Perceptions and Use of Warning Apps – Did Recent Crises Lead to Changes in Germany?

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ABSTRACT

Warning and emergency apps are an integral part of crisis informatics and particularly relevant in countries that currently do not have cell broadcast, such as Germany. Previous studies have shown that such apps are regarded as relevant, but only around 16% of German citizens used them in 2017 and 2019. With the COVID-19 pandemic and a devastating flash flood, Germany has recently experienced severe crisis-related losses. By comparing data from representative surveys from 2017, 2019 and 2021, this study investigates whether these events have changed the perceptions of warning apps and their usage patterns in Germany. The study shows that while multi-hazard emergency and warning apps have been easily surpassed in usage by COVID-19 contact tracing apps, the use of warning apps has also increased and the pandemic has added new desired features. While these have been little-used during the COVID-19 pandemic, especially non-users see smartphone messengers app channels as possible alternatives to warning apps. In addition, regional warning apps appear promising, possibly because they make choosing a warning app easier when there are several available on the market.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**; **Empirical studies in ubiquitous and mobile computing**; *Ubiquitous and mobile computing systems and tools.*

KEYWORDS

Warning apps, emergency apps, COVID-19, crisis informatics, representative survey

1 INTRODUCTION

The research field of crisis informatics investigates the potentials and limitations of mobile crisis apps, which are specifically designed for the dissemination of disaster-related information and communication between authorities, organizations and citizens [41]. Especially in countries that are not currently using cell broadcast, mobile crisis apps are an integral part of timely warnings and meant to complement existing Modular Warning Systems (MoWaS). While some apps are used both in daily life and in emergencies, such as social media, messaging apps and news apps, other apps are specifically designed for emergencies [54]. Their functions can include all phases of the emergency cycle, from preparedness, to response and recovery. Some crisis apps connect citizens with other citizens, especially for co-ordination and collective sense-making [41, 54]. Others primarily connect citizens and agencies, differing in the amount of communication that is one-way (often from agencies to citizens) or two-way, allowing citizens to communicate with agencies [41, 54].

Due to the infrequent occurrence of crises and the resulting infrequent use of the apps as well as due to the criticality of emergency apps, they have particular usability criteria related to reliability, salience of important information and trustworthiness [56]. A study in 2019 showed that while many Germans perceived warning apps as important and useful tools, only 17% were using a warning app. Since then, significant crises have occurred in Germany and potentially changed the attitudes and expectations towards warning apps. A flood in July 2021 had devastating effects, partly because of delayed or missing warnings [13]. The criticism regarding insufficient warnings was added to other failures identified during the national warning day [52]. Both events have lead to the decision to implement cell broadcast in Germany, following other European states [3, 4].

In addition, the highly dynamic and global COVID-19 pandemic resulted in an "infodemic" with a lack of reliable information [7]. Challenges included the dissemination of false information [27, 31] and the effect of excessive information seeking, which can lead to distress, information avoidance and decreased compliance with recommendations [39, 48]. A study investigating the information situation in Germany at the beginning of the pandemic showed that citizens were particularly challenged by regionally and locally differing regulations [21]. At the same time, they felt that it was their responsibility to stay informed, which could cause additional distress, because people who perceive information gathering as an obligatory task appear to be particularly prone to perceived information overload [46]. Citizens expected authorities to provide

easily accessible and understandable information [21]. In order to clearly present the temporally and locally varying regulations related to the pandemic, new apps emerged and warning apps in part started to include COVID-19 information [22]. With these recent crises, this study investigates which crisis apps are currently used in Germany. In addition, it compares the results with data from 2017 and 2019, exploring which changes have occurred.Thus, our research questions are:

- RQ1: What was the usage and the expectations towards crisis information and warning apps in 2021 in Germany?
- RQ2: How have usage and expectations of crisis information and warning apps changed over time since 2017?

The study proceeds as follows: After presenting research findings in crisis app usage in general and during the COVID-19 pandemic in section 2, we present how the data from German citizens was collected in a representative survey and how it is analysed in section 3. Subsequently, in section 4, we present the results, which are further discussed in section 5. Finally, a conclusion is given in section 5.3. In summary, the study shows that while multi-hazard emergency and warning apps have been easily surpassed in usage by COVID-19 tracking apps, the use of warning apps has also increased and the pandemic has added new desired features. The wish for integration of pandemic-related information is in line with a general preference for incorporating more topics, including police-related information. Messengers and regional emergency apps might be explored as alternatives to nation-wide warning apps.

2 RELATED WORK

In the following, we present the state of the art of research investigating warning apps, their usage, continuance and discontinuance of use and the resulting research gap.

2.1 Warning App Usage

Cultural factors play an important role in whether people assume personal responsibility and prepare themselves in the event of a crisis [8, 12]. In research, several risk cultures are identified that differ in terms of the framing of disasters, the target of blame and the trust in authorities. For example, Germany is regarded as a state-oriented risk culture, which is characterised by high trust in authorities, which are assumed to be capable of handling and preventing disasters. In a state-oriented risk culture, citizens have little knowledge and confidence in their individual capability. In contrast, in an individualistic risk culture, it is perceived that individuals can actively shape the outcome in disasters, showing more knowledge and coping behaviours [8, 12]. Finally, in fatalistic risk cultures, trust in authorities as well as individual coping capabilities is low, leading to a perception that not much can be done to prevent or cope with a disaster [8, 12]. A country's risk culture also affects the way that information and communication technologies (ICT) are used [42]. Germans, with Germany being a state-oriented risk culture, rely more strongly on official communication channels and tend to distrust social media [42].

Several studies confirm that users particularly demand a multi-hazard app that combines information about many important types of emergencies, instead of having to install several different apps [9, 24]. A previous study has shown that when it comes to warning app preferences, there are hardly any differences between age groups and gender [24]. Generally, warning apps should allow for transparent interactions, which includes salience of critical information, activation in emergencies and usability [5]. In addition, they should allow for situational awareness, which consists of promptness and actionability [5]. Finally, it is important that warning apps have "representational fidelity", meaning that they are a digital representation of the analogue emergency situation, which implies being exact, current, consistent, complete and relevant [5]. While timeliness plays a role in all three dimensions, particularly representational fidelity is important for whether the app is trusted [5].

Other studies focus on the usability of disasters apps. A review study shows that for these apps it is particularly important to make critical information salient, to design the user interface with consideration of users' cognitive load in an emergency and to build trust bearing in mind the limited interactions with the app [55]. Multiple aspects concerning an app's usability are relevant, which has lead to specific usability guidelines for warning apps, which focus, in addition to common usability aspects, on app dependability, simplicity of design, minimal external links and audio output for critical situations [56].

The use and intention to use a warning app can be conceptualised as a manifestation of protective behaviour motivation [16]. This protection motivation is influenced by many aspects, including trust, social influence (whether friends and family use a warning app), risk and efficacy perceptions [16]. Perceived vulnerability increases non-users' intention to start using a warning app [16]. Therefore, particularly the experience of a severe flood may have changed the atmosphere in Germany in favour of warning apps.

Insight from the field of mobile enabled e-government suggests that users are insensitive to factors that prevent non-users from using a tool, such as concerns about behavioural control or perceived risks and costs [51]. Perceived trust and social norms (particularly whether a partner is using a warning app) influence the intention to start using a warning app [14]. According to a study by Fischer-Preßler et al. [16], the construct of protection motivation is very good at explaining use intention for non-users, accounting for 69% of variance. In contrast, protection motivation only partly (45%) explains why users (dis-)continue using a warning app. [16]. Research indicated that overly complex warning apps are dropped: Users discontinue using apps that have complex user interface graphics or require too much user input [53]. Other factors positively influence the continuance of use, in particular the perception that the app performs its intended function, is reliable and error-free [53]. This is supported by a study that found response efficacy, mediated by trust, to be an important factor for continuance of use intention, in addition to social factors. For both users and non-users, hampering factors such as battery and memory use are important [16]. Finally, users continue using warning apps that make critical information salient and easy to understand [53].

2.2 COVID-19 Information and Contact Tracing Apps

The COVID-19 pandemic revealed some uncertainties about handling information in a dynamic and long-term crisis. In contrast to emergencies, which typically last only a short period of time, the pandemic, once it had started to spread, was on the one hand constant in most countries, but on the other hand also differing in severity, appearing in several waves of intense spreading, hospitalisations, intensive-care hospitalisations and death rates. Judgements therefore differed on whether and how information about the pandemic should be distributed through warning apps [22]. The risk culture also appears to have influenced the perception of the information ecosystem at the beginning of the COVID-19 pandemic: Germans relied strongly on official media channels and press conferences and rather distrusted social media and private information exchanges [21]. In addition, research has found that during the COVID-19 pandemic exposure to information on social media was likely to result in information overload and thus information anxiety and avoidance [49]. Thus, many perceived a gap when it came to structured agency information about regulations [21]. This gap was partly closed by private sector initiative, which emerged to offer apps with information about COVID-19 regulations. In addition, the official warning app NINA also started including such information on regional regulations [22].

