**RISK AND RESILIENCE** REPORT

# A Comparative Assessment of Mobile Device-Based Multi-Hazard Warnings: Saving Lives through Public Alerts in Europe

Andrin Hauri, Kevin Kohler, Benjamin Scharte

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Center for Security Studies (CSS), ETH Zürich

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Authors: Andrin Hauri, Kevin Kohler, Benjamin Scharte
Editor: Christine Eriksen
Client: Federal Office for Civil Protection (FOCP)
FOCP project supervision: Stefan Brem, Head of Risk Analysis and Research Coordination
ETH-CSS project management: Benjamin Scharte, Head of the Risk and Resilience Team, and Oliver Thränert, Head of Think Tank



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# Glossary

**BBK:** German Federal Office of Civil Protection and Disaster Assistance / *Deutsches Bundesamt für Bevölkerungsschutz und Katastrophenhilfe*

**BEREC:** Body of European Regulators for Electronic Communications

**BMI:** Austrian Federal Ministry of the Interior / *Österreichisches Bundesministerium für Inneres*

**CB:** Cell Broadcast

**ECS-PWS:** Public warning system(s) using means of electronic communications services

**EECC:** European Electronic Communications Code

**ETSI:** European Telecommunications Standards Institute

**FOCP:** Swiss Federal Office for Civil Protection / *Schweizerisches Bundesamt für Bevölkerungsschutz*

**LB-SMS:** Location-Based Short Message Service

**MoWas:** Modular Warning System / *Modulares Warnsystem*

**NINA:** German Emergency Information and News App / *Deutsche Notfall-Informations- und Nachrichten-App*

**PEMEA:** Pan-European Mobile Emergency Apps

**PWS:** Public Warning System(s)

**SAIP:** *Système d'Alerte et d'Information des Populations*

**SMS:** Short Message Service

**WEA:** Wireless Emergency Alert

# Executive Summary

## Context

Providing timely warnings can save lives, livelihoods, and resources during disasters related to natural, social, and technical hazards. There are many different forms of public warning systems (PWS) – from traditional sirens, radio, and television, to more recent smartphone-based and mobile systems. PWS that use means of electronic communications services (ECS-PWS) include Location-Based Short Message Service (LB-SMS), Cell Broadcast (CB), and multi-hazard warning apps.

Compared to traditional PWS, ECS-PWS offer several advantages, such as increased reachability, as a large part of the population always has a mobile with them. Each of the three ECS-PWS options in turn offers certain advantages and disadvantages over the other two. For example, CB alerts require little bandwidth, whereas fast warning through multi-hazard warning apps or LB-SMS cannot always be guaranteed in congested mobile networks. Multi-hazard warning apps have the advantage that they can provide users with more information than CB or LB-SMS. However, users must proactively download these apps to be warned, which is not the case with CB or LB-SMS. Therefore, efficient PWS must always be composed of different complementary warning channels, and the introduction of a new channel does not automatically replace the existing ones.

## Objective and Method

This study aims to inform the ongoing discussion on the furthering and optimization of PWS and ECS-PWS in Europe. The findings are specifically used to analyze the future of Switzerland's warning app Alertswiss. To this end, the study discusses what constitutes effective crisis communication via ECS-PWS, and the advantages and disadvantages of ECS-PWS options compared to traditional PWS options. Seven multi-hazard warning apps from eight European countries are compared. These apps are Alertswiss (Switzerland, Liechtenstein), NINA (Germany), KATWARN (Austria, Germany), SAIP (France), GouvAlert.lu (Luxembourg), NL-Alert (Netherlands), and 112 Suomi (Finland). These apps share many similarities in terms of features, such as the ability to send warnings and behavioral recommendations via push notification. However, there are also many differences. For example, some have an integrated emergency call function, and not all use visual elements such as maps. In addition, there are large differences between countries in terms of the percentage of the population that uses the warning app.

## Results

The report identifies two main challenges for multi-hazard warning apps to be meaningful and efficient parts of PWS: 1) the reach of an app in terms of the proportion of a population that uses it, and 2) the sustainable integration of an app into the existing PWS. To overcome these challenges the report makes several recommendations. There should be only one app per country, supporting as many languages as possible. The app should ideally use multiple, clearly delineated warning levels that are used in a consistent manner. Users should be able to customize the messages' content, and the app should be able to override certain local phone settings. Authorities should treat these apps as important elements of the national PWS and integrate them into it as much as possible. This implies a high reliability and robustness of the necessary infrastructure, but also requires a coordinated development phase, and the continuous development of the app as well as its promotion among the population. In terms of potential senders, there should be as few as possible, but as many as necessary to be fast and reliable. Authorities need to use the app for alerting the population whenever appropriate, and address potential data security and privacy issues proactively. The warning app should be as interlinked with other platforms as possible to disseminate its messages far and wide. Co-operation with other widely used apps, such as weather apps, can further increase the app's reach. The app should also make use of graphical elements, such as maps enriched with relevant information, and provide preparedness and response knowledge that is useful during, as well as outside of, major events. Authorities should also consider including a 'call emergency services' function in order to motivate users to install and use the multi-hazard warning app.

Many of these recommendations can be directly applied to future developments of the Swiss warning app Alertswiss. However, it is important to remember that Alertswiss is only one of many communication channels of the Swiss PWS. These channels are not in competition with each other, and the introduction or further development of one channel does not automatically make the others obsolete. Based on the finding of this study, developments in the EU, as well as practical experiences in recent years, we believe it will be expedient for Swiss Civil Protection to also supplement the Swiss PWS with CB in the near future. This would ensure that in time-critical emergencies, public warnings reach as many people as possible, even if one or more warning channels partially or completely fail.

# 1 Background and Introduction

The use of public warning systems (PWS) in civil protection has gained attention in recent years due to the increasing frequency of natural hazards with climate change, and the growing level of social complexity with the dependence on technology in critical infrastructures and for connectivity. Appropriate information on impending threats by the responsible authorities, enable individuals to be better prepared, especially in the event of predictable and slow onset disasters. Proactively prepared and informed individuals are more likely to respond to, and recover from, disasters safely and sustainably.

Individuals who receive timely hazard-warnings and situation-specific recommendations from the authorities during a disaster, are also better equipped to make informed decisions that benefit themselves and their surroundings. This can help save lives, livelihoods, and resources, and thus reduce the damage and cost of such events. As the International Federation of Red Cross and Red Crescent Societies (IFRC) noted in its World Disasters Reports of 2005 und 2013, information now plays a crucial role before, during, and after disasters, and is as important in such situations as access to medicine, food, shelter, and water (IFRC 2013, 73; IFRC 2005). Adequate warning systems are also crucial in countries that are less frequently affected by civil protection related emergencies, as these populations are less familiar with how to deal with potential hazards. A case in point, is the catastrophic floods in Germany in summer 2021 and the subsequent discussion about the reliability and suitability of the country's PWS.

Communication between the authorities and the public before, during, and after emergencies is also increasingly important because people nowadays are accustomed to a greater and a more immediate flow of information. If the authorities fail to provide information in the event of an emergency, or if the information is perceived to be insufficient, people usually have the opportunity to fill the information vacuum through other, potentially less trustworthy, sources. Timely warnings and repeated information during an emergency by the responsible authorities can thus prevent speculation, misinformation, and unnecessary panic (Reuter et al. 2017a, 32f). In their absence, unnecessary uncertainty and a feeling of abandonment can arise among the population, especially during a prolonged crisis (Reuter 2016, 41). For all these reasons, authorities need to provide timely information to the public about imminent dangers, and give advice on how to adequately prepare and respond.

## 1.1 New Possibilities due to Technological Progress

Until the beginning of the 21st century, authorities have mainly used traditional mass media, such as radio, television, and printed newspapers for crisis communication via PWS, complemented by sirens for sudden onset disasters. The exact implementation of this process varied greatly from country to country in the past, e.g., in terms of the type of communication, the means of communication used for dissemination, and the actors authorized to disseminate the warnings.

Thanks to the rapid advances in communication technologies and digitalization since the mid-1990s, a multitude of additional possibilities exist today to inform and warn the population in the event of an emergency. Ubiquitous high-bandwidth Internet coverage and the increasing use of mobile devices with permanent Internet access, particularly for communication via applications (apps) and social media, make mobile devices a crisis communication tool. Accordingly, more and more countries are complementing their traditional PWS with communication channels that specifically target these media consumers. The spectrum ranges from Location-Based Short Message Service (LB-SMS), to Cell Broadcast (CB), to dedicated single or multi-hazard warning apps, to automated calls (see Chapter 3). While authorities in the past had to rely on a few dominant news media to disseminate critical information to the public, online platforms, such as apps and social media, and access to them via mobile devices, such as smartphones, have revolutionized crisis communication and are now an integral part of it. This type of crisis communication offers advantages for the authorities, e.g., by enabling two-way communication. Users also benefit because they can be addressed more selectively in real time and thus be enabled to protect themselves by taking timely and effective countermeasures (Dallo and Marti 2021, 1).

In Europe, different countries have taken different approaches to how to integrate these new possibilities into their crisis communication via PWS, and a great variety of different national practices therefore exists. By introducing Article 110 of the European Electronic Communications Code (EECC) in 2018, the EU sought to ensure a certain basic effectiveness by approximating practices and national laws concerning PWS using means of electronic communications services (ECS-PWS) (BEREC 2020, 6). By 21 June 2022, the article will require all EU Member States to "ensure that, when public warning systems regarding imminent or developing major emergencies and disasters are in place, public warnings are transmitted by providers of mobile number-based interpersonal communications services to the end users concerned" (EU 2018). In other words, the member states must operate an ECS-

PWS that is capable of sending geographically targeted alerts to all mobile phone users located in an area that is in danger of an imminent or developing emergency. The article maintains technology-neutrality, as public warnings can also be transmitted for example via apps. However, alternatives should fulfill five conditions, as mentioned in recital 294 of the EECC: They should be (1) equally efficient in terms of coverage; (2) allow for easy reception of warnings and not require a login; (3) visitors to the country should be informed about them; (4) their transmissions should be free of charge for the user; and (5) their deployment should be in compliance with privacy laws (Vivier 2019, 9; EU 2018). Under the EECC, a country can operate multiple ECS-PWS or different ECS-PWS for different regions within the country, provided they meet these criteria.

Because the importance of PWS is growing at the same time as a multitude of new and fundamentally different options for crisis communication is available, practitioners and the public need to understand the important factors for efficient crisis communication via ECS-PWS, the options available, and what the different options allow in terms of accommodating these factors. One of the options, the multi-hazard warning app, has the capacity to incorporate many of these factors and has therefore become increasingly popular with civil protection organizations and NGOs in recent years. However, the numerous existing apps in Europe differ considerably from each other, e.g., with regards to the available functionalities, the type and level of detail of the crisis communication, or which authorities communicate via the app. Furthermore, in the aftermath of the aforementioned catastrophic floods in Germany in 2021, the question was raised whether a multi-hazard warning app, such as the German app NINA, can actually achieve the desired effect or whether another option, or a combination of options, would be better suited for this purpose (Der Spiegel 2021).

## 1.2 Outline and Aim of Study

Building on the background information provided in this chapter, Chapter 2 first describes how and what to communicate to make crisis communication via ECS-PWS effective. It then describes the necessary technical features that enable effective crisis communication via ECS-PWS. This allows the reader to assess the effectiveness of crisis communication via the various options of ECS-PWS. Chapter 3 first describes the most prevalent forms of ECS-PWS, including information on where systems are primarily used. Then, the three options multi-hazard warning app, LB-SMS, and CB are compared with traditional PWS in terms of reachability, the efficiency requirements discussed in the previous chapter, as well as additional relevant factors, such as privacy concerns. Chapter 4 presents a comparison of the various national multi-hazard warning apps in Switzerland, Germany, Austria, France, Luxembourg, the Netherlands, and Finland in the form of country profiles. Among other things, this chapter answers questions about the different functionalities of the individual apps, their concrete usage, and potential future plans. This comparison enables the reader to compare the different warning apps, and understand what the differences are in terms of design, functionality, and utilization. The country profiles also indicate whether other forms of ECS-PWS exist alongside the warning apps. Based on this comparison, Chapter 5 describes relevant lessons learned to make multi-hazard warning apps a meaningful and efficient part of PWS. Chapter 6 relates relevant lessons learned to the possible further development of the Swiss multi-hazard warning app Alertswiss, and the Swiss ECS-PWS in general. Chapter 7 concludes the report with final remarks. In doing so, we hope to contribute to current discussions on the further development of PWS and ECS-PWS in Europe, as well as specifically to the future optimization of the PWS in Switzerland.

# 2 Effective Crisis Communication via ECS-PWS

Authorities warning the public of impending dangers is an age-old practice, albeit the means for warning have not always been as sophisticated as they are today. An example of a classical PWS is the ringing of church bells in case of danger – be it from fire, weather, or enemies approaching. Even today, in some places church bells are still used for warning the public if PWS fail or are insufficient (Landesregierung Vorarlberg 2021). No matter the specific system, the idea behind PWS is to make all at-risk people aware of imminent danger and thereby enable them to cope with the situation (Bopp et al. 2021, 68). Appropriate warnings could include informing people who are not at-risk – for example about not entering specific areas – and triggering the right behavior from them, too (Fischer-Pressler, Bonaretti, and Fischbach 2020, 11). However, if people receive too many warnings that are irrelevant to them, they may grow tired of the PWS and stop reacting to it. This calls for tailoring messages only to those directly at-risk – in the example above this would mean only warning them should they approach the specific area (Reuter et al. 2017b, 2193).

If authorities succeed in providing at-risk people with timely information about a hazard, it can save lives and prevent damage (Preinerstorfer et al. 2017, 116). This is the ultimate measure of the effectiveness of PWS. In the aftermath of disruptive events, it is not easy to assess whether PWS helped to save lives and prevent damage. Thus, the direct measurement of effectiveness is not possible. Because of that, the effectiveness of PWS needs to be assessed independent of events and with the help of more specific characteristics.

In countries like Germany or Switzerland, most people perceive public warnings to be a task that the state is responsible for (Reuter et al. 2017b, 2188). Authorities need to acknowledge this, as citizens may not act without such public warnings, and they are likely to hold authorities accountable if PWS fail. Many citizens in these countries perceive disruptive events to be rare and unlikely. Most consider the chance of being personally affected by a hazard as low (Reuter et al. 2017b, 2192). This can lead to a lack of interest in knowing about PWS, both in terms of the systems that the authorities use to warn the public, and in terms of the content and style of such warnings (Bopp et al. 2021, 74). The COVID-19 pandemic might lead to a changing risk awareness in countries like Germany and Switzerland. However, the pandemic's long term effects are yet unknown.

People's ability to receive and understand information are two essential criteria of the effectiveness of PWS. To increase effectiveness, crisis communication and the broader information delivered via ECS-PWS should be aligned with regular communication processes and styles (Groneberg at al. 2017, 8). At the same time, messages need to be adapted to the specific situation and the specifics of the at-risk people, communities, or PWS. Conveying the same information in different situations and for different target audiences might include, e.g., different wording, framing, media, and technical systems (Bopp et al. 2021, 68).

As downloading and installing a multi-hazard warning app necessitates an active decision, the perceived usefulness as experienced or expected by users is another important criterion for the effectiveness of this PWS (Kaufhold, Haunschild, and Reuter 2020, 13). For this reason, it is important to consider the needs of users in addition to the technical features when developing such warning apps (Dallo and Marti 2021, 1).

The discussion above leads to two broader criteria that are relevant for the effectiveness of PWS as well as one additional criterion that is relevant for ECS-PWS. The first criterion concerns the content of the warning. What should authorities communicate in order for people to be able to save their lives and prevent damage to their properties and livelihoods? The second criterion concerns the style of warning messages. How should authorities communicate the information? And the third criterion is related to the technical features of ECS-PWS: can authorities reliably reach (almost) all of the population in a timely manner with the help of the ECS-PWS?

