


Article

Multi-Hazard Emergency Response for Geological Hazards Amid the Evolving COVID-19 Pandemic: Good Practices and Lessons Learned from Earthquake Disaster Management in Greece

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Abstract: Since the beginning of 2020, the COVID-19 pandemic has caused unprecedented global disruption with considerable impact on human activities. However, natural hazards and related disasters do not wait for SARS-CoV-2 to vanish, resulting in the emergence of many conflicting issues between earthquake emergency response actions and pandemic mitigation measures. In this study, these conflicting issues are highlighted through the cases of four earthquakes that struck Greece at different phases of the pandemic. The earthquake effects on the local population and on the natural environment and building stock form ideal conditions for local COVID-19 outbreaks in earthquake-affected communities. However, the implementation of response actions and mitigation measures in light of a multi-hazard approach to disaster risk reduction and disaster risk management has led not only to the maintenance of pre-existing low viral load in the earthquake-affected areas, but in some cases even to their reduction. This fact suggests that the applied measures are good practice and an important lesson for improving disaster management in the future. Taking into account the aforementioned, a series of actions are proposed for the effective management of the impact of a geological hazard in the midst of an evolving biological hazard with epidemiological characteristics similar to the COVID-19 pandemic.

Keywords: earthquake emergency; COVID-19 pandemic; hazard interaction; compound emergencies; multi-hazard management; emergency shelters



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1. Introduction

The single-hazard approach is widely used by most countries worldwide in disaster management and disaster risk reduction (DRR) because hazards are considered and managed as isolated and independent phenomena. However, in some cases, different types of hazards overlap and interact in the following ways: (i) natural hazards causing one or more hazard events; (ii) human activities causing natural hazards; (iii) human activities exacerbating natural hazard triggering; (iv) networks of hazard interactions (cascades) forming; and (v) the concurrence of two (or more) hazard events are all examples of human activities triggering natural hazards [1,2].

Gill and Malamund [1] studied how natural hazards, including earthquakes, tsunamis, volcanic eruptions, landslides, floods, fires, and extreme weather events, among others, interact. They were able to identify 90 interactions between 21 natural hazards. It is impressive how the number of interactions can be increased if we add different types

of hazards, such as biological as well as human-made hazards and related disasters and crises. Through this synergy of phenomena and impact, we can imagine how many more challenges, incompatibilities and contrasts can arise when disasters from different hazards occur in parallel.

Since March 2020, when the World Health Organization declared a global pandemic caused by the rapid worldwide spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection [3], the last type of such interaction between biological and natural hazards has become a common occurrence. Since then, many countries have been negatively impacted by natural hazards (earthquakes, floods, fires, hurricanes, and other phenomena) and related disasters [4–7], all while attempting to address and mitigate an evolving biological hazard: the COVID-19 pandemic. It is the most important biological hazard that humanity has recently been called to face, as to date (12 June 2022) SARS-CoV-2 has infected 535,125,479 individuals and has claimed the lives of 6,309,209 people (COVID-19 Dashboard at Johns Hopkins University (JHU); <https://coronavirus.jhu.edu/map.html>, accessed on 12 June 2022). Furthermore, the COVID-19 pandemic has impacted the daily lives of billions of people and has raised many concerns about community exposure, vulnerability, and preparedness. When this evolving biological hazard collides with natural hazards that do not pause for a virus, these issues become even more complicated. Among other complications, the scientific community and disaster risk management authorities are debating the hierarchy of hazards, which can be used to resolve conflicting issues when two (or more) hazards occur simultaneously. Important questions arise to do with the most effective way of responding to competing hazards, and the most efficient disaster management and DRR policies that are incompatible with pandemic mitigation measures. These strategies and policies must be adapted and new innovative multi-hazard approaches should be adopted to reduce individual and community vulnerability.

Many such issues arose during the collision of earthquake-related geological hazards and the evolving pandemic. Many earthquake emergency response actions were incompatible with the pandemic mitigation measures. This fact was highlighted in Greece after the occurrence of large and destructive earthquakes from early 2020. It is important to note that Greece, located in the Eastern Mediterranean region, is characterized by high seismicity [8,9], ranking it first in Europe and sixth in the world among seismic active countries. This high seismicity comprises frequent strong earthquakes [8,9] with a significant impact on the local population, the natural environment, and the building stock, e.g., [10,11]. This is attributed to the occurrence and activation of seismogenic structures, mainly related to the subduction of the Eastern Mediterranean plate beneath the Aegean one along the Hellenic Trench and to major onshore and offshore seismic faults along the margins of neotectonic macrostructures, e.g., [12,13]. Typical examples of such events, which occurred in different waves of the pandemic in Greece and will be examined in the context of this research, are as follows (Figures 1 and 2):

1. The $M_w = 5.7$ Epirus (northwestern Greece) earthquake generated on 21 March 2020 at the beginning of the first pandemic wave and two days before the installation of a strict nationwide lockdown strategy;
2. The $M_w = 7.0$ Samos earthquake generated on 30 October 2020 during the second pandemic wave and 7 days before the installation of a strict nationwide lockdown strategy for the second time in Greece;
3. The $M_w = 6.3$ Thessaly earthquake that occurred on 3 March 2021 during the third pandemic wave;
4. The $M_w = 6.0$ Crete earthquake that occurred on 27 September 2021 during the fourth pandemic wave.

Regarding the seismotectonic setting of the aforementioned earthquake-affected areas, the main source of the $M_w = 5.7$ Epirus earthquake was located on the Margariti thrust fault, within the frontal area of the Ionian fold and the thrust belt of the Hellenic orogen [14]; the $M_w = 7.0$ 2020 Samos earthquake epicenter was located along the southern marginal fault of the North Ikaria Basin [15]; the $M_w = 6.3$ 2021 Thessaly earthquake epicenter was located

along the margins of the Tyrnavos Basin [16]; and the $M_w = 6.0$ 2021 Crete earthquake was strongly related to the NNE–SSW-striking W-dipping faults of the Kasteli fault zone located along the eastern margin of the Neogene to Quaternary Heraklion Basin [17].

