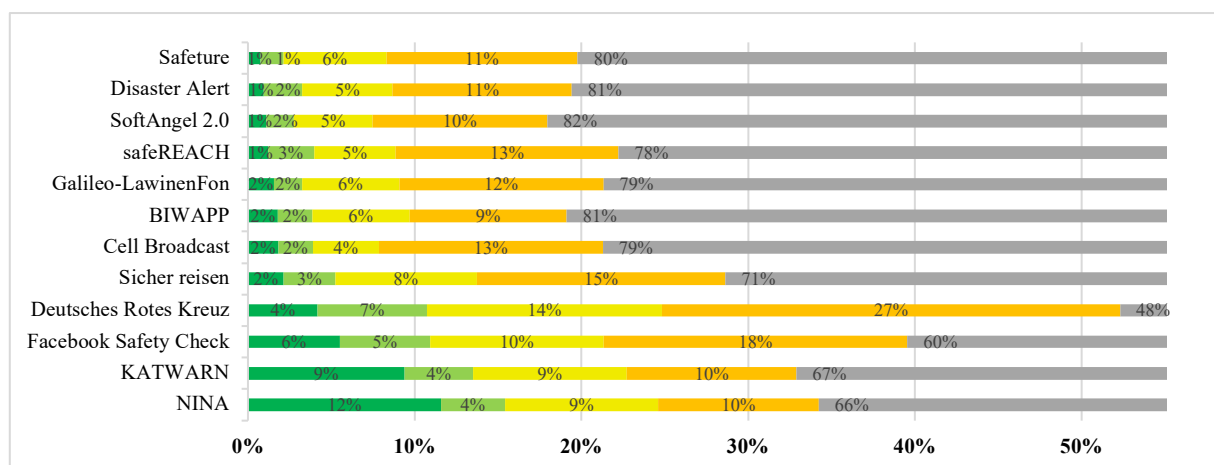


Figure 1. Q1: Use of crisis apps (Yes, I am currently using it, Yes, I have used it in the past (not anymore), Yes, I want to use it in the future, No, neither, I do not know this app)

Looking across emergency apps, 16,5% of Germans currently use any app (19% when including Facebook's Safety Check) and 26% have current or previous experience with a crisis app. This leaves 9,4% of the population having tried out at least one app and discontinued use. Of those, 14% are now using the Facebook Safety Check feature. Looking at those who had used an app, its usefulness is judged positively (63%), more positively than other online sources, including social media. However, personal conversations and especially contact with emergency services surpass apps in their evaluations. An ANOVA shows that neither age ( $p = 0,093$ ) nor gender ( $p = 0,083$ ) have an effect on the evaluation of apps by those who had used them. However, gender is to a small degree significant for whether or not the app was used ( $\chi^2(1) = 12,97$ ,  $p < 0.001$ ,  $\phi = 0,14$ ): Of those who had been in an emergency and had not used an app, 61% were female. Of those who had used the app, 46% were female, and 64% of females had used an app versus 77% of males. In contrast, age (Cramer's  $V = 0,11$ ;  $p = 0,51$ ) and city size (Cramer's  $V = 0,04$ ;  $p = 0,85$ ) do not influence the use of crisis apps in emergencies. While older age (over 65s,  $N = 108$ ) does not decrease the chance of using an app, surprisingly youth (under 25s,  $N = 136$ ) very slightly does ( $\chi^2(1) = 8,175$ ,  $p = 0.004$ ,  $\phi = -,104$ ). Another small non-linear effect can be attributed to education (Cramer's  $V = 0,139$ ,  $p = 0,006$ ), with highest user rates of 75% and 77% among those without school diplomas and those with university degrees. Urbanization is not a significant and relevant factor for the use of a crisis app: neither rural nor urban respondents have significantly more or less experience.

Comparing app use in 2017 with 2019 (Figure 2), an increase in current use can be found across apps and the Facebook's safety feature, with the greatest increase for NINA. Especially NINA has enlarged its current userbase (4% vs. 12%). Furthermore, KATWARN (6% vs. 9%) and Facebook Safety Check (3% vs. 6%) can now report higher figures than two years ago, while Safeture remained at 1%, although it can report higher numbers on future use. A small increase in plans for using crisis apps can also be found for NINA and KATWARN (both 7% vs. 9%), while fewer people are planning on using Facebook's feature (13% vs 10%).

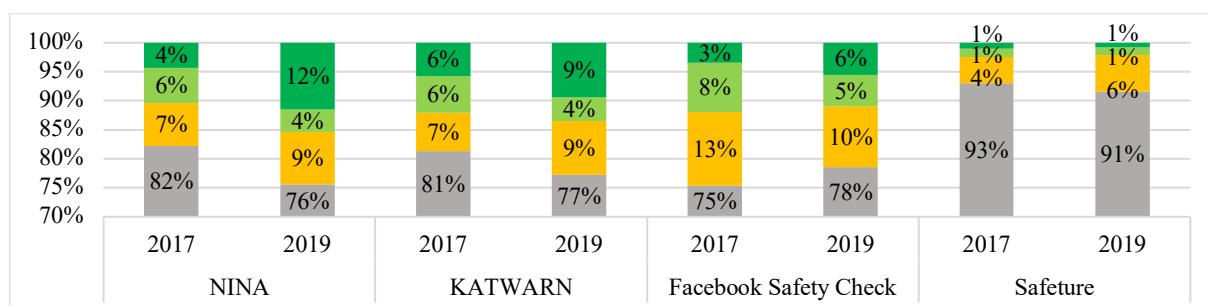


Figure 2. Comparison of crisis apps use (Yes, I am currently using it, Yes, I have used it in the past (not anymore), Yes, I want to use it in the future, Not sure / No, I haven't used it)

Regarding the judgement of helpfulness by those who had been in an emergency and used the source, crisis apps ( $N = 536$ ) are well-rated (Figure 3): 63% rate them as rather or very helpful, surpassing the judgements of social media and other online sources. However, radio, television, personal and telephone conversations and contact to rescue services are generally judged more positively. An analysis of preferences has identified distinct preference groups (Haunschild, Kaufhold and Reuter, 2020): Fans of crisis apps also particularly favour other online sources, contact with emergency services and local announcements, as well as social media. In contrast, those who favour newspapers do not judge apps positively, while they are a success for those who prefer direct contact with emergency services. However, those who like using social media in emergencies do not particularly appreciate apps. This suggests that all sources fulfil particular needs that differ between users. It also indicates that app users in emergencies are a group that particularly seeks out privileged information from emergency services, be it through an app, direct contact or their websites. Other affected people may also be using their mobile phones in emergencies, but they may be fulfilling different needs by accessing social media. Then again, people who contact emergency services are also favourable towards apps, so this is a group that may be particularly interested in crisis apps.