## 2.1 What to Communicate

As a traditional PWS, sirens are well known to many people in many countries. In general, sirens are only able to communicate a simple message: "Attention! Imminent danger!". Sirens do not give any additional information about the event itself (Reuter et al. 2017b, 2188). In general, people at-risk need to know what is happening, when it will happen, how it will likely affect them, and what they should do (Dallo and Marti 2021, 3). One additional important detail concerns the source of the warning. Where does the information come from? As one example of ECS-PWS, these basic requirements are also important for warning apps (Fischer, Putzke-Hattori, and Fischbach 2019, 640). Taken together, the five most important elements of a warning message are: hazard, location, time, guidance, and source (Bean et al. 2016, 139; 2015, 62).

**Hazard:** One crucial element of public warnings is the type and severity of hazards that the warning is about (Bean et al. 2015, 62). Depending on the specific situation, the amount and type of available information differs greatly. Still, the information about the hazard should be as precise as possible. For example, warning

about weather-related hazards is often capable of communicating details, such as expected wind speeds, inundation levels along rivers or at shores, temperatures, or time of expected impact. In contrast, in unexpected, rapidly evolving events like terror attacks, information about the danger can be vague.

**Location:** Public warnings need to entail information about the location of the hazard (Bean et al. 2015, 63). Some events affect only small areas. This might, e.g., be true for localized extreme weather events like thunderstorms. Other events, such as the coronavirus pandemic, can threaten large areas, whole countries, or multiple continents. A third category of events might affect different places at different times, or the exact locations can be unclear. During mass shooting events in densely populated urban areas, the scene of the event can change quickly. Authorities have to give precise information about the affected areas and update this information whenever possible.

**Time:** The third element of public warnings is information about the time and duration of the hazard. This element entails two important aspects. The first is information about when the hazard starts, how long it might last and when it is expected to end (Bean et al. 2015, 63). This will again be different for different hazards, including uncertainty about start, duration, and the end of events. The second aspect is that the effectiveness of PWS depend on timeliness (Vivier et al. 2019, 9). At-risk people benefit from early warnings (Dallo and Marti 2021, 6). However, depending on the type of hazard, it might be a matter of minutes before the event happens. Communicating clearly about the urgency and expected impact time is crucial. Whether the at-risk people actually receive the warning in time, is a different question due to complex situational dynamics.

**Guidance:** Hazards can cause life-threatening situations for many people. Under extreme circumstances, some degree of panic is likely. People often have only little time to react. The fourth element of what to communicate via ECS-PWS is therefore guidance on how to act – or how not to act – when disaster strikes (Dallo and Marti 2021, 6). Warnings need to be clear even under extreme circumstances. They should be as informative and precise as possible, because this increases the chances that people actually act upon the warnings (Bean et al. 2015, 63f). This includes being context-specific, adapted towards the local situation, and actionable (Dallo and Marti 2021, 6).

**Source:** Information about the warning source also needs to be communicated (Dallo and Marti 2021, 6). People are looking for information and advice from credible sources (Bean et al. 2015, 65). In general, in countries like Switzerland or Germany, people still place most trust in authorities. Warnings from local and / or federal authorities are thus most effective (Dallo and Marti 2021, 2). However, the credibility of specific authorities might differ with respect to different hazards. Warnings should always be issued by those authorities that the public deems most credible, e.g., national weather services for meteorological hazards or the federal police for terrorist attacks (Bean et al. 2015, 75). Given that some ECS-PWS only provide little space for information, most warnings can only entail one source. Placing the source at the beginning of the message sometimes improves its effectiveness (Dallo and Marti 2021, 6).

## 2.2 How to Communicate

The content of a message is crucial for its effectiveness, but findings from crisis communication research show that the communication style is equally important (Pfeil and Dressel 2017, 66). It is not only a matter of what authorities communicate but how they communicate it to diverse cross-sections of society with different levels of hazards experience and vulnerability. Against this backdrop, warnings should be understandable for the highest possible percentage of people. Therefore, information should be clear, correct, consistent, specific, unambiguous, simple, accurate, authoritative, and short (Bean et al 2016, 139; 2015, 65; Dallo and Marti 2021, 6). As some PWS, especially ECS-PWS, only allow for sending short messages, it is key to prioritize information. This links the question of how to communicate to the question of what to communicate. As information needs differ in different phases of a disruptive event, and change over time, it is also key to adapt warnings to before (preparation, prevention, mitigation), during (response), and after (recovery) an event (Dallo and Marti 2021, 5f; Reuter et al. 2017b, 2188).

Related to the style of communication is the format and / or the visual representation of the message. While many PWS do not allow for choosing different formats or ways to represent messages, this is a dedicated strength of warning apps. Warning apps can provide content in different formats, e.g., in form of texts, maps, visualizations, and videos. Depending on individual preferences, users might be able to choose the way of displaying warnings most appropriate for their needs (Dallo and Marti 2021, 5). Much like PWS in general, warning apps should not have too many functions, as people's information-processing capacity might be significantly reduced when faced with a hazard (Dallo and Marti 2021, 5). Therefore, it is crucial for app designers to optimally balance the implementation of diverse functionalities and graphical features with the need for easy to grasp information.

## 2.3 Technical Features of ECS-PWS

A technical report by the Body of European Regulators for Electronic Communications (BEREC 2020) gives "Guidelines on how to assess the effectiveness of PWS transmitted by different means". In our study, we added findings from BEREC's guidelines to the two areas of effectiveness described above: the content and style of warnings. These findings mostly refer to characteristics that are guaranteed with the help of the technical capabilities of the respective ECS-PWS. The BEREC report breaks this down into two broad categories: coverage and capacity to reach end-users.

**Coverage:** The coverage of ECS-PWS refers to both geographical and population coverage. Effectiveness increases with coverage. The objective is to "ensure that warning messages can be sent to the destination of the endangered end-users" (BEREC 2020, 20). As ECS-PWS rely on telecommunications infrastructure this means that in countries like Switzerland, were network providers are private companies, the authorities might have to maximize geographical coverage by regulation. In addition, geographical coverage depends on the topographical features. For example, mountainous areas make geographic coverage more challenging, although the Swiss telecommunications infrastructure is well developed in the Alps. Population coverage refers to the percentage of the population an ECS-PWS can reach. Depending on the distribution of the population it makes sense to improve telecommunications infrastructure in highly populated, urban areas while not covering geographical parts of countries, where only few people live (BEREC 2020, 21). Geographical or population coverage are the prerequisites for effective ECS-PWS. Only if there is a reliable telecommunications infrastructure, including when disaster strikes, warning the population via ECS-PWS is possible.

**Capacity to reach end-users:** The second broad category for assessing the effectiveness of ECS-PWS is their capacity to reach end-users. This concerns the actual warning technology and the devices used to receive warnings – mobile and smartphones mostly. An ECS-PWS is effective in its capacity to reach people, if it succeeds in conveying the message to people at-risk in time for them to act (BEREC 2020, 21). To reach people, ECS-PWS need to have certain functionalities and excel in specific tasks. First, they need to be able to target specific geographic areas with their messages. This includes leaving out other areas (BEREC 2020, 21). The next functionality is sufficient scalability. Some hazards only affect localized areas. Other events affect large cities or areas, necessitating timely and simultaneous warning of millions of people (BEREC 2020, 22).

Also of importance for the effectiveness of ECS-PWS is how many – if any – steps it takes to ensure at-risk people can receive warnings. Ideally, the number of steps is zero, meaning that warnings are displayed automatically on targeted devices. ECS-PWS, like warning apps, need action by the end-user. They have to download them and adapt settings towards their own needs (BEREC 2020, 23). This also means that people have to decide actively whether they want to use ECS-PWS or not.

Reliability is also important in terms of a network's ability to deliver messages to at-risk people no matter what (BEREC 2020, 24). All ECS-PWS discussed in this study, including multi-hazard warning apps, depend on a functioning telecommunication and energy infrastructure. Some hazards like flooding, earthquakes, or storms can damage or destroy the actual physical infrastructure that builds the networks – cables, antennas, distributing stations, operations center, etc., which may fully or partially disable ECS-PWS. The more robust such networks are, the lower the risk for failure in an extreme event and the more effective the ECS-PWS. An energy shortage, where the reliable supply of energy to the network is interrupted, requires an emergency power supply for a network to send messages. Without sufficient energy supply, all ECS-PWS will stop functioning after a while and will no longer be able to provide emergency information. In such cases, only dedicated means like mobile sirens or mobile emergency networks, which are provided by the military in Switzerland, can maintain the flow of information to the public. However, if experts predict a natural hazard to threaten the functioning of physical infrastructure, the same hazard will likely also directly threaten the life and well-being of people in the area at risk. Thus, they need to issue timely warnings before a disaster, while the physical infrastructure still works. Another threat to the reliability of ECS-PWS is network congestion. In an emergency, many people will try to communicate at the same time. Also some ECS-PWS require more network capacity than others. Depending on the type of ECS-PWS, there might not be enough network capacity for the warnings to reach at-risk people in time.

An ECS-PWS is effective, if it succeeds in delivering warnings to all people affected, even if they enter the affected area after the initial warning, or if people are visiting, travelling through an impacted area, or are unable to understand the local language (BEREC 2020, 22). Reaching all potentially affected people includes people with disabilities, e.g., people who are blind, deaf, or hard of hearing. While some ECS-PWS might be better able to send accessible warnings, this often depends more on the devices used by affected people with disabilities (BEREC 2020, 24). For ECS-PWS to be able to distinguish between different needs of at-risk people, they need to gather sensitive data. The less private data an ECS-PWS needs, the better. However, with respect to differentiated user needs, it might make sense to include some personalized data in order to improve the warnings for specific groups

of people. The responsible handling of sensitive data is a prerequisite for the success of an ECS-PWS (Dallo and Marti 2021, 9). This includes cyber-security. ECS-PWS should be hard to infiltrate because the impact of sending false warnings might be catastrophic, as shown by an inadvertent ballistic missile alert issued in January 2018 in Hawaii (Karl and Lytle 2019; Vivier et al. 2019, 24).

Taken together, these three broad categories – warning content, warning style, and technical features of ECS-PWS – allow for a thorough assessment of the effectiveness of PWS, and ECS-PWS more specifically.

# 3 Public Warning Systems Using Means of Electronic Communications Services

There are multiple ways to leverage the ubiquity of mobile devices such as smartphones or tablets for PWS. This chapter focuses on three options: multi-hazard warning apps, LB-SMS, and CB. After briefly explaining how each of them functions, their performance is compared based on effectiveness criteria discussed in section 3.5 of this chapter. Furthermore, there is a brief overview of their prevalence as PWS in OECD countries.

## 3.1 Multi-Hazard Warning Apps

Mobile apps refer to software for smartphones that is mostly developed by third parties. The two most common mobile operating systems are Android and iOS. Android is developed by Google and runs on about 73 per cent of global and 47 per cent of Swiss smartphones, including those produced by Samsung or Xiaomi (Statcounter 2021a, 2021b). iOS is maintained by Apple and runs on iPhones, which account for about 26 per cent of global and 53 per cent of Swiss smartphones (Statcounter 2021a; 2021b). Due to economic, convenience, and security reasons, app stores have emerged as the gatekeepers for third party software on these operating systems. The Google Play Store and Apple's App Store both review apps before they can be included in their stores, and they put restrictions on how much data an app can track. For example, in the case of apps that were designed to support the contact tracing during the coronavirus pandemic, Apple and Google decided to deny apps background access to Bluetooth unless the apps store the logs of the proximity between two devices on the devices itself rather than on an external server. Given their market power, this undermined efforts to build an app that would not conform to their list of specifications, such as those originally planned in the United Kingdom and France (Fischer, Kohler, and Wenger 2020, 3). To get a regular mobile app, a smartphone user needs to pro-actively look for it in an app store and download it. However, several apps are already pre-installed by the hardware manufacturer before the user buys a new smartphone. Mobile network providers may add even more pre-installed apps on Android. In contrast, Apple does not allow providers to add any pre-installed apps on iOS. Note that in the specific case of contact tracing apps, Google and Apple also explicitly refused to pre-install any government mandated apps. Fur-

thermore, there are ongoing discussions in the European Union about limiting the pre-installation of apps on smartphones and banning practices, such as the blocking of de-installation of pre-installed software.

Multi-hazard warning apps may offer a range of functionalities, such as location-based push-notifications for messages, up-to-date risk maps for hazards such as avalanches, in-depth information on hazards and preparedness and behavioral responses to them, the ability to store and share personal evacuation plans, as well as emergency buttons that allow the user to easily share their exact location and type of individual emergency with the relevant authorities. However, user experience has been mixed so far with some warning apps receiving low average scores on Google Play Store and Apple Store. To receive a warning message from the operator of an app, the user's smartphone needs Internet access. Based on such a signal, the app can then send out a push notification to the smartphone user. As the underlying operating system is regularly changing, any mobile app will require regular updates. Further maintenance costs include eliminating bugs, adding functionalities, creating relevant new content, and running servers.

## 3.2 Location-Based SMS

SMS is a well-established text-messaging format. SMS have a length limit of 160 characters. Longer messages need to be sent in multiple parts. Sending SMS in bulk to mobile devices in a particular geographical area is one option for public warnings. BEREC calls this LB-SMS. However, it is worth pointing out that LB-SMS is not a separate standard, but a combination of databanks that contain the location of users and SMS. From the perspective of the network and mobile user, a LB-SMS message is a regular SMS message.

There is no need to activate anything on the mobile device or in the network to enable LB-SMS. However, in order to deliver LB-SMS to all mobile devices in a targeted location the network provider must maintain an up-to-date database of all users currently registered at a cell tower. An SMS requires an individual message to be sent over the network for every receiver. An advantage of SMS is that failed deliveries are registered, which enables targeted attempts at redeliveries. Furthermore, it is possible for a country to warn its citizens that are currently travelling abroad if the country that they are visiting faces a hazard. Vice versa, local authorities can decide to send a public warning SMS to in-bound travelers in a non-local language, based on their mobile country code. Lastly, authorities may find the ability to monitor the movement and density of a crowd via aggregated location data from network operators useful. During the COVID-19 pandemic, some governments used such data to monitor compliance with social distancing rules, albeit in aggregated form, with time delays, and on a temporary basis. The disadvantage of individual messages is that all of them require bandwidth and time. For example, in 2018 it took Portugal an hour to either reach 80–90 per cent of 300,000 persons or 40–50 per cent of 1,000,000 people via a public warning LB-SMS (BEREC, 2020, 31). There has been some progress in increasing LB-SMS throughput. However, for rapid onset hazards, such as terror attacks or earthquakes, the expected delay remains a clear handicap compared to CB. Lastly, institutionalizing government access to real-time location data creates privacy risks. For example, political demonstrations could be framed as social hazards that require monitoring.

## 3.3 Cell Broadcast

CB is a one-to-many text communication format. It works analogous to traditional radio broadcasting and radio receivers. Except that the message is transmitted with a cell tower as sender and all mobiles within its cell that are configured to listen as its receivers. The technology is sometimes also referred to as CB-SMS or SMS broadcast. However, to avoid any confusion with regular SMS, which is a standard for point-to-point communication between two devices, this report uses the terms 'CB messages' for ge-

| EU-Alert Type | WEA Type | Comment |
|---|---|---|
| EU-Alert Level 1 | Presidential Alert | Opt-out not allowed |
| EU-Alert Level 2 | Extreme Alert | Opt-out is allowed |
| EU-Alert Level 3 | Severe Alert | Opt-out is allowed |
| EU-Alert Level 4 | Public Safety Alert | Opt-out is allowed |
| EU-Info | - | Opt-out is allowed |
| EU-Amber | Child Abduction Alert | Only based on opt-in |
| EU-Monthly Test | Required Monthly Test | May or may not involve public |
| EU-Test | State / Local Test | Opt-out is allowed |

Table 1. Types of CB alerts. Adapted from ETSI (2019, 10).

neric broadcast text-messages and 'CB alerts' for broadcast texts that specifically contain a public warning. The great advantage of CB compared to point-to-point formats is that it only requires enough bandwidth for a single message to be sent by the cell tower and is thus still functional in congested mobile networks. Hence, CB alerts can be distributed within seconds to millions of devices. If a mobile is turned off or not within the targeted warning area during the broadcast, it will not receive the message. However, CB alerts can be repeated at set intervals from 1.8 seconds to 128 minutes (ETSI 2020b, 44). Every CB alert has a serial number and phones will not display a message with the same serial number twice. This way users are not harassed by repeating alarms. A CB page has space for 93 characters of text. However, messages can contain up to 15 pages, which allows for a total of 1395 characters in a CB alert with the same serial number.