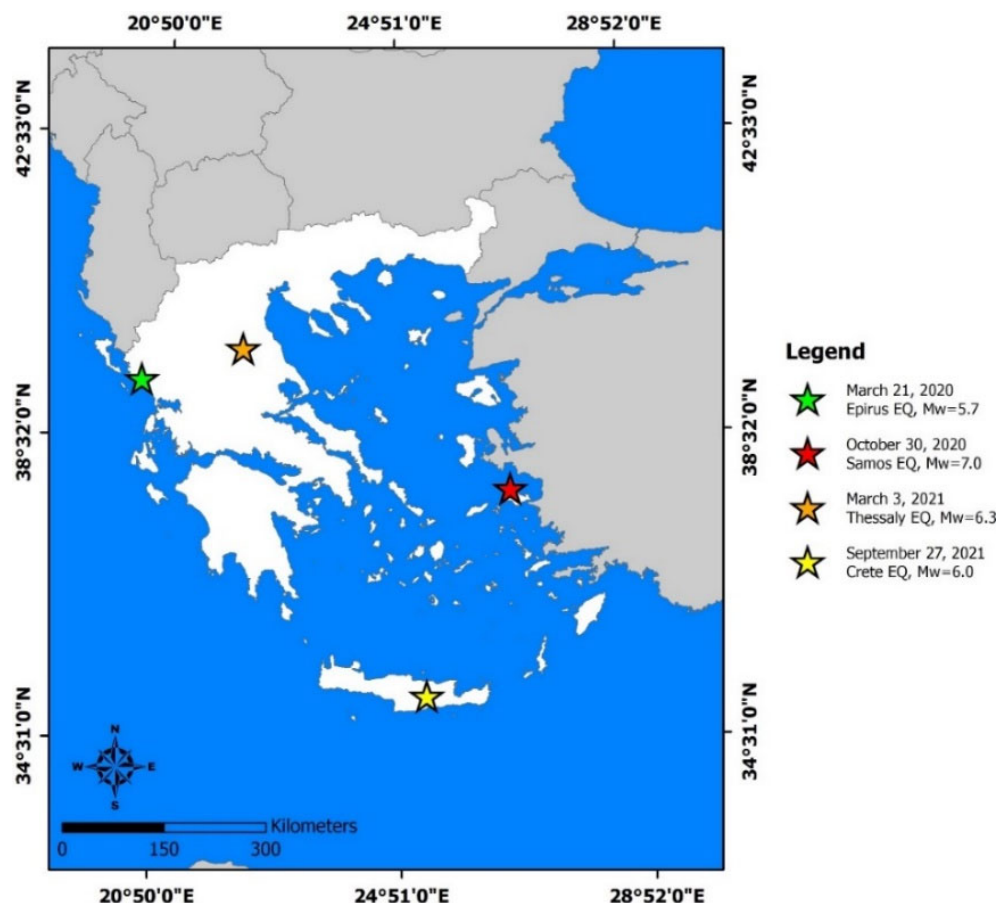


Figure 1. The epicenters of the studied earthquakes in Epirus, Samos, Thessaly, and Crete. They were all generated in different waves of the COVID-19 pandemic in Greece.

Regarding the impact on the local population of Greece, these earthquakes resulted in limited human losses (two fatalities from the Samos earthquake, one from the Thessaly earthquake, and one from the Crete earthquake) attributed to the partial or total collapse of unreinforced masonry structures. The reported losses could be characterized as minimal, considering the extensive structural and non-structural damage observed especially in old unreinforced buildings with load-bearing walls (Ref. [18] for the Samos earthquake; Ref. [19] for the Thessaly earthquake). It is significant to note that the Samos seismic event was the largest in Europe and Turkey and the most fatal worldwide amid the first year of the COVID-19 pandemic evolution, if we also consider the 117 fatalities reported in Izmir city attributed to the partial or total collapse of buildings with reinforced concrete frames and infill walls [17].

Regarding the earthquake environmental effects, the Epirus earthquake triggered rockfalls and river water turbidity in the earthquake-affected area. The Samos earthquake induced primary effects comprising coseismic uplift and surface ruptures and secondary phenomena including slope failures, ground cracks, liquefaction phenomena and hydrological anomalies and the largest tsunami in Greece since 1956 [20]. The Thessaly earthquake triggered extended liquefaction phenomena in recent deposits in the riverbeds of the earthquake-affected area [19]. The Crete earthquake generated mainly rockfalls and slides, as well as ground cracks within or close to landslide zones.

Taking into account the new adverse conditions that have emerged in the field of disaster risk reduction and management, this paper aims to (Figure 3):

1. Highlight the contradictory issues that arose in the emergency response to the aforementioned earthquakes during different phases of the evolving COVID-19 pandemic that did not exist in the pre-pandemic period;
2. Share the practices used during the emergency response;
3. Present the approaches that need to be adapted and adopted during emergency response to earthquakes not only amid the current pandemic but also when geological hazards collide with evolving biological hazards.

Furthermore, in the earthquake-affected regions of Epirus, Samos, Thessaly, and Crete, an analysis of the COVID-19 pandemic's evolution is carried out (Figure 3). The goal of this post-event analysis is to determine the impact of the earthquake on the pandemic's progression in the affected areas, as well as to evaluate the effectiveness of the actions taken in the early hours and days of the emergency response phase.

In this context, a brief description of the Civil Protection framework in Greece is given, with emphasis on the existing general plan for the emergency response and immediate management of the earthquake impact and effects (Figure 3). Particular emphasis is placed on the single-hazard nature of this plan. The absence of a plan that takes into account the interactions between geological and biological hazards is also highlighted. In addition, reference is made to the COVID-19 pandemic mitigation strategies and measures implemented during the last two years in Greece.