In response to the pandemic, many technological tools were developed to help cope with the crisis [60]. These included apps for identifying symptoms, tracking infections [26] and coordinating volunteers [19]. Hundreds of apps were developed that related to the COVID-19 pandemic, with the greatest increase in spring 2020 [58]. Around that time, most apps were dedicated to information and news and symptoms checking and many were provided by governments and involved health agencies, but many were also developed by private companies [11].

In addition, during the COVID-19 pandemic, contact tracing apps emerged as a new type of app to help in the tracking of the spread of the virus and to warn people who had come in contact with an infected person [1, 32]. Because these apps need access to precise location data as well as sensitive health information, their implementation was not without controversy. At the same time, it was clear that mobile contact tracing was only going to be successful if a large majority of the population was using it [6]. A large body of research thus investigated acceptance and worries related to tracing apps, privacy preserving features and ethical aspects of these apps [2, 25, 40, 57, 61].

For example, a study analysing peoples' perceptions and news coverage of contact tracing apps in German-speaking countries during the pandemic's first wave has shown that there was a lot of distrust regarding contact tracing apps, framing them as governmental surveillance tools and thus a potential risk to individual freedom and privacy rights [63]. Unsurprisingly, user numbers were therefore relatively low. In Germany, for example, only 25% of the total population had downloaded the app and around 21% actively used it in 2020 [44]. Privacy concerns pose the main hindering factor when it comes to user's willingness to use contact tracing apps. Motivating factors for using contact tracing apps are in turn a perceived benefit, the apps expected performance, social influence,

and trust in government [2, 18, 23, 38, 47, 62, 63]. A large scale qualitative study, analysing normative positions towards COVID-19 contact-tracing apps in nine European countries, found that positions are varied, ranging from clear opposition, over scepticism of feasibility and pondered deliberation, to resignation and distinct support [29]. In addition, the functions of different apps are relevant for how they are judged, with contact tracing apps being viewed more positively than quarantine enforcement [59]. Similarly to apps offering information on regulations, there were both official government and private contact tracing apps. In the context of Germany, Munzert et al. [35, 36] have compared the two most popular COVID-19 warning apps, that is, the official "Corona-Warn-App" (Corona warning app) and the privately launched app "luca" at different times. Generally, they found that users of the official Corona warning app were more likely to comply with the COVID-19 rules and have greater trust in science, the government, and the German health care system. They also found that despite the advantages of the official app over private apps, scepticism about the app's privacy, security and efficiency prevailed among non-users.

2.3 Research Gap

Research suggests that experience with an emergency results in increased vulnerability perception and motivation to take precautions [10]. Germany has recently been affected by two large crises. First, the COVID-19 pandemic came to Germany in March 2021. The pandemic affected the whole population, leading to nation-wide restrictions. In the course of the pandemic, over 8,000 people died in the first three months with over 20,000 deaths in one month at its peak [45]. Then, in July 2021, a flash flood incurred a large death toll of 182 killed people in Germany, partly due to a lack of evacuations and warnings [30]. Both crises may have increased the perceived vulnerability and the perceived need to take preventive action and be informed in a timely manner, possibly leading to an increase in warning app use. At the same time, warning apps were criticised during both crises: The flood showed that even though the international weather service had issued a warning of a severe flood, in some regions the warnings were delayed, leading to missing warnings in the media and warning apps, and no actions were taken. In addition, cell broadcast is currently not available in Germany, meaning that only those actively using a warning app could receive the warning directly through the main warning channel. Such problems had already become clear in the evaluation of the first national warning day in September 2020 which was largely considered a failure [52]. While older systems such as sirens are no longer maintained in many places, the warning apps were over-burdened. Cell broadcast, which sends a text-based warning to all mobile phones in the relevant vicinity could be an alternative, as it requires less data and is universally available to all mobile phone users without having to install an app or own a smartphone. Due to the flood, a law was passed to implement cell broadcast in Germany as of 2022 [3].

During the first wave of the pandemic, German citizens on the one hand felt that sufficient information was available, but when searching for specific answers, e.g. about current laws in place to contain infections, which vary locally and regionally, they also

Table 1: Representative demographic variables and values

Variable	Values
Age	18-24 (8,9%), 25-34 (14,3%), 35-44 (15,0%), 45-54 (16,8%), 55-64 (18,3%), 65+ (26,6%)
Gender	Female (51,1%), male (48,7%), diverse (0,1%), not stated (0,1%)
Education	Lower secondary education (28,2%), middle or high school (55,9%), academic degree (16,0%)
State	BB (3,0%), BE (4,5%), BW (13,5%), BY (16,0%), HB (0,8%), HE (7,6%), HH (2,3%), MV (1,4%), NI (9,7%), NW (21,7%), RP (5,0%), SH (3,6%), SL (1,1%), SN (5,0%), ST (2,3%), TH (2,6%)
Income	Less than 1,500€ (23,7%), 1,500€ to 2,600€ (30,9%), 2,600€ to 4,500€ (29,0%), more than 4,500€ (16,4%)

often perceived that authorities should do more to provide reliable information [21]. While the warning app NINA (run by the Federal Office for Civil Protection and Disaster Assistance) included the first COVID-19 information around two months after the beginning of the pandemic in Germany, it only started including local regulations in December 2020, nine months after the pandemic's spread to Germany. Those apps that emerged to inform about pandemic-related regulations proved to be difficult to maintain, because the relevant information was often only available as a legal text or government announcement. Even though the apps informing about local regulations were highly appreciated, an analysis of user reviews showed that the lack of machine-readable information and personnel resources to update them lead to inconsistencies, uncertainty and diminishing trust in the provided information [22]. Another new phenomenon are messenger channels maintained by official sources, such as the German Ministry of Health's WhatsApp and Telegram channel that informed about the pandemic, sought to counter false information and encourage vaccination. While the expansion of smartphone messengers and their development towards social media components has been noted [37], the use of messengers as a communication channel that could complement or replace warning apps has not been explored so far.

It remains unclear whether and how these different experiences in the last years have changed usage patterns and expectations of warning apps in Germany and whether these differ for current users and non-users of warning apps. This study addresses this gap by comparing data from October 2021 with data from 2019 and 2017. While previous studies have focused on representative investigations of social media in crises and a European comparison [20, 42], as well as on warning app design preferences [24, 55] and user feedback [15], this study is the first one to investigate temporal changes in a replication study.

3 METHOD

To analyse the usage and expectations towards warning apps in 2021, we conducted a representative survey in Germany. We compare the data with representative survey data from 2017 [17, 43] and 2019 [24].

3.1 Survey Design

We designed the questionnaire to allow a comparison with previous surveys, but also to ask novel questions about the COVID-19 pandemic and changes in the crisis app market. First, in order to be able to analyse group differences and relevant independent variables and

to ensure representativeness, we collected socio-demographic information on **age**, **gender**, **income**, **education** and region (**Q1-Q5**). In order to evaluate whether people with emergency experiences have different attitudes and expectations than those without [16], the questionnaire asked about respondents' **experiences with acute emergency situations** (**Q6**). We defined an emergency situation as "spontaneous and usually unforeseen event that affects several people and for which immediate action must be taken to minimise its negative impact. These include, but are not limited to: Epidemics, earthquakes, (large-scale) fires, major accidents (e.g., train, plane, pile-up), floods, severe storms, and other life-threatening emergency situations."

To compare warning apps with other sources and to evaluate their usefulness during the pandemic, we inquired about the **helpfulness of information sources**, including warning apps, in emergencies (**Q7a**). Because new apps and new information sources, such as ministry messenger channels, have emerged during the COVID-19 pandemic, another question explicitly asks about the helpfulness of sources and ICT during the COVID-19 pandemic (**Q7b**)).