CB alerts may originate from several entities, which are connected to a CB center. This center then distributes the messages to one or several network providers, which forward it to the affected cell towers. The protocols for sending and receiving CB alerts may differ slightly between countries. The two most prominent CB PWS protocols are the Wireless Emergency Alert (WEA), which is defined and implemented by the US, and the EU-Alert, which is defined by the European Telecommunications Standards Institute (ETSI) (2020a). However, there is no EU-wide system implementation of the EU-Alert standard. Rather, there are national implementations of the EU-Alert, which are named based on national abbreviations, such as NL-Alert, UK-Alert, FR-Alert, DE-Alert. Both the WEA and EU-Alert standard reserve message identifiers that correspond to specific categories of alarms. These message identifiers also enable authorities to send any alert type in additional languages, which are only displayed to select users based on language preferences. Furthermore, there are still many unassigned numbers for message identifiers. Hence, new categories may be added in the future. For example, CB could also serve as a backup way to alert civil emergency organizations.

An activation of a national CB system requires three steps. First, the government must initiate an alert mechanism and a message-forwarding interface to each of the participating network providers. Second, network providers must activate the CB functionality in their networks. The state can mandate this step through legislation or contractual agreement. Third, the providers of mobile operating systems (Google, Apple) activate cell broadcast settings on smartphones using these network providers with the next operating system update. Fourth, smartphone users can opt-in to receive lower-level CB alerts in their settings. On Android phones, the location of the settings to receive governmental CB may vary based on manufacturer. On iPhones the setting is under heading notifications. This process is simple and civil protection authorities may support users with step-by-step online guidance (e.g., General Secretariat for Civil Protection of Greece 2021; Ministry of Interior of the Republic of Lithuania 2021). In many countries, CB alerts are activated by default in phones that are newly sold or that have been updated to the newest versions of iOS or Android. However, users can still opt-out from all alerts except for the highest level. In the US, this is the Presidential Alert. In Europe it is EU-Alert Level 1.

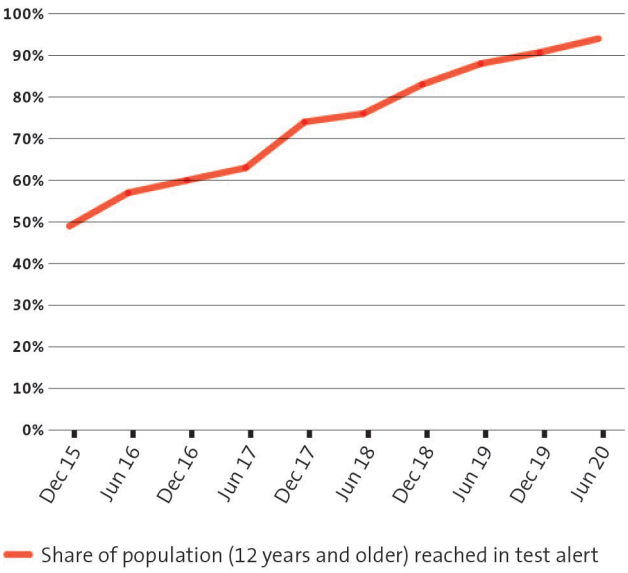
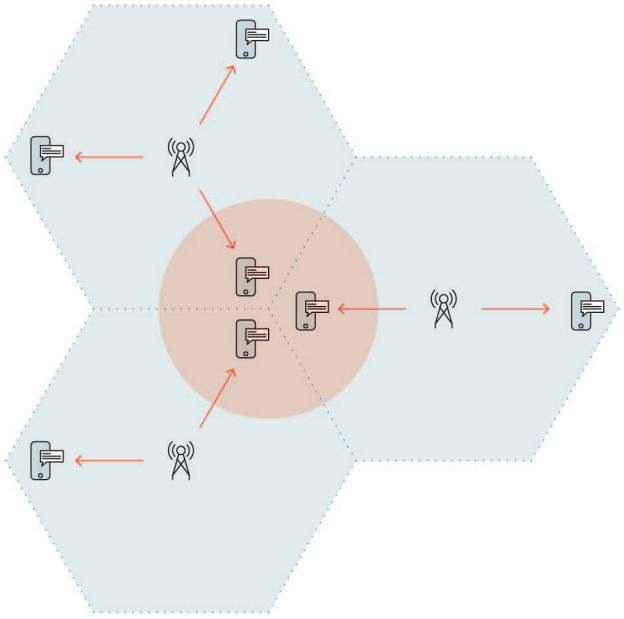



Figure 1. Reach of CB test alerts in the Netherlands, 2015–2020. Data from Ministry of Justice and Security (2021a).

It is likely that the reach of CB messages will improve over time as the share of by default CB-enabled phones grows and the awareness amongst smartphone users increases with annual tests or actual alerts. For example, as highlighted in figure 1, test alerts in the Netherlands have continued to reach more people with every iteration for many years after the initial launch in 2012.

Past discussions about CB may have included concerns that are of limited relevance today. First, as highlighted in the Netherlands' example above, a high portion of current mobile devices support CB. Second, it has been argued that activation of CB on phones is too complicated without external assistance. However, experience from early adopter countries shows that most users are able to activate it by themselves. Third, CB has been included in every generation of mobile network standards since 2G. There will be new networking standards in the future. However, as CB is used by ever more countries as part of their PWS, it is reasonable to assume that it will be included in all foreseeable future standards. In an expert survey by the United Nations Development Programme (2012, 7) "the respondents agreed that all foreseeable mobile wireless technologies will have at least as much capability as existing CB systems". Fourth, the price of CB



Each hexagon represents the area served by a given cell.

The red circle surrounds the Warning Area Coordinates as specified by the warning message sender. Devices in the warning area will display the alert.

Devices outside the warning area may receive an alert but will not display it to the user.

Figure 2. Visualization of device-based geo-fencing CB (adapted from BEREC 2020, 11).

alerts is not dictated by network providers. In countries such as Bangladesh, India, Maldives, Nigeria, Samoa, and Sri Lanka, the network providers deliver this public service for free either voluntarily or based on a legal obligation (Al-dalahmeh et al. 2018, 101). This is not dissimilar to the public warning obligations of radio broadcasting services and TV stations in some countries. This is not to say a service level agreement between the government and network providers that includes some compensation for and limits legal liability of providers in exchange for technical guarantees, is not a good option. However, the state has the power to decide if compensation is warranted, and how much it should be.

There are several extensions to standard CB messages, which provide additional functionalities. These are only available to a limited set of devices at first. However, it is reasonable to assume that they will become more broadly available over time. Most notably, there is a device-based geo-fencing feature. This enables the CB center to include geographically targeted information within the CB alert. Mobile devices within the reach of cell towers, which have relevant overlaps, receive such CB alerts, compare the information to their own location, and decide whether to display a warning or not (figure 2). This enables geographic targeting of warning messages that is more granular than cell towers. This feature was specified at the request of the US Federal Commission for Communications (FCC) in the WEA-format, however, it has also been added to the standardization specifications for worldwide availability. It will likely also be available in Europe in the future (BEREC 2020, 10f). Furthermore, newer devices support the automatic preservation of CB alerts for at least 24 hours, so that users can reread the content (FCC 2021).

## 3.4 Other ECS-PWS Options

The three approaches discussed above are the most popular options for ECS-PWS. However, there are many other possible ECS-PWS, a selection of which is briefly highlighted below:

**Website:** Websites are particularly useful in providing information outside of emergencies, or during slow-onset disasters. In rapid onset disasters, they mostly serve as a source that can be linked to for additional information but they are not a primary channel for the initial warning. While it is technically possible to send web-based push notifications, they depend on prior user agreement and/or download of a web-based app. As such, they face the same prevalence issue as regular apps, except that they are less popular.

**Social Media:** Emergency services increasingly include social media into their communication plans and disseminate alerts and preparedness knowledge through organizational accounts on the major platforms, such as Twitter and Facebook. Aside from pushing warnings, social media can also be useful to address rumors and disinformation, as well as to disseminate information according to the needs of specific groups of citizens.

**Email:** Personal email addresses are usually not stored in any national or regional directory. Therefore, any email alert has to be an opt-in service based on prior registration. Registered email addresses can be notified of developing or predicted emergencies as well as suggestions for the proper course of action to take at a given time.

**Emergency Telephone Alert System:** The public switched telephone network as well as voice-over-IP can be used to deliver emergency messages to landline phones. An emergency telephone alert system delivers recorded audio messages in order to warn citizens at home and provide them with instructions. The location of each fixed phone number is stored in an outbound calling database, so that the alert is only sent to geographically targeted areas. Emergency telephone alert systems recognize standardized tones, e.g., for an occupied line, as well as voicemail systems, and can implement pre-defined procedures for each delivery failure.

**Satellites:** Global navigation satellite systems can broadcast a public warning signal that can reach large parts of the population in targeted geographic regions even if the terrestrial telecommunications infrastructure is limited or degraded. However, this comes with two caveats. First, this type of public warning is still in development, and is not yet operational. Second, there are only a handful of GNSS satellite networks. Switzerland would have to rely on the EU network Galileo.

## 3.5 Comparison

This section compares the three main ECS-PWS discussed above and the most common traditional PWS (sirens, radio broadcasting, and TV), using the example of Switzerland. The traditional Swiss PWS alarms the public with sirens, followed by information via radio. Switzerland maintains about 5,000 fixed and 2,200 mobile sirens (FOCP 2019, 3). Furthermore, it requires all licensed radio and TV broadcasters to "insert in their programme services without delay urgent police messages which are indispensable to the maintenance of public order and safety or the safety of persons, as well as official alerts and instructions" (Federal Council 2021, Art. 8a). In practice, the government primarily focuses on radio operators and maintains a back-up network of radio transmitters. Multi-hazard warning apps, LB-SMS, and CB are the three options that were included in the last evaluation of PWS in Switzerland (FOCP 2017). As with traditional PWS, these options are not mutually exclusive and can potentially complement each other. Switzerland introduced a multi-hazard warning app in 2018, but does not currently use CB and LB-SMS as part of its PWS.

Table 2 compares different PWS with regards to reachability in different contexts. As visible, ECS-PWS have a clear advantage over traditional PWS in terms of principal reachability, as most of the population always has a mobile on them.

Table 3 evaluates the PWS based on requirements discussed in Chapter 2, namely warning content and efficiency of delivery. It highlights how the three components of the traditional PWS are complementary, as sirens do have a good reach, but only radio and TV can communicate details and instructions. In terms of ECS-PWS, there is an important distinction with regards to congestion management. CB alerts require little bandwidth, whereas the fast warning through multi-hazard warning apps or LB-SMS cannot be guaranteed if the mobile network is degraded or congested. Furthermore, LB-SMS messages can be sent by anyone. Hence, some receivers may not trust the message to be authentic. With regards to multi-hazard warning apps, the main issue is that there is no country in which a majority of the population has pro-actively downloaded such an app.

Table 4 highlights factors that are not listed by ETSI but that are nevertheless relevant. Broadcast approaches are the most privacy-friendly because they do not require, and are not able to collect, any information on the mobile devices within a broadcast area. A strong point of apps is that their content is not limited to push-information and they can therefore be more informative. Furthermore, they can also be an Internet-based complement to emergency telephone numbers. The procurement and maintenance costs are particularly high for sirens and the back-up radio system, which require expensive specialized hardware. In contrast, it is cheap to enable warnings through CB or LB-SMS as these have established international standards that are already integrated into cell towers and modern mobile phones. The cost of distributing LB-SMS *en masse* is higher than that of CB messages because the former requires more bandwidth. A further factor for mobile device-based warnings is whether the format is clearly distinguishable from regular messages, and whether it can override settings in case of highest order alerts. Specifically, push notifications of a warning app can be turned off, whereas the highest level of CB alerts will always get through. A warning via LB-SMS is not readily distinguishable from a regular SMS, and may not reach the attention of the receiver, whereas a CB alert initiates a unique tone and format.

| Reachability while | Siren | Radio | TV | Multi-hazard warning app[1] | LB-SMS | CB |
|---|---|---|---|---|---|---|
| **At home** | partially compliant[2] | compliant | compliant | compliant | compliant | compliant |
| **At work** | partially compliant[2] | non-compliant | non-compliant[3] | compliant | compliant | compliant |
| **In public venues** | compliant | non-compliant | non-compliant[3] | compliant | compliant | compliant |
| **On foot** | compliant | non-compliant | non-compliant[3] | compliant | compliant | compliant |
| **In a vehicle** | partially compliant[2] | compliant | non-compliant | compliant | compliant | compliant |
| **Visiting another European country[4]** | compliant | compliant | compliant | partially compliant | compliant | compliant |
| **In protective shelters[5]** | non-compliant | civilian: non-compliant, military: partially compliant[6] | non-compliant | non-compliant | non-compliant | non-compliant |

Table 2. Compliance of PWS with service objectives in Switzerland in terms of reachability (adapted from ETSI 2020b, 16–18).

1 Not included in the ETSI evaluation.

2 Sirens are not heard under all circumstances at work.

3 ETSI judged TV to be compliant in these categories. However, we judge that most people are not reachable via TV at work, in public venues, or on foot.

4 Assumes correct configuration (CB) and access to hardware in local housing (TV). In theory, one could download a multi-hazard warning app of a country that is visited, but in practice only very few countries have one and no country asks visitors upon arrival to download their app.

5 Not included in the ETSI evaluation.

6 Standard civilian radio stations (FM/DAB+) are not powerful enough to send radio signals to shelters. However, state-run emergency transmitters (FM) are able to reach large parts of the population in shelters.

| Method sufficiently supports | Siren | Radio | TV | Multi-hazard warning app | LB-SMS | CB |
|---|---|---|---|---|---|---|
| **Instructions regarding actions to be taken** | non-compliant | compliant | compliant | compliant | compliant | compliant |
| **Identification of the message originator** | partially compliant[1] | compliant | compliant | compliant | partially compliant[1] | compliant |
| **Planned messages for a specified time** | compliant | compliant | compliant | compliant | non-compliant | compliant |
| **Simultaneous delivery to targeted large audiences or geographical areas** | compliant | non-compliant[2] | non-compliant[2] | non-compliant[2] | non-compliant[2] | compliant |
| **Provision of details of the emergency situation** | non-compliant | compliant | compliant | compliant | compliant | compliant |
| **Retry of delivery if the initial message fails** | compliant[3] | compliant[3] | compliant[3] | compliant | compliant | compliant[3] |
| **Special needs (e.g., hearing impaired)[4]** | non-compliant | partially compliant | partially compliant | partially compliant | partially compliant | partially compliant |
| **Multiple languages** | non-compliant | compliant | compliant | compliant | compliant | compliant |
| **Delivery despite congested networks** | compliant | compliant | compliant | non-compliant | non-compliant | compliant |

Table 3. Compliance of PWS with service objectives in Switzerland in terms of warning content and delivery (adapted from ETSI 2020b, 16–18).

1 ETSI judges sirens to be compliant. However, since most alarms do not include a voice recording, we only judged it to be partially compliant. LB-SMS are judged partially compliant because anyone can principally send them. Hence, the receiver may not trust the stated message originator to be authentic.