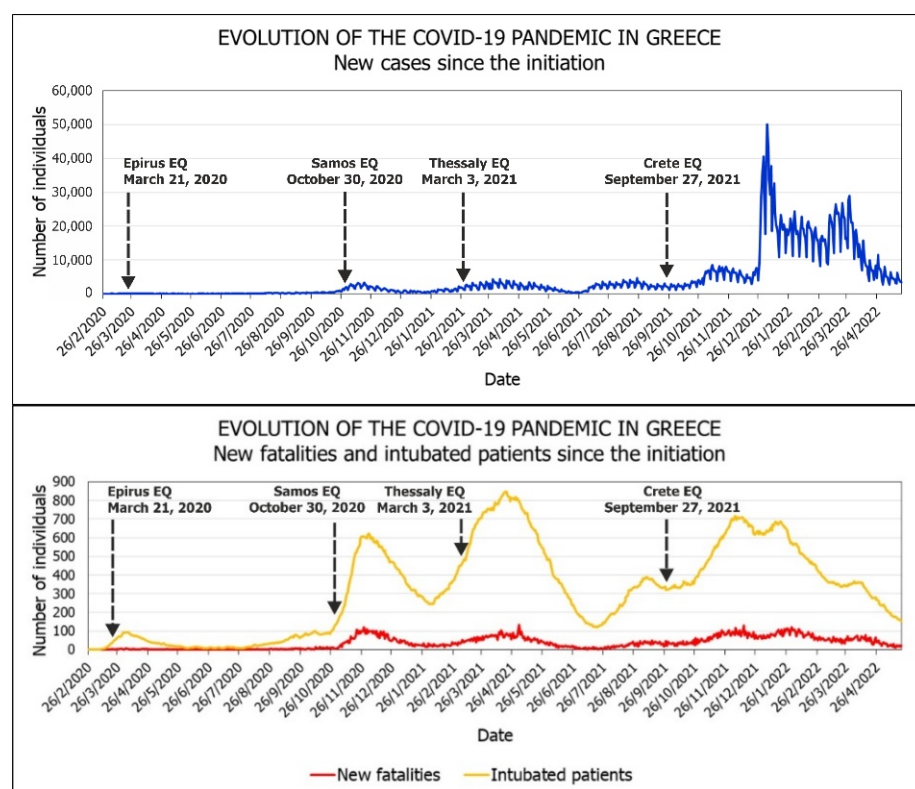


Figure 2. The laboratory-confirmed daily-reported COVID-19 cases, intubated patients and fatalities in Greece from the pandemic onset in February 2020 until late April 2022 based on the daily reports of the National Public Health Organization (NPHO) of Greece. The studied earthquakes of Epirus, Samos, Thessaly, and Crete are also presented.

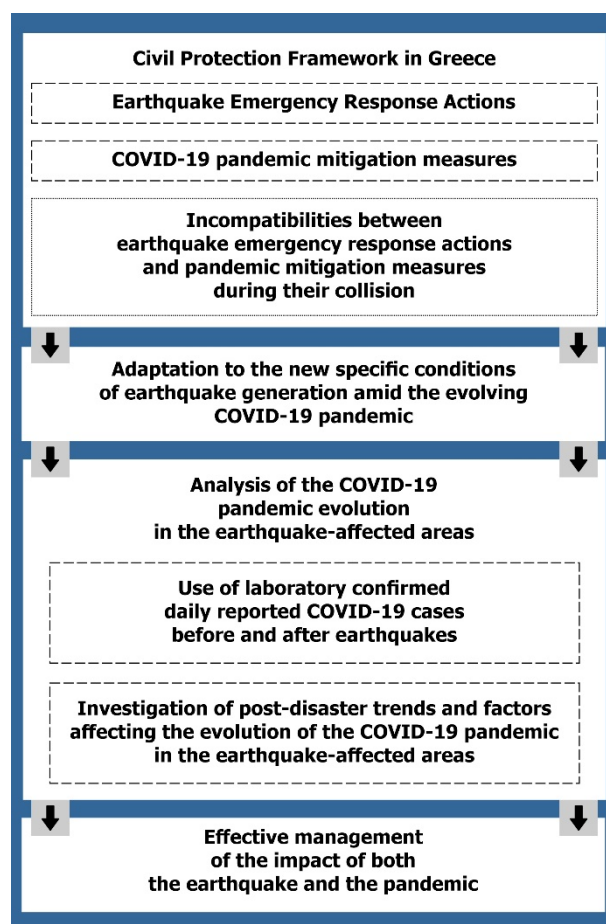


Figure 3. Flow chart showing the approach followed in the present study.

2. Civil Protection Framework in Greece

In late February 2020, the pandemic came knocking on Greece’s door. The general plans for dealing with emergencies and managing the consequences of each hazard were also released at the same time. The General Secretariat for Civil Protection (GSCP) announced the formulation of the “Enceladus” earthquake plan, the “Dardanos” flood plan, the “Iolaos” forest fire plan, the “Talos” plan for volcanic activity in the Santorini complex (Aegean Sea), the “Voreas” plan for snowfall and frost, and the “Heraclitus” plan for large-scale technological accidents, all of which are publicly available online at the GSCP site (<https://www.civilprotection.gr/en>, accessed on 10 May 2022).

In terms of earthquakes, the “Enceladus” plan aims to provide an immediate and coordinated response from authorities at the national, regional, and local levels in order to effectively respond to earthquake effects and manage them. The most significant flaw or omission identified in the aforementioned is the lack of a general plan for dealing with emergencies and managing the consequences of biological hazards. This gap, in the case of the COVID-19 pandemic, was filled by the prevention measures against SARS-CoV-2 issued by the Ministry of Health (<https://www.moh.gov.gr/articles/health/dieythynsh-dhmosias-ygieinh/metra-prolhpshts-enanti-koronoioy-sars-cov-2/>, accessed on 10 May 2022) from 28 February 2020 and the information material and specialized instructions of the National Public Health Organization (NPHO) (<https://eody.gov.gr/en/covid-19/>, accessed on 10 May 2022) from early February 2020 until the present. These bodies are in constant contact with the European Center for Disease Prevention and Control (ECDC) and the World Health Organization (WHO) to ensure that prevention measures, information materials, and specialized instructions are kept up to date, taking into account the pandemic’s evolution in Greece. The analysis of these plans also reveals that the existing

plans use a single-hazard approach to assessing hazard potential, in which hazards are treated as separate and unrelated events.

What happens, however, if a disaster induced by a natural hazard strikes in the midst of the COVID-19 pandemic in Greece? Unfortunately, no plans exist to consider potential interactions between natural and biological hazards. This is due to the fact that the pandemic is a constantly evolving biological hazard that poses unprecedented challenges and threats to all, including citizens and governments, patients, and health systems around the world, putting public health and many other aspects of daily life and human activities at risk. The COVID-19 pandemic has evolved into a rapidly changing emergency, with data and measures constantly changing across Europe and around the world, affecting people at all levels.

3. COVID-19 Pandemic Mitigation in Greece

On 26 February 2020, the first confirmed case of SARS-CoV-2 infection in Greece was reported. Since then, the Greek government and authorities involved in the COVID-19 pandemic management in Greece have taken precautionary measures to limit the spread of the novel virus in the community and the pandemic's effects on public health. Mavroulis et al. [6] present the measures taken during the first and second waves of the COVID-19 pandemic in Greece. During the first wave of the pandemic, Greece implemented a strict nationwide lockdown strategy on 23 March 2020, which was extended until 4 May 2020. The emergency COVID-19 restrictive measures were gradually deescalated as of 4 May, with the gradual reopening of retail businesses, commercial stores, educational and religious activities, the lifting of travel restrictions across the country, and the gradual lifting of national and international restrictions.