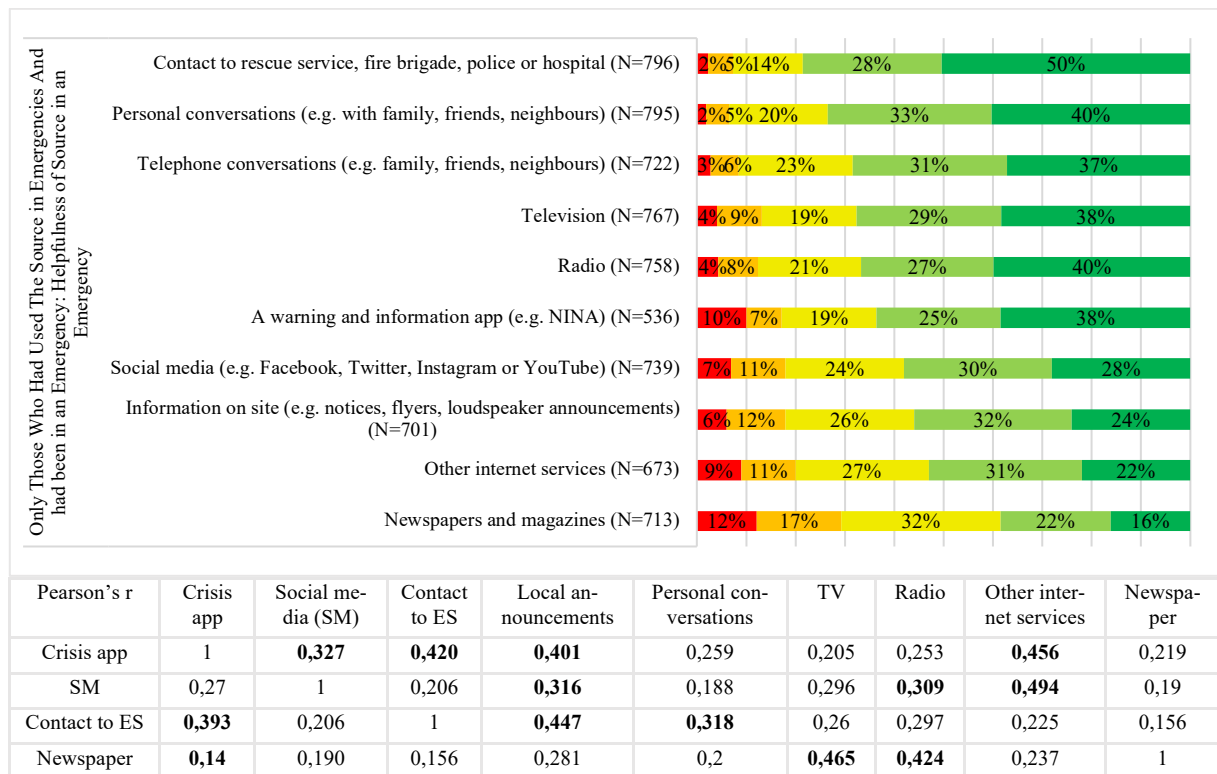


Figure 3. Q2: Helpfulness of and correlations between information sources (*not, not very, moderately, quite, very helpful*)

## 4.2 Attitudes and Sharing Behaviour regarding Crisis Apps (Q3, Q4)

Despite the low crisis app use, almost 70% agree that some form of crisis app implementation is desirable and reasonable. Strong agreement (65%) can be found regarding the wish for centralisation in one standardised app that is fed by several emergency services, which is mirrored by peoples' resistance to installing more than one crisis app (44%). Having an app preinstalled on phones upon purchase is also supported by 55%, while 19% are opposed. However, people mainly want to maintain control over being able to deactivate such a preinstalled app (45%). While a surprising number of people wish for an app to replace other existing information sources (41%), a large portion also oppose this idea (31%). Apps complementing other sources is widely supported (65%). Regarding people's design and implementation wishes for a crisis app, patterns are very similar (56% to 63% approval and 12% to 19% opposition). Most agree that such an app should only send messages in acute emergencies (63%), the status should always be visible on the lock screen, and messages should be sent each time an event is updated. In contrast, 50% are also in favour of only one message being sent for each event. Gender influences a few of these judgements, but only slightly: A t-test for independent samples shows that women are less prepared to have several crisis apps ( $t(1119) = -3,204, p = 0.001$ ), and oppose apps replacing other sources more strongly ( $t(1113) = -1,88, p = 0.06$ ), while they favour the idea of a pre-installed app more strongly than men ( $t(1132) = 2,776, p = 0.006$ ). An ANOVA's  $R^2$  shows that even where significant, age explains less than 2,5% of the observed variation and is therefore not relevantly connected to the judgements made. Support for crisis apps has not changed significantly since 2017 (Figure 4). Although opposition against a standardized app has almost doubled (7% vs. 13%), the overall image shows a majority in favour (68% vs 65%). Support for pre-installed crisis apps has grown from 44% to 55% and resistance against pre-installed crisis apps has also dropped from 26% to 19%. However, while in 2017 the survey did not specify the origin of the pre-installed application, in 2019 it was specified as an app provided by the government, which may also play a role in the increase in support.