2 According to ETSI, an alert should be able to reach 50 per cent of the citizens in the relevant area within 3 minutes; and 97 per cent of the citizens in that area within 5 minutes. (This may include people warning others in their vicinity that did not receive the warning directly.)

3 In broadcast formats, non-delivered messages are not registered, but the warning message can be repeated at regular intervals.

4 Many deaf or hearing-impaired individuals have lights or vibrators attached to their mobile devices. Many blind or visually impaired persons use text-to-speech conversion software. CB alerts are accompanied by an audio attention signal and vibration. CB alerts to pre-identified or ad hoc subgroups of the population are possible by designating a special message identifier and ensuring that all the members of the group have CB capable handsets.

| Evaluation criteria | Siren | Radio | TV | Multi-hazard warning app | LB-SMS | CB |
|---|---|---|---|---|---|---|
| **Privacy-preserving** | yes | yes | yes | depending on app design[1] | requires database with phone numbers and location | yes |
| **Two-way communication possible** | no | no | no | yes | yes | no, but may include number to text or call back |
| **Easy way to share location and type of individual emergency with authorities** | no | no | no | yes, through an emergency button | through calling on same device | through calling on same device |
| **Offer individual disaster preparedness knowledge / tools** | no | limited | limited | yes | limited | limited |
| **Highest level alert receives attention at night[2]** | yes | no | no | depending on app design | no | yes |
| **Suitable for lower level alerts[3]** | no | limited | limited | yes | yes | yes |
| **Opt-out from lower level alerts** | no | no | no | depending on app design | depending on database | yes |
| **Alerts still possible after a blackout[4]** | yes | only to battery-operated radio receivers (incl. in cars) | only to buildings with back-up power | for a limited time | for a limited time | for a limited time |
| **Procurement costs[5]** | very high[6] | very low to very high[7] | very low | moderate | low | moderate to high[9] |
| **Maintenance costs[5]** | high[6] | very low to high[7] | very low | moderate | moderate to high[8] | low to moderate |
| **Population coverage** | very high | high | high | low[10] | very high | very high |
| **Public support** | n/a | n/a | n/a | mixed[11] | n/a | very high[11] |

Table 4. Additional evaluation criteria of PWS. These are not included in ETSI (2020b).

1 For example, the Alertswiss app is privacy friendly, as it only stores personal data on the device.

2 According to a survey in the UK, 92 per cent sleep with their phone present in the same room, but the majority has their phone on silent, and 89 per cent would not read an SMS at any time during the night. In contrast, a highest-level CB alert would cause the phone to make loud noise independent of audio settings (Grant 2020). However, phones that are turned off or in 'airplane mode' at night would still not get the CB alert.

3 This category is already covered indirectly above. However, it is worth highlighting explicitly that there are many situations with increased health hazards that warrant public communication, which are not judged immediate and severe enough to activate sirens (e.g., unavailability of emergency numbers, intermediate storm warning, local fire, local water pollution) for fear that they would primarily cause panic and confusion. Radio and TV are only judged of limited suitability because the public would still need to tune in at the right time.

4 In Switzerland the sirens would still be operable for days after a blackout. TV receivers are rarely battery-operated. Mobile phone based solutions depend on mobile phone battery and the emergency power supply of the mobile network. States can mandate the number of hours for which service still has to be guaranteed.

5 These are meant as a rough indications only. As the costs depend on factors such as legislation and negotiations with mobile network operators, they can vary substantially between countries.

6 There are 5,000 fixed sirens in Switzerland, which cost 10,000–20,000 CHF per siren in procurement and about 350 CHF per year per siren to maintain. Additionally, there are 2,200 mobile sirens, which cost about 4,000 CHF in procurement. These numbers are based on the FOCP (2019, 3; 2020, 1), and would indicate procurement costs close to 100 million CHF per life cycle of the sirens and annual maintenance costs of about 1.75 million CHF. The full costing is about 25,000 CHF per fixed siren.

7 This is based on the back-up radio network "IBBK" in Switzerland. The cost of asking commercial radio broadcasters to send public warning messages is low.

8 Sending LB-SMS creates little direct costs to network providers. However, the state may still agree to pay providers for the service. At 0.01 CHF per LB-SMS this would amount to about 85,000 CHF for a nationwide LB-SMS test-alert in Switzerland.

9 The direct procurement costs for the state are limited to the interfaces. However, network providers may incur conversion costs, which may be reimbursed by the state. For example, the Netherlands paid 12 million EUR to network providers for this (State Fire and Rescue Service 2020, 28).

10 Based on downloads, the German multi-hazard warning app NINA has a population coverage of about 10 per cent. The Swiss warning app Alertswiss has a population coverage of about 12 per cent.

11 Reviews on Google Play Store and Apple's App Store hint at mixed public feelings towards multi-hazard warning apps. In contrast, surveys in the Netherlands and the UK show a very high public approval of CB alerts (Grant 2020).

## 3.6 Prevalence

OECD states that have established or are in the process of establishing CB for public warning include: Australia, Austria, Canada, Chile, Denmark, France, Germany, Greece, Israel, Italy, Japan, South Korea, Latvia, the Netherlands, New Zealand, Spain, the UK, and the US.

OECD states that have established or are in the process of using LB-SMS for public warning include: Australia, Belgium, Estonia, France, Iceland, Norway, and Sweden.

OECD states that have established or are in the process of establishing multi-hazard public warning apps include: Austria, Finland, Germany, Luxembourg, the Netherlands, and Switzerland.

France launched a multi-hazard warning app in 2016 but retracted it and is now rolling out CB. While there are quite a few countries using LB-SMS, there also appears to be a trend towards using CB in recent years. For example, the Central and South American industry association 5G Americas (2018) explicitly advocates for using CB rather than LB-SMS or multi-hazard warning apps. Similarly, Australia is in the process of switching from LB-SMS to CB due to its higher reliability during emergencies. This trend is in accordance with the strong performance of CB in the comparisons provided in section 3.5. However, as with traditional PWS, there are benefits to complementing CB with other options. For example, the Israeli government can reach all its citizens within seven to eight seconds through CB, but a private multi-hazard warning app still offers complementary information, as well as a panic button that shares the exact location and type of emergency with authorities. Similarly, the Netherlands, the CB pioneer in Europe, has recently launched an official NL-Alert app to complement its PWS with information that is relevant outside of immediate emergencies.

# 4 Country Comparison of Multi-Hazard Warning Apps

## 4.1 Switzerland and Liechtenstein – Alertswiss

After a three-year pilot phase, the Alertswiss app has been available to the public in Switzerland and Liechtenstein since autumn 2018 to deliver alerts, warnings, and other information from the authorities on various hazards directly via smartphones (FOCP 2021). Alertswiss was developed as a joint project between the Confederation and the 26 cantons. The messages in the app are issued directly by the locally responsible authorities in civil protection on the cantonal level. The Swiss Federal Office for Civil Protection (FOCP) is responsible for its operation and the necessary infrastructure. The FOCP pursues a multi-channel strategy in the dissemination of Alertswiss messages in order to maximize their reach. For this reason, Alertswiss also includes the website www.alert.swiss, where all messages are published in parallel to the app. The FOCP also disseminates the messages via Twitter, and offers the cantons the opportunity to do the same via their own Twitter channels. In 2021, the dissemination of Alertswiss alerts was expanded via the MeteoSwiss app, the official weather app of the Swiss Federal Office of Meteorology and Climatology, which has been downloaded around 20 million times (FOCP 2021a). Users of this app receive a push message that redirects them to the Alertswiss website if they are in an at-risk area or have subscribed to a particular area as a favorite in the app. Information and warnings continue to be distributed simultaneously via the Alertswiss app and website, and via connected communication channels. In addition, an 18-month pilot project has been running since May 2021, which delivers Alertswiss messages to all private radio broadcasters in Switzerland via a channel they are accustomed to from the news agency Keystones-SDA (FOCP 2021b). State television and all licensed private radio and TV stations in Switzerland are already obliged to broadcast important information from the authorities in their program. The pilot project is intended to help the private radio broadcasters to streamline the required processes, and to allow important messages to flow directly into the editorial system. Since its official launch in 2018, around 1,200 messages and updates have been disseminated via Alertswiss (FOCP 2021c).

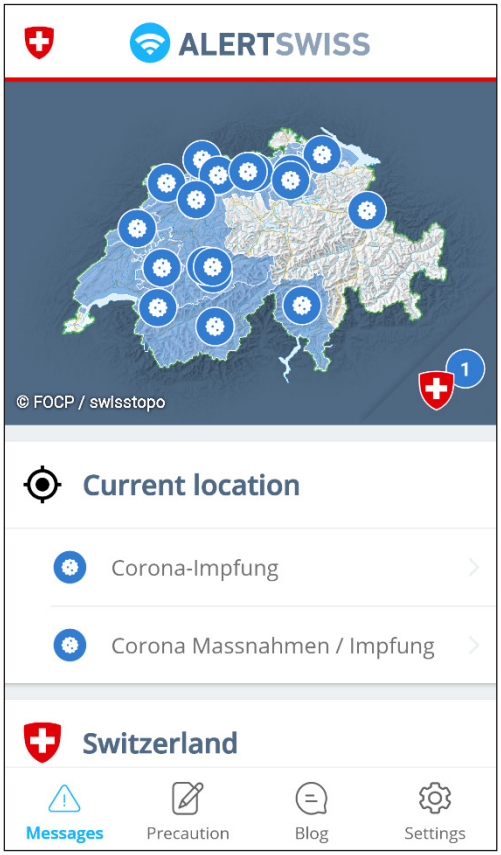



Figure 3. Screenshot Alertswiss.

### Who is responsible for operating the app?

The Federal Office for Civil Protection (FOCP) (*Bundesamt für Bevölkerungsschutz* (BABS)).

### Year of introduction

2015. Introduction of alert function in 2018.

### Other widely used multi-hazard warning apps

None.

### Which hazards does the app cover?

The app follows an all-hazard-approach, covering a broad range of possible disruptive events. The respective senders are responsible for the content of the messages and the specific dangers that are warned against.

### Who can feed information into the app?

- Cantonal authorities, usually the cantonal police forces.
- The National Emergency Operations Centre (*Nationale Alarmzentrale* (NAZ)).

## User numbers

Over a million, or ca. 12 per cent of the population (FOCP 2021c).

## Rating in Google Play Store (number of ratings) / Apple App Store (number of ratings) as of November 2021

3.3 ★ out of 5 (1,580) / 3.7 ★ out of 5 (422)

## Smartphone usage

In Switzerland, 97 per cent of the population over the age of 18 owned a smartphone in 2020 (Statista 2021a). In the same year, mobile penetration in Switzerland was around 126 mobile connections per 100 inhabitants (Statista 2021b).

## Functions – Warnings

- Users receive push notifications about imminent and emerging hazards for the current location if geolocation tracking is enabled, for national threats affecting the whole of Switzerland, and for those cantons individually selected by the user in the app.
- No personal data is collected and no movement profiles are created. However, to benefit from the full functionality, Android users need to give the app permission to access identity, contacts, and photo / media / files, to receive push notifications or to export created emergency plans.
- The app distinguishes between three message levels: 1) information, for safety-relevant messages below the warning threshold; 2) warning, for possible dangers or events with behavioral recommendations; 3) alarm, for immediate dangers with mandatory behavioral instructions. Users can decide which danger levels they want to be informed about.
- All messages are displayed on a map of Switzerland and Liechtenstein with a corresponding icon. Unrestricted zooming in and out on the map is possible, e.g., to see messages in areas that are not saved as favorites. If a message does not concern a whole canton, e.g., in case of a flood, the relevant area is visually delineated when zooming in on the map. Additionally, all messages are displayed in the app in list form.
- The app can override individual setting preferences when the smartphone is set to silent.
- Push notifications and icons can be selected to obtain more detailed information on particular hazards, as well as recommendations or instructions on how to behave (e.g., stay in place, close windows and doors, seek shelter).

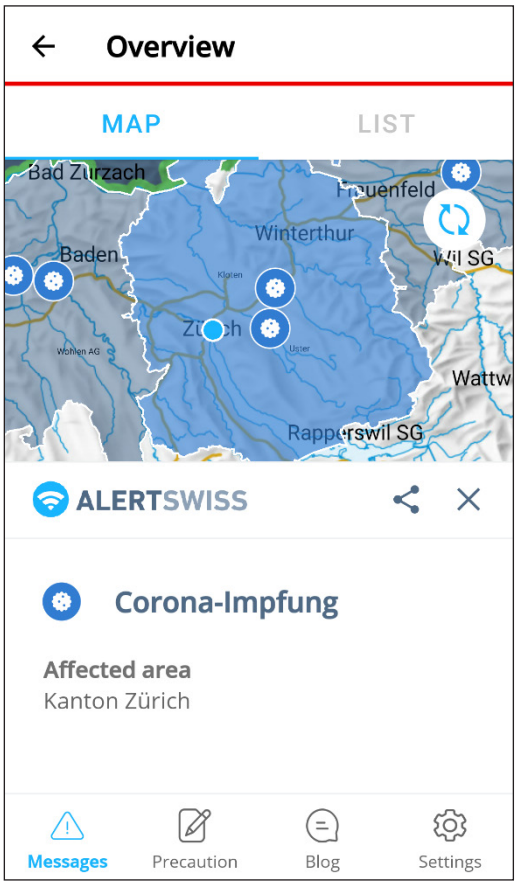



Figure 4. Screenshot Alertswiss.

## Functions – Information

- In addition to messages regarding specific hazards, the app includes sections titled Precaution and Blog.
- Under the Precaution section, more detailed information is available on particular hazards: earthquake, flood, storm, heavy snowfall, forest fire, heat wave, cold spell, power outage, pandemic, chemical plant accident, dam accident, and nuclear power plant accident. The following aspects are highlighted about these hazards: What is the issue? What does that mean for me? Examples, general and specific instructions, and links to more information. Furthermore, it is possible to create and export your own emergency plan in the app. This covers topics such as contact details of relatives, individual procedures in case of an evacuation, predefined meeting points, or baggage to bring in an emergency.
- The Blog section consists of a blog managed by the FOCP that addresses civil protection-related topics in Switzerland in general. In addition, a so-called social wall can be accessed on which tweets relevant to civil protection are collected from Swiss federal and cantonal authorities as well as from neighboring countries.
- On www.alert.swiss, additional information and videos can be found, e.g., about the meaning of siren

tones and behavioral recommendations, or the different partner organizations of Swiss Civil Protection.

### Functions – Communication

- Users can share official messages from the app via e-mail, SMS, social media, messenger, and other apps installed on their devices. The forwarded messages consist of a link that leads to the corresponding message in the app or on www.alert.swiss.

### Functions – Settings

- Available languages: German, French, Italian, and English. The messages within the app are in the language in which they were entered by the sender.
- Test function for push notifications.
- Push levels: users can select from which level (information, warning, alarm) they will receive push notifications.
- Users can enable / disable geolocation tracking.

### Other ECS-PWS used in the country

None so far (see Plans).

### Additional information

The devastating floods in Germany in July 2021 resulted in new discussions at the political and expert level in Switzerland about the potential introduction of CB as an additional option for PWS. In September 2021, various motions were submitted on this issue on the cantonal and national level (Motion 21.4152). In 2017, the introduction of CB was examined in a report by FOCP together with cell phone providers and subsequently rejected. Due to recent developments, the FOCP will re-examine the value of alerting with CB (FOCP 2021c).

### Plans

The FOCP intends to continue linking the various channels used in the dissemination of Alertswiss messages, and to further increase its reach in the future. With this goal in mind, new dissemination channels are also being developed, such as the collaboration with the MeteoSwiss app. From 2022, the FOCP will also participate in an innovation project in collaboration with the University of Zürich, which aims to develop technological solutions that can automatically translate messages into simplified language and sign language (FOCP 2021c).

