

Original articles

Deploying a user-friendly GIS mapping tool in post-earthquake Turkey and Syria

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Background

The February 2023 earthquakes in Turkey and Syria exposed significant gaps in healthcare information systems, which severely hampered communication, coordination, and the overall public health response. These disruptions were primarily due to the lack of real-time, accessible data on healthcare facilities.

Methods

In response, an interactive Geographic Information System (GIS) tool, coupled with an integrated WhatsApp chatbot, was developed under the platform [Afetsaglikharitasi.org](https://afetsaglikharitasi.org). This system enabled real-time mapping and updates on the status of healthcare services, even in areas with limited internet connectivity, facilitating more efficient resource coordination during the disaster response.

Results

By March 30, 2023, the disaster health map included data from 537 health centers and had reached over 800,000 individuals via social media platforms such as Instagram, Facebook, and Twitter. The platform attracted over 3,500 unique users, with most accessing it via mobile devices to locate healthcare services. Additionally, shortcomings in the Turkey National Disaster Response Plan (Türkiye Afet Müdahale Planı – TAMP) were identified, particularly the lack of integration of digital health technologies, which hindered resource allocation during the earthquake response and underscored the need for their inclusion in disaster management strategies.

Conclusions

This study demonstrates the effectiveness of digital health tools in enhancing disaster response and underscores the importance of integrating user-centered, deployable technologies to improve healthcare delivery in emergency settings.

INTRODUCTION

THE POST-EARTHQUAKE SITUATION IN TURKEY

After the magnitude of 7.8 earthquakes in Kahramanmaraş on February 6, 2023, and the subsequent event in Hatay on February 20, which resulted in 59,259 fatalities, with 50,783 in Turkey and 8,476 in Syria,¹ Turkey faced severe challenges in infrastructure, public health, and displacement. In addition to the destruction of health facilities, healthcare providers faced significant challenges in coordination and organization within the earthquake zone. The lack of effective coordination and collaboration hindered the sharing of vital information and best practices, further impeding response efforts. Primary healthcare services includ-

ing vaccination, maternal-infant care, mental health and chronic diseases services were severely disrupted increasing the possibilities of epidemics in addition to a lack of accurate information about operational healthcare facilities and their locations, leading to ineffective communication and coordination among healthcare providers. Logistical challenges, including transportation issues, further limited access to healthcare for earthquake victims.² This situation exacerbated the public health crisis during the post-earthquake context.

Studies related to the healthcare situation after the earthquake in Turkey highlight this miscommunication among actors. The literature mainly tackles the impacts of the 6th February earthquake on the healthcare system in Turkey, reflecting the precarious post-earthquake con-

ditions of the primary healthcare level cumulated with already existing fragilities among the populations living in Southern Turkey.³ Possibilities of disease outbreaks have also been considered with disruption of basic services such as access to water infrastructures.⁴ Additional studies have a particular focus on specific health issues and services.⁵ However, the use of the technologies in improving access to services for populations affected by the earthquake in Turkey is unexplored in the academic field. This paper aims to explain the role of digital and mobile health technologies in humanitarian response, and especially in the post-earthquake situation in Turkey, as a case study. It details the development, testing, and implementation processes of these technologies.

THE USE OF HUMANITARIAN TECHNOLOGIES IN RESPONDING TO THE TURKEY-SYRIA EARTHQUAKES

In the aftermath of the earthquake, digital health technologies have been largely pointed out since they are capable of generating locally supported, adaptable, and agile solutions for humanitarian aid. Digital health, as defined by the World Health Organization (WHO), involves using information and communications technologies to improve health outcomes.⁷ The WHO's classification of digital health interventions, based on user types and health system needs, provides a framework for categorizing new technologies. However, the practical implementation of these technologies often faces challenges, as what works in theory may not always be effective in the field. In this regard, the 'back to basics' approach has addressed identifying problems from the beginning, centered on end-user demand, with functional solutions varying from 'no-tech' to 'high-tech'.⁸

For instance, the United-Nations'(UN) Cluster Approach, aimed at organizing and coordinating humanitarian response, was only partially implemented in the 2023 earthquakes highlighting the challenges in adapting international frameworks to local contexts in Turkey and Syria.⁹ In countries like Turkey that have experienced in managing local organizations, the knowledge and utilization of open-sourced data collection tools, such as Kobo Toolbox or DHIS2, were limited. Among the few entities utilizing these tools was Médecins du Monde, an international humanitarian organization focused on providing medical care and advocating for healthcare access. Expanding knowledge sharing with local and grassroots organizations is crucial to broaden the use of these technologies, leading to more uniform data collection and informed decision-making.