All daily activity resumptions and restrictions were accompanied by the majority of the population's continued protective measures. These included hygiene and social distancing measures, restrictions on the maximum number of people allowed indoors and outdoors, and guidelines for the use of masks and disposable gloves, both optional and mandatory on occasion. Furthermore, authorities involved in COVID-19 pandemic management, such as the Ministry of Health, the NPHO, and the GSCP, imposed COVID-19 and SARS-CoV-2 transmission prevention measures, taking into account all updated scientific data on the pandemic's evolution in Greece and around the world.

Despite the measures taken, the number of COVID-19 cases increased, and a second wave of the pandemic began in Greece in early August, with a more aggressive course than the first, according to daily reports of laboratory-confirmed COVID-19 cases, ICU patients, and fatalities [21]. By mid-September 2020, the number of cases had surpassed the first wave's peak, and the number of ICU patients and fatalities had surpassed those of April 2020 when a nationwide lockdown was imposed. On 20 October, an upward trend in cases began, peaking on 12 November with 3316 daily reported COVID-19 cases [21]. There was a corresponding increase in the number of fatalities, which peaked on 28 November with 121 casualties [21]. In December and January, there was a gradual decrease in daily COVID-19 cases, ICU patients, and casualties. These figures never recovered to pre-October 2020 levels. This means that the virus was prevalent in the community and that an increase in cases could occur at any time.

The main measures implemented by the government and the involved authorities to limit the spread of the novel virus in the community during the second wave of the COVID-19 pandemic in Greece were local-scale restrictive measures, such as local-scale lockdowns in large cities, towns, and settlements, as well as a second national-scale lockdown, which began on 7 November 2020. The earthquake on Samos struck on 30 October, just days before the second national-scale lockdown.

The main guidelines announced by the involved authorities for preventing SARS-CoV-2 transmission, from the start of the pandemic in Greece on 26 February 2020 until the second wave, included personal hygiene measures, cleaning and disinfecting areas, surfaces, and items, restricting contact, and avoiding gatherings and overcrowding indoors and

outdoors. The announced guidelines included hygiene measures in health-related businesses, hygiene rules for public transportation, protection measures in sports facilities, educational units, workplaces, elderly care units, health units, health service units, and the country's entrance gates, as well as temporary reception and accommodation facilities for refugees seeking asylum and unaccompanied minors and youths, and public infrastructure protection measures.

Personal hygiene guidelines and advice comprised the following actions in order to reduce the infection risk:

- Keeping hands away from the eyes, nose, and mouth;
- Avoiding sharing personal items;
- Covering the mouth and nose with a tissue, sleeve or flexed elbow when coughing or sneezing and throwing the tissue into a closed bin after use;
- Regular hand washing with liquid soap and water for at least 20 s and careful hand drying with disposable paper towels;
- Using alcohol-based hand sanitizer containing at least 70% alcohol;

The cleaning and disinfection guidelines comprised:

- Systematic and adequate ventilation of all areas with complete and frequent air renewal;
- Frequent cleaning of commonly used smooth surfaces (e.g., knobs, handles, handrails or railings, taps, etc.) with common cleaners and disinfectants;
- The use of appropriate protective equipment (gloves and work uniform) during cleaning and disinfection;
- Cleaning objects and surfaces of which a person who showed symptoms of SARS-CoV-2 infection had come into contact.

Physical social contacts were reduced by keeping a distance of at least 1.5 to 2 m and avoiding contact with people who had infection symptoms (shaking hands, hugs, and kissing), avoiding gatherings and overcrowding, reducing contact with people who belonged to vulnerable groups, and minimizing group activities and non-essential movements.

Since the second wave in Greece, the implementation of vaccines—initially for health workers and very high-risk population groups and then for all other age groups of the population—and the subsequent administration of antiviral drugs to patients with COVID-19 infection have been useful tools for halting the pandemic and limiting its negative consequences on public health and all sectors of human activity. However, the imposition or withdrawal of these pandemic containment measures—even after the arrival of vaccines and medicines—is carried out according to the burden that the pandemic occasionally places on the national health system.

4. Earthquake Emergency Response Actions, Incompatibilities with the COVID-19 Pandemic Mitigation Measures, and Adaptation for Dealing with Both Earthquake and Pandemic Effects

Following the aforementioned earthquakes, the Greek government launched a massive resource mobilization effort to aid the affected population. For disaster management, public authorities from all levels of government, Civil Protection agencies and security and armed forces, are mobilized. The main actions taken by agencies during the response to an earthquake disaster can be divided into 11 categories [6,19,22]:

1. Initial earthquake notification;
2. First assessment of the impact, followed by mobilization of and coordination by the Civil Protection authorities;
3. Civil Protection guidelines through emergency communications services;
4. Search and rescue (SAR) operations, first-aid administration and medical care;
5. Mobilization and contribution of volunteers;
6. Set up of emergency shelters;
7. Provision of emergency supplies and donations;
8. Psychological support for the affected population;

9. Raising awareness and education for protective measures to successfully deal with the continuous aftershock sequence;
10. Post-earthquake hazard mitigation and building inspections;
11. Immediate financial relief measures.

The emergency response actions for the mobilization, intervention, and management of earthquake effects had never been tested before in the context of another crisis that posed an additional risk to public health and, thus, human life. In the pre-pandemic period, this sequence of actions would be completely unconcerned. With the earthquakes in Epirus, Samos, Thessaly, and Crete, the local population and Civil Protection authorities were confronted with unprecedented circumstances, including considerable earthquake-triggered effects and the ongoing threat of the COVID-19 pandemic. During the COVID-19 pandemic, many conflicting issues arose from the start of the emergency response, owing to the fact that the majority of emergency actions were incompatible with the pandemic mitigation measures that had been implemented. This is due to the fact that, from the first moments after an earthquake, emergency response actions and people's reactions involve or require the gathering of a large number of people in one location for an extended period of time, the interaction of locals with rescue teams, volunteer teams, and disaster management staff, as well as the unintentional violation of many basic hygiene rules (e.g., regular hand washing, surface disinfection). During the pandemic, these actions may result in clusters of SARS-CoV-2 infection cases within the affected area, hampering emergency response and slowing the recovery process.

To overcome the incompatibilities between earthquake emergency response actions and pandemic mitigation measures, earthquake emergency response actions were adapted to the unprecedented conditions of the parallel occurrence of geological and biological hazards. These adaptations were made in light of a multi-hazard approach at all stages of the earthquake emergency response, starting from the initial mobilization of the Civil Protection authorities up to the conduction of awareness and education activities for the protection of the local population during the continuous aftershock sequence.

