# Adoption, Use and Diffusion of Crisis Apps in Germany: A Representative Survey

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## ABSTRACT

The research field of crisis informatics examines the potentials and limitations of information and communication technology in crises, disasters, and emergencies. Although ICT plays an increasingly large role in crisis response and management, in-depth studies on crisis apps and similar technology in the context of an emergency have been missing. Based on responses by 1024 participants in Germany, we examine the diffusion, usage, perception and adoption of mobile crisis apps as well as required functions and improvements. We conclude that crisis apps are still a little-known form of disaster ICT, but have potential for enhancing communication, keeping users up to date and providing a more effective crisis management as supplement to other media channels dependent on different underlying infrastructures. However, they should be adaptable to user characteristics, consider privacy, allow communication and offer valuable information to raise awareness of potential disasters without creating an overload. Also, the familiarity with and trust in crisis apps should be addressed to maximize their beneficial impact on crisis communication and management. We discuss further implications as well as directions for future research with larger target groups and specific usage scenarios.

## CCS CONCEPTS

• **Human-centered computing → Empirical studies in collaborative and social computing**

## KEYWORDS

Crisis apps, disaster communication, crisis informatics, representative survey, Germany

## 1 Introduction

Germany is a typical example of a Central European country, where storms and floods are most likely natural disasters, causing human and material damage [1], [2]. At the same time, most German citizens have never experienced a disaster and therefore do not consider the risk very high, which is different to other countries in the Middle East or Pacific region [3]. 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 [4]. One topic which has raised the attention for crises is terrorism in Europe in the recent years [5]. However, such human-induced disasters are only one part of the crisis spectrum which can also be natural incidents, bio-medical or chemical emergencies, or accidents [6], whose potential is rising with issues such as global warming and international conflict.

Information and communication technologies (ICT) have been researched as a tool to help manage these crises under the term of crisis informatics [7], [8]. However, in past studies, crisis informatics heavily focused on the utilization of social media by diverse actors [9] and current research suggests a broadening of its scope [10]. Among other crisis-related ICT, we can find mobile crisis apps, such as KATWARN or NINA [11], which support different crisis types, warning and communication functionality, and different degrees of configurability. Their advantage, among others, 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. However, especially due to the mentioned lack of threat awareness, their diffusion is still low: According to a recent representative survey, only a sixth of all participants are using crisis apps in general, where particularly weather information is being retrieved [12].

For this paper, we are reviewing literature concerning crisis communication and its demands, specifically referring to crisis apps as a form of ICT (section 2). The literature review revealed that there is a low coverage of crisis apps in research, while existing research focuses on factors which need to be addressed to increase their dissemination and the benefit they offer for crisis support. Therefore, our aim is to answer the following research questions on the diffusion, use and adoption [13] of mobile crisis apps among the German population:

- **RQ1**: What is the awareness and diffusion of mobile crisis apps among the German population?
- **RQ2**: What are the desired behaviors and features for mobile crisis apps?
- **RQ3**: What are characteristics and requirements for the adoption of mobile crisis apps?

We address these research questions by conducting a mixed-method study via a survey with a representative sample of German citizens (*n*=1024), concerning their usage of and attitude on crisis apps (section 3). We also ask for reasons and seek for improvement suggestions to offer implications for further design. Our results indicate that Facebook Safety Check, KATWARN and NINA are the most diffused crisis apps in Germany (section 4). We then present our results (section 4) are and discuss implications in section 5.

## 2 Background and Related Work

In 2018, about three billion people were using smartphones, a number which is estimated to increase to 3.26 billion in 2019 [14]. Since the introduction of smartphones, according apps have been popular worldwide and in Germany: Facebook is currently the most used social network with over two billion users, followed by YouTube and WhatsApp [15]. Among other purposes like messaging, blogging and sharing media, these networks have also been used to seek information in crisis situations and communicate this information to others [16]–[20]. Besides general-purpose apps mostly for social media, specific mobile crisis apps have been developed to supplement crisis management efforts [21]. While crisis communication has been previously understood as being bound to an organization [22], citizens can now play an active role in emergency management and offer valuable support via active and digital participation [9], [23]–[25]. However, information demands vary throughout crisis phases and there are certain prerequisites for and barriers to an effective crisis communication and management via ICT.

### 2.1 Citizens' Information Demand during Crises

A crisis seldom occurs at once, but usually is preceded by prerequisites or counter-measures and often has lasting effects. Therefore, there are frameworks dividing such events into different stages. Based on earlier theoretical works, Coombs [26] distinguishes between the pre-crisis, crisis response and post-crisis phases. Similarly, according to Fischer, Posegga and Fischbach [27], a crisis situation can be divided into four stages:

The mitigation phase, where measures are taken to prevent a crisis or to decrease its potential impact; the preparation phase, which precedes a disaster; the response phase immediately after the incident; and the recovery phase, where material and social structures are reconstructed. Citizens' information expectations differ throughout these stages and equally depend on the crisis type (natural or man-made) and the associated predictability. While preparation and response have been widely researched, information demands in recovery and mitigation have been less considered academically [17].

In general, information from various sources and channels has to be managed by organizations and emergency services in order to deliver up-to-date, credible and relevant notifications to recipients potentially affected by the crisis [7]. During the **mitigation** phase, many citizens concerned by the crisis take precautionary measures [28]. Organizations inform others about risks as well as potential actions and take steps to reduce further risks [27], [29]. What is important here is not only the physical, but also community resilience [6], [30], [31]. Measures to prevent man-made crises stretch further than the local communities, into politics and international relations.