THE ROLE OF INTERNATIONAL ORGANIZATIONS AND UN ENTITIES IN PROMOTING INNOVATIVE INITIATIVES

Larger organizations, including UN entities, often play a pivotal role in amplifying local innovations and voices. They are also key in coordinating funding for innovation directed towards local actors. During the Turkey – Syria Earthquake response, while local innovations were present, larger actors tended to promote solutions that were neither open-sourced nor easily replicable. For instance, the UN Refugee Agency's, United Nations High Commissioner for

Refugees (UNHCR), Services Advisor, originally created to assist refugees in locating local services, was modified in April 2023 to include services in the earthquake zone. However, this system, requiring registration and substantial information for adding new services, was not optimally utilized due to challenges in service addition and delayed updates on the map. These efforts, which hindered agile responses, opened the floodgates to applying existing tools to quicker and more efficient problem-solving. As these solutions have already been tested and proven effective in real-world scenarios, they are targeted for more risk-averse actions.¹¹

THE INTEGRATION OF TECHNOLOGIES IN PREPAREDNESS PLANS AND THE CASE OF GIS

Preparedness plans should include knowledge sharing dedicated to humanitarian technologies, encompassing rapid data sharing and understanding of local capacities. In this regard, GIS is a promising decision-making tool for humanitarian logistics and planning, particularly during critical field operations.¹² It enables network analysis and data visualization, as well as implementing spatial or geographic precision in raw data.^{8,12} Therefore, it has been integrated into several humanitarian aid technologies, ranging from crisis maps and dashboards to artificial intelligence and predictive analytics.⁸ However, the degree of effectiveness of this technology depends on its alignment with field realities and its successful implementation by field teams. The support of local governments is also crucial in this context. Correspondingly, the post-earthquake interventions should not only focus on implementing GIS but also initiate 'ground truthing' - developing agile tools that actively respond to field demands and real-time data. This approach is critical for deploying practical, adaptable, and locally relevant solutions and interventions in a humanitarian crisis. Creation of a user-friendly map and Chatbot for active services after the disaster is a prime example of this approach. To conclude, the potential for larger organizations to leverage such local technological innovations, integrating them into broader humanitarian frameworks, could significantly enhance the effectiveness of disaster response efforts.

OVERVIEW OF THE DIGITAL HEALTH SOLUTIONS

After the earthquake, a significant gap in accessible information regarding active healthcare facilities, newly established field hospitals, and damaged health centers emerged, as such data was not publicly shared by the Turkish Ministry of Health (Türkiye Cumhuriyeti Sağlık Bakanlığı) or UN partners. To address this information void and facilitate effective healthcare delivery, HERA Digital Health and Medical Rescue Assoc of Turkey (MEDAK), developed the 'afetsaglikharitasi.org'. This initiative focused on mapping active health centers and providers, providing real-time updates from field workers, and ensuring accessible and up-to-date healthcare facility information in the earthquake-impacted areas.

In response to the limited internet access in the disaster area, there was a need for a low-data communication