The staff of the Civil Protection authorities, who contributed to the earthquake disasters' management, came mostly from other areas with different infection rates and different degrees of public health emergency and risk for SARS-CoV-2 infection. Regarding the implementation of self-protection measures and the protection of the local population by the Civil Protection staff that participated in the emergency management in the earthquake-affected areas, the main adaptations included the mandatory use of masks outdoors and the frequent use of antiseptics, keeping physical distance from the local population, and the disinfection of equipment and tools used by many people. These measures were strictly used especially in actions that required interaction and closer contact with the local population, such as SAR operations, the assessment of building damage, as well as the provision of basic necessities and emergency supplies to the affected residents.

The adaptations for avoiding overcrowding and maintaining physical distancing in emergency shelters comprised the use of a large number of different types of shelters (Figure 4). A typical example of this approach is the emergency shelters used in the 2020 Samos earthquake-affected area. Many homeless and affected people were accommodated in hotel rooms and tourist accommodation facilities. This measure ensured not only the maintenance of physical distance between the affected people, but also the avoidance of overcrowding in outdoor emergency shelters. This solution was possible because the earthquake occurred during the autumn when the tourist traffic in Samos was low, resulting in empty or closed hotels in the earthquake-affected areas. The accommodation of homeless and severely affected people in the unaffected houses of relatives and friends also aided the maintenance of physical distance.



Figure 4. Several types of emergency shelters for the immediate housing of people in need after an earthquake which were used at the Damassi (Thessaly) camp (a) after the 3 March 2021 Thessaly earthquake. They comprised (b) camper vans, (c) tents, and (d) temporary container-type structures in the same area. Amid the pandemic, the use of many different types of shelters contributed to the avoidance of overcrowding in camps and the maintenance of physical distance in order to limit the spread of the novel virus in the earthquake-affected community.

The same approach of using a large number of different types of emergency shelters was applied in the case of the 2021 Thessaly earthquake, which occurred a few months later during the third pandemic wave. The Civil Protection authorities used outdoor emergency shelters, hotel rooms and tourist facilities, camper vans, and temporary container-type facilities (Figure 4) as well as accommodation in the houses of relatives and friends. In this way, it was possible to ensure a certain amount of space between groups and individuals who camped in outdoor emergency shelters, which before the pandemic usually housed the majority of earthquake-affected people.

During the collection and distribution of essentials, and especially during the distribution of meals to the affected people, volunteers used personal protective equipment at all stages of the process (Figure 5a–c). As for the daily meals, these were most often prepared in packet form (Figure 5c,d) for further distribution to the affected people.

Regarding the post-earthquake building inspections, information activities were carried out for civil engineering teams outdoors or in closed spaces with adequate ventilation in the earthquake-affected areas. The appropriate physical distances between the participants were effectively maintained. For example, these activities were held either outdoors, such as in the central square of the Town Hall of Eastern Samos in the capital city of the homonymous municipality, or in large indoor spaces, such as indoor sports facilities with large spaces, ensuring the maintenance of physical distance and adequate ventilation, which ensured the safety of the participants during these briefings (Figure 6). In the case of the Thessaly earthquake, the briefings were held in open spaces in the most-affected settlements. In the case of the Crete earthquake, these briefings were held in the courtyard of the 2nd Primary School of Arkalochori town, where the operational center had been established by the Civil Protection authorities (Figure 6).



Figure 5. Typical views of the distribution of relief supplies: (a) in the operational center in the Town Hall Square of the Eastern Samos municipality; (b,c) in the earthquake camp in Damassi (Thessaly); and (d) in the earthquake camp at the exhibition center of the earthquake-affected town of Arkalochori on Crete Island. The distribution of relief supplies was adapted to the new conditions formed by the pandemic. Civil Protection personnel, members of the armed forces and voluntary groups used personal protective equipment at every stage of the preparation and distribution of supplies (c), and the meals were served packed (c,d).

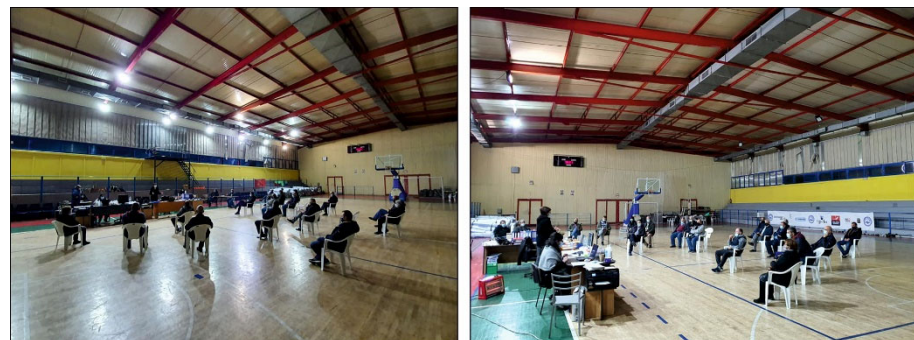


Figure 6. Information activities for building inspections on the affected island took place in indoor sports facilities after the 2020 Samos earthquake.

Moreover, building-damage documentation centers were set up outdoors. In these centers, especially during the first hours and days of the emergency phase, it was impossible to implement the measures of physical distancing due to the fact that many residents gathered to report building and property damage. In this case, the use of masks and hand sanitizers was vital. Thus, personal protective equipment supplies were available not only for the affected people but also for the involved personnel.

Coordination meetings of the Civil Protection authorities involved in disaster management took place during the emergency response, with the aim to assess the situation and organize, coordinate and implement further actions. These meetings were conducted in specially designed outdoor sites, which provided not only protection from large aftershocks, but also comfort in maintaining physical distance (Figure 7). In these areas, all personal protective measures including masks, hand sanitizers and disposable gloves when neces-

sary, were available for both the affected people and the Civil Protection staff. In addition, food supplies including bottled water and packaged food were also immediately available and distributed to those in need by complying with all precautions against COVID-19.



Figure 7. (a,b) The coordination operation center after the 2020 Samos earthquake was set up outdoors with spatial arrangement adapted to the pandemic mitigation measures. (c,d) The same approach was applied in the case of the Arkalochori (Crete) earthquake. The coordination operation center was also set up outdoors in the courtyard of a school, providing space for maintaining physical distance and avoiding overcrowding.