To **prepare** the population for a disaster, threat awareness in combination with early and accessible warnings as well as information on potential threats, their consequences and required behavior is needed [29], [32], [33]. In Germany, reasons for low threat awareness are poor local preparation, instruction and warning systems [34], [35]. It is therefore necessary to provide guidelines [36] and utilize as many channels as possible: While authorities mostly use mass media like TV and radio or audio cues, ICT enable to reach a broad audience considering the high usage of smartphones in the population [14], [37]–[39].

In the **response** phase, those concerned need targeted information on the origin, duration and consequence of the crisis, as well as instruction on behavior and the safety status of close ones [40]–[42]. In this stage, knowledge is interpreted, disseminated and discussed, which has a significant effect on citizens' behavior [23], [43]. This means reliability, consistency and correctness are especially relevant and determine the usage of a certain information channel [17], [32], [44]–[46]. Emergency services, friends and eye witnesses are the most trusted sources especially on social media [17], [47]–[49]. While ICT play a role for active social media users, they should not replace, but add to traditional information sources [44], [47], [50].

During crisis **recovery**, communication is equally important: Those who experienced the crisis are concerned with (re-)establishing contact with family and friends as well as asking for further help to enable the recovery [43], [51]. ICT is mostly used for organization of volunteers and collaboration of organizations with each other and with citizens [27], [52]. Once the disaster has passed and the impacted community has recovered, the cycle begins again with the mitigation phase.

### 2.2 ICT and Apps for Crisis Management

Ever since September 11th, 2001, ICT have played a role in fulfilling these information demands and helping concerned

parties communicate with each other [16]. Apart from acute warnings, ICT like crisis apps can be used to provide information, give behavior advice and support communication and cooperation between citizens, authorities and emergency managers [53]. However, ICT are not the only channel to be relied on for effective crisis management. Fischer, Posegga and Fischbach [27] have identified social barriers for crisis communication via ICT like information overload, quality and reliability issues as well as inconsistency. "Social overload" [54] can keep users from seeing relevant posts or even from using social media altogether. Besides individual and organizational characteristics, technology with a poor configuration of aspects such as system breakdowns, usefulness, complexity, reliability, presenteeism, anonymity and pace of change may induce technostress, thus hindering the adoption and use of ICT [55], which is likely to be a particular issue during stressful crisis situations. Furthermore, privacy and the threat of technical dysfunction keep citizens from using ICT in disasters [12].

When power outages occur, crisis apps can have an advantage over other ICT applications [35], while one of the barriers for organizations to apply or develop ad-hoc apps for disaster management is a common data language [56]. 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 [38]. Meanwhile, their functions can range from location-based warning of and information on disasters to instructions and support to eye witness reporting and information sharing as well as emergency calls [21]. This way, they can support information and communication demands throughout several crisis stages.

Groneberg et al. [57] have so far conducted the broadest international crisis app comparison based on categories of information, communication and preparation. Accordingly, 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 behavior advice and to help emergency services by providing on-site information [12]. However, communication and preparation functions are less widely spread in crisis apps [57]. The medical aspect of emergencies has also become the focus of apps where information and an option to contact emergency services is provided [58]. Of over 600 apps analyzed by Bachmann et al. [58], more than half are directed towards the public.

Among the most popular existing apps in Germany is KATWARN, which warns its users of crises either by knowing their GPS coordinates or by letting the users indicate a region they would like to be informed about [59]. For testing purposes, a test alarm can be set to see how the app works. Furthermore, NINA warns of crises based on GPS or Wi-Fi coordinates and offers recommendations for action and general tips [60]. Affected people can inform contact points and tell them to what extent they are affected by the crisis or not (in terms of an all-clear signal). An overview and comparison of all free crisis apps currently available in the German app store *Google Play* is

provided in Table 1, where we have motivated the categories in the table based on our pre-study (see section 3). We can see that most apps offer location-based warnings and according settings mostly apply to the location and notification type. Furthermore, some apps offer mostly occasional or static behavior advice while communication is limited to sharing a warning on other media channels, but seldom includes contacting emergency services or authorities. The development of a crisis app supporting user needs across all crisis stages requires further insight into current grievances, expectations and wishes.

## 2.3 Research Gap

As several authors have found, there are currently only few studies focusing on the usage of existing mobile crisis apps [57], [61]. Especially how crisis apps should be designed in order to be widely used needs to be examined to increase their popularity and usefulness for crisis management, thus facilitating communication and creating a higher awareness for potential disasters in the German population, or even revealing other ways of usage. Reuter et al. [12] have already conducted a representative study on crisis apps in Germany to find out how many locals intend crisis apps for which purpose, especially to receive warnings and safety tips, and Fischer et al. [62] identified that perceived risk, trust, and subjective norms positively influence usage intention and compliance intention.

However, there is still a lack of extensive research on expectations and needs to increase crisis app diffusion, facilitate use and support adoption. In contrast to previous work and considering the potential of technostress [54], [55], our paper aims to broaden the focus by comparing more apps and by finding out which app functionalities are desired or, in contrast, not needed by German population and how usage barriers can be overcome. We focus on aspects such as how many functions a single app should provide, how much effort users are ready to invest as well as the attitude towards test warnings. Our findings can inform longitudinal (quantitative or mixed-method) studies, context-related (qualitative) research and the design of effective, efficient and satisfactory crisis apps which are well established and help raise awareness and citizen safety level for crisis situations.