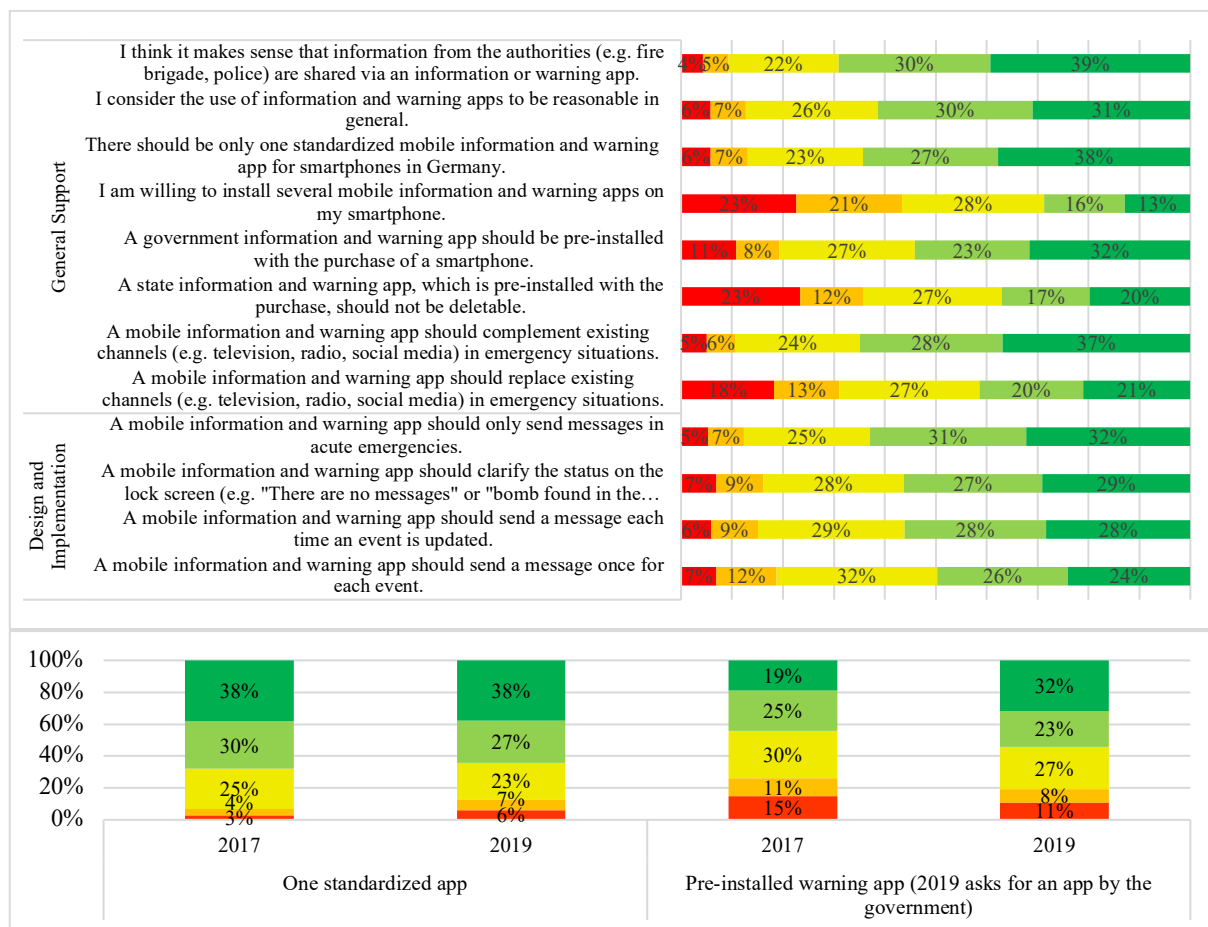


Figure 4. Q3: Agreement to statements and comparison of crisis apps attitudes (strongly disagree, disagree, neutral, agree, strongly agree)

Confidence in secure use of personal data by the police and fire brigades is relatively high (52%) and only 19% have no such confidence (Figure 5). This is supported by the fact that more than 75% of participants would make image or video data available to the authorities and would also transmit live footage during a crisis. On the other hand, 32% indicate that they have no trust in a secure transmission of their location by an app of a private provider and only one third trusts rather than mistrusts software. Despite this mistrust, a majority is prepared to transmit their location automatically as part of an emergency call function or in emergency situations, while 64% would also like to be asked before each location transmission. A large group of smartphone users (42%) would be ready to contribute their phone as part of an ad-hoc network, potentially contributing to infrastructure resilience, which is a major concern regarding app use in crises. A test for Spearman's  $r$  shows significant correlations (all  $p < 0.001$ ) between the statements about data sharing and distrust in the secure use of data. A large effect size is found between distrust towards police and fire departments and distrust towards private companies regarding GPS data transmission ( $r = 0,473$ ), but only a slight negative connection with trust in software generally ( $r = -0,107$ ). Another strong negative connection exists between preparedness to share photos and videos and distrust in ES ( $r = -0,308$ ), while the effect is less strong regarding live transmission ( $r = -0,185$ ). Distrust towards private companies' sharing of GPS data somewhat stops users from transmitting evidence ( $r = -0,076$ ) and only slightly influences their reservations towards sharing GPS information outside of emergencies ( $r = -0,226$ ) and their demands for being asked before transmitting information ( $r = 0,204$ ). General trust in software enhances peoples' readiness to submit GPS data automatically ( $r = 0,396$ ) and to share photos and videos with ES ( $r = 0,196$ ), including live ( $r = 0,223$ ). Gender plays a minor role for some judgements, with women slightly more prepared to share videos and photos (Cramer's  $V = 0,108$ ;  $p = 0.01$ ), live transmission ( $V = 0,095$ ;  $p = 0.037$ ) and they insist slightly more on being asked before transmitting GPS data ( $V = 0,115$ ;  $p = 0.005$ ). However, the connections are not strong

and for many judgements, such as levels of trust, gender is not significant. Along with other studies (Appleby-Arnold et al., 2019; Haunschild, Kaufhold and Reuter, 2020), our analysis finds that age is generally not a relevant factor in crisis communication. In our survey, age only correlates with increased trust in the secure transmission of GPS data to emergency services (Spearman's  $r = -0,125$ ,  $p < 0,001$ ).