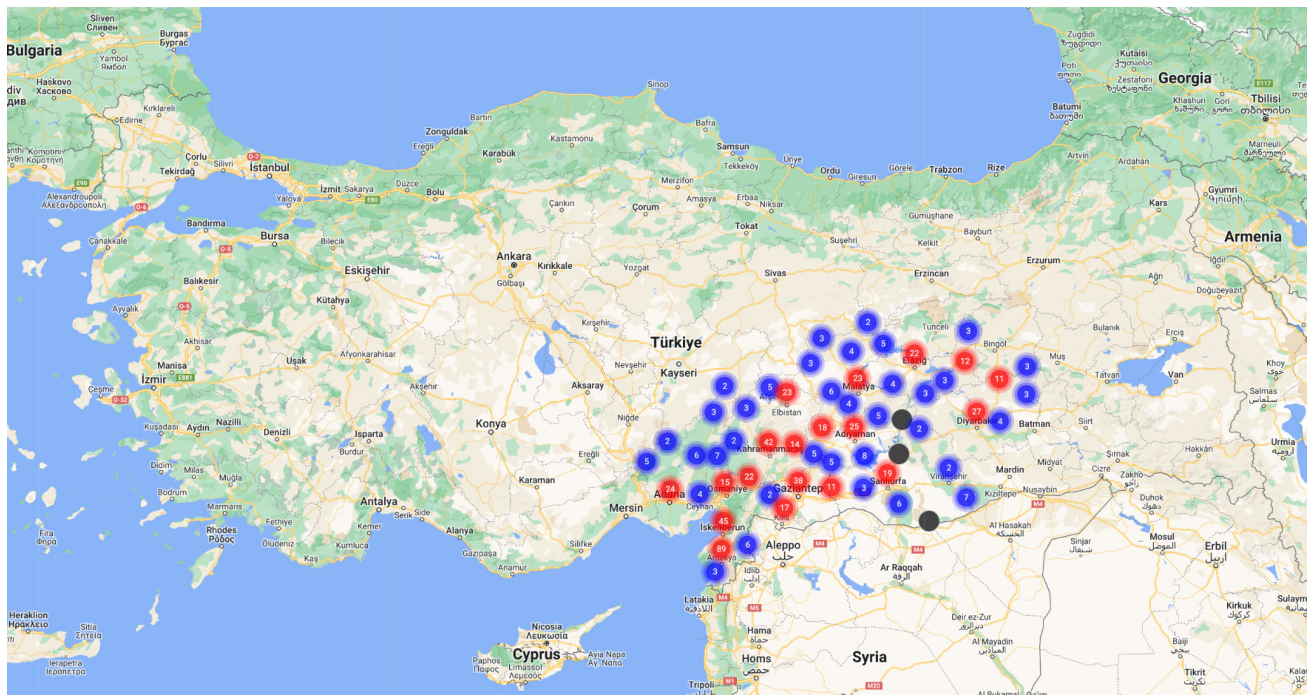


Figure 1. The map from ‘afetsaglikharitasi.org’ illustrating the distribution of active health facilities in the earthquake-affected regions of Turkey (afetsaglikharitasi.org).

method. A WhatsApp Chatbot was created in partnership with [Turn.io](https://turn.io/), a Public Benefit Corporation (PBO) that assists organizations in developing impactful software and chat applications. Utilizing WhatsApp’s application programming interfaces (API) facilitated efficient data exchange and reporting. The automation capabilities of WhatsApp’s APIs provided users with a direct line of communication, enhancing the messaging workflow. This system, built on Twilio, a cloud communications platform, enabled seamless information transfer from mobile phones to the central system, effectively addressing connectivity challenges in the disaster-affected region.

The Chatbot provided a practical solution, but reaching end users remained difficult due to the lack of internet and even basic utilities such as electricity in the area. Field observations revealed the extent of these challenges, leading to inefficient resource allocation and coordination among NGOs.¹³ To address this, the WhatsApp Chatbot was transformed into a focused coordination tool as a second phase. Organizations could now share essential information upon arriving at a location through the Chatbot like the name of the organization, the sector of intervention, location, resource details, and contact person duration through the Chatbot. This shift aimed to improve overall coordination among various organizations.

Despite initial testing and use by certain organizations, maintaining continuous engagement with this system and ensuring its long-term effectiveness presented ongoing challenges. This development process reflects the agile response to the urgent needs of the disaster, illustrating the creation of ‘quick and dirty’ coordination tools for disaster response. This solution offers an open-source, cross-plat-

form solution, scalable and easily replicable for future disasters and humanitarian crises.

METHODS

STUDY DESIGN AND SETTING

This study was conducted in the aftermath of the 2023 Turkey-Syria earthquake to evaluate the implementation of digital health tools for enhancing healthcare delivery and coordination in a disaster setting. The primary focus was on developing and deploying a Geographic Information System (GIS) tool, afetsaglikharitasi.org, and a WhatsApp-based Chatbot to facilitate real-time data collection, visualization, and communication among healthcare providers and responders.

DATA COLLECTION METHODS

The data collection for this study followed a three-phase approach, comprising Identification, Verification, and Geocoding, to ensure comprehensive and accurate mapping of healthcare facilities affected by the earthquake. This three-stage approach took place over six days, from February 8 to February 13, 2023. The collected data was subjected to real-time checks every 10 minutes, and any updates were promptly integrated into the database using automated scripts developed in Python, linked with PostgreSQL for backend data management. This approach provided that the operational statuses of healthcare facilities were accurately represented in real-time on the GIS methodology.