## 3   Representative Study: Methodology

The presented questions are taken from a representative online survey, which we conducted in Germany in July 2017 using the ISO-certified panel provider GapFish (Berlin). Our overall survey included 30 questions in total and also covered other topics, such as [36], [63]–[65]. In this work, we are specifically examining three of these (Q4 – 6) which are related to the adoption, use and diffusion of mobile crisis apps. We used two closed and one open-format question, which leads to both quantitative and qualitative results and thus characterizes our mixed-method study. Participants were asked whether they have used or planned to use diverse crisis apps (Q4) and to indicate the reason

**Table 1: Comparison of free crisis apps in Germany**

| App | Crisis types | Warnings | Communication | Instructions | Emergency Contacts | Settings |
|---|---|---|---|---|---|---|
| NINA (DE) [60] | Natural disasters | Push notifications based on entered and current location; map overview | / | Hints by BBK (Office of Civil Protection and Disaster Assistance) | / | GPS or custom locations, push message on/off and sound, types of crises |
| KATWARN (DE) [59] | Natural disasters, crimes, missing persons | Location-based warning; public displays, websites; text, symbol and map; int. network | Sharing warnings over social media; sending own information | Based on preferred types of events | / | GPS or custom locations (worldwide); test warning available |
| Disaster Alert (INT) [88] | Natural and bio-medical disasters | Worldwide map and list overview of current warnings | / | / | / | Map view and push notification settings |
| Safeture (INT) [89] | Political events, accidents, natural and human-induced crises | Location-based list overview of incidents | Personal tracking and sharing position with friends | Advice for each incident | Emergency numbers indicated for each country | Country |
| Facebook Safety Check (INT) [90] | Natural disasters and terrorism | Indication if people in user's location used the service | Informing friends of one's own safety during an incident | Display of news and recommendations from different sources | Can be included in news | / |
| Sicher reisen (INT) [91] | Natural and human-induced disasters; political unrest | Location-based travel warnings and push notification | Option to send an all-clear message to contacts | Information on travel preparation and behavior in an emergency | / | Custom locations and notification type |
| BIWAPP (DE) [92] | Natural, chemical, bio-medical disasters, power outage, terrorism and police reports | Push notification with location and incident information; overview of alerts and catastrophes | Option to share notifications in social media | Can be included in alert message | Option to call directly from app | Location and size of notification area; test warning available |
| Cell Broadcast (INT)[93] | Mostly natural disasters | Warning message issued by broadcaster | / | Depending on the message | Can be included in the message | Dependent on mobile network |
| SoftAngel (DE) [94] | Personal, child or pet emergency: Medical, transport or general assistance | Calls for help by and for app users | Send messages to friends and emergency contacts; play siren or SOS light | / | Entry of personal or general emergency numbers | Location, emergency numbers, notification, Bluetooth, sound and light |
| Deutsches Rotes Kreuz (DE) (DRK, 2018) | Medical emergencies, accidents | News concerning DRK (German Red Cross) activities; no warnings | / | First aid and behavior in emergencies; view of own coordinates | Overview of national emergency numbers | / |
| safeREACH (AT, DE) [96] | Organizational emergencies | Push notification SMS to all concerned organization members | Users can issue an alarm | Included in the message | / | Target groups, communication channels, scenarios |

for this, depending on their answer (Q5.1 and Q5.2). Also, they should rate their agreement with different settings and functionalities of such apps (Q6). Six options of Q6 based on a qualitative pre-study that was already published as part of a research paper [38]. In Table 2, the most important crisis app features are displayed which have been found as a result of 22 individual interviews. Among the participants, whose age ranged between 19 and 32 years, were eight males and 14 females.

## 3.1 Characteristics of Survey Participants

The sample of survey respondents (*n*=1024) was adapted to the distribution of age, region, education and income according to the general German population [66]–[68]. Our sample consisted of 49.5% female and 50.5% male respondents between 18 and 64 years, nearly half being 45 and older (48%). We recruited participants from every federal state of Germany, where the largest sample came from North Rhine-Westphalia (22%) and Bavaria (16%). Only 1% of participants did not graduate from a school, while 15% held a degree from a university or college. The majority (69%) earned between 1500€ and 3.500€. Almost half of participants indicated to use a smartphone daily (49%). Similar results could be found for daily usage of social media, namely Facebook (46%), instant messaging services (43%) and YouTube (29%). Another third even stated an hourly usage of smartphones (43%) and messengers (33%).

## 3.2 Data Analysis

Our data analysis was undertaken in several steps. First, we eliminated missing values, reducing the participant sample from *n*=1,069 to *n*=1,024. Also, we combined demographic variables to categories for a better comparison. We then computed frequencies and percentages of our closed survey question responses in Microsoft Excel. To statistically analyze quantitative data, we used IBM SPSS Statistics 25 [69]. Non-parametric tests were chosen based on ordinal data. Chi-squared cross-tabulations served to explore significant differences between demographic factors, media use habits and attitudes and correlations between variables were determined using Spearman's Rho.

Regarding the qualitative analysis of open-ended questions, we used open coding [70] by carefully scanning the responses and establishing codes which were jointly verified and adapted. Each open-ended response was assigned to one or multiple codes to achieve an overview of the relevant topics, and in the last step, meta-codes or categories were derived. Previously acquired knowledge from the literature review and quantitative analysis was used to increase theoretical sensitivity.