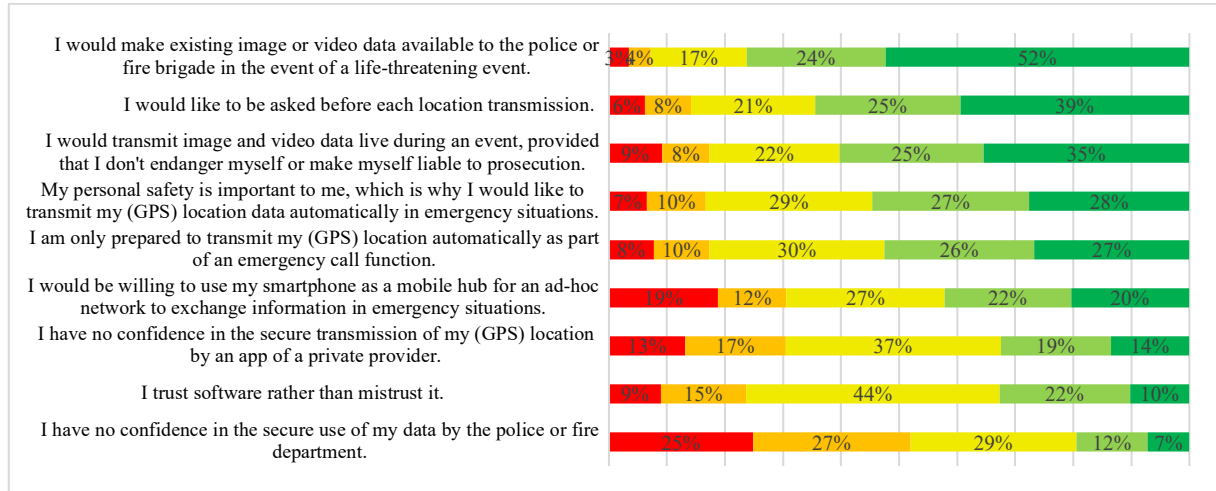


Figure 5. Q4: Agreement regarding statements about willingness to submit multimedia or location data (*strongly disagree, disagree, neutral, agree, strongly agree*)

#### 4.3 Configurability and Functionality of Crisis Apps (Q5 - Q7)

All suggested design features receive wide support (Figure 6). This ranges from 85% support for easy use and being self-explanatory to 61% supporting internationality and 59% multilingualism. More than 90% also consider a senior's mode, location-related information, operability for people with restrictions and the ability to turn on and off certain information types important. Age correlates (all  $p < 0.001$ ) lightly with the wish for specific characteristics: Older people particularly value above all easy ( $r = 0.191$ ) and inclusive usability ( $r = 0,185$ ), followed by a seniors' mode ( $r = 0,172$ ) and self-explanatory design ( $r = 0,171$ ), location specific information ( $r = 0,12$ ) and control over information types ( $r = 0,115$ ).

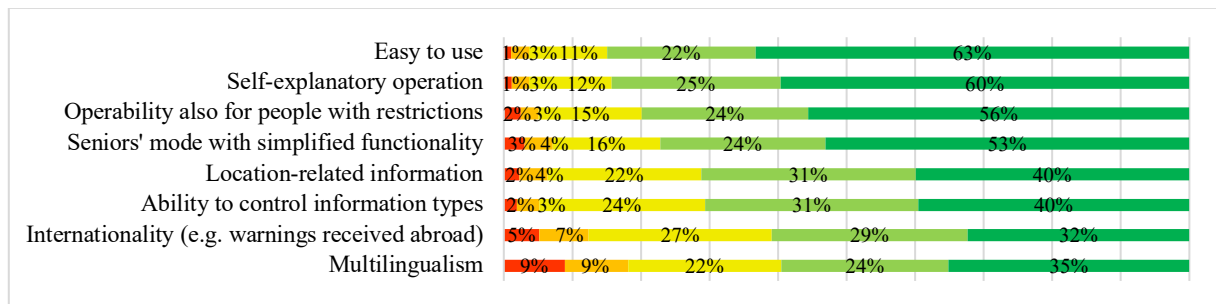


Figure 6. Q5: Importance of characteristics (*not, not very, moderately, quite, very important*)

Regarding emergency functions, both regular emergency calls and GPS enhanced calls are desired by over 75%, while direct messages are also a favoured feature. Over 60% support text emergency messages, a chat function and news tickers are also welcome. The large support for many warning functions shows the relevance of staying informed. While disaster warnings are the most popular feature, crime, traffic, health and weather-related warnings are also hugely supported. Warnings about speed gauges and school cancellation are regarded as less relevant and even encounter some resistance. Over 60% also wish for links to further information and instructions on how to prepare for and how to behave in an emergency. Almost 70% would also like to support the search for missing persons and over half would like to be able to register as volunteers and receive calls for eyewitnesses to come forward. This underlines the collaborative potential of such apps.