In Samos, the operations coordination center was set up shortly after the earthquake occurrence in the square in front of the Eastern Samos Municipality building in Vathy (Figure 7a,b). There were seats placed at appropriate distances and personal protective equipment supplies available for all involved when it was not possible to maintain distance. The use of masks was mandatory. In Crete, the operations coordination center was set up shortly after the earthquake occurrence in a courtyard of a primary school (Figure 7c,d) located at the town most affected by the main shock on 27 September 2021.

Regarding raising awareness and education activities for the local population, seminars were held by the Earthquake Planning and Protection Organization of Greece for certain targeted population groups in all earthquake-affected areas in Epirus, Samos, Thessaly and Crete. These seminars were not held indoors, but outdoors (Figure 8), where all the protection measures against the pandemic could be applied. The provided information included training and guidelines for protection during the aftershock period against both possible large aftershocks and the further transmission of the novel virus.

Regarding psychological support for the earthquake-affected people, it was provided to everyone who was experiencing significant psychological stress by the regional and local authorities and voluntary organizations acting in the earthquake-affected Samos, always in excellent cooperation. In order to apply social distancing practices and to avoid overcrowding during sessions, the psychological support was usually provided after making an appointment for in-person counseling, while remote communication via teleconference or videoconference was also available. In the case of in-person meetings, wearing masks and keeping the appropriate physical distance was mandatory both indoors and outdoors.

Table 1 summarizes the main actions taken during the first hours and days of the emergency response that were incompatible with pandemic mitigation measures, as well as the adaptations made in order to effectively deal with both the earthquakes and the pandemic.



Figure 8. Awareness-raising and educational activities were conducted by the staff of the Earthquake Planning and Protection Organization of Greece in the earthquake-affected Samos. Amid the pandemic, the activities were held outdoors with participants using personal protective equipment (mask, gloves and antiseptics). (a–d) Views from workshops for the directors of primary and secondary schools in Vathy town located at the northeastern part of Samos Island.

Table 1. Earthquake emergency response actions, incompatibilities with the pandemic mitigation measures, and adaptations for the effective management of both the earthquakes and the pandemic.

Earthquake Emergency Response Actions in the Pre-Pandemic Period	Pandemic Mitigation Measures and Incompatibilities with Earthquake Emergency Response Actions	Adaptations for the Effective Management of both Earthquakes and the Pandemic
Mobilization of Civil Protection Authorities		
Civil Protection staff should be on time in the earthquake-affected area.	It is prohibited to move, by any means, outside the boundaries of an area with a larger viral load and higher infection rate. It is prohibited to visit an area with larger viral load and higher infection rate.	Two exclusive flights operated by Civil Protection transported all required personnel a few hours after the earthquake. All the necessary safety measures were taken during the flight (masks throughout the whole journey, one person sitting in each seat row, hand sanitizer).
Coordination of the Civil Protection Authorities		
Coordination meetings take place usually indoors in unaffected buildings with the staff involved in disaster management.	Gathering many people indoors for several hours should be avoided.	Set up of Emergency Operations Centers outdoors, with seats placed at appropriate distances, personal protective equipment supplies available for all involved, mandatory use of face masks.

Table 1. Cont.

Earthquake Emergency Response Actions in the Pre-Pandemic Period	Pandemic Mitigation Measures and Incompatibilities with Earthquake Emergency Response Actions	Adaptations for the Effective Management of both Earthquakes and the Pandemic
SAR Operations		
SAR operations require close and frequent contact not only with the affected local population and local authorities, but also with other rescue teams and volunteers.	Rescuers should maintain the appropriate physical distancing.	Mandatory use of masks indoors and outdoors, frequent use of antiseptics, keeping physical distance from the local population and disinfection of equipment and tools used by many rescuers.
The special equipment can be used by many members of rescue teams.	The use and exchange of items, tools and equipment and the frequent use of surfaces and spaces by many individuals carries the risk of transmitting the novel virus.	
Set up of Emergency Shelters		
Overcrowding and coexistence of many people in emergency shelters over a long period of time.	The accommodated people should maintain physical distancing.	Use of different types of emergency shelters. Outdoor camps, accommodation in hotel rooms, tourist accommodation facilities and unaffected houses of relatives and friends. Personal protective equipment supplies available for all involved in all shelters.
High mobility usually observed in emergency shelters during the first hours and days of the emergency.		
Mobilization and Contribution of Volunteers		
Volunteers not only from the affected area, but from every corner of the country rush to the affected area and provide support.	It is prohibited to move, by any means, outside the boundaries of an area with a larger viral load and higher infection rate. It is prohibited to visit an area with larger viral load and higher infection rate.	Mandatory use of masks indoors and outdoors, frequent use of antiseptics, keeping physical distance from the local population and disinfection of items, tools and equipment.
Volunteers distribute humanitarian aid gathered from various sources.	The distribution of items, tools and equipment and the frequent use of surfaces and spaces by many individuals carries the risk of transmitting the novel virus.	
Volunteers distribute meals to affected people where necessary.		
Voluntary teams and their members come into close contact with many people and for many hours in the affected area.	Volunteers should maintain the appropriate physical distancing.	
Provision of Emergency Supplies and Donations		
People from around the country and worldwide are mobilized in order to donate essential emergency supplies to the affected population.	The whole process, from the collection of emergency supplies to their final distribution to the affected population, involves risks for the public health attributed to touching undisinfected items and surfaces.	Mandatory use of masks indoors and outdoors, frequent use of antiseptics, keeping physical distance from the local population and disinfection of items, tools and equipment.

Table 1. Cont.

Earthquake Emergency Response Actions in the Pre-Pandemic Period	Pandemic Mitigation Measures and Incompatibilities with Earthquake Emergency Response Actions	Adaptations for the Effective Management of both Earthquakes and the Pandemic
Post-earthquake Hazard Mitigation and Building Inspections		
Evacuation of the affected population from several heavily affected areas.		The involved Civil Protection staff applied necessary individual preventive measures for their safety and the protection of the affected community (mandatory use of masks, regular hand washing, and maintaining physical distance).
Civil engineers inspect buildings during the emergency response. This action requires interaction with homeowners.	Residents and Civil Protection staff should maintain the appropriate physical distancing	Information activities were carried out for participants in civil engineering teams in open or closed spaces with adequate ventilation. Civil engineers applied necessary individual preventive measures for their safety and the protection of the affected community (mandatory use of masks, regular hand washing, and maintaining physical distance). Building damage documentation centers were set up in open spaces.
Psychological Support for the Affected Population		
Psychological support and counseling sessions are carried out in person and indoors.	These sessions pose a risk of spreading the virus among participants and then in the community.	Remote communication via teleconference or videoconference was available. In the case of in-person meetings, mandatory mask-wearing and keeping appropriate physical distance both indoors and outdoors
Awareness-raising and Education Activities on the Earthquake Effects and Protective Measures		
Seminars take place indoors in educational facilities, properly designed to accommodate many people for many hours.	Gathering of many people indoors for several hours should be avoided.	Outdoors seminars in safe places away from the adverse effects of possible aftershocks and easy application of pandemic mitigation measures comprising mainly maintaining of physical distance. Transmission of information through the loudspeakers of police patrol vehicles, calling on the people to comply with the pandemic prevention measures.