In order to compare whether **experience using an information and warning app** have changed over time, we asked respondents about their experiences with such apps: "By an information and warning app (e.g. NINA, KATWARN or Corona-Warn-App) we mean an application that is installed on a smartphone. On the one hand, this provides information on how to behave before, during and after an emergency situation (e.g. recommendations for action before, during and after a flood) and, on the other hand, also transmits warnings to the user about acute or imminent emergency situations (e.g. attack, discovery of a bomb, pileup or approaching storm front)." First, we asked whether respondents had ever downloaded an information and warning app, which type of app and which specific app (**Q8-Q10**). The question about the downloaded app types (Q9), which was asked in 2017, was revised for this survey to allow for a more nuanced insight, that now also includes whether a particular type of app is still being used, has been abandoned or whether its future use is planned (see Appendix A1). Similarly, in 2017 we only asked respondents to name the source that had been most helpful (Q7a), rather than judging the helpfulness of all sources, which allows for a more detailed comparison. Due to these differences, we exclude this question from the temporal comparison. Finally, the questionnaire contained questions about the **main aim of smartphone app use in emergencies** (**Q11**), the **relevance of specific functions and features** (**Q12**) and **general preferences** (**Q13**). Due to different emphases in the surveys, Q11, Q12 and Q13 were only asked in one of the past surveys, which still
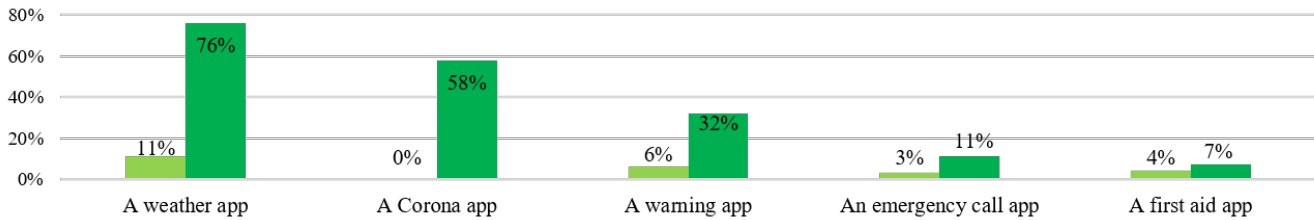
Figure 1: Comparison of the usage of certain information and warning apps 2017 (left): Percentage having downloaded such an app, 2021 (right): Percentage currently using and having used such an app in the past
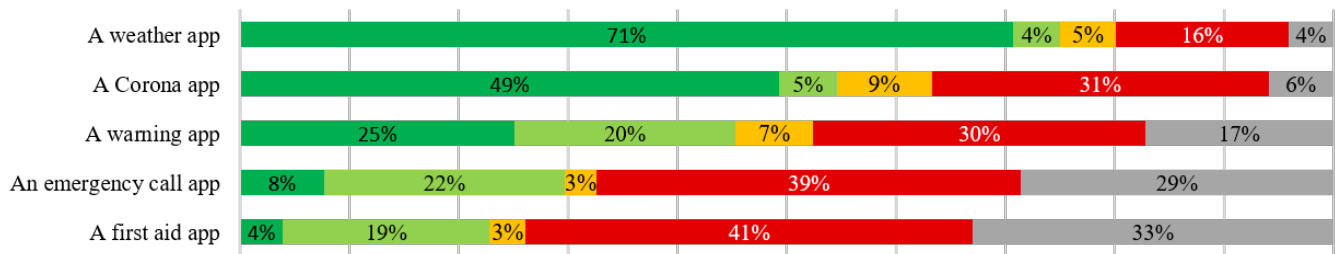

Figure 2: Extent of current, past and future planned use and awareness of smartphone apps relevant for emergencies (left to right: current, planned, past, no use, no awareness of such apps)

allows for insights into temporal changes and also indicates which attitudes have remained rather stable.

3.2 Data Collection

To ensure a representative sample, we used the survey provider GapFish. GapFish is an ISO-certificated panel provider, guaranteeing panel quality, data quality, security, and survey quality through various (segmentation) measurements for each survey within their panel of 500,000 active participants. We submitted the questionnaire alongside the desired demographic distribution to GapFish, who then conducted the survey using their panel and afterwards provided the results via Excel and SPSS files. The survey was conducted in October 2021 and contained a total of 32 questions covering media and Information and Communication Technologies (ICT) use in crises and during the COVID-19 pandemic, of which those related to warning apps are analysed here. Only respondents who passed the quality assurance questions were considered, which resulted in N=1,090 reliable answers. Details on the demographic variables and values are given in Table 1.

3.3 Data Analysis

For all generated items, we followed guidelines for valid item design by phrasing the questions in a positive, clear, short, concise and understandable way, limiting them to one statement per item and avoiding leading questions [33]. Though items should be related to the present [34], due to the infrequent nature of emergencies, we resorted to previous experiences, so that answers relating to past events may be less reliable due to distortions resulting from remembering. Questions are on a 5-point interval Likert scale (allowing for "no response") to evaluate the degree of agreement with

a statement, the judgement of relevance of functions and design features and the helpfulness of sources. An approximation of normal distribution can be assumed due to the sample size [28].

Depending on the scale of the dependent and independent variables, we use Cramer's V and Kendall's tau-b to analyse the data. For the categorical variable app use experience, we applied the t-test for independent samples, paying attention to the assumption of homogeneity of variance through a Levene test. For the statistical analysis we use IBM SPSS Statistics Version 27. We use the studies with data from 2017 (N=1,069) and 2019 (N=1,219) to see if and how crisis app use patterns and expectations have changed. The comparison data come from surveys conducted in Germany [17, 24, 43]. Because a previous study has shown that age and gender hardly have any significant influence on warning app preferences, we mainly focus in this study on differences between users and non-users of warning apps, which have been shown to be motivated by different aspects [16].

4 FINDINGS

In the following, we present the findings concerning the use of warning apps and other crisis-related apps and how these have changed over time. We then present attitudes towards the apps and their functionalities.

4.1 The Use of Warning Apps in Emergencies

The survey shows that around one third of respondents (60.5%) stated that they had been in an acute emergency situation in the past, whereas 31% disagreed and 8.5% were unsure. As the definition of an emergency situation explicitly included pandemics, this shows that many participants had not perceived the pandemic as
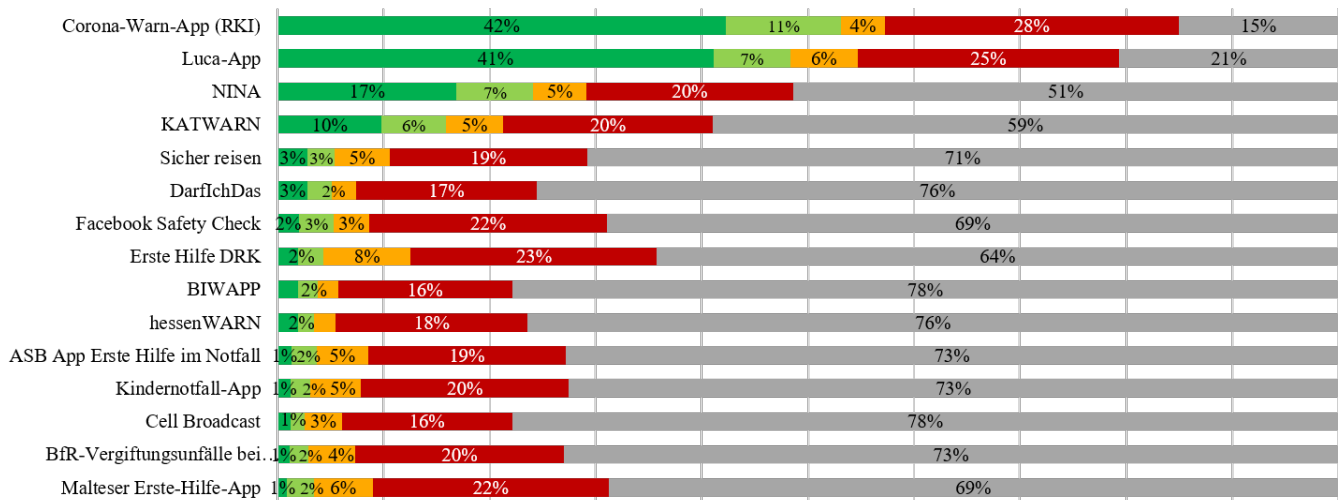
Figure 3: Extent of current, past and future planned use and awareness of emergency warning and information apps (current, planned, past, no use, no awareness of this app)
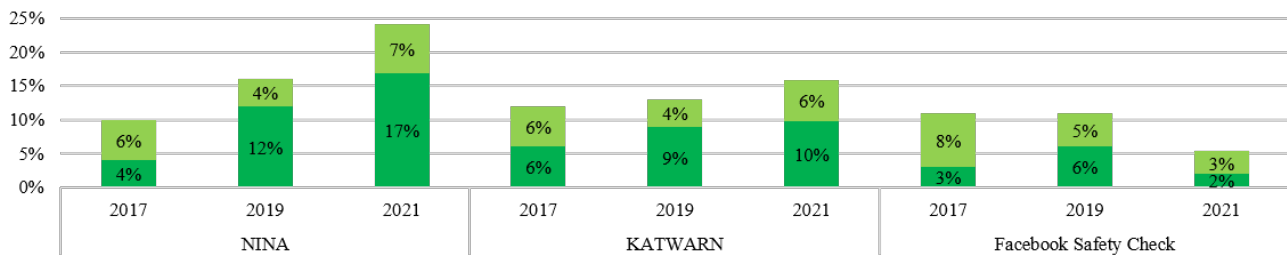
Figure 4: Comparison of crisis apps use 2017, 2019 and 2021 (bottom: current use at the time, top: planned future use)

an acute emergency situation. Compared with the data from 2017 (Figure 1), significantly more people (32%, compared with 6%) have ever downloaded an information or warning app (hereafter called "warning app"). Kendell's tau-b for ordinal variables shows that age is a significant but very small factor ($\tau b = 0.06$, p=0.038), with fewer older people having ever downloaded a warning app.