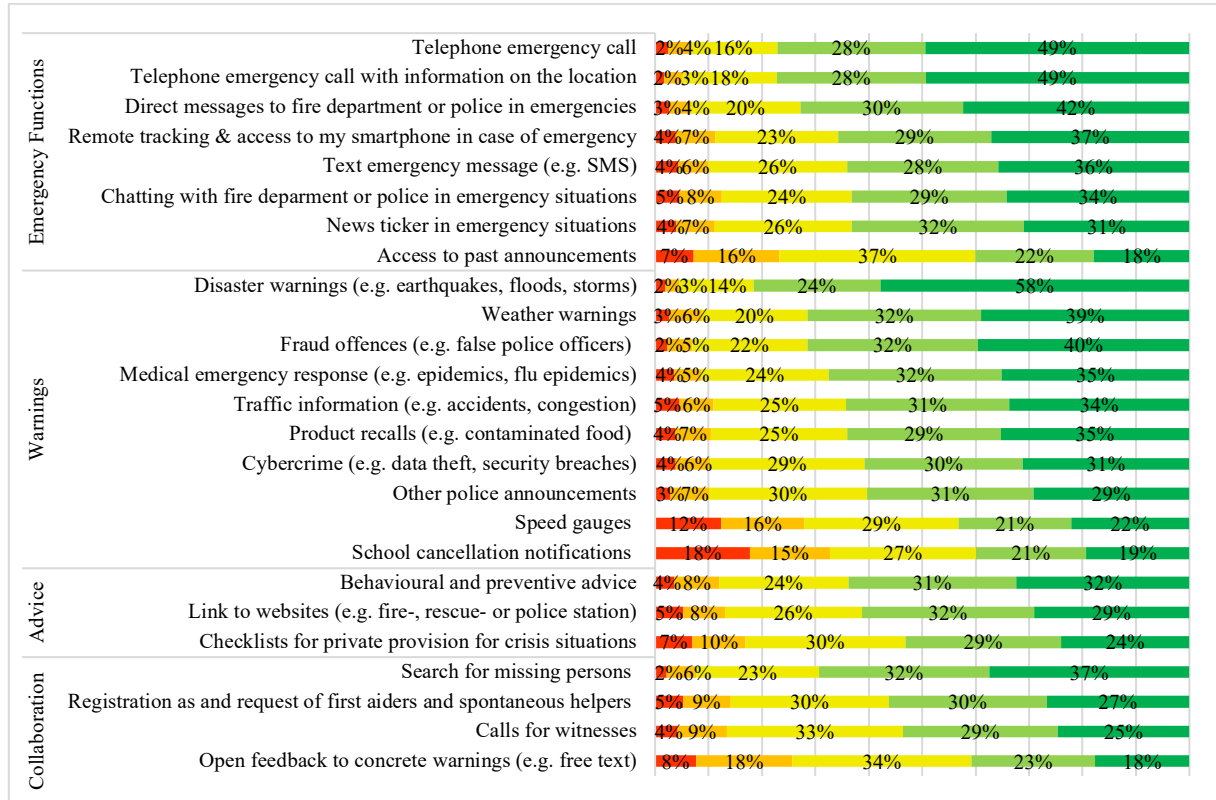


Figure 7. Q6: Importance of functions (not, not very, moderately, quite, very important)

Here, gender plays a small role (Cramer's V between 0,1 and 0,15) for usability and accessibility features, but not for the other design aspects. Women also want to be slightly more involved in the search of missing persons ( $V=0,113$ ,  $p=0,006$ ), but for other collaborative features gender does not play a role. Women are also slightly more interested in some types of warnings (emergency warnings:  $V=0,133$ ,  $p=0,002$ ; police messages:  $V=0,121$ ,  $p=0,002$ , school cancellations:  $V=0,102$ ,  $p=0,019$ , cybercrime:  $V=0,105$ ,  $p=0,014$ ). They are also slightly more interested in direct messages to ES ( $0,144$ ,  $p<0,001$ ), telephone ( $V=0,127$ ,  $p=0,001$ ) and GPS-enhanced emergency calls ( $V=0,137$ ,  $p<0,001$ ), and the access of their remote location ( $V=0,104$ ,  $p=0,017$ ). Analysing the preferences of those who had used an app but are not using it anymore, their preferences do not differ greatly from the others. In contrast to what could be expected, this groups' opinions are generally less extreme (with the exception of whether warnings, where both the groups wanting more and less warnings are bigger). Those who are not using apps anymore also prefer somewhat less advice, less access to past posts and less open feedback on disasters.

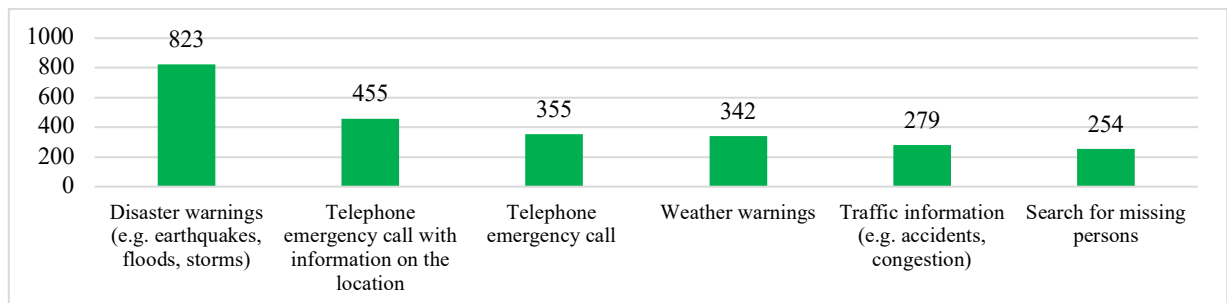


Figure 8. Q7: Most important functions of a crisis app (most frequent mentions)

When asked about the three most important functions of crisis apps (Figure 8), respondents show a clear prioritization of disaster warnings, followed by GPS-enhanced and regular emergency calls. Weather and traffic warnings are also favoured. For 254 respondents, the possibility to assist in the search of missing persons is also a priority.

## 5 Discussion and Conclusion

In this paper, we examined the awareness, use, helpfulness, preferences, as well as favoured configurability and functionality of mobile crisis apps by German citizens. Our survey of a representative sample (N=1.219) of the German population was informed by a workshop with civil protection and police officers and a previously published survey. However, as only two questions were re-integrated for comparative analysis and even extended, the paper contributes by the examination of five new questions. Our results provide insights into the following three research questions.

**What is the citizens' past, current and expected future use and the perceived helpfulness of crisis apps in comparison to other media channels (RQ1)?** We found that NINA and KATWARN are still the most used crisis apps in Germany, which slightly increased between 2017 and 2019. Almost two thirds of the participants who had been in an emergency rated crisis apps as quite or very helpful information source, which however is surpassed by radio, television, personal and telephone conversations and contact to rescue services. Especially those preferring direct contact to ES also like to use crisis apps. Where direct contact is putting a strain on ES or where citizens perceive that ES are too unavailable, promoting crisis apps can reassure particularly this group of citizens and save ES' resources that are under strain in emergencies. The use of crisis apps, which are a relatively new phenomenon, is on the rise and it is not crowded out by other channels or features, such as Facebook Safety Check. However, the analysis of use patterns and attitudes shows a discrepancy between the general support and perceived relevance of such apps and their actual use, which is currently at 16.5% including all relevant emergency apps in Germany. The analysis shows that almost 10% of the population had tested a crisis app at some point but is not currently using any, which calls for additional research on the experience, functionality, satisfaction and usefulness influencing the continuance of use (Fischer, Bonaretti and Fischbach, 2020).

**What are citizens' preferences on the deployment as well as the information and warning behaviour of crisis app (RQ2)?** In general, our participants had a positive attitude towards crisis apps but one of the biggest contentions for users is having to install more than one app, while great support exists for the concept of one single state-supported app, which may even come pre-installed (but deletable) on the smartphone. The finding that people who value apps also value direct privileged information from ES supports this wish for centralization. This suggests that crisis apps are an area where people long for a trusted, centralized actor to combine information from different agencies. In addition, peoples' willingness to allow for apps to be preinstalled shows the positive potential that is expected from such apps and potentially also shows that citizens are aware of the risk perception biases identified in research (Wachinger et al., 2013). This would be in line with their high evaluation of using apps to receive advice. In crisis, they were furthermore willing to transmit their GPS location, image and video data to emergency services as long as they are not endangered. Allowing those measures may be related to the security-sensitive nature of crisis apps.