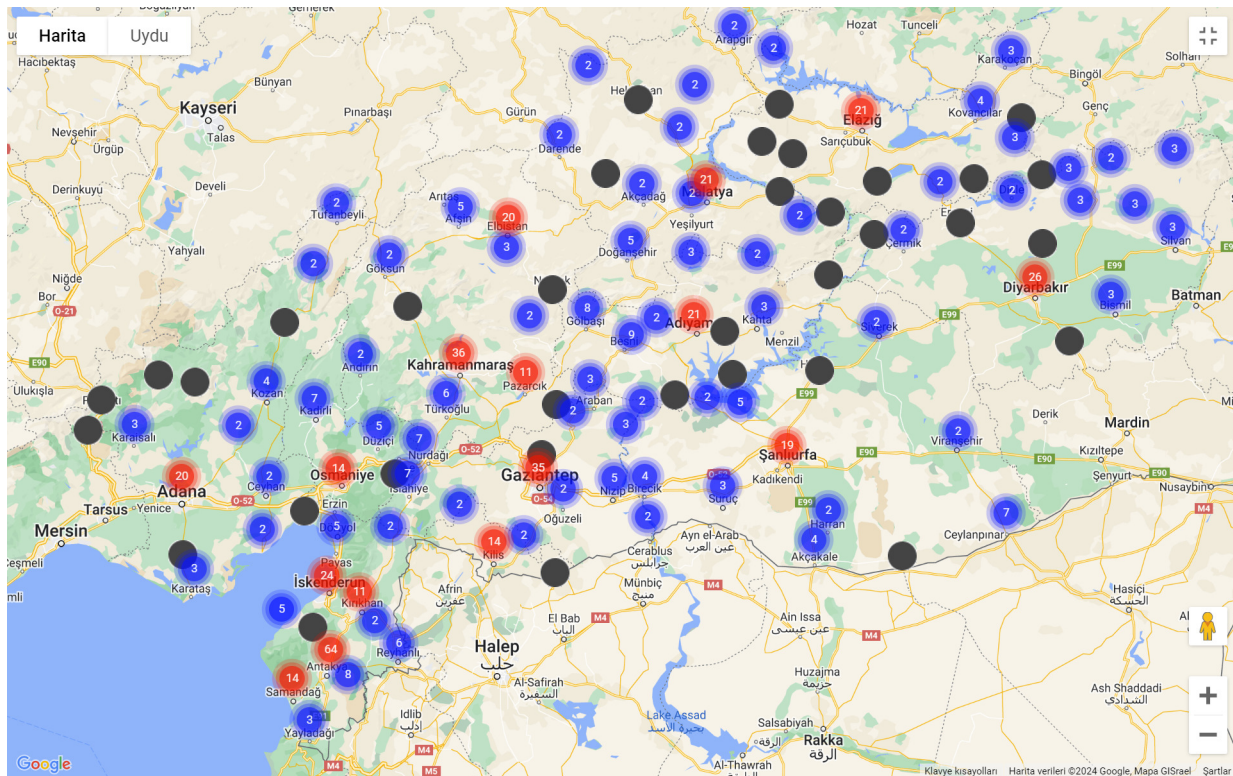


Figure 2. The map from 'afetsaglikharitasi.org' illustrating the distribution of active health facilities in the earthquake-affected regions of Turkey ('afetsaglikharitasi.org').

Identification phase: The initial phase involved identifying healthcare facilities impacted by the earthquake. A team of 40 volunteers and professionals from MEDAK and HERA Digital Health were deployed to systematically gather data on healthcare facilities, including hospitals, clinics, and field hospitals across the affected regions. The goal was to compile a comprehensive list encompassing all healthcare facilities in the earthquake-impacted regions. Publicly available resources such as healthcare directories, organizational websites, and verified online platforms were used to compile a preliminary list of facilities.

Information collected included the facility name, type, address, and geospatial coordinates. A total of 646 health facilities were initially documented and recorded in a centralized database using Google Sheets, with entries categorized by geographic regions (e.g., Hatay, Kahramanmaraş, Gaziantep).