Regarding the types of apps used that are relevant for emergencies, the multi-purpose weather apps are most widely used (Figure 2). 71% currently have a weather app on their mobile phone, and only 20% have never used one or are unaware of such apps. The second most-widely used warning apps are single-hazard apps in the context of the COVID-19 pandemic, which 49% are currently using, 9% have stopped using, and 31% are not planning on using.

Warning apps for hazards other than specifically COVID-19 are currently used by 25% of respondents, a steep increase from 2019, when this number was just under 17%. Seven percent of respondents had abandoned the use of warning apps, while one third has no interest in using one. Remarkably, around 20% are planning on using a warning app, emergency call app or first aid app in the future. Only 17% are unaware of the existence of warning apps. In comparison, only 11% have experience in using an emergency call app and 7% in using a first aid app.

The analysis of the use of applications developed specifically for disasters shows that only a few apps are relevant (Figure 3), which are the two COVID-19 contact tracing apps and the two nation-wide official multi-hazard warning apps *NINA* and *KATWARN*. These are followed by the federal ministry of foreign affair's app *SicherReisen*, which supports safe travelling abroad. A noteworthy newcomer is DarfIchDas (which translates to "*Am I Allowed*"), which is an app from the private sector that presents current regulations related to the COVID-19 pandemic. Another interesting case is the regional warning app *HessenWarn*, which is used by almost 17% of the residents of the federal state Hessen, surpassing the values of the national apps *NINA* (15%) and *KATWARN* (16%) in that region. The app is unknown to only 20% in that region. Further apps that were inquired about *(safeREACH, Galileo-LawinenFon, Safeture, CoroBuddy, Disaster Alert, EchoSOS, SoftAngel 2.0)* were all unknown to about 80% of the population, with only 1-2% current, planned and past use each. Looking at the most widely used warning apps *NINA* and *KATWARN*, we see that their usage has kept on increasing over time. Both of these apps are run by German agencies dedicated to crisis response. Users can choose warnings based on their GPS location or by defining regions that are relevant to them. In contrast to the growing usage of warning apps, the use of the Facebook tool for signalling that one is safe in emergencies has decreased
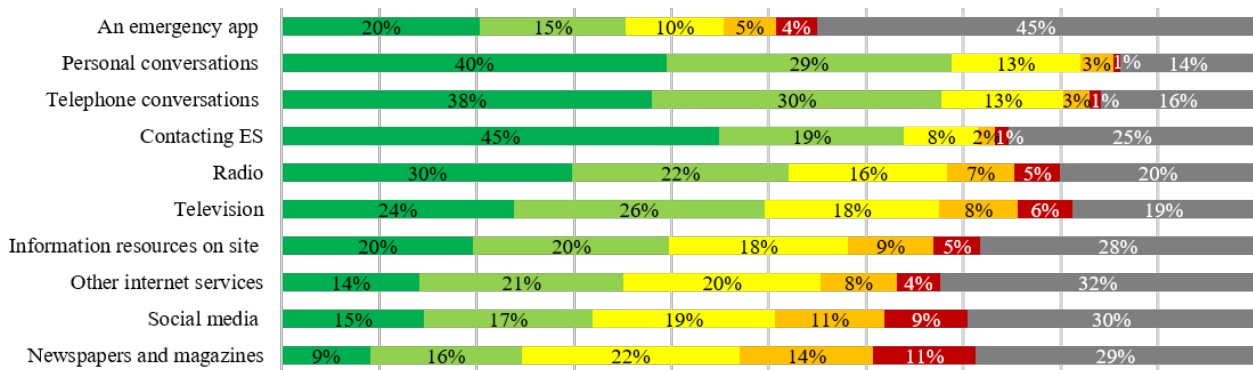
Figure 5: Perceived helpfulness of sources and channels in past emergencies (very helpful, rather helpful, moderately helpful, rather unhelpful, very unhelpful, did not use it)
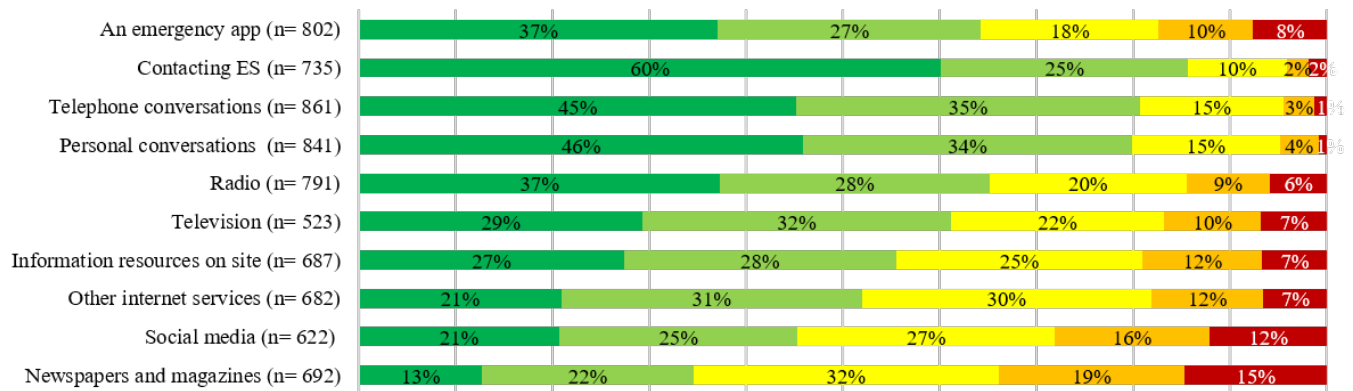

Figure 6: *Only those who use the channel or source:* Perceived helpfulness of sources and channels in past emergencies (very helpful, rather helpful, moderately helpful, rather unhelpful, very unhelpful)

in relevance (Figure 4). The unequal growth rates between the different emergency-related apps indicate that the growing usage in the main warning apps represents a growing interest in these apps, rather than a general increase in app use.

4.2 Attitudes towards Warning Apps and their Functionalities

One reason for adopting or ignoring warning apps could be their perceived usefulness. Therefore, we compare the perceived helpfulness of warning apps with other information sources and ICT. The analysis shows that channels and sources that had been helpful in emergencies had primarily been personal and telephone conversations, followed by direct contact with emergency services (ES) and the legacy media radio and TV (Figure 5). Emergency apps were deemed similarly helpful as other internet sources and social media. Of those who have been in an emergency, 40% did not use a warning app. Looking at those who have been in an emergency and used warning apps, 69% stated that warning apps had been helpful or very helpful and only 27% disagreed (M=3.55, SD= 1.4). There are

no significant differences in the age groups (Kruskal Wallkis test: p=0.48) and gender also does not play a role (Levene test: p=0.73).

Looking only at those respondents who had used the respective channel or source (Figure 6), we see that emergency apps fare quite well, about as well as TV and radio, with over a third saying that they had been very helpful and about one quarter stating that they had been rather helpful. In 2019, the percentage of people who had found warning apps quite or very useful in an emergency was almost identical (63%) and surpassed by the same sources [24]. The only source that changes noticeably in 2021 is social media, falling from 58% to 46%.