Investigating under which conditions and in which fields users desire a centralized app and perceive it being preinstalled as legitimate is an interesting question to explore in future research. However, while the availability of many options and the preinstallation of apps are desired, these should come paired with design features that allow to individually configure the types of emergencies that users receive warnings about, as well as the option to delete the app and to communicate with emergency services. While such communication requires resources on the part of ES, the potential for exchanging information, for preparing and guiding citizens before and during emergencies and for engaging them as volunteers and witnesses may outweigh these costs. It should be further explored which institutional changes are necessary to facilitate empowering citizens and enable the co-production of security by citizens and emergency services. One fruitful avenue may be to further explore how VOST or similar "trusted volunteers" could contribute to maintaining crisis apps (St. Denis, Hughes and Palen, 2012). Further personal resources would allow the establishment of bidirectional communication, allowing citizens to report emergencies and situational updates as eyewitness or first responders and ES, for instance, to request additional information from the incident scene (Kaufhold et al., 2018).

**What are citizens' demands on configurability, required and most important functionality of crisis apps (RQ3)?** Besides ease of use and self-explanatory operation, citizens valued operability for

people with restrictions, a simplified senior mode and a high degree of configurability in terms of content- and location-specific information. Here, gender and age to some degree influence preferences. Our results indicate that not only crisis-specific information, but also general, such as product recalls and traffic, and police-oriented information, such as cybercrime, fraud offences and search for missing people, are desired. Still, disaster warnings, telephone emergency calls (with information on the location) and weather warnings were mentioned as the most important functionalities of a crisis app. Since other studies have identified perceived benefit as a major factor shaping whether or not an app is installed, an app that unifies the functions of the available apps and the addition of further warning categories may be positive for increasing usage of crisis apps and providing more value despite the infrequent nature of crises. Especially supporting the search of missing persons is a priority for many. Peoples' interest in contacting ES through the app via direct messages or chat support other findings which have identified the need for bidirectional communication and the relevance of multi-functionality (Kaufhold et al., 2018). In accordance with other findings, we also find that age does not significantly influence peoples' willingness to use an emergency app or their preferences, and neither does urbanisation or education (Appleby-Arnold et al., 2019). Gender also plays only a minor role, which is supported by other findings (Reuter et al., 2019). Supporting previous findings about app functions, natural disaster and weather warnings are the most relevant aspects of crisis apps to users, but we also find that users are willing to receive advice for how to behave. We also confirm that people are willing to use apps to offer support in emergency situations. This indicates that despite Germans' predominantly state-oriented risk culture that emphasizes the states' responsibility in emergencies (Dressel, 2015), there is an interest in taking on active roles as witnesses and volunteers (Kaufhold and Reuter, 2016).

For risk governance and communication, we can derive that the adaptation of a single authorized app and its preinstallation would be welcomed by most. Considering the high willingness to receive advice, administrators could use crisis apps to clarify the limits of state precautions and individual responsibilities and give advice to specific audiences, such as homeowners. This reaches a group that is different from the one using social media in emergencies (Haunschild, Kaufhold and Reuter, 2020). Designers should foster the centralization of a crisis app that includes all branches of ES, such as fire and police departments. Such an app should enhance the users' safety but offer a high level of configurability to provide value despite the infrequent nature of crises, including health and (cyber-) crime related information, as well as varying user or risk group needs. Since users are also interested in participating as volunteers and witnesses, for instance to report incidents and seek missing people, a move towards bidirectional communication is suggested. Due to the willingness to receive advice, designers should also consider segmenting users according to risk-relevant information provided by users, in order to be able to transmit audience-specific advice and nudge vulnerable groups towards taking relevant action.

This paper is subject to limitations: The biggest challenge is that online surveys are biased towards people who engage online. Although the survey provides representative results according to age, gender, geography, urbanization and education, it excludes those people who are most resistant to using technology. The categories for urbanization used here should also be made more fine-grained in the future to further explore the potential differences in behaviour and needs in emergencies of particularly rural areas and very big cities. Furthermore, in multiple questions, a caveat results from capturing emergency services more generally, without differentiating between different types of organizations. Finally, the paper focuses on practical implications, with limited explanatory power. Therefore, future research should explore the role of crisis apps through a theoretical lens, i.e. using the framework of risk cultures, perception bias and nudging, the use of apps for community building sense-making in crises, trust towards authorities and target of blaming if emergency response is not successful (Dressel, 2015; Newman et al., 2019; Shklovski, Palen and Sutton, 2008).

**Acknowledgements.** This work has been co-funded by the LOEWE initiative (Hesse, Germany) within the emergenCITY centre, by the German Federal Ministry of Education and Research (BMBF) and the Hessen State Ministry for Higher Education, Research and Arts (HMKW) within the SecUrban mission of the National Research Center for Applied Cybersecurity ATHENE, and by the BMBF within the research group 'KontiKat' (no. 13N14351).