5. The Evolution of the COVID-19 Pandemic in the Earthquake-Affected Areas

The findings of the study on the pandemic's post-disaster evolution during the first weeks of emergency response and recovery in earthquake-affected areas are presented in this section. They are based on laboratory-confirmed and daily-recorded COVID-19 cases in earthquake-affected regional units derived from the NPHO's COVID-19 epidemiological surveillance daily reports. These reports are freely available online on the NPHO's website (<http://eody.gov.gr/epidimiologika-statistika-dedomena/ektheseis-covid-19/>, accessed on 30 January 2022).

Regional units are the smallest local government organizations for which daily case numbers are announced in Greece and include the affected areas based on the above data and the available sources of daily COVID-19 cases. As a result, we used data from the above source in our research for the following regional units (Figure 9):

- The Arta, Thesprotia, Ioannina, and Preveza regional units of the Epirus region, which were affected by the Epirus earthquake;

- The Samos, Ikaria and Chios regional units of the North Aegean region, which were affected by the Samos earthquake;
- The Karditsa, Larissa, Magnesia and Trikala regional units of the Thessaly region, which were affected by the Thessaly earthquake;
- The Heraklion regional unit of the Crete region, which was affected by the earthquake on 27 September 2021.

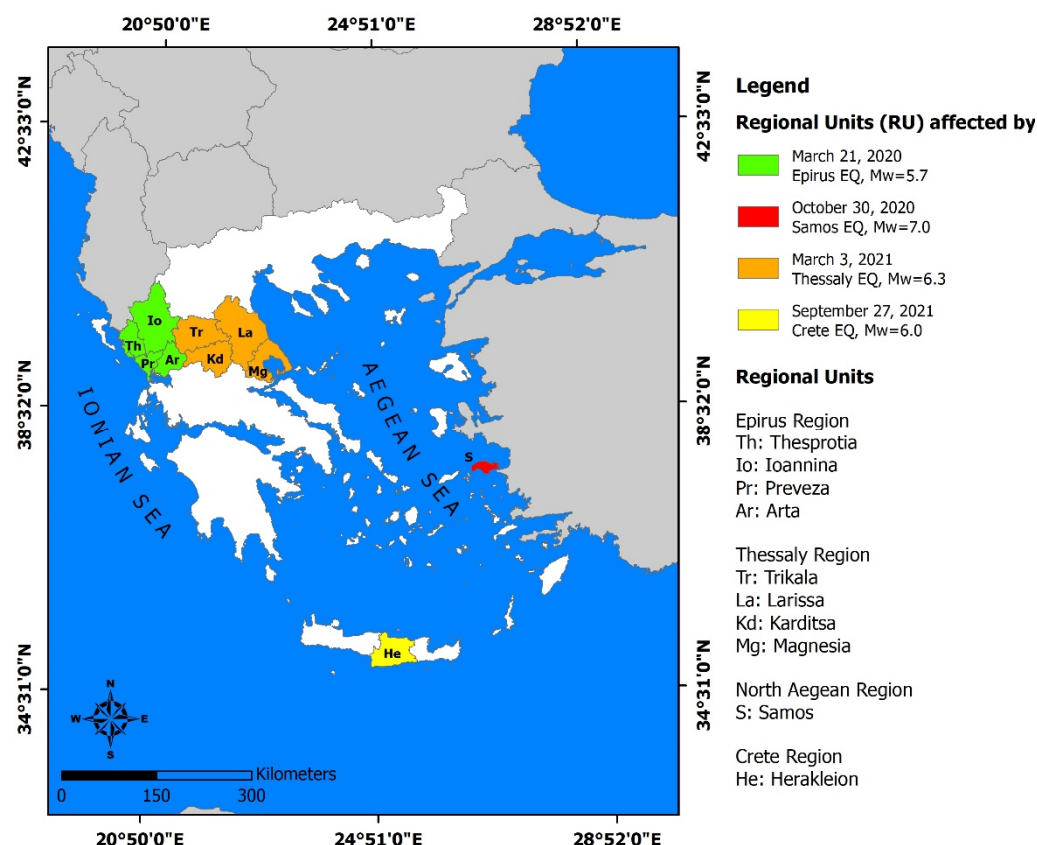


Figure 9. The earthquake-affected regional units in Greece during the COVID-19 pandemic.

Mavroulis et al. [6] used the same methodology to investigate post-disaster trends and factors affecting the evolution of the COVID-19 pandemic in areas affected by geological and hydrometeorological hazards in Greece. In particular, it was taken into account that the estimated incubation period of SARS-CoV-2 ranges from 2 to 14 days (median incubation time: 5 days) [23,24] and that SARS-CoV-2 can be detected by the polymerase chain reaction (PCR) test in infected patients up to 21 days after the onset of symptoms [25,26]. As a result, COVID-19 cases reported 5 days after disasters could be attributed to disaster-related adverse effects. Mavroulis et al. [6] suggested that it was appropriate to track the number of daily confirmed cases in the 7 days (1 week) leading up to the disaster to determine the pre-existing viral load and infection rate in each affected area.

Taking into account all the aforementioned data, the number of daily COVID-19 cases in the present study was tracked:

- From 14 March to 11 April 2020 for the Epirus earthquake generated on 21 March 2020 (Figure 10);
- From 23 October to 21 November 2020 for the Samos earthquake generated on 30 October 2020 (Figure 11);
- From 24 February to 24 March 2021 for the Thessaly earthquake generated on 3 March 2021 (Figure 12);
- From 20 September to 10 October 2021 for the Crete earthquake generated on 27 September 2021 (Figure 13).