**Table 2: Main functions of the crisis app prototype**

| Functionality | Description |
|---|---|
| Warning messages | Overview about current and upcoming crises in a map view |
| Recommendations for action | Information on how people should behave before, whilst, and after a crisis with detailed explanations and pictures |
| Warning and all-clear | Inform private persons or official contact points via call or SMS |
| Chat and organization | Exchange with others and with relief organizations via chat and map of current helpers |
| Settings | Individual settings of crisis types, site, tone etc. |
| Emergency contacts | Setting personal contacts relevant during crises |

## 4  Results

## 4.1 Distributions of Crisis App Usage: Little Awareness and Interest

In the first question, we asked whether the participants had used, were using or planning to use a crisis app (see Table 3). For every crisis app, we found a negation for 61 – 77% of all respondents. NINA and KATWARN are the apps relatively many participants have used in the past (6% each) and were planning to use in the future (7% each). Even greater was the readiness to use the Malteser app (9%), "Sicher reisen" ("Travelling safely", 11%) and Facebook Safety Check (13%). For the latter, 8% indicated they had already made use of it during a past crisis, making this the most well-known crisis app. The percentage of those who have not used a crisis app and do not intend to use one is over 50%. In another question in our survey (Q7), which was not analyzed in-depth for this paper, 15% indicated they have used crisis apps and for additional 10%, they were even a very useful source of information.

Generally, the answers for all crisis apps significantly correlated (p<.01). For chi-squared tabulations to determine differences between demographic groups, we aggregated the responses over all items in Q4. Again, Spearman correlations were used to determine the direction of the trend. The overall usage of crisis apps was significantly positively influenced by everyday usage of social media ($\chi^2$(1200, 1024)=2998.13, p<.0001; r=.248) and income ($\chi^2$(120, 1024)=152.57, p<.05; r=.043), while negatively influenced by age ($\chi^2$(200, 1024)=270.50, p<.005; r=-.099) and education ($\chi^2$(200, 1024)=361.36, p<.0001; r=-.031). We did not find significant dependencies for other demographic variables.

## 4.2 Attitudes towards Crisis Apps: Low Effort, High Functionality

To find out which features and characteristics a crisis app should have, we asked about participants' attitude towards different related statements (see Table 4). Most participants (68%) agreed that there should be a single crisis app for Germany, while only 21% would install several of them.: 44% would like to have an app preinstalled on their phone, but 49% would like to have one with everyday utility. The attitude towards a combination with a weather app is almost equally split: 33% would embrace it, 32% would disagree and 35% are neutral.

It becomes clear what kind of functions are required in a crisis app: For 73%, it would be the possibility to configure the types of disasters they are warned of themselves, and recommendations for action are met with an acceptance rate of 71%. Two thirds (67%) of participants wished for support in their individual preparation for disaster and 57% would like the app to notify contacts of danger and resolution of a crisis. With only 42% of agreement, the chat function is least popular.

In general, only around one third (35%) of respondents would trust warnings they receive without prior setup or agreement. Concerning the frequency of mock warnings, the majority disagreed to receiving them daily (14% agreement), while the

most popular frequency was monthly, accepted by 33%. More frequent test warnings would be rather annoying (66%) than accepted (46%). In contrast to that, only about a fifth (21%) would be bothered by too rare notifications.

**Table 3: Have you ever used one or more of the following crisis apps, are you currently using them or planning to use them in the future? (Q4)**

| | Yes, I used it | Yes, I am using it | Yes, I will use it | No, neither | Uncertain/may be |
|---|---|---|---|---|---|
| Facebook SC | 8% | 3% | 13% | 61% | 14% |
| KATWARN | 6% | 6% | 7% | 67% | 14% |
| NINA | 6% | 4% | 7% | 69% | 13% |
| Sicher reisen | 4% | 3% | 11% | 66% | 17% |
| Malteser | 3% | 2% | 9% | 68% | 18% |
| Another crisis app | 2% | 1% | 6% | 68% | 23% |
| Galileo-LawinenFon | 2% | 1% | 6% | 75% | 16% |
| saip | 2% | 1% | 5% | 76% | 17% |
| Cell Broadcast | 2% | 2% | 3% | 77% | 16% |
| Safeture | 1% | 1% | 4% | 76% | 17% |
| ANIKA | 1% | 1% | 4% | 77% | 17% |
| BIWAPP | 1% | 1% | 4% | 77% | 17% |
| SoftAngel 2.0 | 1% | 1% | 4% | 77% | 17% |

As for the effort, over two thirds preferred only one crisis app and receive monthly test warnings rather than more frequent ones. Concerning functionalities, most of them are appreciated except for the chat, and an included feature which is useful outside of a crisis suggests that participants would rather have less applications to handle, while having as many possibilities of interaction as possible. Also, the option of configuration and individualization is strongly supported.

For a better comparison of demographic data and the responses, we divided and clustered the sub-aspects from the second quantitative question (Q6) into further two groups based on related insights: Required effort to use the app (including using as few apps as possible) and desired functionalities. In the effort group, we included statements on how many apps participants would like to install and if they should be combined with other functions.

To verify whether the variables in the groups were interrelated, we correlated them using Spearman's Rho[1]. The answers to statements in the functionality cluster showed highly significant correlations (p<.001). Similarly, we also found significant correlations for all variables in the effort group (p<.05). The initially included statements about the attitude towards frequency of warnings did not correlate with all variables and have therefore been comprised in a separate group. For this purpose, we combined these statements and applied a corresponding weighting (the higher the result, the more

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[1] For the sake of clustering, we reverted the answer coding (for example, giving the answer option Strongly agree the coding 1 instead of 5 for the statement I am willing to install several mobile crisis apps on my smartphone). Therefore, a lower code can be assigned to a lower readiness to put in effort.

frequent participants wish the warnings to be). Furthermore, we regarded general trust in warnings as a separate item. All in all, we arrived at four groups: Effort, functions, trust and warning frequency. With these groups, we aimed to determine whether demographic factors and media usage behavior influenced attitude towards crisis apps. The results of chi-squared tests are displayed in Table 5.