Verification phase: The verification phase aimed to confirm the operational status and service capabilities of the identified facilities to ensure data accuracy and reliability. A separate team conducted direct outreach via telephone calls to facilities wherever possible. Additionally, an extensive online verification was performed through social media monitoring and reviewing news outlets to gather real-time updates on each facility's status. In order to guarantee that the database reflected the capacities of the facilities in real time, this phase was a key determinant.

Geocoding phase: The final phase involved geocoding the verified data to map the precise locations of healthcare facilities. A dedicated team used geospatial software integrated within the afetsaglikharitasi.org platform to convert

address data into latitude and longitude coordinates. The geocoded information was directly fed into the GIS tool, enabling real-time visualization and navigation for end-users. Additionally, this data was linked to the WhatsApp Chatbot, allowing users to access updated facility information directly through mobile devices.

DIGITAL TOOLS DEVELOPMENT AND IMPLEMENTATION

GIS TOOL ([AFETSAGLIKHARITASI.ORG](https://afetsaglikharitasi.org))

The GIS tool was developed using React JS for the front-end and Node JS with PostgreSQL for the backend. This tool was designed to provide real-time, accurate visualization of operational healthcare facilities and their locations.

The backend infrastructure leveraged Amazon ECS and AWS Fargate for scalable server management. All data transmissions were encrypted using X.509 SSL certificates to ensure secure communication between the server and client devices. The system was designed to comply with Health Insurance Portability and Accountability Act (HIPAA) standards, ensuring all personal data was anonymized or masked. Two-factor authentication (2FA) was implemented for all administrative access to the platform.

WHATSAPP CHATBOT

A specialized WhatsApp Chatbot was developed using [Turn.IO](https://turn.io)'s APIs to facilitate data collection and real-time communication among healthcare providers and the af-

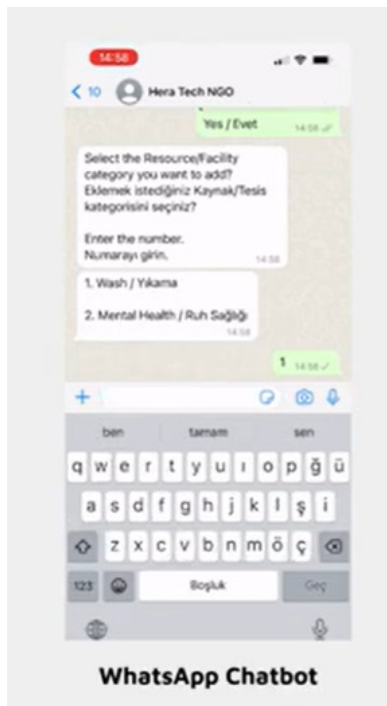


Figure 3. Illustration of the Chatbot.

affected population. The Chatbot supported the rapid addition of service centers or points within the disaster zone, with a capability of adding over 18 locations to the map per minute. It used hardcoded text keyword recognition and logic branching based on user responses to guide data entry.

Over the first three months, 240 users contributed data through the system, adding approximately 75 unique locations. The Chatbot integrated with the afetsaglikharitasi.org platform to ensure seamless data synchronization.

All data interactions were protected through SSL encryption to safeguard against data breaches. Only non-verifiable information was gathered, such as first names and facility details, while sensitive personal data was not stored. The platform complied with HIPAA and General Data Protection Regulation (GDPR) regulations and had business associate agreements (BAAs) with Amazon Web Services (AWS) to ensure that data handling met all legal standards.

RESULTS

As of March 30, 2023, the numerical data reflecting the impact of the disaster health map included the display of data from 537 health service centers. Informative efforts on social media platforms like Facebook and Instagram reached approximately 800,000 people, increasing the visibility of the disaster health map. The tool saw over 3,500 end-users and more than 6,500 page views, with the highest usage in Adana and Diyarbakır provinces within the disaster region.¹⁴ The majority of our users accessed the map through social media platforms. Channels such as Instagram, Twitter, and Facebook played a significant role in helping users discover the map and access information. The most used features of the map include finding locations on the map,

searching for health centers, and listing health centers. These features allowed users to quickly and effectively access the information they needed. 57% of users accessed the map via iOS, and 56% via Android operating systems. 77% of users used mobile devices to access the map. The most commonly used browsers included 57% Chrome, 38% Safari, and 27% Android Webview.