Looking at the most helpful sources of information in the recent health crisis, during the COVID-19 pandemic, reveals that similar to other crises, offline mainstream media sources were perceived as most helpful. Among the internet-based resources, health related and local city and county websites were perceived as most helpful. The contact tracing app is the most helpful app (helpful to 40% of all respondents), while general emergency apps are surpassed by apps dedicated to data about the pandemic.
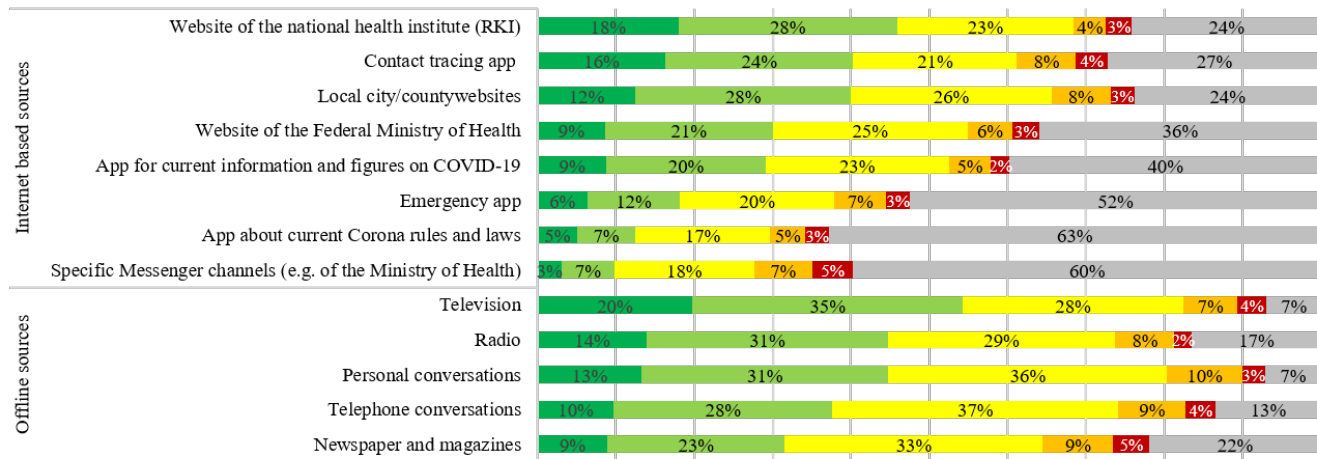
Figure 7: Helpfulness of sources of information about the virus, associated restrictions and recommendations during the COVID-19 pandemic. (very helpful, rather helpful, moderately helpful, rather unhelpful, very unhelpful, did not use it)
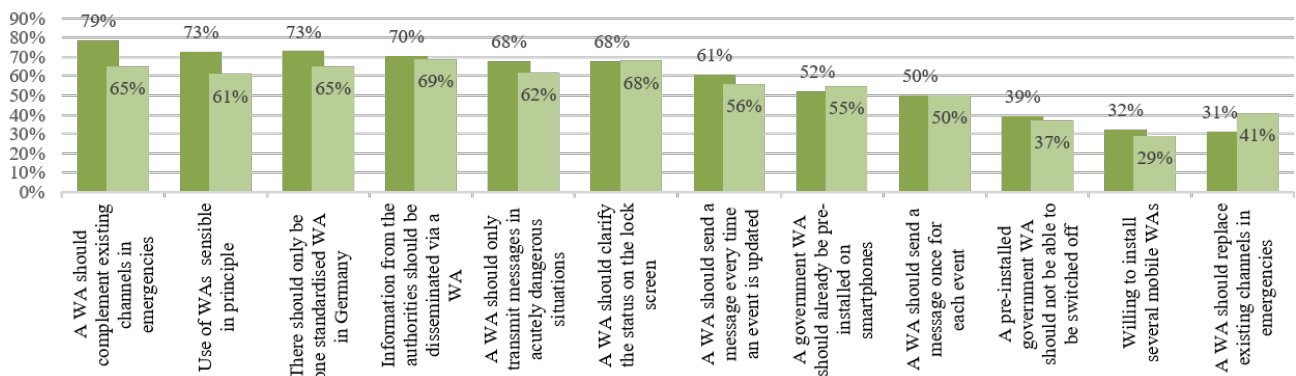
Figure 8: Changes in general attitudes towards warning apps (WA) (sum of rather agree and totally agree, left: 2021, right: 2019)

Compared with two years earlier, general attitudes towards information and warning apps remain largely the same in 2021 (Figure 8). Even more people than before (73%) agree that warning apps are an important channel that should be used by agencies, complementing other information channels (79%).

Fewer people are in favour of warning apps replacing other channels such as radio and TV for alerting, which could be a result of diminished trust in warning apps, possibly due to the failure of the warning day or during the flood, but it could also reflect the helpfulness of mainstream media during the COVID-19 pandemic. The attitude concerning the replacing or complementing of other channels is the only attitude that has changed by more than a few percent points. When it comes to the number of warning apps, 73% of the population, slightly more than in 2017 (68%) and 2019 (65%), feel that there should be only one emergency app. Although slightly decreasing, a slim majority still feels that a warning app could even be pre-installed upon purchase of a smartphone (2017: 44%, 2019:56%, 2021: 52%). The comparison across all three survey

instances shows that there is no clear trend, but only minor shifts [24].

The main purposes of using a smartphone app in an emergency is receiving an alert (over 75%, Figure 9). However, for more than half of respondents, emergency-related advice, receiving information and sharing information are also important features. Indeed, only 3% state that the only purpose would be the alert. For almost 60%, both alert and advice are main purposes, indicating that when using cell broadcast, adding advice should also be considered. For just under half of the respondents, contacting emergency services through the app and coordination with other citizens are also important. All aspects of warning and emergency apps have increased in relevance since 2017, indicating a growing interest in these apps. Interestingly, the areas that have gained the most interest concern those that are related to contacting emergency services. Over half of the population can see themselves using an app instead of the emergency hotline, with only 22% opposed. In 2017, 42% still rejected this idea. Similarly, 20% more people envision themselves using an app in the future to share information with emergency services.
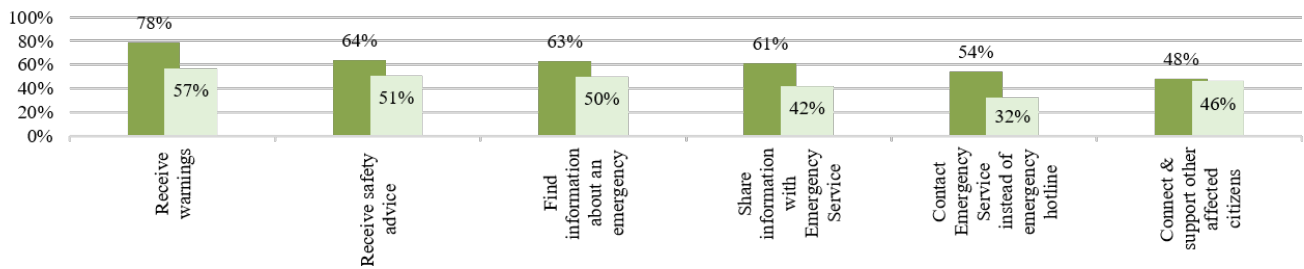
Figure 9: Main purposes for using a smartphone app in an emergency in the future (sum of very and quite likely, left: 2021, right: 2017)
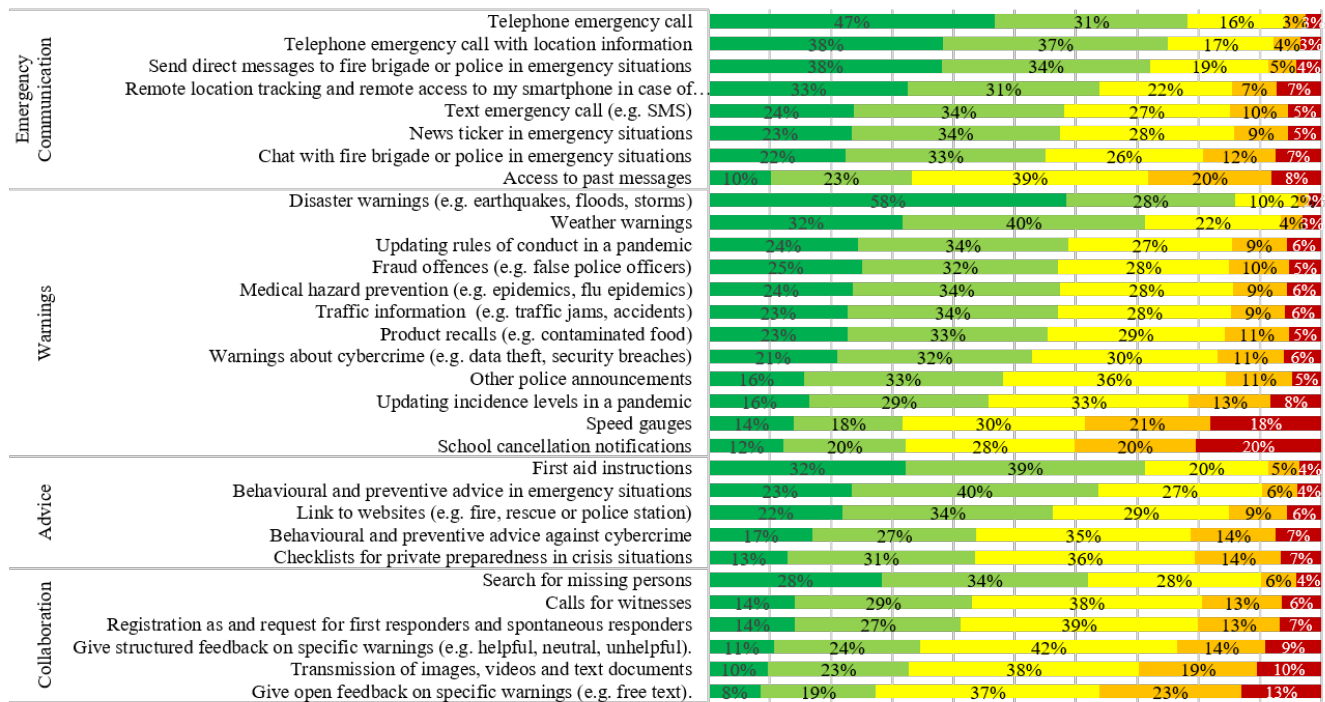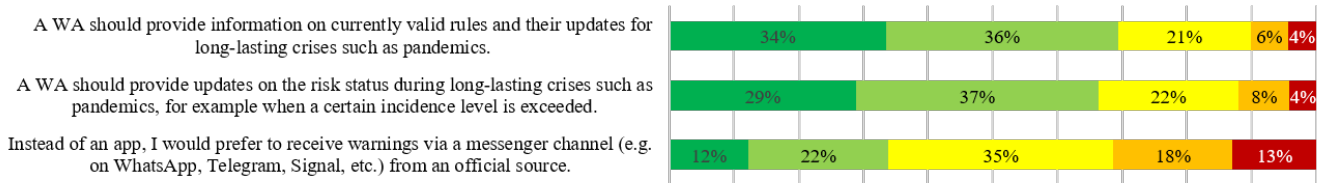