## References

- Alam, F., F. Ofli, and M. Imran (2019). "Descriptive and visual summaries of disaster events using artificial intelligence techniques: case studies of Hurricanes Harvey, Irma, and Maria." *Behaviour & Information Technology (BIT)*, 1–31. DOI: 10.1080/0144929X.2019.1610908
- Appleby-Arnold, S., N. Brockdorff, L. Fallou, and R. Bossu (2019). "Truth, trust, and civic duty: Cultural factors in citizens' perceptions of mobile phone apps and social media in disasters." *Journal of Contingencies and Crisis Management (JCCM)*, 1–13. DOI: 10.1111/1468-5973.12282
- BBK (2015). *Warn-App NINA*. URL: [https://www.bbk.bund.de/DE/NINA/Warn-App\\_NINA.html](https://www.bbk.bund.de/DE/NINA/Warn-App_NINA.html)
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. NJ Lawrence Earlbaum Associates, 2nd Edition. Hillsdale, N.J.: L. Erlbaum Associates.
- Dressel, K. (2015). "Risk culture and crisis communication." *International Journal of Risk Assessment and Management*, 18 (2), 115–124. DOI: 10.1504/IJRAM.2015.069020
- Fischer, D., D. Bonaretti, and Fischbach (2020). "Effective Use of Mobile-Enabled Emergency Warning Systems." In *European Conference on Information Systems (ECIS)*.
- Fraunhofer FOKUS (2018). *KATWARN*. URL: <https://katwarn.de/>
- German Federal Ministry of the Interior (2015). *Nationale Strategie zum Schutz Kritischer Infrastrukturen (KRITIS-Strategie)*. Berlin, Germany.
- Grinko, M., M.-A. Kaufhold, and C. Reuter (2019). "Adoption, Use and Diffusion of Crisis Apps in Germany: A Representative Survey." In F. Alt; A. Bulling; and T. Döring (eds.): *Mensch und Computer 2019*. Hamburg, Germany: ACM.
- Groneberg, C., V. Heidt, T. Knoch, and J. Helmerichs (2017). *Analyse internationaler Bevölkerungsschutz-Apps*. Bonn.
- Guha-Sapir, D., D. Hargitt, and P. Hoyois (2004). *Thirty Years of Natural Disasters 1974-2003: The Numbers*. Louvain-la-Neuve, Belgium: Presses universitaires de Louvain.
- Haunschild, J., M.-A. Kaufhold, and C. Reuter (2020). "Sticking with Landlines? Citizens' and Police Social Media Use and Expectation During Emergencies." In *Proceedings of the International Conference on Wirtschaftsinformatik (WI)*. Potsdam, Germany: AIS Electronic Library (AISel).
- Helmerichs, J., S. Klos, V. Heidt, T. Knoch, and C. Groneberg (2018). *Sozialwissenschaftliche Evaluation der Feldübung: Ergebnisse quantitativer und qualitativer Erhebungen der smarter-Feldübung im September 2017*.
- Höppe, P. (2015). *Naturkatastrophen – immer häufiger, heftiger, tödlicher, teurer?*.
- Hughes, A. L., L. Palen, J. Sutton, S. B. Liu, and S. Vieweg (2008). "“Site-Seeing” in Disaster: An Examination of On-Line Social Convergence." In *Proceedings of the 5th International ISCRAM Conference*. Brüssel: ISCRAM, p. 1–10.
- Karl, I., K. Rother, and S. Nestler (2015). "Crisis-related Apps: Assistance for Critical and Emergency Situations." *International Journal of Information Systems for Crisis Response and Management (IJISCRAM)*, 7 (2), 19–35.
- Kaufhold, M.-A., M. Bayer, and C. Reuter (2020). "Rapid relevance classification of social media posts in disasters and emergencies: A system and evaluation featuring active, incremental and online learning." *Information Processing and Management*, 57 (1), 1–32. DOI: 10.1016/j.ipm.2019.102132
- Kaufhold, M.-A. and C. Reuter (2016). "The Self-Organization of Digital Volunteers across Social Media: The Case of the 2013 European Floods in Germany." *Journal of Homeland Security and Emergency Management (JHSEM)*, 13 (1), 137–166. DOI: 10.1515/jhsem-2015-0063
- Kaufhold, M.-A., N. Rupp, C. Reuter, C. Amelunxen, and M. Cristaldi (2018). "112.social: Design and Evaluation of a Mobile Crisis App for Bidirectional Communication between Emergency Services and Citizens." In *European Conference on Information Systems (ECIS)*. Portsmouth, UK: AIS Electronic Library (AISel).
- Kaufhold, M.-A., N. Rupp, C. Reuter, and M. Habdank (2020). "Mitigating Information Overload in Social Media during Conflicts and Crises: Design and Evaluation of a Cross-Platform Alerting System." *Behaviour & Information Technology (BIT)*, 39 (3), S. 319-342. DOI: 10.1080/0144929X.2019.1620334

- Kim, Y. H., D. J. Kim, and K. Wachter (2013). "A study of mobile user engagement (MoEN): Engagement motivations, perceived value, satisfaction, and continued engagement intention." *Decision Support Systems*, 56, 361–370. DOI: <https://doi.org/10.1016/j.dss.2013.07.002>
- Klaft, M. (2013). "Diffusion of emergency warnings via multi-channel communication systems an empirical analysis." In *Eleventh International Symposium on Autonomous Decentralized Systems (ISADS)*. Mexico City, Mexico: IEEE, p. 1–5. DOI: 10.1109/ISADS.2013.6513437
- Kotthaus, C., T. Ludwig, and V. Pipek (2016). "Persuasive System Design Analysis of Mobile Warning Apps for Citizens." In *Adjunct Proceedings of the 11th International Conference on Persuasive Technology*. Salzburg, Austria.
- Leonhart, R. (2008). *Psychologische Methodenlehre/Statistik*. München: UTB.
- Lindgren, I., C. Ø. Madsen, S. Hofmann, and U. Melin (2019). "Close encounters of the digital kind: A research agenda for the digitalization of public services." *Government Information Quarterly*, 36 (3), 427–436. DOI: 10.1016/j.giq.2019.03.002
- Markwart, H., J. Vitera, S. Lemanski, D. Kietzmann, M. Brasch, and S. Schmidt (2019). "Warning messages to modify safety behavior during crisis situations: A virtual reality study." *International Journal of Disaster Risk Reduction*, 38 (July), 101235. DOI: 10.1016/j.ijdr.2019.101235
- Mirbabaie, M., D. Bunker, S. Stieglitz, and A. Deubel (2019). "Who Sets the Tone? Determining the Impact of Convergence Behaviour Archetypes in Social Media Crisis Communication." *Information Systems Frontiers*. DOI: 10.1007/s10796-019-09917-x
- Moosbrugger, H. and A. Kelava (eds.) (2012). *Testtheorie und Fragebogenkonstruktion*. Berlin, Heidelberg: Springer Berlin Heidelberg. DOI: 10.1007/978-3-642-20072-4
- Mummendey, H. D. and I. Grau (2014). *Die Fragebogen-Methode*. Hogrefe.
- Nestler, S. (2017). "Flächendeckende Kommunikation im Stromausfall durch regionale IKT Krisenszenario: Längerfristiger Stromausfall." In M. Burghardt; R. Wimmer; C. Wolff; and C. Womser-Hacker (eds.): *Mensch und Computer 2017 – Workshopband*. Bonn: Gesellschaft für Informatik e.V., p. 9–16.
- Newman, N., R. Fletcher, A. Kalogeropoulos, and R. K. Nielsen (2019). "Reuters Institute Digital News Report 2019." *Ssrn*. DOI: 10.2139/ssrn.2619576
- Nikou, S. and J. Mezei (2013). "Evaluation of mobile services and substantial adoption factors with Analytic Hierarchy Process (AHP)." *Telecommunications Policy*, 37 (10), 915–929. DOI: <https://doi.org/10.1016/j.telpol.2012.09.007>
- Olteanu, A., S. Vieweg, and C. Castillo (2015). "What to Expect When the Unexpected Happens: Social Media Communications Across Crises." In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. New York, USA: ACM, p. 994–1009. DOI: 10.1145/2675133.2675242
- Olubusola, A. O. (2015). "User satisfaction in mobile applications." *Research Paper at School of Computer Science, University of Birmingham*.
- Palen, L. and K. M. Anderson (2016). "Crisis informatics: New data for extraordinary times." *Science*, 353 (6296), 224–225. DOI: 10.1126/science.aag2579
- Palen, L., K. M. Anderson, G. Mark, J. Martin, D. Sicker, M. Palmer, and D. Grunwald (2010). "A vision for technology-mediated support for public participation and assistance in mass A Spreadsheet-Based Collaboration Way for Disaster Info Sharing 583 emergencies and disasters." *Proceedings of the 2010 ACM-BCS Visions of Computer Science Conference*, 87.
- Pors, A. S. (2015). "Becoming digital—passages to service in the digitized bureaucracy." *Journal of Organizational Ethnography*, 4 (2), 177–192.
- Reuter, C. and M.-A. Kaufhold (2018). "Fifteen Years of Social Media in Emergencies: A Retrospective Review and Future Directions for Crisis Informatics." *Journal of Contingencies and Crisis Management (JCCM)*, 26 (1), 41–57. DOI: 10.1111/1468-5973.12196
- Reuter, C., M.-A. Kaufhold, I. Leopold, and H. Knipp (2017). "Katwarn, NINA, or FEMA? Multi-Method Study on Distribution, Use and Public Views on Crisis Apps." In *European Conference on Information Systems (ECIS)*. Guimarães, Portugal: AIS, p. 2187–2201.
- Reuter, C., M.-A. Kaufhold, S. Schmid, T. Spielhofer, and A. S. Hahne (2019). "The Impact of Risk Cultures: Citizens' Perception of Social Media Use in Emergencies across Europe." *Technological*