## 4.2 Germany – NINA

In Germany, two warning apps have roughly the same functionalities. For this country comparison, we decided to focus on the official multi-hazard warning app NINA, which stands for *"Notfall-Informations- und Nachrichten-App"* (Emergency Information and News App), as the German Federal Office of Civil Protection and Disaster Assistance (BBK) runs the app, and it has the most users. Its main competitor, the privately developed and run warning app KATWARN, is the main warning app used in Austria, which we examine in section 4.3. Germany has so far used the NINA warning app as their main ECS-PWS, and has not introduced CB or LB-SMS. In contrast to Switzerland, Germany has reduced its sirens significantly after the end of the Cold War. Only about 15,000 remain of the over 80,000 sirens installed until the 1990s (MDR 2021). Sirens are no longer managed at the federal level, as it was during the Cold War, but are financed and maintained by *Bundesländer* (cantons), which can individually decide whether they want to afford them (Casper 2020). As a consequence, the federal authorities can no longer use sirens to issue alarms, and warning apps have grown in importance for the distribution of warnings.

In September 2020, Germany held its first National Warning Day in decades. The idea was to test all available PWS in Germany. The test showed significant shortcomings in the German PWS. For example, users of NINA did not receive the warnings as planned, due to an overload of the Modular Warning System (*Modulares Warnsystem,* MoWaS) that the German authorities use to feed information into warning apps (Casper 2020). During the National Warning Day, the BBK as well as authorities in the *Bundesländer* and at the local level all fed messages into the system, which caused delays in the delivery of warnings (ZEIT ONLINE 2020). The BBK had hoped the lessons learned during the National Warning Day would improve future public warnings in Germany. However, the catastrophic flooding in July 2021 proved that there is still further need for improving its PWS (Koch, 2021; see Additional Information and Plans further below).

### Who is responsible for operating the app?

The Federal Office of Civil Protection and Disaster Assistance (*Bundesamt für Bevölkerungsschutz und Katastrophenhilfe* (BBK)).

### Year of introduction

2015, current version: 3.40 (September 8, 2021).

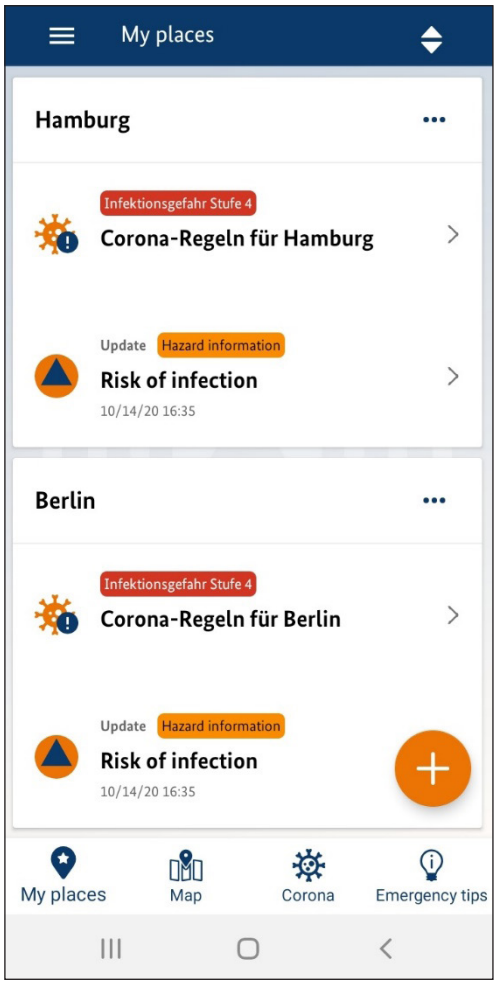



Figure 5. Screenshot NINA.

## Other widely used multi-hazard warning apps

*KATWARN:* This app is similar to NINA. It provides essentially the same functions and serves the same purpose. The main difference is that BBK hosts NINA, while KATWARN was developed by the Fraunhofer-Institute for Open Communication Systems FOKUS on behalf of public insurance companies. KATWARN has about 3.8 million users (Stiftung Warentest 2021).

*BIWAPP:* This app has since 2016 offered disaster and hazard warning functionalities on top of more everyday warnings, like roadwork, police news, or information about school closure. The information on hazards comes from MoWaS. The developer of the app is Marktplatz GmbH (Stiftung Warentest 2021; Marktplatz GmbH 2021).

KATWARN and BIWAPP use information provided by MoWaS to inform their users about imminent danger.

## Which hazards does the app cover?

The app follows an all-hazard-approach, covering a broad range of possible disruptive events, such as heavy precipitation, dam breaks, or biological hazards.

## Who can feed information into the app?

- The responsible authorities on the federal and state levels (including fire departments, police, civil protection offices) via MoWaS.
- The German Meteorological Service (*Deutscher Wetterdienst* (DWD)).
- The Interstate Flood Portal (*Länderübergreifendes Hochwasserportal* (LHP)).
- BIWAPP operators.
- KATWARN operators.

## User numbers

More than 8 million, or ca. 10 per cent of the population.

## Rating in Google Play Store (number of ratings) / Apple App Store (number of ratings) as of November 2021

3.3 ★ out of 5 (21,474) / 2.6 ★ out of 5 (3,599)

## Smartphone usage

In Germany, 60.74 million people above the age of 13 used smartphones in 2020 (Statista 2021c). This accounts for roughly 84 per cent of this part of the population. From 2009 to 2020, smartphone usage increased approximately tenfold (Statista, 2021c).

## Functions – Warnings

- Push notifications about imminent and emerging hazards, either location-based (if geolocation tracking is enabled, the location is not shared with BBK or any other organizations) or for specific areas that users can choose. Users can also choose the warning level they want to receive messages for (hazard information, danger, and extreme danger). Push notifications for extreme danger warnings cannot be switched off.
- All messages are displayed on a map of Germany with colors indicating the level of alert. Unrestricted zooming in and out on the map is possible, e.g., to see messages in areas that are not saved as favorites. Additionally, all messages are displayed in the app in list form (for areas saved as favorites and current location, if enabled).

- Push notifications also contain behavioral recommendations like stay in place, close windows and doors, seek shelter, etc.
- A list of all current warnings.
- Current warnings on a map for all of Germany.

## Functions – Information

- Emergency tips include a list of articles that give users information about what to do in an emergency, tips for personal emergency planning, power-saving tips for smartphones, and tips for specific hazard situations (terror attacks, missile strikes, flooding, severe weather, power outage, fire, hazardous substances). The information is also available offline and in different languages (including simplified German).
- There is a section specifically on COVID-19, including general information on the pandemic, behavioral recommendations in case of symptoms, vaccination information, measures against the pandemic, and contact details / links to relevant authorities. This information is only available in German.

## Functions – Communication

- Users can share warnings via e-mail, social media, messenger apps, and other apps installed on their devices.


Figure 6. Screenshot NINA.

## Functions – Settings

- Available languages, including parts of warnings etc.: German, English, French, Spanish, Turkish, Polish, Russian, Arabic, and simplified German.
- FAQ / introduction to the app.
- Enable / disable “current location”.
- It is possible to configure warnings to the warning level the user wishes to receive push notifications for, the warning tone, and other notification options (blinking, vibration, display on home screen, etc.). The app settings link directly to the phone settings. It includes the option to overrule “silent” device settings.

## Other ECS-PWS used in the country

None so far (see Plans).

## Additional information

The devastating flooding in July 2021 triggered a public debate on Germany’s PWS. The debate focused on shortcomings during the floods, and argued that the large number of deaths (more than 180) were at least partially due to PWS failures (bpb 2021; Koch 2021). Neither sirens, local radio and TV stations, nor NINA, KATWARN and BIWAPP successfully warned the population of the unfolding life-threatening situation. Other ECS-PWS were not available (Koch 2021). In contrast, the Netherlands used their CB system to disseminate flood warnings and prevented deaths (Koch 2021). Due to the localized nature of the most extreme damage from these floods, the situations in Germany and the Netherlands cannot be directly compared but it led to a questioning of the effectiveness of warning apps, especially when compared to CB (Koch 2021).

## Plans

On 7 September 2021, the German parliament passed an amendment to the Telecommunications Act of Germany, allowing for the introduction of CB (Krempl 2021). The BBK will be responsible for the rollout of CB in Germany and plans to implement it by the end of 2022 (BBK 2021b).

## 4.3 Austria – KATWARN Austria

Since mid-2017, Austria has been using the multi-hazard warning app KATWARN Austria as a supplement to other PWS, such as sirens, loudspeakers, or the media. The KATWARN warning system only passes on official warnings and recommendations for action, but does not itself create warnings. The technology and infrastructure of KATWARN offers the Austrian authorities further possibilities for multifunctional public warnings and alerts, such as siren control and on digital information boards in public transport and on electronic advertising boards. Originally, KATWARN was developed for Germany by the Fraunhofer Institute for Open Communication Systems FOKUS, where it has been in use since 2011. However, only a few *Bundesländer,* such as Rhineland-Palatinate, individual counties *(Landkreise)* and independent cities *(kreisfreie Städte)* use the system in Germany, while Austria is using it nationwide. Although Austria offers its own national app with KATWARN Austria, users in Austria and Germany only need to install one app to receive warnings from both countries, making KATWARN the first internationally networked multi-hazard warning app. KATWARN Austria is operated by the Austrian Federal Ministry of the Interior (BMI) with a license for the whole of Austria. It is available to all authorities entrusted with police or crisis and disaster management tasks.

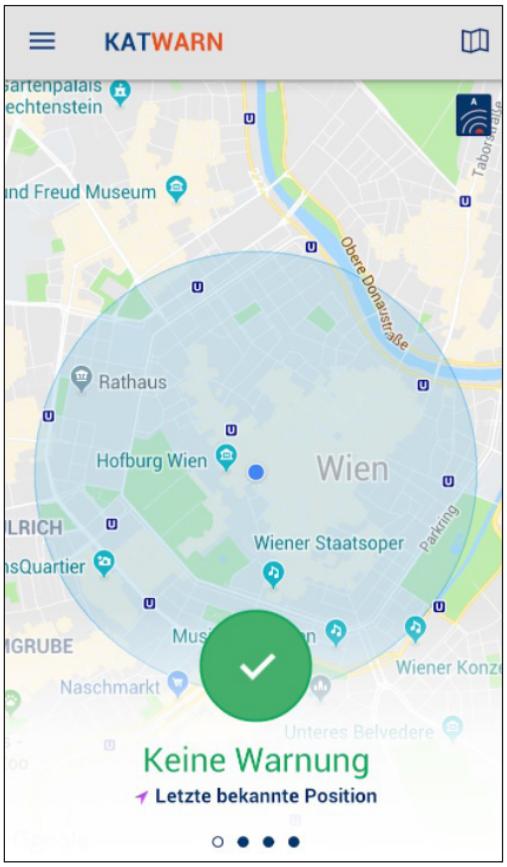



Figure 7. Screenshot KATWARN Austria.

### Who is responsible for operating the app?

The Federal Ministry of the Interior (*Bundesministerium für Inneres* (BMI)).

### Year of introduction

2017, current version: 1.2.8 (September, 2021).

### Other widely used multi-hazard warning apps

None.

### Which hazards does the app cover?

The app follows an all-hazard-approach, covering a broad range of possible disruptive events.

The BMI explicitly mentions the following possible applications: police operations, natural hazards and extreme weather, major events, industrial accidents, appeals to the public (e.g., search for missing persons), traffic disruptions, local security-relevant events (e.g., ski lift closures due to storms in tourist areas or the cancellation of school activities).

### Who can feed information into the app?

- The Federal Warning Center (*Bundeswarnzentrale* (BWZ)). Provincial warning centers *(Landeswarnzentralen)* and other authorities can trigger warnings and alarms via the Federal Warning Center.
- The Central Institute for Meteorology and Geodynamics (*Zentralanstalt für Meteorologie und Geodynamik* (ZAMG))
- The Center of Excellence for Missing Persons (*Kompetenzzentrum für abgängige Personen* (KAP))

### User numbers

Ca. 105,000 downloads, or ca. 1.2 per cent of the population.

### Rating in Google Play Store (number of ratings) / Apple App Store (number of ratings) as of November 2021

KATWARN Austria only: 2.6 ★ out of 5 (468) / 3.0 ★ out of 5 (109)
Including KATWARN Germany: 3.2 ★ out of 5 (9,349) / 3.0 ★ out of 5 (722)

## Smartphone usage

In Austria, 83 per cent of the population over the age of 15 owned a smartphone in 2020 (Statista 2021d). In the same year, mobile penetration in Austria was around 119 mobile connections per 100 inhabitants (Statista 2021e).

## Functions – Warnings

- Users receive push notifications about imminent and emerging threats either for their current location if geolocation tracking is enabled (called Guardian Angel feature in the app) or for up to seven user-selected zip codes. The Guardian Angel feature warns the user even when the app is switched off.
- No personal data is collected and no movement profiles are created.
- In general, KATWARN distinguishes between four escalating warning levels: 1) topic information, containing safety-relevant information as a preliminary stage to a warning; 2) warning; 3) alarm (extreme danger); 4) all-clear. The user cannot deregister from categories 2 to 4.
- Unlike the German version, KATWARN Austria does not feature the category of topic warnings. Topic warnings in the German version is information relating to specific situations where caution is advised, such as exhibitions or music festivals. Users receive this information regardless of their location but only when they specifically sign up for it.
- Receipt of topic information is indicated by the normal SMS tone, while warnings and alarms are indicated by a special siren tone, similar to the real sirens of the Austrian PWS. If the smartphone is set to silent, the app cannot override it.
- Individual opt-out from the four categories is not possible. However, users who have neither turned on Guardian Angel, nor selected specific zip codes in the app, will not receive any messages or warnings.
- Push notifications for warnings and alarms usually include concrete behavioral recommendations (e.g., stay in place, close windows and doors, seek shelter).
- All relevant official messages are displayed on a map centered on the current location of the user or areas selected by the user. Unrestricted zooming out on the map is possible to see warnings and other information in other areas (including in all of Germany).
- The KATWARN system also offers the possibility to be warned by e-mail or SMS. This is important if there is no connection to the Internet.

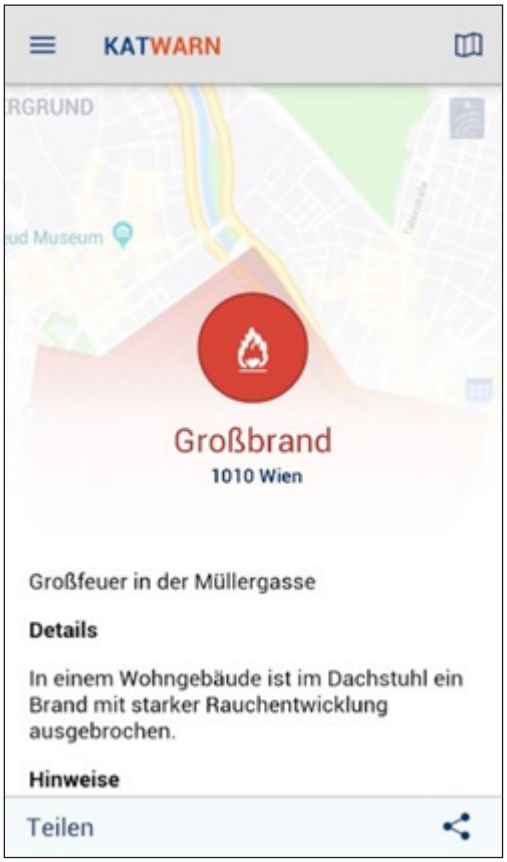



Figure 8. Screenshot KATWARN Austria.

## Functions – Information

- The app does not provide general emergency information beyond information and behavioral recommendations for concrete warnings and alarms.
- The topic information category allows the authorities to send safety-relevant information below the level of warnings or alarms.

## Functions – Communication

- Users can share official messages from the app via e-mail, SMS, social media, messenger, and other apps installed on their devices. The forwarded official messages cannot be changed.

## Functions – Settings

- Available languages: German and English.
- Users can enable / disable a “Guardian Angel” function.
- Test function for push notifications.