Figure 10: Importance of warning and emergency app functions 2021 (very, rather, moderately, rather not, not at all important)

Only 14% oppose this idea in 2021, whereas this number was 33% in 2017. This indicates a greater openness towards sharing data and contacting emergency services even from those people who are not currently using a warning app. There are no stark differences regarding these aspects between current users and non-users of warning apps.

4.3 Messengers as Additions to Warning Apps

Research has shown for a while that messenger apps increasingly include functionalities similar to social networks, such as communication in large anonymous groups [37]. Our findings indicate that German citizens favour the use of multi-purpose apps, including information and warnings regarding natural hazards, crimes, and

pandemics (Figure 10). Although disaster warnings were still perceived as the most relevant functionality (86%), respondents also valued opportunities for bidirectional communication, e.g., integrated telephone emergency calls (78%) or sending direct messages to emergency services (72%). Besides natural disasters, more than half of the respondents also welcomed the integration of crime and police related information, such as search for missing persons (62%), fraud offences (57%), or warnings about cybercrime (53%). With regard to pandemics, most respondents liked to received information on medical hazard prevention (58%) and 45% also incidence level updates. Updates about pandemic-related rule (58%) emerged as one of the most relevant warning categories. Compared with attitudes in 2019, there are almost no changes with regard to the other items, only the wish for direct contact with emergency services has increased (by 9%) [24]. Most features are thus regarded as helpful

A WA should provide information on currently valid rules and their updates for long-lasting crises such as pandemics.	34%	36%	21%	6% 4%
A WA should provide updates on the risk status during long-lasting crises such as pandemics, for example when a certain incidence level is exceeded.	29%	37%	22%	8% 4%
Instead of an app, I would prefer to receive warnings via a messenger channel (e.g. on WhatsApp, Telegram, Signal, etc.) from an official source.	12% 22%	35%	18%	13%

Figure 11: Importance of COVID-19-related information in warning apps and messengers as alternatives to warning apps (very, rather, moderately, rather not, not at all important)

and respondents are in favour of integrating more functions. Only few items are controversial, especially whether to include school cancellation and speed measuring notifications. This stresses the importance of allowing for personalisation in the apps.

In addition, the pandemic with its long-term effects and dynamic need for regulation and policy change has opened up new demands for information [21, 22]. We therefore asked participants whether a) rules and regulations and b) relevant incidence levels should be included in warning apps. The results show that for a large majority these are important aspects that should indeed be included (Figure 11). This applies to the inclusion of currently applicable rules (73% agree, 12% disagree; of warning app users even 82% agree and only 6% opposed) and for updates of risk levels (70% in favour, 10% opposed; of warning app users even 77% agree and only 9% opposed). This shows that pandemic-related updates are an important new field for warning apps. Another prospective change in the field may be the use of messenger channels. One third agrees that they would rather receive warnings through an official messenger channel, while another third disagrees. However, of the current non-users of warning apps 36% strongly or rather prefer such a channel (versus 27% of current users). This represents a small significant difference between the groups (t(1002) = 3.0; p = 0.003; d = 0.21).

5 DISCUSSION AND CONCLUSION

In this study, we have collected representative data about the use of warning apps and attitudes towards them for Germany. With the experience of the COVID-19 pandemic, a failed warning day and a flood in 2021, we investigate whether there are any changes in the warning app landscape by comparing these data with data from 2019 and 2017. In addition, we investigate aspects that concern the inclusion of pandemic-related information into warning apps and the increased significance of messenger apps as a new trend that might impact warning apps. The study contributes these main findings:

- Between 2017 and 2021, the use of warning apps has continually increased.
- For those people who have used a warning app in an emergency, it has been more helpful than other internet services or social media.
- Multi-purpose warning apps have been overtaken by specific COVID-19 related apps for contact tracing.
- The regional app hessenWARN has overtaken the national apps in the relevant region.

- The inclusion of COVID-19 related information about infections data and regulations are strongly desired features, especially by users of warning apps.
- Most attitudes and preferences have remained largely stable.
- People are now more open towards using warning apps to contact emergency services in emergencies.
- a third of non-users of warning apps would prefer a messenger app channels as an alternative to warning apps.

5.1 The Usage and Expectations Towards Warning Apps Between 2017 and 2021

Answering RQ1, we find that 25% of Germany were using a warning app in 2021. This number has risen from 17%. However, weather apps dominate, indicating the prevalence of apps designed for everyday use. Emergency apps continue to be evaluated by their users as more helpful than other online sources, but less helpful than direct contact with emergency services, personal exchanges or mainstream media. During the COVID-19 pandemic, other online sources have been perceived as more helpful, supporting previous findings that the apps failed to provide important information that instead had to be gathered through other channels, often leading to insecurity about the quality of information [21, 22].

Around every fifth person states that they plan on using a warning app in the future. Asking about the planned use of specific emergency apps, these numbers are significantly smaller, suggesting that one aspect preventing citizens from using warning apps may be lacking information about which app to chose. This would be in line with previous research that suggests that users strongly prefer having only one app for all related functions and hazards [9, 24]. Emergency managers may thus focus their public relations efforts more on informing about these apps and any differences, but also emphasise that the main functions of alerting are guaranteed in all major emergency apps.

At first glance, it seems that the new regional warning app hessenWARN, which was launched in 2020, is insignificant with only 2% current users. However, it has a large user group among the residents of that federal state, with 17% of Hessian respondents currently using the app. Indeed, it appears that adding another app has increased usage in that state, with 10% more Hessians using a warning app than the national average. It appears that the attention has even increased the awareness and usage of the national version of the app, KATWARN, which is also used by 6% more Hessians and is known to 60% of Hessians (compared to 40% national average). HessenWARN is compatible with NINA and KATWARN and also

reports all warnings that are transmitted through these apps. The app can thus also send warning related to regions outside Hessen. While the design is similar to KATWARN, hessenWARN the app has put into practice this study's and previous findings [24] in that it has integrated police-related matters, including warnings about cyber fraud, missing persons and product recalls, while offering the option to personalise the app so that it only sends the warning types that the individual user deems relevant. While other warning apps can also be set up to only convey regionally relevant warnings based on GPS and selecting personally relevant regions, the explicit local connection may increase users' trust in the relevance of the notifications and make it easier to choose an app. However, whether it is the increased public relations effort connected to the launch of a new app, the inclusion of more warning types or the fact that users feel "at home" using a regional app, remains an open question.