**Table 4: What do you think of crisis apps that you can install on your smartphone? (Q6)**

| | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|
| One crisis app | 38% | 30% | 25% | 4% | 3% |
| Crisis app with everyday utility | 16% | 33% | 34% | 9% | 8% |
| Preinstalled crisis app | 19% | 25% | 30% | 11% | 15% |
| Crisis app in weather app | 10% | 23% | 35% | 18% | 14% |
| Several crisis apps | 7% | 14% | 27% | 28% | 24% |
| Warning configurator | 35% | 38% | 19% | 3% | 4% |
| Recommendations for action | 38% | 33% | 21% | 3% | 4% |
| Support of personal preparation | 28% | 39% | 25% | 3% | 4% |
| Warning and all-clear function | 24% | 33% | 32% | 5% | 6% |
| Chat function | 16% | 26% | 39% | 12% | 7% |
| General trust in warnings | 10% | 25% | 38% | 18% | 9% |
| Bothered by frequent test warnings | 37% | 29% | 23% | 7% | 4% |
| Acceptance of frequent test warnings | 18% | 28% | 35% | 11% | 8% |
| Monthly test warnings | 9% | 24% | 32% | 19% | 16% |
| Quarterly test warnings | 10% | 20% | 36% | 17% | 17% |
| Bothered by seldom test warnings | 7% | 16% | 36% | 25% | 16% |
| Weekly test warnings | 6% | 15% | 31% | 26% | 23% |
| Daily test warnings | 5% | 9% | 29% | 30% | 27% |

Correlations show that younger participants have greater trust in warnings without a known source (r=.154, p<.001). A greater smartphone use led to a greater tendency to accept effort concerning crisis apps (r=.137), the need for more functions (r=.185) and a greater trust in warnings (r=.126). The latter was also positively influenced by social media use (r=.234). However, the more participants used social media, the less they agreed to more frequent warnings (r=-.013). Similarly, posting behavior negatively influenced a need for more functions (r=-.027). Interestingly, greater use of crisis apps had a positive influence on function expectation (r=.060) and trust (r=.125), but a negative influence on agreement to frequent test warnings (r=-.129).

**Table 5: Chi-squared results for crisis app expectations. Values which were not significant are indicated in grey. * p<.05, **p<.01**

|  | Effort | Functions | Trust | Warning frequency |
|---|---|---|---|---|
| Gender | $\chi^2(25,1024)=18{,}87$ | $\chi^2(19,1024)=11{,}53$ | $\chi^2(4,1024)=4{,}82$ | $\chi^2(45,1024)=39{,}79$ |
| Age | $\chi^2(125,1024) =120{,}87$ | $\chi^2(95,1024)=96{,}09$ | $\chi^2(20,1024)=49.63^{**}$ | $\chi^2(225,1024)=250{,}92$ |
| Region | $\chi^2(350,1024)=420.91^{**}$ | $\chi^2(266,1024)=278{,}12$ | $\chi^2(56,1024)=47{,}01$ | $\chi^2(630,1024)=692.48^*$ |
| Education | $\chi^2(125,1024)=140{,}32$ | $\chi^2(95,1024)=107{,}98$ | $\chi^2(20,1024)=23{,}24$ | $\chi^2(225,1024)=231{,}13$ |
| Income | $\chi^2(75,1024)=74{,}66$ | $\chi^2(57,1024)=34{,}86$ | $\chi^2(12,1024)=12{,}78$ | $\chi^2(125,1024)=132{,}95$ |
| Smartphone use | $\chi^2(100,1024)=177.14^{**}$ | $\chi^2(76,1024)=158.93^{**}$ | $\chi^2(16,1024)=30.81^*$ | $\chi^2(180,1024)=202{,}70$ |
| Social media use | $\chi^2(750,1024)=760{,}86$ | $\chi^2(570,1024)=594{,}72$ | $\chi^2(120,1024)=194.90^{**}$ | $\chi^2(1350,1024)=1949.08^{**}$ |
| Posting rate | $\chi^2(100,1024)=89{,}81$ | $\chi^2(76,1024)=100.18^*$ | $\chi^2(16,1024)=10{,}66$ | $\chi^2(180,1024)=181{,}85$ |
| Crisis app use | $\chi^2(1000,1024)=931{,}80$ | $\chi^2(760,1024)=831.66^*$ | $\chi^2(160,1024)=268.09^{**}$ | $\chi^2(1800,1024)=3058.88^{**}$ |

## 4.3 Reasons for (Non-)Usage of Crisis Apps: Ignorance is the Primary Issue

In our open question, we asked participants to give the reason for their respective answer to whether they have used or would use crisis apps and indicate features they would like to see in a crisis app. Q5.1: *(If Yes): For what reasons have you used one or more crisis apps, are currently using them or planning to use them in the future?* and Q5.2: *(If No): Why have you not used a crisis app yet, which functions do you miss and/or do you not want to use one in the future?*

For Q5.1, we identified *n*=486 valid answers by eliminating those who did not give an answer, made statements like "I would not use it" without stating a reason, or replied "I don't know". For Q5.2, the number of valid answers amounted to *n*=538. As some of the answers for Q5.1 contained negative statements and vice versa, thus creating overlapping replies, we did not separate between the questions for the coding, and thus are analyzing 1024 answers in total.