## Other ECS-PWS used in the country

None so far (see Plans).

### Plans

As early as 2019, the then Federal Ministry for Transport, Innovation, and Technology (*Bundesministerium für Verkehr, Innovation und Technologie* (BMVIT)) announced the intention to establish a CB system in Austria as a supplement to the existing warning options. Today, the Federal Ministry of Agriculture, Regions, and Tourism (*Bundesministerium für Landschaft, Regionen und Tourismus* (BMLRT)) is responsible for the telecommunications agendas, and works together with civil protection, mobile network providers, and various research institutions to define the framework conditions for an Austrian CB system (Kotrba 2021). Its introduction in Austria requires a change in the law, as mobile network providers are currently only allowed to send information to their customers with their consent. In the wake of the devastating floods in Germany in July 2021, these efforts gained new urgency. In mid-September 2021, the Austrian federal government decided to amend the Telecommunications Act to implement, among other things, the EU requirements for a uniform Europe-wide warning system for crises and disasters (Vienna Online 2021). On this basis, a CB system is also to be introduced for the whole of Austria by 2022.

The BMI does not see KATWARN Austria as a competitor to CB, since the latter can theoretically also be controlled by the KATWARN system (Wiener Zeitung 2021). However, since the future design of the overall system is not yet clear, the BMI currently refrains from actively promoting KATWARN Austria.

## 4.4 France – SAIP

The *Système d'Alerte et d'Information des Populations* (SAIP) app was developed in two months by the firm Deveryware on behalf of the Ministry for the Interior for ca. 300,000 EUR ahead of the European Football Championship hosted by France in 2016. The app was launched on 6 June, and the games went by without a large incidence. However, during the French National Holiday on 14 July 2016, a terrorist weaponized a truck that drove into a crowd that had watched a fireworks display in Nice. The deadly attack started at 10.30 pm and was stopped by the police at around 10.36 pm. However, the alert on SAIP only went out three hours later at 1.34 am, thus failing its first real test. Due to the tight development deadline of the app, the software was hosted on a single server of the company Numergy instead of a multi-server redundancy, as is the norm for sensitive services. On 13 July 2016, the app was inoperable due to a server outage. The server was operational again on 14 July but the app also contained a bug, which was only discovered when the attempted alarm failed (Bascoul and Audureau 2016).

In subsequent incidents, authorities often opted not to use the app. For example, when a terrorist started shooting on the Champs-Elysée on 20 April 2017, the authorities communicated via Twitter and did not send a message through the app (Vogel 2017, 37f). The app also disseminated three false alerts related to exercises on 17 September 2016, 13 October 2017, and 12 December 2017 (Parc 2017).

A Senate commissioned review of the SAIP app noted that the need to integrate mobile phones into the PWS was first recognized in 2008. However, the Directorate General of Civil Security and Crisis Management spent most of the 81.5 million EUR budget for the modernization of France's PWS on the procurement and maintenance of sirens (Vogel 2017, 17–20). The original plan in 2011 was to also introduce CB as part of this modernization. However, for reasons of "network operator willingness" and costs, the Ministry of the Interior decided to go for an app instead in 2015 (Vogel 2017, 31–34). The report also highlighted that SAIP had a smaller user base and a slower reaction speed than communication through Facebook, Twitter, and Google Maps (Vogel 2017, 39).

In May 2018, less than two years after the launch of the SAIP app, the Ministry of the Interior (2018) announced its discontinuation.


Figure 9. Screenshot SAIP.

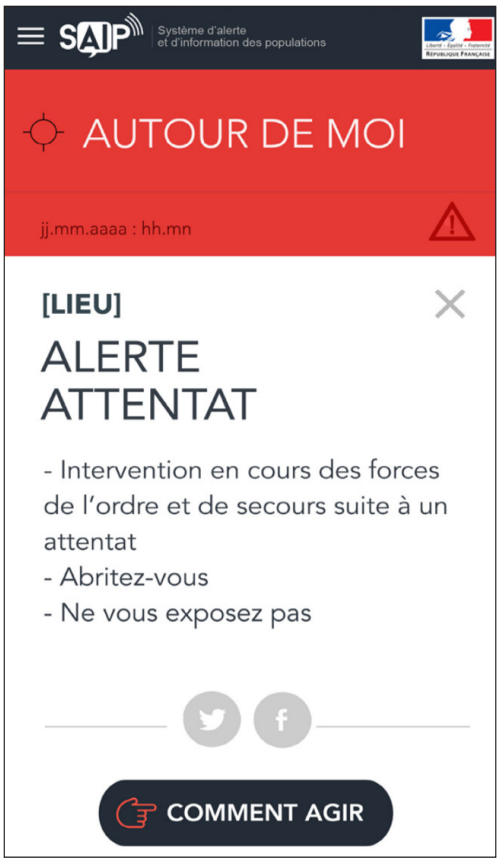



Figure 10. Screenshot SAIP.

## Who was responsible for operating the app?

The Ministry of the Interior *(Ministère de l'Intérieur)*.

## Year of introduction

June 2016. Discontinued in May 2018.

## Other widely used multi-hazard warning apps

None.

## Which hazards did the app cover?

In 2015 and 2016, France suffered from a wave of deadly terror attacks by Islamic extremists. As such, the development of the app was primarily motivated by fears of terror attacks, and it was regularly called an "anti-terror" or "terror warning" app in the media. However, as highlighted in the screenshot (Figure 9), it did also contain information on nuclear incidents, dam failures, and dangerous products. The app was far from comprehensive. Still, the plan had been to gradually extend the app to a more comprehensive version, integrating all major civil protection risks, such as flooding, avalanches, and earthquakes (Ministry of the Interior 2016, 10).

## Who could feed information into the app?

The heads of the executive branch on their respective levels (Vogel 2017, 15).

- The Prime Minister (national level).
- Seven prefects of Defense and Security Zones (zonal level).
- Ca. 100 prefects of departments (departmental level).
- Mayors of communes (communal level).

## User numbers

ca. 900,000 (mid-2017), or ca. 1.3 per cent of the population.

## Rating in Google Play Store (number of ratings) / Apple App Store (number of ratings)

3.4 ★ out of 5 (2'202) as of March 2017 / 2 ★ out of 5 (447) as of August 2017

## Smartphone usage

In France, about 84 per cent of the population above the age of 12 used smartphones in 2020 (Autorité de régula-

tion des communications électroniques, des postes et de la distribution de la presse 2021).

### Functions – Warnings

- Push notifications about imminent hazards based on location, if geolocation tracking was enabled, and for specific zip codes that the user could choose.
- Push notifications for warnings could not be switched off.
- Push notifications also entailed recommendations for action (like stay in place, close windows and doors, seek shelter, etc.).

### Functions – Information

- Emergency tips: Gave users information about what to do in a specific type of emergency.

### Functions – Communication

- Users could share warnings via Twitter and Facebook.

### Functions – Settings

- Available languages: French, English.
- Enable / disable "current location".

### Other ECS-PWS used in the country

None so far (see Plans).

### Plans

France has decided to implement a nationwide PWS via CB and LB-SMS by June 2022 (Senat 2020).

## 4.5 Luxembourg – GouvAlert.lu

The official multi-hazard warning app of Luxembourg is GouvAlert.lu. This app combines the two most important functions of warning and emergency apps: crisis notifications by the authorities and the ability to make emergency calls directly from the app. According to the government of Luxembourg, the app supplements the existing PWS, which consists of warnings via the Internet, social and traditional media (Hoffmann 2021). There is also a siren alert system in Luxembourg. These are available in all communes but, to date, the authorities have only used the sirens for warnings in case of a nuclear incident or to inform emergency services if their normal notification system fails (Schnuer 2021).

### Who is responsible for operating the app?

State of Luxembourg, Grand Ducal Fire and Rescue Corps (*Corps grand-ducal d'incendie et de secours / Großherzogliches Feuerwehr- und Rettungskorps* CGDIS, 112).

### Year of introduction

2018, current version: 1.2.0 (September 21, 2021) (Hoffmann 2021).

### Other widely used multi-hazard warning apps

None.

### Which hazards does the app cover?

The app follows an all-hazard-approach, covering a broad range of possible extreme or disruptive events.

Users receive alerts about emergencies, which could affect public safety, or a crisis as defined by the High Commission for National Protection law of 23 July 2016. This law defines a crisis as "any event which, by its nature or effects, is detrimental to the vital interests or essential needs of all or part of the country or population, which requires urgent decisions and which necessitates coordination at the national level of the actions of the Government, administrations, services and bodies under the authority of the public authorities, and, if necessary, also at the international level" (Le Gouvernement du Grand-Duché de Luxembourg 2016, Art. 2).

### Who can feed information into the app?

- Grand Ducal Fire and Rescue Corps.
- High Commissioner for National Protection.

## User numbers

Ca. 23,000, or ca. 4 per cent of the population (Hoffmann 2021).

## Rating in Google Play Store (number of ratings) / Apple App Store (number of ratings) as of November 2021

2.8 ★ out of 5 (101) / 3.3 ★ out of 5 (35)

## Smartphone usage

In 2019, 93 per cent of the population of Luxembourg between the age of 15 and 75 were smartphones users (Statista 2019f).

## Functions – Warnings

- Push notifications about imminent and emerging hazards, location-based (if geolocation tracking is enabled, the location is not shared with any organizations). The app can display local notifications in case of an accident, fire, or similar events. It can also display warnings that the government issues nationwide.
- Displays a location-based list of current warnings.

## Functions – Information

- On its home screen, the app contains symbols for nuclear emergencies, terrorist attacks, power cuts, extreme weather conditions, mass casualty events, flooding, and events related to drinking water. By clicking on these symbols, the user gets a short list of bullet points that provide advice on how to behave in the event of an alert. The user can also click on a list of links, leading, e.g., to civil protection related brochures, governmental emergency and contingency plans, or further explanations on what to do during specific hazardous events, such as extreme weather events (very violent gale, severe snow or ice, violent storm, extreme heat, extreme cold, torrential rain). The app does not give a direct explanation of these hazards. The information about what to do is also available offline.

## Functions – Communication

- Emergency call function. The app contains a big orange "CALL 112" button on the top of its home screen. Emergency calls using the app will automatically deliver location of the user to the emergency services. The function is also available offline. Without data connection, users have to read their location from the screen and let the emergency call operator know.


Figure 11. Screenshot GouvAlert.lu.

## Functions – Settings

- Available languages: German, French, and English. Luxembourgish, the mother tongue of more than half the population and the lingua franca of many in everyday life, is not available. However, almost all people in Luxembourg speak French (and/or German or English) (Le Gouvernement du Grand-Duché de Luxembourg 2021b).
- Include user's phone number in app.
- Two types of alerts can be switched on or off: general alert and 112 – fire and rescue alert.
- The app cannot be downloaded and run on a tablet.

## Other ECS-PWS used in the country

None so far (see Plans).

## Additional information

The flooding in Europe in July 2021 also triggered a discussion about the adequacy of PWS in Luxembourg, as the app did not deliver timely warnings, and some users did

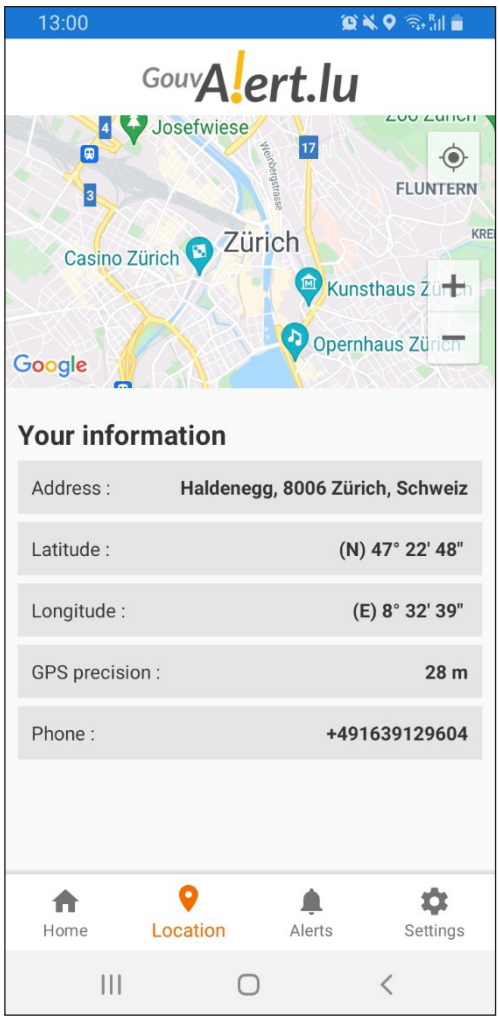



Figure 12. Screenshot GouvAlert.lu.

not receiving any alarm. As of September 2021, the authorities had issued a total of seven fire warnings (local incidents), a storm warning, and a flood warning (national incidents) via the app (Hoffmann 2021).

### Plans

According to the Luxembourgish Minister of the Interior, the government has been working on introducing CB for some years. The plan is to introduce CB by the end of 2022 (Aulner 2021).

In the future, more actors will be able to feed information into the app, including Meteolux (the Luxembourgish meteorological services), the police, and the water administration (Hoffmann 2021).

## 4.6 Netherlands – NL-Alert

The Netherlands is Europe's pioneer in using CB as part of its PWS. NL-Alert was first introduced in 2012 and formed the basis for the ETSI's EU-Alert Standard. CB test alerts reach more than 90 per cent of the population in the Netherlands (Ministry of Justice and Security 2020a). In turn, the government planned to phase out its sirens, which reach about 80 per cent of the population and are used less often as they are considered too severe a warning tool for most cases. However, this has been postponed due to concerns about the reach of NL-Alert in border regions, and the wish to keep sirens in specific contexts, such as in the immediate vicinity of chemical industrial complexes (Grapperhaus 2019). A new plan is to be decided by the cabinet, while a cost-benefit analysis has confirmed the limited attractiveness of sirens (Wiebe et al. 2021, 16)

It is in this context that the NL-Alert app was launched as a complement to the CB-based alert, with the government explicitly advising users of the app not to turn off CB (van Miltenburg 2020). The app became available in app stores in March 2020. Apart from providing additional information on disaster preparedness and response, the app had two target groups. The first target group is people with a communicative disability who are not always reached with a regular NL-Alert message. For this reason, the app was developed in collaboration with interest groups for people with visual and/or hearing impairments. The second target group concerns residents of the border regions who sometimes automatically connect to Belgian and German mobile networks with their phones and therefore do not always receive NL-Alert messages (Ministry of Justice and Security 2021b, 3).

On 30 April 2020, a specialized law firm informed the Dutch Data Protection Authority about a possible data breach on the NL-Alert app. The government informed the public and advised the 58,000 users who had downloaded the app to delete it (Ministry of Justice and Security 2020b). The app was subsequently removed from app stores, and data of the parties involved in operating the app was deleted.

The subsequent investigations by the Central Government Audit Service and the external company Fox-IT found no evidence that an actual data breach had happened. However, they confirmed a substantial security vulnerability and noted shortcomings in the management, control, and supervision of the project (Ministry of Justice and Security 2021b, 2). Hence, rather than restarting with a patched version, the government announced that it will develop a new app.

## Who was responsible for operating the app?

The Ministry of Justice and Security *(Ministerie van Justitie en Veiligheid)*.

## Year of introduction

4 March 2020; discontinued on 30 April 2020.

## Other widely used multi-hazard warning apps

None.

## Which hazards did the app cover?

Like the CB NL-Alert, the app was meant to cover all hazards. The government specifically mentioned flu epidemics, radiation incidents, and major fires.

## Who could feed information into the app?

While there is no explicit information on the app, the general NL-Alert can be activated by joint control rooms. These local control rooms are connected by a network and operate 24/7 to assist people in need and to support emergency services. They are jointly operated by the police, fire brigade, ambulance care, and the royal military police.

## User numbers

ca. 58,000 (April 2020), or ca. 0.3 per cent of the population.