Looking at how the usage and expectations towards warning apps have changed (RQ2), we see that usage of the main warning apps has increased, while other emergency related apps have remained unused and less-known. Respondents report an increased relevance of all warning app functions that increases their likelihood of using such an app in the future. A noticeable increase can be found in the readiness to use a warning app to share information with emergency services and contact them in case of an emergency. When it comes to the relevance of functions and design preferences, there are only small changes. However, functions related to health crises, including updates of rules related to the pandemic, are now regarded as some of the most relevant warning types (see Section 5.2). Due to the increased usage of the main warning apps, which is not paralleled by other emergency-related apps, it appears that, despite the criticism that these apps and the warnings system as a whole has received in Germany, the recent past has motivated rather than demotivated the use of warning apps. However, looking at the number of people who can see themselves using a warning app to receive alters (78%) and for other functions, at the number of people who are planning on using a warning app in the future (20%), as well as considering the helpfulness that users of warning apps attest these tools, there seems to be a considerable adoption gap. Some of this can be explained by the lack of awareness of these apps. Looking at NINA, half of the population is unaware of the app. Of those who know it, only 5% have abandoned the app and 20% have no interest in using it. If this is similar among the 50% who are unaware of the app, another 25% of the population might be interested in using the app when made aware of it. In this study, we reaffirm users' strong desire to have a large number of issues, including police-related notifications and significant COVID-19-related changes, included in the same app [9, 24]. This insight is something that we see implemented in hessenWARN, which is widely used where it is known. We can thus derive one technical and one socio-political implication: Rather than fearing that warning apps' notifications will be perceived as not warranting a warning, designers of warning apps should include a large set of warning types and leave it to users to personalise the app to fit their needs. Secondly, a lot more should be done to increase awareness of these apps. Because users want only one app that covers all warnings, such PR efforts should stress the compatibility of all the main warning apps and clearly show that using any of the main apps,

users will receive largely the same warnings. This might make it easier for people to choose. The public discussion of warning apps should also consider attitudes that have to do with Germany being a state-centric risk culture [42], which makes people less inclined to feel personally responsible for their own safety. Appealing to citizens' cooperation and communicating that safety depends both on emergency services *and* citizens might increase citizens' willingness to take the step and install a warning app [12, 14]. Since about half of the population agrees that a warning app may be pre-installed on smartphones upon purchase, this could also be a avenue that could be discussed.

It is unclear, whether the insights from this study can be applied to other countries. In 2017, a European study compared the use of warning apps across Germany, Italy, the Netherlands and the United Kingdom [42]. According to the study, warning apps were only used by 17% in total, but in larger proportions in the Netherlands (28%). The most downloaded apps were weather apps, used by 42% in total, mostly by Germans (69%), and warning or alert apps, used by 42% in total, with a visibly higher proportion in the Netherlands (53%). For future use, the most likely aims mentioned were receiving emergency warnings, mentioned by 57% in total, with the UK (39%) having the least interest. Receiving information about an emergency was mentioned in the countries by between 40% to 65% (54% on average across all countries). Advice about how to stay safe was similarly envisioned as a reason for using a warning app in the future, by 50% on average, with Italians in the lead (61%). The average numbers across the surveyed European countries were similar to those of Germany in 2017, suggesting that changes seen here may be similar across Europe. However, looking at individual states, differences also emerged that can be explained by differences in risk cultures [42]. For example, respondents in the United Kingdom judged themselves to be significantly less likely to use an emergency app for any of the purposes in the future. Some countries, such as the UK, are thus less likely to follow a trajectory similar to Germany.

5.2 On the Relation of COVID-19 Contact Tracing and General Warning Apps

Comparing the COVID-19 contact tracing apps with warning and crisis apps reveals stark differences. Warning apps have existed for a long time and users have always stressed the importance of combining all hazards into one app [9, 24]. It could thus be expected that similarly to other crises, integration of COVID-19 information in a warning app would be the best option. Clearly, this is not the case for contact tracing apps, which perform very specific crisis related tasks that differ significantly from those of warning apps. In the COVID-19 pandemic, the main challenge was not to raise awareness of the danger and the measures to limit the risks (even though keeping track of local regulation was a challenge from citizens' perspective [21]), but to warn people who may have become infected because they have been in the vicinity of infected people. This required access to sensitive data and high trust in the app-providing organisation.

Due to privacy concerns, the German version of the app uses Bluetooth instead of GPS, contains features that hide the identity of people who have been tested positively for the virus and is managed

by the national health institute RKI [36, p. 9-10]. As this sensitive type of information is not needed to alert users of warning apps, a separation of apps was feasible in this case. The high number of users of the COVID-19 apps could be explained by the public attention that it received and the social pressure that was generated to use them, because it was expected that it would only work if many people used it. In addition, *luca* and later on also the *Corona-Warn-App* made it more convenient to check in at locations, thus offering advantages beyond tracking one's COVID-19 risk. While public attention and social pressure were likely factors to increase the usage of the COVID-19 apps, the warning apps also received a lot of attention since 2020, albeit mainly centred around the apps' failures.

The data show that one new important field for warning apps are pandemic-related updates, for which a strong demand exists, especially among current users of these apps. The relevance of apps showing pandemic-related data and of websites with local information indicates that in the case of the COVID-19 pandemic, warning apps have failed to integrate pandemic-related data in time. However, previous research also shows that maintaining information about locally specific and dynamically changing regulations is currently a manual and resource-intensive task [22]. The huge demand for this type of information shows that investing resources and establishing collaborations that enable relevant agencies to submit this type of information in a machine readable format would be worthwhile. While more controversial, a third of respondents also perceives that messenger apps could be good alternatives to warning apps. Another interesting aspect is the decrease of the Facebook safety check feature in relevance. Since it is a feature that is not prominent in warning apps, it is more likely to be attributed to the decreasing relevance of social media for interpersonal communication and the increased relevance of smartphone messenger apps.

5.3 Limitations and Future Work

This research is subject to limitations and potentials for future work. The online survey's results might be biased due to possible self-selection of volunteering individuals. Our findings are based on individuals' answers and not observation of actual behaviour. However, citizens' perceptions were our focus and, as such, the study provides valuable results, not at least with respect to potential further implementation of crisis and warning apps. Due to the high interest in COVID-19 related information within warning apps and the interest in messengers in the context of crises and emergencies, these aspects should be explored in future crisis informatics research. Due to the conversational nature of messenger channels, this would require investigating their usability and how conversational agents could be used to personalise the information on such a channel [50, 56].

With the decision to implement cell broadcast in Germany [3], future research could look into how warning apps and cell broadcast interact. Past research indicates that in the Netherlands, where cell broadcast has been used since 2012, warning app use is relatively low [42]. Cell broadcast might thus make warning apps obsolete for alerting in acute emergencies and even offer the advantage of being resilient to internet outages and available for older mobile phones and thus more citizens. On the other hand, due to the text-based nature of cell broadcast notifications, they are limited in the media formats that can be transmitted and their only way of differentiating between users is based on their location. Warning apps might therefore still have a lot to offer when it comes to reliable information, including about non-life threatening incidents, with regard to prevention and multi-media offers. For example, warning apps allow users to set e.g. thresholds for incidence numbers that are relevant for their protective behaviour. In addition, areas other than one's current location may be of interest, e.g. the place of work, where one's parents live etc., which would not be covered by cell broadcast notifications. By allowing to set individual preferences, users can stay informed and receive reliable safety and security information and receive acute or non-acute information as per their preferences, optimising the app's utility and representational fidelity to fit their perception [15, 53].

Because research on risk cultures shows that trust in authorities is an important factor, future research should investigate whether the past experiences in Germany have resulted in a decline in the typically quite high trust in agencies in Germany and whether this also leads to limited trust in the tools provided by these agencies, or rather in an increased perceived need to take individual measures, e.g. by downloading a warning app. These open questions apply not only to safety threats experienced during the flood and the pandemic, but also to the security threat resulting from the the war in Ukraine 2022, which might change the perception of preparedness as a value and increase the urgency of the question what role ICT can play for civil defence.

Finally, we have seen that the regional app hessenWARN has been successfully established in the federal state that initiated its development and gives the app its name, leading to more warning app users in Hessen compared to the national average. Future work should explore the reasons for that increased usage by focusing on the adoption process by hessenWARN users. These insights might be used to also increase warning app adoption in other regions, leading to an overall increase in crisis preparedness.