By applying open coding, we divided the answer codes in four general categories: 1) *advantages*, 2) *features*, 3) *scenarios* and 4) *disadvantages*. An overview of the total number of responses for each category together with the five most frequent answers is provided in Table 6. For every citation in the following, the respondent ID is given in R[ID].

In the *advantages* category, we summarized all responses highlighting a reason for participants to use a crisis app. The most frequent reply was up-to-date information (named by 129 participants). Related to this were fast and efficient warnings (26 responses): *"In case of an accident, it could be a matter of seconds, so it is helpful to have a direct connection"* (R409). Safety (mentioned 46 times), including being prepared for a crisis, ranked second in this category. Ten participants indicated that they would simply feel safer having a crisis app installed. An equal number referred to the growing need: "Since recently, 'crises' have been occurring more often, I think it is important to be informed and to know what to do in specific situations" (R273). This is especially the case for terrorist attacks where Facebook Safety Check has been used. A particularly important advantage for six individuals was that they can reach a large group of people: *"My circle of acquaintances stretches out all over the world, so it is helpful to know in what kind of situation someone is or what might lie ahead of myself"* (R965). In total, six participants already had a positive experience where a crisis app helped them in an emergency, and further six particularly pointed them out to be reliable. Three even view them as an alternative to other media and communication channels regarded as less reliable: *"Once I was very ill and was staved off by the emergency service on the phone, I used an app by an aid agency. Should I find myself in a situation where I can see that several people are in danger, I would immediately use a crisis app"* (R882).

For 19 respondents, the warnings issued by crisis apps provide a possibility to avoid threats and to *"prepare for crises and similar situations and react to them faster"* (R30). Six participants value the practical nature of the app: *"Since there are more and more bad things happening in the world, it makes sense to use these apps, because most people have their smartphone with them all the time anyway"* (R449). Finally, 39 respondents indicated they used or would use crisis apps out of interest or curiosity.

Although *features* were another frequent reason for usage, we looked at them distinctly from advantages in order to get an idea which functions most appreciated in a crisis app. These included warnings, named by 46 participants, and a communication function (mentioned 41 times). One feature that 19 participants named was calling for help, especially based on previous experience: *"Since I recently had a traffic accident, I realize more and more that it is more important in this situation to provide help for the victims, and that this, of course, also facilitates the emergency managers' work"* (R286). Slightly less (14) also mentioned they would benefit from instructions for action. New features were not suggested apart from a unified crisis app, more recommendations for action and up-to-date information.

The category of *scenarios* included all cases participants mentioned for the possible usage of such apps. Travelling was particularly frequent, followed by terrorism (24 and 23 each), while several simply stated they would use it for future cases (31 responses). Twelve people indicated they used them professionally or as part of an emergency management organization. Also, traffic accidents or jams were named a few times. Other scenarios included floods, accidents at chemical factories and natural disasters.

Eventually, especially among responses for question 5.2, we identified *disadvantages*, or reasons not to use crisis apps. These barriers were mostly psychological or circumstantial rather than technical. Most respondents in this category (212) said that they never heard of crisis apps, while 207 stated they would not need it in the past or present: *"I live in a city which I think is quite unremarkable, and most events (terrorists etc.) won't happen here anyway"* (R146). Because of other media (internet, traditional media or on-site information) they could use, 32 respondents did not see crisis apps as necessary. 16 further were not convinced of their overall benefit. The problem mainly lies in a lack of understanding concerning the functionality (14 responses), as there is "too little information on significance and use" (R3013). Nine individuals would like to see only one standardized crisis app: *"The biggest problem is that there is no one unified public app, but many different ones. One can never be sure to get all warnings"* (R846).

For six participants, crisis apps even implied a negative effect of over-sensitization: *"I don't want to be paranoid if there is no reason for it"* (R58). 34 individuals did not have a smartphone, mobile internet, storage space or other technical requirements to download and use crisis apps. The limitation to a device means *"we have to keep in mind that the smartphone can probably also be damaged"* (R177).

Concerning the functions, they were described as unreliable and the whole process of app usage as too much effort (twelve and seven statements each). R257 stated: *"In Germany, this kind of information and crisis management is still in its infancy"*. While one participant lamented the lack of recommendations for action, six others indicated they already knew how to behave in a crisis situation or where to seek information, therefore lacking a need for related apps. In five answers, people expressed the concern that crisis apps could even draw gazers to the site of the emergency, thus getting in the way of crisis responses and helpers: *"[I would use crisis apps] simply to be informed about potential natural events or larger damaging events. EXPLICITLY NOT for posting them in social media (!!!!), so that rescue works or rescuers are obstructed by others"* (R628). A concern on privacy and bad functionality was further expressed: *"I am unsure about the trustworthiness of many providers"* (R118).

However, from the problems mentioned, we can derive that such apps should be tailored especially to users' location to give relevant and up-to-date information to them, all the while indicating trustworthy sources to be able to complement or even replace other media channels. Furthermore, the knowledge about crisis apps in general, as well as their purpose, functions and importance, is still too low, where one participant agrees *"this should be better explained and advertised"* (R380). All in all, almost half of participants did not know or never needed a crisis app. By interpreting the responses, we assume that the number is probably much higher including those who did not explicitly state their lack of awareness.