- Forecasting and Social Change*, 148 (119724), 1-17. DOI: 10.1016/j.techfore.2019.119724
- Sharma, S. K., A. Al-Badi, N. P. Rana, and L. Al-Azizi (2018). "Mobile applications in government services (mG-App) from user's perspectives: A predictive modelling approach." *Government Information Quarterly*, 35 (4), 557–568. DOI: <https://doi.org/10.1016/j.giq.2018.07.002>
- Shklovski, I., L. Palen, and J. Sutton (2008). "Finding Community Through Information and Communication Technology During Disaster Events." In *Proceedings of the Conference on Computer Supported Cooperative Work (CSCW)*. San Diego, USA: ACM-Press.
- Soden, R. and L. Palen (2018). "Informing Crisis: Expanding Critical Perspectives in Crisis Informatics." In *Proceedings of the ACM on Human-Computer Interaction*. New York, NY: ACM. DOI: <https://doi.org/10.1145/3274431>
- St. Denis, A. L., A. L. Hughes, and L. Palen (2012). "Trial by Fire: The Deployment of Trusted Digital Volunteers in the 2011 Shadow Lake Fire." In L. Rothkrantz; J. Ristvej; and Z. Franco (eds.): *Proceedings of the Information Systems for Crisis Response and Management (ISCRAM)*. Vancouver, Canada: ISCRAM, p. 1–10.
- Statista (2018). *Bevölkerung in Deutschland*. URL: <https://de.statista.com/statistik/studie/id/11844/dokument/vergleich-der-bundeslaender-statista-dossier/>
- Stieglitz, S., M. Mirbabaie, J. Fromm, and S. Melzer (2018). "The Adoption of Social Media Analytics for Crisis Management - Challenges and Opportunities." In *Proceedings of the 26th European Conference on Information Systems (ECIS)*.
- Stieglitz, S., M. Mirbabaie, and M. Milde (2018). "Social Positions and Collective Sense-Making in Crisis Communication." *International Journal of Human-Computer Interaction*, 34 (4), 328–355. DOI: 10.1080/10447318.2018.1427830
- Sturm, C. and S. Nestler (2018). "Internationale und interkulturelle Aspekte." In C. Reuter (ed.): *Sicherheitskritische Mensch-Computer-Interaktion. Interaktive Technologien und Soziale Medien im Krisen- und Sicherheitsmanagement*. Springer, p. 183–202.
- Susanto, T. D., M. M. Diani, and I. Hafidz (2017). "User Acceptance of e-Government Citizen Report System (a Case Study of City113 App)." *Procedia Computer Science*, 124, 560–568. DOI: 10.1016/j.procs.2017.12.190
- Tan, M. L., R. Prasanna, E. Hudson-Doyle, K. Stock, D. Johnston, and G. Leonard (2018). "Usability Factors Affecting the Continuance Intention of Disaster Apps." In *ISCRAM Asia Pacific 2018 Proceedings - 1st International Conference on Information Systems for Crisis Response and Management Asia Pacific.*, p. 326–338.
- Tan, M. L., R. Prasanna, K. Stock, E. Hudson-Doyle, G. Leonard, and D. Johnston (2017). "Mobile applications in crisis informatics literature: A systematic review." *International Journal of Disaster Risk Reduction (IJDRR)*, 24, 297–311. DOI: 10.1016/j.ijdr.2017.06.009
- Tarute, A., S. Nikou, and R. Gatautis (2017). "Mobile application driven consumer engagement." *Telematics and Informatics*, 34 (4), 145–156. DOI: 10.1016/j.tele.2017.01.006
- VOSG (2019). *Virtual Operations Support Group - About*. URL: <https://vosg.org/about/>
- Wachinger, G., O. Renn, C. Begg, and C. Kuhlicke (2013). "The risk perception paradox-implications for governance and communication of natural hazards." *Risk Analysis*, 33 (6), 1049–1065. DOI: 10.1111/j.1539-6924.2012.01942.x
- Weichselgartner, J. ... I. Wienand (2018). "Urban Resilience and Crisis Management: Perspectives from France and Germany." In *Urban Disaster Resilience and Security*, p. 473–494. DOI: 10.1007/978-3-319-68606-6\_27