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A APPENDIX: SURVEY QUESTIONS 2021, 2019 AND 2017, *ITALIC: ONLY SURVEYED IN 2021*

- Q1: **What is your age?** (18-24; 25-34; 35-44; 45-54; 55-64; 65+)
- Q2: **Please indicate your gender**. (male; female; diverse; no indication)
- Q3: **What is your income?** (under 900 EUR; 900€ to under 1300€; 1300€ to under 1500€; 1500€ to under 2000€; 2000€ to under 2600€; 2600€ to under 3200€; 3200€ to under 4500€; 4500€ to under 6000€; 6000€ and more)
- Q4: **What is your highest educational qualification?** (without a school diploma; certificate of secondary education ("Hauptschulabschluss"); other qualification; polytechnic secondary school qualification; general certificate of secondary education ("Realschulabschluss"); qualification for partial university entrance ("Fachabitur"); qualification for university entrance ("Abitur"); University of Applied Sciences degree; university degree)
- Q5: **Which region in Germany are you from?** [list of all German federal states]
- Q6: **Have you ever been affected by an acute emergency situation?** (Yes; No; Don't know; Not sure)
- Q7a: [only posed in 2019 and 2021] **Please indicate how helpful you find the following sources of information in an emergency situation that has affected you.** (Not helpful; not very helpful; moderately helpful; quite helpful; very helpful; have not used; not specified):
  – Newspaper and magazines
  – Television
  – Radio
  – Face-to-face conversations (e.g., with families, friends, and neighbours)
  – Telephone conversations (e.g., with families, friends, and neighbours)
  – Contacting emergency medical services, fire department, police, or hospital
  – On-site information outlets (e.g., notices, flyers, and loudspeaker announcements)
  – Social media (e.g., Facebook, Twitter, Instagram, or YouTube)
  – Other internet outlets
  – An emergency app (e.g., KATWARN or NINA)
- Q7b: *Please indicate how helpful you found the following sources of information during the COVID-19 pandemic for information about the virus, associated limitations, and recommendations.* (I did not use it; not helpful; not very helpful; moderately helpful; fairly helpful; very helpful)

- Face-to-face conversations (e.g., with families, friends, and neighbours)
- Telephone conversations (e.g., with families, friends, and neighbours)
- Contacting emergency medical services, fire department, police, or hospital
- On-site information opportunities (e.g., notices, flyers, and loudspeaker announcements)
- Newspapers and magazines
- Trade publications
- Television
- Radio
- Current incidence figures and maps on websites (e.g. Berliner Morgenpost, Zeit Online)
- Website of the Robert Koch Institute (RKI) | Website of the Federal Ministry of Health ('Together against Corona')
- Website of my city/county
- Microblogging platforms (e.g. Twitter)
- Multimedia platforms (e.g., Instagram, YouTube)
- Social networking sites (e.g., Facebook)
- Messenger (general, e.g., Signal, Telegram, WhatsApp)
- Messenger channels (specific, e.g., Ministry of Health Telegram channel)
- Emergency app (e.g., KATWARN or NINA)|Contact tracking app (e.g., Corona-Warn-App, luca App)
- App about current Corona rules and laws (e.g., CoroBuddy, "Darf-ich-das?" app)
- App for current information and figures on COVID-19 (e.g. Infection Info, current case numbers)

- Q8: **Have you ever downloaded an information and alert app that could help in a disaster or emergency situation?** (Yes; No; Don't know; Not sure)
- Q9: **Please indicate what types of information and warning apps you use, have used, or plan to use.** (I currently use it; I have used it in the past (not anymore); I would like to use it in the future; neither; I do not know these types of apps):
  - A weather app
  - A warning app
  - A first aid app
  - An emergency call app
  - *A corona app*
- in 2017: **What type of app did you download?**
  - A weather app
  - A warning app
  - A first aid app
  - An emergency call app
  - KATWARN
  - NINA
  - Other
- Q10: **Please indicate to what extent you use, have used, or plan to use any of the following information and alert apps.** (I currently use it; I have used it in the past (not anymore); I would like to use it in the future; neither; I do not know this app / [in 2017: Unsure/Maybe]):
  - NINA
  - KATWARN

- BIWAPP
- *hessenWARN*
- *Corona-Warn-App (RKI)*
- *CoroBuddy*
- *luca App*
- *DarfIchDas*
- Disaster Alert
- Galileo-LawinenFon
- Safeture
- Facebook Safety Check
- Sicher reisen
- Cell Broadcast
- SoftAngel 2.0
- safeREACH
- *EchoSOS*
- *ASB App Erste Hilfe im Notfall*
- *BfR-Vergiftungsunfälle bei Kindern*
- Erste Hilfe DRK
- *Kindernotfall-App*
- *Malteser Erste-Hilfe-App*

- Q11: [Only asked in 2017 and 2021] **Please indicate whether you would use a smartphone app in an emergency in the future for each of the following purposes.** (Do not agree at all; Somewhat disagree; Partly disagree; Somewhat agree; Totally agree; Not specified):
  - To receive emergency warnings
  - To get advice on how to stay out of danger
  - To search for information about the emergency
  - To share information about the emergency with an ES
  - To contact an ES instead of dialling the emergency number (112)
  - To connect with other affected citizens to help them
- Q12: [Only asked in 2019 and 2021] **Please indicate to what extent the following functionalities are important to you for an information and alert app.** (Not at all important; Rather not important; Moderately important; Rather important; Very important):
  - Disaster warnings (e.g., earthquakes, floods, storms)
  - Telephone emergency call
  - Telephone emergency call with location information
  - Text emergency call (e.g. SMS)
  - Witness calls
  - Search for missing persons|Fraud offences (e.g. false police officers)
  - Other police reports|Speed measuring points | Traffic reports (e.g. traffic jams, accidents)
  - Product recalls (e.g. contaminated food)
  - School cancellation notifications | Weather warnings
  - Cybercrime warnings (e.g., data theft, security breaches)
  - Checklists for private preparedness for crisis situations
  - *Transmission of images, videos and text documents*
  - Send direct messages to fire department or police in emergency situations
  - Chat with fire department or police in emergency situations
  - Registration as and request for first responders and spontaneous volunteers

- Medical emergency response (e.g., epidemics, flu epidemics)
- *Updating of rules of conduct in a pandemic*
- *Updating of incidence values in a pandemic*
- News tickers in emergency situations
- *First aid instructions*
- Behavioural and preventive instructions in emergency situations
- *Behavioural and preventive instructions against cybercrime*
- Link to websites (e.g. fire, rescue or police station)
- Remote location and access to my smartphone in case of emergency
- Access to past alerts | Provide open feedback on specific alerts (e.g., free text)
- *Provide structured feedback on specific alerts (e.g., helpful, neutral, not helpful)*

- Q13: [Only asked in 2019 and 2021] **Please indicate the extent to which you agree with the following statements regarding your actual or potential use of information and warning apps on your smartphone**. (Do not agree at all; Somewhat disagree; Partly disagree; Somewhat agree; Totally agree; Not specified):
  - In principle, I consider the use of information and warning apps to be sensible.
  - There should only be one standardised mobile information and warning app for smartphones in Germany.
  - I am willing to install several mobile information and warning apps on my smartphone.
  - I think it makes that information from the authorities (e.g., from the fire department, police) are shared via an information and warning app.
  - A government information and warning app should be pre-installed when a smartphone is purchased.
  - A government information and warning app that is pre-installed at the time of purchase should not be able to be turned off.
  - A mobile information and warning app should complement existing channels (e.g., television, radio, social media) in emergency situations.
  - A mobile information and warning app should replace existing channels (e.g., television, radio, social media) in emergency situations.
  - A mobile information and warning app should clarify the status on the lock screen (e.g., "There are no messages" or "Bomb detection in the area").
  - A mobile information and warning app should send a message once for each event.
  - A mobile information and warning app should send a message every time an event is updated.
  - A mobile information and warning app should only send messages in acute emergencies.
  - *A mobile information and warning app should also send updates on the danger situation during long-lasting crises such as pandemics, for example, when a certain incidence is exceeded.*

- *A mobile information and warning app should also send information on currently applicable rules (e.g., masking requirements) and their updates to long-lasting crises such as pandemics.*
- *Instead of an app, I would prefer to receive warnings via a messenger channel (e.g. on WhatsApp, Telegram, Signal, etc.) from an official source such as the Federal Office of Civil Protection and Disaster Assistance (BBK).*