Our study seemed to be a first step towards a higher awareness: *"Due to this survey, I decided to use a crisis app in the future, because I want to always be up to date"* (R15). The prerequisite is a visible advantage above other types of media: *"I*

would probably use [crisis apps], if it means information is transferred more precisely and faster"* (R798). Still, there will be an issue of acceptance to a certain degree: While 31 participants explicitly stated they would probably use crisis apps in the future, 31 had no interest in this technology at all (not including those who did not need it or had other reasons). Nine participants specifically demonstrated an aversion against apps in general.

**Table 6: Overview of the code categories in open responses (Q5). Only the five most frequent codes are displayed with the according number of responses in parentheses**

| Disadvantages (610) | Advantages (317) | Scenarios (124) | Features (121) |
|---|---|---|---|
| Unknown (212) | Current information (129) | Future (31) | Warning (46) |
| No need (207) | Safety (46) | Travelling (24) | Communication (41) |
| Technical prerequisites (34) | Interest (39) | Terror (23) | Ask for help (19) |
| Other media (32) | Fast (26) | Profession (12) | Behavior instructions (14) |
| No interest (31) | Increased need (10) | Accident (10) | Capture gazers (1) |

## 5 Discussion and Conclusion

While ICT in disasters and emergencies have been used and researched for over 15 years [9], [10], specialized applications for mobile technology beyond social media, especially in Central Europe, is an area of research which needs more attention [57], [61]. By comparing different crisis apps and interrogating a representative sample of citizens, we could gather important findings on the perception of and user requirements for crisis apps in German society. Our findings not only complement existing studies with a broader target group, but also offer an insight into expectations and needs concerning communication in crises via specific apps as well as practical implications for them to become more use- and helpful in such situations.

### 5.1 Main Results

In the following, we briefly summarize the essential results of our representative survey based on the predefined research questions.

**RQ1: What is the awareness and diffusion of mobile crisis apps among the German population?** Compared to the earlier studies [37], [38] where 16% of participants indicated the use of crisis apps, the awareness did rise: The percentage of participants using or ever having used a crisis app has reached 25%. Furthermore, based on Q7 from our survey, of all crisis app users, 40% considered crisis apps as a very helpful source, which is similar to the perceived helpfulness of radio, television and contacting emergency services (all 41%) and even more useful than social media (36%), other online offers (28%), personal conversations, phone calls (both 23%) and newspapers (22%).

This suggests that crisis apps are and will be a worthwhile complement to existing media channels used for crisis response. On the other hand, only 13% are ready to use a crisis app in the future and between 61% and 77% are still refusing to adopt this type of ICT at all. The most frequent reasons for this are that participants simply are not familiar with or not interested in crisis apps due to their safety perception.

**RQ2: What are the desired behaviors and features for mobile crisis apps?** In our open responses, it became clear that relevant, reliable and up-to-date information plays a large role in crisis app functionalities, as found in prior works [7], [27], [29], [32]. Over two thirds of participants would like to have only one crisis app and almost half would like it to have everyday functionalities included. A similar number wished for a preinstalled app. Participants appreciated all features, with the warning configurator and recommendations for action being the most popular (over two thirds agreed). At the same time, the trust in warnings was relatively low: Only 35% agreed to this point. Test warnings should occur as seldom as possible, with one third of participants voting for the monthly alternative. Overall, we can state that participants would like to have as little effort as possible while being offered as many functions as possible at the same time.

**RQ3: What are characteristics and requirements for the adoption of mobile crisis apps?** Demographic aspects do not play a large role in crisis app perception apart from age, in contrast to earlier studies concerned with technology adoption [44], [71]. However, the more users are already utilizing smartphones and crisis apps, the more they trusted in warnings, wished for functions and accepted effort in using the crisis apps. The main reasons for using crisis apps, according to our respondents, are up-to-date information, reliability as well as increased perceived safety and preparedness. An alternative for communication and fast help was also a criterion. While false information, data security and potential malfunction have been the main barriers for using ICT in disasters [12], lack of knowledge, threat awareness and advantage above other channels are predominant reasons not to use crisis apps in our study. Some participants expressed general skepticism towards this type of ICT such as false alarms, over-sensitization, privacy and gazers.

## 5.2 Implications of our Findings

Responses to our open question showed that our participants feel relatively safe, which stands in contrast to increasing natural and human-induced disasters in Germany and Central Europe in general [3]. Risk awareness is comparably low in German citizens, but this is not only a national problem [72]. Therefore, our main implication is that crisis apps and their benefits need to be advertised among Central Europeans, for example via widely used traditional media, in order to be diffused, adopted and effectively used in crises. The fact that many indicated to feel safer with a crisis app shows a general need for crisis preparation, both on a mental and infrastructural level. Linking crisis apps to diverse social media and other communication

channels could support the spread of information as well as the usage of the app itself. Although in their answers, most participants referred to the response and sometimes to the preparation or pre-crisis phases [26], [27], crisis apps should already be introduced in the mitigation stage to make sure information and communication is guaranteed throughout all stages of crisis. Consequently, they can help avoid larger consequences induced by low threat awareness, the so-called "vulnerability paradox" [4], which means the impact of a disaster is higher due to low material and mental citizen preparedness coming from low threat awareness.

As a prerequisite, crisis apps thus need to be more available, offer useful functions appreciated by users, require minimum effort, include information that is accurate, recent and significant, as well as consider users' privacy and personalization concerns. This would increase trust, which is a crucial factor for adoption of new ICT [73], [74] as well as social resilience in case of disasters. At the same time, by reducing the number of required apps and test warnings as wished by our participants, we can address the issues of technical and social overload [54], [55], [75], which would add to the stress already induced by a crisis. Another factor which should be considered is the effort of adopting a new technology, while it is equally an opportunity for those who do not wish to use social media [76].