Figure 13. Screenshot NL-Alert.

## Rating in Google Play Store (number of ratings) / Apple App Store (number of ratings)

2.4 ★ out of 5 (169) as of August 2020 / 2.6 ★ out of 5 (70) as of June 2020

## Smartphone usage

In the Netherlands, about 93 per cent of the population above the age of 12 owned smartphones in 2020 (Screenforce 2021).

## Functions – Warnings

- Push notifications about imminent hazards based on location, if geolocation tracking is enabled, and/or for specific zip codes that the user can choose.
- Push notifications also entail recommendations for action (like stay in place, close windows and doors, seek shelter, etc.).
- Push notifications can be read aloud.
- Display of currently active warnings and non-active warnings from the last seven days on a map.

## Functions – Information

- Emergency tips: Gives users information about what to do in a specific type of emergency.
- These tips can also be read aloud.

## Functions – Communication

- Not available.

## Functions – Settings

- Enable / disable push notifications.
- Enable / disable sound.
- Enable / disable nationwide warnings.
- Enable / disable warnings based on current location.
- Add personal locations.
- Available languages: Dutch and English.

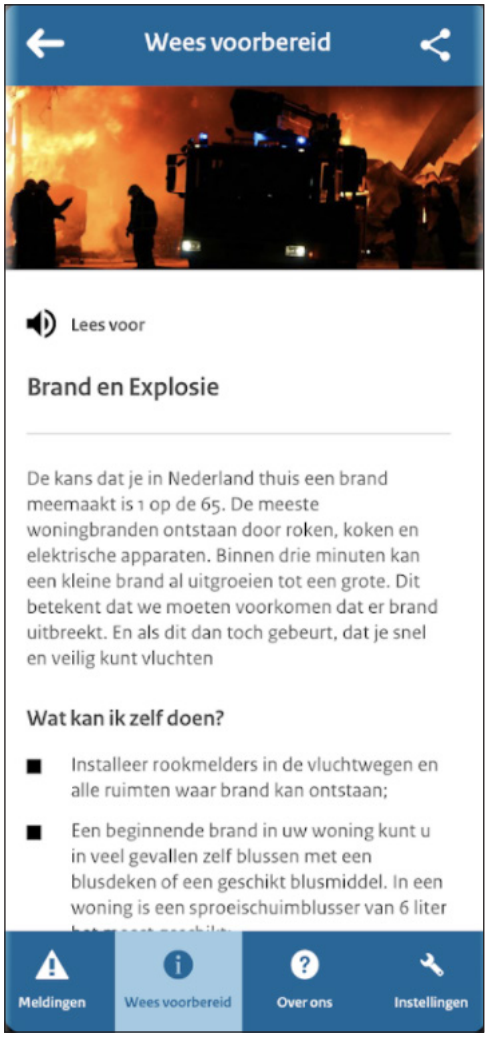


Figure 14. Screenshot NL-Alert.

### Other ECS-PWS used in the country

CB.

### Plans

The Ministry of Justice and Security (2021b, 3) is developing a new NL-Alert app, which will follow the privacy-by-design principle and be tested by external experts before being launched.

## 4.7 Finland – 112 Suomi

In Finland, the national Emergency Response Centre Agency runs the app 112 Suomi. This is different from other countries, where it is rather civil protection authorities, which run such apps. The software company Digia in cooperation with the Emergency Response Centre Agency developed the app. One distinctive feature of the 112 Suomi app, is its participation in the network of Pan-European Mobile Emergency Apps (PEMEA) (EENA 2021), which enables users of the app to click on the "Call 112" button and the app will automatically call the local emergency services and send the location of the user to the services. This is only functional in countries that participate in the PEMEA system. Finland was the first country where the system was operational as of early-2021. In Italy, the system can be used via the "112 Where Are U App" in Lombardy. In Spain and Romania, the system is in "ongoing deployment".

Overall, the app is not a classical warning app like Alertswiss (see Section 4.2), NINA (see Section 4.3), or KATWARN (see Section 4.4). In line with the overall purpose of the ERC running the app, it is rather an emergency app focusing on the functionality of fast and reliable emergency calls. Nevertheless, the app allows for receiving public warnings about "exceptional situations" (see below).

The traditional PWS in Finland are sirens, radio, and TV. Local emergency warnings are issued via the radio channels of the Finnish Broadcasting Company (YLE) and all commercial radio channels that are active in the affected area. Authorities can issue nationwide warnings via TV channels. They also use websites and teletext. To maximize their reach, authorities issue warnings in Finnish, and Swedish (Ministry of the Interior Finland 2021; Pelastustoimi 2021; Vivier et al. 2019, 32f).

### Who is responsible for operating the app?

The Emergency Response Centre Agency (*Hätäkeskuslaitos,* (ERC)).

### Year of introduction

2015, current version 4.2.21 (September 14, 2021).

### Other widely used multi-hazard warning apps

None.

### Which hazards does the app cover?

Neither the app nor the 112 Suomi website explicitly outline which hazards they cover. Rather, the ERC mentions exceptional situations, emergency missions, drills, or circum-

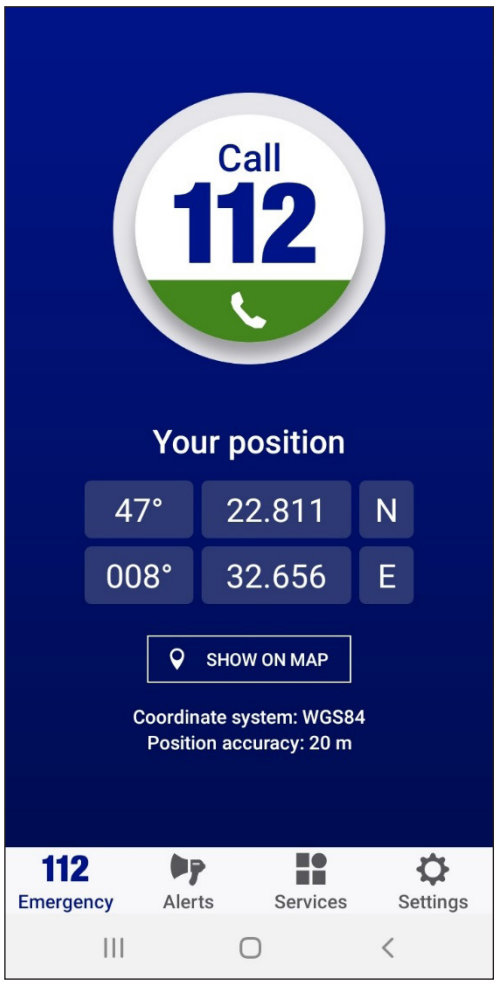



Figure 15. Screenshot 112 Suomi.

stances that require rumors to be dispelled, to prevent unnecessary calls to the emergency number, or to instruct people on how to act. This can be interpreted as an all-hazard approach, as no specific hazards (like natural hazards) are mentioned. The app is also able to display traffic alerts.

## Who can feed information into the app?

- The ERC feeds warnings from authorities, other public notifications, and traffic alerts into the app.
- Traffic alert information is provided by Traffic Management Finland's Digitraffic service.

## User numbers

Ca. 1.7 million downloads, or ca. 30 per cent of the population (Vivier at al. 2019, 32).

## Rating in Google Play Store (number of ratings) / Apple App Store (number of ratings) as of November 2021

4.2 ★ out of 5 (4,584) / 3.4 ★ out of 5 (241)

## Smartphone usage

In 2021, 98 per cent of the Finnish population between the age of 16 and 74 used smartphones (Statista 2021g).

## Functions – Warnings

- Push notifications about imminent and emerging hazards, location-based (if geolocation tracking is enabled, the location is not shared with any organization). The app distinguishes between public warning and public notification.
- Push notifications about local traffic alerts, location based (if geolocation tracking and receiving traffic alerts is enabled, the location is not shared with ERC or any other organizations).
- Push notifications can also entail recommendations for action.
- Displays a list of current warnings (location-based).

## Functions – Information

- Nearest defibrillator: the app allows for checking the nearest defibrillator (when in Finland) by checking the defi.fi database, which is managed by the Finnish Heart Association, the Finnish Red Cross, and the Finnish Resuscitation Council. By clicking on the button (geolocation tracking needs to be active), a map application opens and navigates the user to the defibrillator.
- Symptoms of stroke: The app provides a list of symptoms that are typical for a stroke (paralysis, drooping moth, etc.). It advices the user to always call 112 in case of such symptoms.
- Emergencies or problem situations on water: The app provides behavioral recommendations in case of several different emergencies that might occur while the user is on a boat (distress calls, man overboard, engine problem, fire on board, etc.). The instructions are given in an easy to understand language, in short and active sentences, with a clear order. They also include additional emergency contacts (mainly telephone numbers).

## Functions – Communication

- An emergency call function is a central part of the app (start screen of app). Emergency calls using the app will automatically deliver the location of the user to the emergency services. The function is also available offline. Without data connection, users have to read their location from the screen and inform the emergency call operator. The app transmits the location signal for 60 minutes and it is stored for 24 hours on a proxy server. This means that the emergency services can retrieve it, if the user

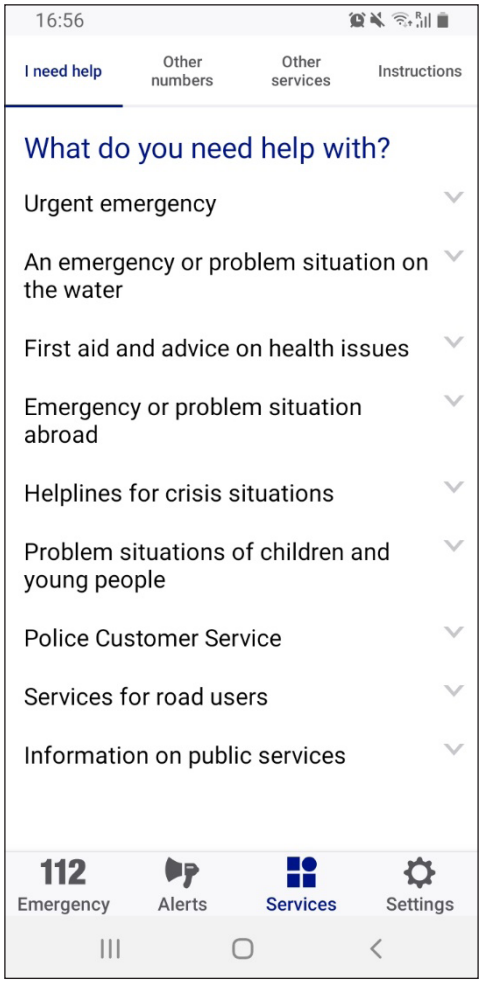



Figure 16. Screenshot 112 Suomi.

issues another call, even if no data connection is available during this second call.

- The app contains a list of different situations and topics for which the user might need help (domestic violence, poisoning, medical situation, stroke, missing children, hotline for children and young people, consular services, police customer service, etc.), and it gives specific phone numbers the user can click on and call (when in Finland).
- Travel notifications: the app provides a link to the Finish Ministry of Foreign Affairs, where the user can register travel plans and contact details so that the authorities might be better able to help in an emergency.

## Functions – Settings

- Available languages: Finnish, Swedish, and English (warnings are only available in Finnish and Swedish )
- Traffic alerts can be switched on and off.
- Public warnings make a distinctive sound that many people in Finland know from public warnings on TV and radio. The sound lasts between two and three seconds and resembles the Morse code sound for "CQ" (seek you). Public notifications have a short "ti tu" sound signal, lasting for half a second. The sounds only play once. If the smartphone is in silent mode, the sounds will not play and the warnings will only show on the home screen and in the app.

## Other ECS-PWS used in the country

None so far (see Plans).

## Plans

On 1 January 2021, Finland adopted the EECC into national law. Regarding ECS-PWS, the official press release of the Ministry of Transport and Communications read: "The current emergency warning channels will be accompanied by an application-based emergency warning system. In future, the emergency warnings will not only be broadcast into television and radio, but also an application provided by the Emergency Response Centre Agency, such as the 112 Suomi application. This will improve the availability of targeted information in emergency situations. Radio receivers being installed into new vehicles must receive and play FM and DAB broadcasts" (Ministry of Transport and Communication Finland 2021).

## 4.8 Overview Table: Country Comparison

| | Alertswiss | NINA | KATWARN | SAIP | GouvAlert.lu | NL-Alert | 112 Suomi |
|---|---|---|---|---|---|---|---|
| **Years in use** | 2018 – ongoing | 2015 – ongoing | 2017 – ongoing | 2016 – 2018 | 2018 – ongoing | 2020 – 2020 | 2015 – ongoing |
| **Number of users** | >1 million | 8 million | 104,000 | 900,000 (2017) | 23,000 | 58,000 (2020) | 1.7 million |
| **Percentage of population** | 12 per cent | 10 per cent | 1.2 per cent | 1.3 per cent (2017) | 4 per cent | 0.3 per cent (2020) | 30 per cent |
| **Warning via push notification** | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Option to override silent mode for push notifications** | Yes | Yes | No | unknown | unknown | unknown | No |
| **Emergency call via app** | No | No | No | No | Yes | No | Yes |
| **Information about hazards outside of emergencies** | Yes | Yes | No | Yes | Yes | Yes | Partly |
| **Behavioral recommendations in an emergency** | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Languages** | German, French, Italian, English | German, English, French, Spanish, Turkish, Polish, Russian, Arabic, simplified German | German, English | French, English | German, French, English | Dutch, English | Finnish, Swedish, English |
| **Number of and actual rating (1 to 5) in Google Play Store (November 2021)** | 1,580 / 3.3 ★ | 21,474 / 3.2 ★ | 468 / 2.6 ★ | 2,202 / 3.4 ★ (March 2017) | 101 / 2.8 ★ | 169 / 2.4 ★ (August 2020) | 4,584 / 4.2 ★ |
| **Number of and actual rating (1 to 5) in Apple App Store (November 2021)** | 422 / 3.7 ★ | 3,599 / 2.6 ★ | 109 / 3.0 ★ | 447 / 2 ★ (August 2017) | 35 / 3.3 ★ | 70 / 2.6 ★ (June 2020) | 241 / 3.4 ★ |

Table 5. Overview of functionalities, usage, and other relevant factors of the multi-hazard warning apps analyzed in this report.

# 5 Lessons Learned for Warning Apps

Our study identifies two main challenges that multi-hazard warning apps have to overcome in order to be a meaningful and efficient part of PWS. The first challenge is the reach of a warning app in terms of the proportion of a population that uses the app and thus can be warned and informed via the app. The second challenge is the sustainable integration of an app into existing PWS. Our comparison of the roll-out and usage of multi-hazard warning apps in seven European countries highlights a number of lessons learned in terms of addressing these two challenges.

**Have one (official) multi-hazard warning app per country:** From the authorities' point of view, one single warning app enables a more targeted promotion and dissemination of the app and its purpose, and a resource-efficient and sustainable integration of the app into the national PWS. It also increases the likelihood that all relevant authorities see the added value behind this additional communication channel, and thus use it consistently. From the user's point of view, the ability to rely on one (official) app that warns of multiple or all hazards avoids confusion and distrust. This enhances the chances of the app being downloaded, used, and the instructions followed in an emergency.

**Cooperate with other widely used apps and / or pre-install the warning app on new devices:** To increase the awareness and reach of warning apps, it can be expedient to collaborate with already established and thematically related apps that have high user numbers nationally, such as weather or traffic apps. For example, the collaboration with MeteoSwiss, one of the most widely used apps in Switzerland, has boosted Alertswiss messages since 2021. It may also be worth considering institutionalized collaboration between the authorities and companies such as Google, in order to ensure that official messages from warning apps are immediately integrated into widely used services, such as Google Maps. Google has done this unilaterally in the past for certain terrorist attacks, e.g., in France, when it temporarily marked areas to be avoided in Google Maps. Another option worth considering to increase reach is pre-installation of warning app on new devices before they are sold. However, as noted in Chapter 3, Apple explicitly prohibits network providers from performing pre-installations on their devices. Therefore, Apple would have to agree to do this.