DISCUSSION

The Turkey National Disaster Response Plan (Türkiye Afet Müdahale Planı - TAMP), formulated in 2014 by the Disaster and Emergency Management Authority (Afet ve Acil Durum Yönetimi Başkanlığı - AFAD) of Turkey, details the roles and responsibilities of involved entities in disaster management.¹⁵ The absence of humanitarian health-specific technologies planning in the TAMP led to challenges in resource allocation during the earthquake, particularly where infrastructure was heavily impacted, and highlighted the importance of digital health strategies in national disaster response frameworks.

While advocating for standardization is essential, it is imperative to recognize that an excessive focus on centralization can inadvertently impede local innovation. Turkey's healthcare transformation since 2003, which includes the development of a national electronic health records system aggregating the health records of all its citizens in a single database, is a case in point.¹⁴ However, this system's design lacks the capability to share data or communicate with other databases using standards like Fast Healthcare Interoperability Resources (FHIR) for interoperability.¹⁶ Consequently, the data collected by humanitarian health actors during the earthquake could not be uniformly shared or integrated with local health actors' systems.

During the acute phase of the disaster in Turkey, technological collaboration, notably through platforms like Açık Yazılım Ağı, afetsaglikharitasi.org, deprem.io, beniyiyim.com, and afetharita.com, mapping various services, such as food, healthcare, and non-food items. However, the proliferation of various independent service mapping platforms resulted in disorganized efforts and resource duplication, as reported by NGOs following our needs assessment analysis.¹³ Strengthening collaboration between local governments, UN organizations, and these platforms could streamline the distribution of services and optimize efficiency.

Also, the limited internet access in disaster areas, necessitated a solution that required minimal data usage. As the situation evolved, the role of the Chatbot expanded from simple data exchange to facilitating effective coordination among NGOs, thereby emphasizing the importance of resource allocation. This shift accentuated the need for adaptable, real-time solutions in global health initiatives, especially in crisis situations. The key takeaway is the emphasis on implementing ground truthing and embracing agile methodologies, rather than just creating GIS systems. In emergency healthcare, prioritizing functional and responsive solutions with modifiable structures is crucial, as these can be readily adapted to various large-scale disasters.

ters. It is recommended that such solutions be developed by teams with extensive field experience and be supported by major partners like the UN to ensure broader effectiveness.

The development of the ngo.heradigitalhealth.org platform, in conjunction with the Chatbot, was driven by field teams' specific needs for enhanced coordination in disaster-stricken areas. Recognizing the challenges in inter-organizational communication and coordination, this platform was designed to enhance collaboration among organizations operating in the disaster zone. Its primary goal was to prevent duplication of aid and services while facilitating NGOs to add necessary aid or services to the afetsaglikharitasi.org map. This tool was designed to address the critical need for a low-tech, efficient system capable of tracking field workers in real-time. The open access platform enabled this coordinate-based information sharing on a single map via the WhatsApp Chatbot, providing field teams with real-time status updates and a customizable admin panel for bulk transactions and reporting.

STRENGTHS AND LIMITATIONS

The strengths of the tool include an innovative approach to address issues of coordination between aid providers and access to services in real-time, low-resources and disasters settings. The facilitated access to information related health services available, which are crucial in post-disaster context, through the map and its possibilities of updates thanks to a Chatbot used by organizations is an innovative approach.

However, this paper presents limitations. Because of the emergency situation and the rapid development of the tool, the design methodology and protocol is limited and focuses on the technology itself rather than the evaluation and its impact on the users. Furthermore, the development and implementation of the tool depended on the reality on the ground such as the disruption of electricity and internet services. There is a recognition of the innovative aspects of the tool, however, its implementation faced the realities of the ground, limiting access for normal users and turned into a coordination tool. While the tool was implemented for improved coordination efforts between stakeholders, the creation of afetsaglikharitasi.org was a standalone process with a lack of coordination with additional plat-

forms and technologies settled in the post-earthquake period with a potential risk of resource duplication.

CONCLUSIONS

Real-time solutions in post-crisis settings play a major role in terms of coordination between stakeholders involved in the response. The case of the post-earthquake situation in Turkey and the example of the HERA tool demonstrated the relevance of the use of technologies to face coordination issues in low resources settings (disruption of electricity and access to internet). However, this case on the other side reflected the delicate aspects of coordination and effectiveness of innovative initiatives if a lead organization does not supervise ground initiatives in crisis settings.

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AUTHORSHIPS

All authors contributed to the manuscript.

DECLARATIONS

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