Functions to which our participants most agreed can be categorized as information and preparation, while communication mostly referred to an all-clear notification [57]. Based on our analysis of existing apps, there is a lack of apps who fulfil these requirements found in our study together with the desired degree of personalization, where specialized apps need to be created for different target groups and cultures. The need for production of own information did not appear often in our sample apart from seeking help. However, communication is an essential part of crisis ICT, in previous work as well as in our open answers; as suggested by Mirbabaie and Zapatka [23] as well as the UN [72], users are able and willing to fulfil different roles in crisis prediction and communication across the crisis phases, while crisis apps can offer this opportunity. Crisis communication via ICT is only effective if locals participate accordingly [53]. In our participants' interest in using the app in the future, also for specific cases such as terrorism, travels or traffic, we can see a tendency in an increased readiness to prepare for potential threats which may be further researched.

## 5.3 Limitations and Outlook

Firstly, there are limitations and potentials for future **quantitative survey design**. As diffusion, use and adoption of crisis apps is still low, most responses have been given in a hypothetical context. Asking our participants whether they had experienced a crisis before could help differentiate between behavior in the mitigation, preparation and response phases. As we found especially in our open question, apart from diverse usage contexts, there are different categories of users: for example, members of crisis management organizations and civilians. These stakeholders have different requirements and

expectations concerning crisis apps. The open question could also be equipped with a "no answer" option to reduce the number of invalid responses. Instead of limiting the survey to 13 given crisis apps, giving participants the option to add more apps they know and use could paint a more accurate picture of current diffusion and perception, especially since a general usage question produced more positive replies than asking about specific apps.

Since our study has been conducted online, a certain degree of experience with technology is a prerequisite. While our participant sample has been only representative concerning demographic aspects, therefore, results linked to technology usage should be further verified offline and with a broader participant sample. Klafft and Reinhardt [77] pointed out that in order to be able to address all potential users of crisis apps, language and literacy barriers as well as physical and mental impairments have to be considered. A future prototype of an optimized crisis app should take into account these aspects and support all kinds of users by utilizing multimodal, specifically focused information and suggestions.

As our sample is restricted to the German population, studies in other countries should expand the results we have gained, especially considering cultural aspects such as risk cultures, where, for example, the responsibility for crisis prevention and management is perceived differently [78]. Since Germany is considered a state-oriented risk culture, we estimate that individual-oriented risk cultures, such as the Netherlands, are more motivated to use ICT as a means for individual preparation.

Secondly, we identified potentials for future **qualitative user studies**. For now, our study corresponds to the pre-prototype approach testing user acceptance proposed by Davis and Venkatesh [79]. Similar to their work, we found that perceived ease of use in terms of effort, usefulness and social influence are significant factors for technology acceptance [79], [80]. A user study carried out in an actual or simulated crisis situation could help validate and extend our results, adding to features and characteristics of crisis app required for a disaster.

By conducting a user study based on one or several crisis apps, more insights could further be gained on desired and required functionality and user experience (UX) design, perceived effort and effectivity of as well as satisfaction with this type of ICT. While the desired functionalities were similar to those found in previous studies [12], especially in actual crisis situations, their use, adoption and support of disaster management as well as potential problems should be examined using a case study which addresses local and situational differences [13], [57]. Furthermore, as we found that users would like to invest as little effort as possible, a case study would further give the opportunity to directly measure technostress using an established scale [81].

Since mobile apps can influence behavior to different levels especially depending on their UX, conformity with expectations, and perceived usefulness [82], case studies could help research how these dimensions can support user needs and crisis management throughout the different stages. This can also occur via simulations using technologies like VR with embedded

mobile apps, which have the potential to prepare and even replace resource-intensive real crisis simulations if further developed and improved [83]. Here, it would be most interesting to examine to what extent those who answered "Yes, I will use [a crisis app]" are prone to keeping their resolution and which factors influence their adoption of this ICT.

Based on this, further mixed-method research could benefit from the application of acceptance theories, such as the Technology Acceptance Model (TAM) [84] or the Unified Theory of Acceptance and Use of Technology (UTAUT) [85] to generate further theoretical insights, as already demonstrated by Fischer et al. [62].

Thirdly, future research should comprise **technical feasibility studies**. We could compare their added value to the benefit of other ICT, such as social media and websites, for crisis communication. While some crisis apps like Facebook Safety Check are connected to other platforms, the benefits of standalone apps need to be discussed, such as stability during infrastructure breakdowns. The latter often require costly and elaborate recovery plans [6], while crisis apps are usually only limited by phone battery life. The latter can be enhanced by power banks, while internet connectivity issues can be overcome by mobile ad-hoc networks [86]. Since these networks are often small, local and decentralized, Low Power Wide Area Networks (LoRaWAN) might help to connect local networks, ensuring a widespread distribution of information or warning messages. In future, this could not only be realized by static nodes using emergency generators but also mobile nodes, such as drones, robots or vehicles.

The informing of all citizens, which was identified as insufficiently developed by Nestler [35], can be supplemented by an app covering all relevant types of crisis in the users' area, and especially used by a maximum number of locals. As suggested by the United Nations [72], a global network built on national warning systems will help predict, prepare for and effectively and cooperatively manage emergencies. At the same time, it may increase the perceived benefit and citizens' readiness to use crisis apps.

## ACKNOWLEDGMENTS

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