**Support as many languages as possible in the warning app, including for warnings and messages:** The more languages supported by an app, the greater its benefits are for linguistic minorities, foreign nationals, and tourists. It is important to note that although most analyzed warning apps support different languages, the messages or warnings within the app are often only available in the language in which the sender has written them. In order to maximize the benefit of the warning app for its users, and to achieve the highest possible compliance rate in an emergency, all messages and alert should be translated into all languages supported by the app. In order to ensure timeliness, this could either be done in rudimentary form by an upstream automated translation or by translating a number of standard warnings and alerts in advance.

**Enable the warning app to override phone settings to sound alerts when on silent:** One of the central functions of a warning app in the alerting chain is to warn users of imminent dangers. Warning apps can only fulfill this function in an emergency if they can temporarily override the local device settings at times, such as in the middle of the night, when devices are often set to silent. The catastrophic floods in the summer of 2021, for example, impacted many German communities in the dead of night. The importance of warning apps' ability to override local settings is all the greater when local authorities cannot alert the public via sirens.

**Provide relevant preparedness and response knowledge in the warning app that is also useful outside of an emergency:** Additional information in multi-hazard warning apps, such as basic preparedness recommendations or tips for individual emergencies like burns, increases the likelihood of users interacting with the app regularly. The Finnish warning app, e.g., informs users where the nearest defibrillator is located and what the symptoms of a stroke are, among other things. In the Swiss app, precautionary emergency plans can be created and there is a blog on topics relevant to Swiss Civil Protection. We consider information on individual preparedness, first aid, and behavioral recommendations for various crisis situations to be particularly useful (Maduz et al. 2018, 33). Such information should also be available offline in the app. Such information exchanges ideally create trust in the app and its messages before a crisis, which increases the probability that users will follow instructions in an emergency. Also, regular interaction with the app creates familiarity with it in everyday life, so that it can be used more efficiently in an emergency. With all these efforts, however, it is important not to turn useful information into information overload, and consequent user fatigue.

**Be transparent about data security and privacy, and address these issues proactively:** By sharing their current location, creating individual emergency plans, and entering contact details of relatives, users of warning apps provide access to private details. Many of these features are necessary to benefit fully from the app's functionality and utility. Hence, it is important that issues of data security and privacy are proactively raised and openly discussed by the relevant authorities in order to address unfounded concerns and generally create user-trust in the app.

**Let the user customize the content of messages:** The more tailored the messages in warning apps are to the needs of individual users, the higher the usefulness of the app. This, in turn, increases the likelihood that the app is used and instructions are followed. Therefore, it is sensible to allow users to configure the app according to their needs. For example, distinctions could be made for particular age groups and people with disabilities or health restrictions. These inclusivity features could then be used to optimize information or warning times for the respective user groups, and to better tailor the behavioral recommendations to their individual situation. Elderly people could be warned more urgently and in more detail about heat waves. Asthmatics could be informed earlier about changes in air quality in case of critical smoke development, or people with mobility impairments could receive more specific instructions on how to act if areas should be avoided or evacuated.

**Display messages in a visualized manner in the warning app, e.g., on a map:** One of the big advantages of warning apps over CB or LB-SMS is that more detailed information about specific warnings and alarms can be provided. This advantage should be capitalized on. As stated in Chapter 2, many users find it helpful to visualize messages, e.g., through maps, graphs, or tables, for a better and faster understanding of their content. In the apps studied, a map was the most used graphical element, which is unsurprising if ones current location is shared with the app. The usefulness of maps in these apps can be increased by enriching them with additional information, such as the location of defibrillators, lifebuoys, or fire hydrants. This can either be done by the authorities, or the users could be involved through crowd-sourcing. During crises, users could also help authorities gain a more comprehensive picture of a situation by uploading images of damage sites via the app. However, if users were to be involved in these efforts, the provided information would have to be treated with caution until official verification.

**Include a 'call emergency services' function in the warning app:** Integrating this function makes sense conceptually, as the same emergency services are usually responsible for both collective hazards and individual emergencies, and collective hazards also lead to individuals needing these services. Instead of just listing the various emergency numbers in the app, a function for contacting the responsible emergency call center should be directly integrated. This can be combined with the automatic transmission of location data or the camera function to convey relevant information in an emergency. If the connection could be established either via the regular telephone network or the Internet, such a function would also give the public a fallback option in case the emergency services are temporarily unavailable via telephone, as has happened in Switzerland and Germany in recent years, e.g., due to technical problems. By participating in the PEMEA project and adopting the corresponding standards, the function could also be implemented in such a way that users can use their own country's warning app to contact the emergency services when they are traveling in other European countries (EENA 2021). The Finnish warning app already meets this standard. Of the seven apps analyzed in this report, 112 Suomi reaches by far the largest share of the respective national populations. This hints at the usefulness of implementing an emergency call option into multi-hazard warning apps. Integrating this function would also increase the usefulness of the app outside of emergency situations.

**Ensure the uniformity and quality of the messages transmitted via the warning app:** In most cases, numerous authorities can send messages via the warning app, especially in federal states where responsible authorities operate at different levels of government. Due to the different handling of messages by the sending authorities, for example in terms of presentation, level of detail, or language, this can be a challenge, as warnings may lack overall uniformity. This can have a negative impact on the quality and usefulness of the message for the user, which ultimately also reduces the user's trust in the app. Possible remedies include detailed and jointly agreed guidelines, the standardization of messages through the input interface, and regular dialogue between all involved parties about changes and new possibilities in the app.

**Use the various warning levels (warning, alarm, etc.) of the warning app in a consistent manner:** If different authorities send out warnings about the same hazard in the app, or if the same hazard is warned about several times, a uniform warning level should be used. This coordination is not always guaranteed at present. For example, in the German warning app NINA in autumn 2021, reports by the respective authorities about the temporary nationwide failure of emergency numbers ranged from information and warning to alarm depending on the *Bundesland*. Uniformity creates trust in the sender, increases the likelihood that messages are taken seriously, and that instructions are followed.

**Interlink the warning app as much as possible:** To maximize the impact of messages from the app, it should be made easy to directly share messages through as many additional channels (social media, email, SMS, website, etc.) as possible. Such amplification of messages will also alert people who do not use the app itself. However, the sovereignty of the authorities who write the original message must be maintained, i.e. the forwarded messages must be immutable in order to prevent misuse.

**Ensure that authorities communicate via the warning app whenever appropriate:** A high usage rate of the warning app by the authorities increases its usefulness for users, and creates trust in its reliability, which in turn is likely to lead to more downloads. Therefore, it is key to the success of the app that it is used consistently as

planned by the authorities, and informs, warns, or alerts about any relevant danger. If users experience arbitrary in reliability, trust and usage quickly dwindles. This was the experience of the French authorities in 2017 following a terrorist attack in Paris, when warnings were mainly issued via Twitter instead of the app. Furthermore, experience shows that a certain regularity of messages sent via the apps is necessary to keep the responsible authorities familiar with the required procedures. At the same time, too much information or an overload of irrelevant information is also counterproductive. It is therefore important to work with all stakeholders to pre-define what type of incidents and emergencies an app should be used for, and to ensure that everybody involved consistently implements this.

**Have multiple clearly delineated warning levels, and let users determine for which levels they receive messages:** As the line between too little and too much information is fluid and varies from user to user, the app should have a number of different warning levels. In addition, in order to tailor the app to the needs of the individual user as much as possible, it should be possible to individually set the warning level for which messages are received. This increases the usefulness of the app for the individual user and protects against user fatigue. There should always be a maximum warning level for which no one can opt out, so that authorities can always warn of urgent danger. In the area of CB, e.g., there is the EU-Alert Level 1, where end-users are always warned regardless of local device settings.

**Have an infrastructure behind the warning app that can withstand periods of peak load:** This applies not only to the infrastructure for operating the actual app, but ideally also to the mobile Internet in general, as apps typically require a functioning data connection for their core functions. During acute emergencies, when the app is particularly needed, the (regional) telecommunications infrastructure is usually already heavily loaded or possibly impaired by the event. However, if an app with all its functions is too late, only partially, or not at all available during an emergency due to technical issues or an insufficiently reliable infrastructure, users quickly lose confidence in the app. For example, during the terrorist attack in Nice in 2016, the French app did not issue a warning until three hours after the event, and it was not available at all the day before due to insufficient server capacity.

**Have as few potential senders as possible, but as many as necessary:** The fewer agencies that can send messages in the warning app, the easier it is to ensure consistency. However, with a small number of senders, the necessary processes for alerting from the bottom up also become more complex and response times tend to be longer. The longer the processes are, the better aligned they need to be to prevent errors. As stated in Chapter 2, people tend to have more trust in warnings that are disseminated by the authorities responsible for the respective hazards, e.g., the weather service in the case of extreme weather events. Therefore, a broader sender base than, e.g., just the national alerting center or police dispatch centers may be beneficial. Potentially purposeful additional senders could be selected operators of critical infrastructures, such as national power grid operators or large water suppliers, national weather centers, or additional government agencies. In Austria, e.g., the Center of Excellence for Missing Persons can also send messages in the national warning app.

**Treat the warning app as an important element of PWS and integrate it into it as much as possible:** Warning apps offer important advantages over other ECS- or traditional PWS. For example, apps can be used to inform and alert people who are otherwise difficult to reach, such as the hearing impaired, people in border regions whose mobile devices connect regularly to foreign antennas, or tourists and commuters who want to be informed about dangers near their homes. Accordingly, warning apps have become important elements of modern and comprehensive alarming chains, and should be treated accordingly by the authorities involved. In addition to an appropriate development and pilot phase, this should ideally also includes an integration process coordinated with all stakeholders with clear objectives regarding the future role and use of the app, a sustained and appropriate financial and personnel commitment to its operation and further development, as well as continued promotion of the app within the population as an important communication channel of the authorities. If these processes are cut short or skipped because warning apps are not considered an integral and permanent element of the alarm chain, this can lead to suboptimal results, as the experience in France has shown.

# 6 Alertswiss: Potential Future Developments

With Alertswiss, Switzerland has a mature official multi-hazard warning app that complements the traditional PWS of sirens, radio, and television. Nevertheless, some of the lessons learned identified in this report could aid further development of the Swiss warning app.

**Support more languages, including in the messages themselves:** Given the multilingualism of the country, the high proportion of non-Swiss residents, and numerous tourists from all over the world, the app could benefit from an expansion of the supported languages. For example, the German warning app supports eight different languages compared to the four languages available in Alertswiss. A potential language expansion should ideally include all information, warnings, and alerts.

**Include information for individual emergencies and allow the personalization of messages:** The app could be expanded to include offline information and behavioral recommendations for individual emergencies, e.g., how to provide first aid for severe burns or strokes, like the Finnish warning app does. Integrating the possibility of more personalization of messages in the app, for example by age group, would increase its usefulness for the individual user.

**Enrich the map with more information, possibly through crowd-sourcing:** The usefulness of the existing map in the app could be increased by adding more relevant information, such as the locations of defibrillators or emergency meeting points as defined by local civil protection organizations. Users could be directly involved in this process by encouraging them to help enrich the map with relevant local information, which would then be verified by local authorities over time. In case of a major event, crowd mapping of damaged sites via the app could also be useful to the authorities to gain a more complete picture of a situation faster, if the data were only accessible to them. However, involving users in the basic function of the app is a complex and time-consuming process with many potential pitfalls. It would entail extensive revision of the app, especially in the case of crowd-mapping in a crisis. If this project were to be undertaken, the inclusion of all stakeholders in the planning and pilot phase would be strongly advised - not only to prevent opportunities for misuse, but also to maximize the benefits to the authorities. It should also be noted that an easy-to-use user interface sets certain limits to the addition of more functions, and the integration of too many functions in one app can be detrimental to user-friendliness.

**Include an emergency call function with PEMEA standards:** The integration of an emergency call function directly in the app could increase user interaction, and serve as a fallback option if the emergency telephone call services are temporarily unavailable, as has been the case several times in recent years. Such an integration would ideally be done in consideration of the PEMEA standards, so that the function would also be available abroad.

**Cooperate with more apps and services:** Cooperation with more apps beyond MeteoSwiss could also help to increase coverage. For example, cooperation with the travel app of the Swiss Federal Department of Foreign Affairs could be useful and create certain synergies. The same applies to an institutionalized cooperation with services, such as Google Maps, in order to make the information from the app available to a wider audience. A limiting factor in such efforts is that operators are not always interested in extending the basic functionality of their apps or services. An efficient solution could be to offer all interested app and service operators a freely accessible interface. A link to warning apps in other countries would also be useful, although such an integration could take time due to the many administrative and technical hurdles. In order to ensure the cross-linking of Alertswiss with other channels in the long run, the trends in social media should be closely monitored, and the ability to share warning messages should be ensured through the ongoing addition of new platforms in the latest version of the app.

**Examine an expansion of senders:** Already today, the wording of critical infrastructure operators' notifications to the authorities is largely adopted in the official messages in the app. Nevertheless, an expansion of possible senders to selected operators of critical infrastructures could help to optimize response times and the level of information available to the public. For example, electricity companies could inform the public directly about local power outages via Alertswiss. A limiting factor, however, could be the 24/7 availability of the necessary staff at the operators of critical infrastructures. In addition to selected operators of critical infrastructures, the expansion of possible senders to include more federal or even cantonal authorities might also be worth examining.

**Consider ECS-PWS as complement and add CB to the Swiss PWS:** In all these efforts, it is important not to forget that multi-hazard warning apps are only one of many communication channels of the PWS. They do not compete with the others or make them obsolete in the foreseeable future. Even with the best preparation, it cannot be ruled out that one channel will temporarily fail or malfunction in an emergency. In order to reach as many people as possible in time-critical emergencies, it is important that there are always several channels that can complement and at least partially replace each other. Based on the findings of this study, the EU requirements for PWS from mid-2022, and the lessons learned from the 2021 summer floods in Europe, we believe it will also be

expedient for Swiss Civil Protection to supplement the Swiss PWS with CB in the near future. In this way, Switzerland could learn from others without having to experience similar trial and errors. As in other European countries, a possible introduction of CB in Switzerland would not make the already existing warning channels of the Swiss PWS obsolete, but would rather complement them.

# 7 Conclusion

Today, mobile based warning channels are core components of sophisticated and future-oriented PWS. The three options analyzed in this report – multi-hazard warning apps, CB, and LB-SMS – do not compete with traditional PWS, such as sirens, radio, or television. The introduction of one or more of these options in a country should therefore not lead to the discontinuation of the previously used warning channels. Rather, they complement them in order to increase the range and timeliness of warnings and alerts, and to reach parts of the population that can only be insufficiently reached via the traditional channels. They offer new forms and ever-expanding possibilities for crisis communication between authorities and the public via PWS. The three options are not necessarily in competition with each other either. They can complement each other well, even if there is some overlap. For example, CB is in most cases the fastest and most efficient way to warn as many people as possible in a particular area of an imminent danger, while warning apps are better suited to inform the public about possible precautionary steps, as well as providing more detailed information about possible dangers and developing events. Therefore, a combination of these options makes sense for a national PWS. Due to rapid technological progress, it is likely that new options will continue to develop rapidly in the future, both in terms of completely new channels and additional possibilities for existing ones. It is therefore crucial that the responsible authorities follow these developments closely, and continuously develop the channels used in their ECS-PWS.

The suitability of a PWS for efficient crisis communication is best tested in an emergency situation. It is therefore all the more important to analyze the experiences of other countries, and to draw the right conclusions for one's own PWS. This applies not only to the composition of ECS-PWS with regard to the various options, but also to the concrete design and use of its elements. By comparing the different options available and identifying lessons learned from seven different warning apps, we hope that this report contributes to the future optimization of the PWS in Switzerland and elsewhere.

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