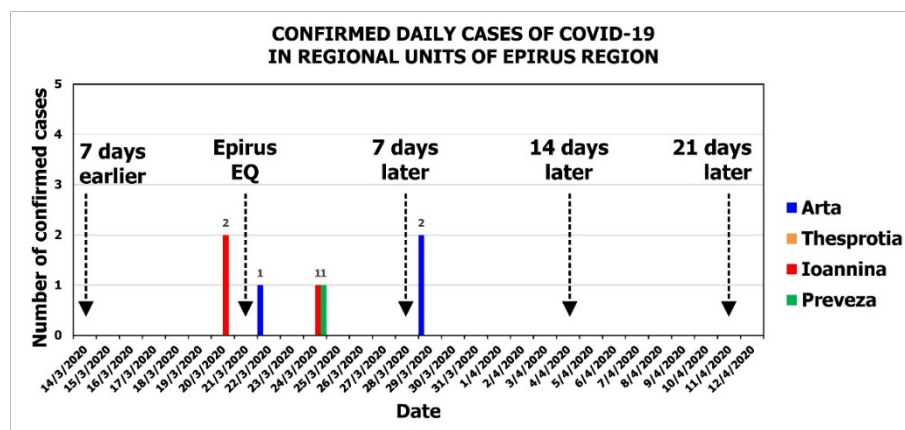


Figure 10. The evolution of COVID-19 cases in the earthquake-affected regional units of the Epirus region before and after the occurrence of the 21 March 2020 Epirus earthquake. The laboratory-confirmed, daily-recorded COVID-19 cases are from the NPHO's COVID-19 epidemiological surveillance daily reports [21] covering the period from 14 March to 12 April 2020.

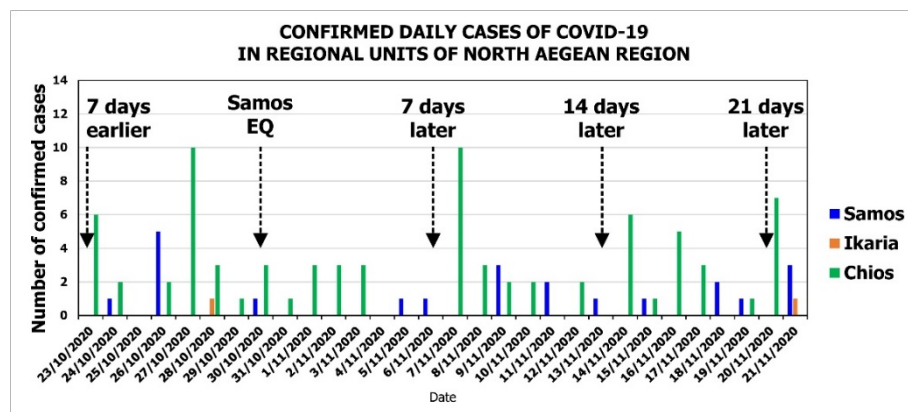


Figure 11. The evolution of COVID-19 cases in the earthquake-affected regional units of the North Aegean region before and after the occurrence of the 30 October 2020 Samos earthquake. The laboratory-confirmed, daily-recorded COVID-19 cases are from the NPHO's COVID-19 epidemiological surveillance daily reports [21] covering the period from 23 October to 21 November 2020.

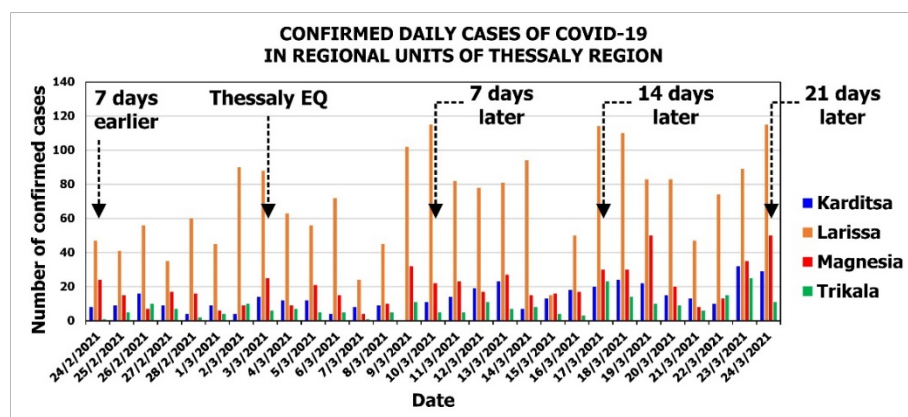


Figure 12. The evolution of COVID-19 cases in the earthquake-affected regional units of the Thessaly region before and after the occurrence of the 3 March 2021 earthquake. The laboratory-confirmed, daily-recorded COVID-19 cases are from the NPHO's COVID-19 epidemiological surveillance daily reports [27] covering the period from 24 February to 24 March 2021.

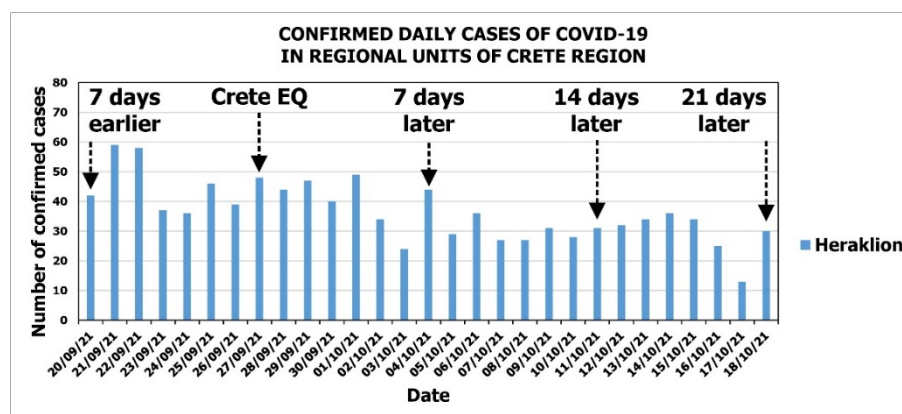


Figure 13. The evolution of COVID-19 cases in the earthquake-affected regional units of the Crete region before and after the occurrence of the 27 September 2021 Arkalochori earthquake. The laboratory-confirmed, daily-recorded COVID-19 cases are from the NPHO’s COVID-19 epidemiological surveillance daily reports [27] covering the period from 20 September to 18 October 2021.

According to the following graphs of the laboratory-confirmed and daily-recorded COVID-19 cases (Figures 10–13), it is concluded that no considerable increase in the number of COVID-19 cases was detected in the selected post-disaster period for the earthquake-affected regional units of Epirus, North Aegean, Thessaly or Crete.

In disaster-affected areas around the world, a similar post-disaster trend in the evolution of the pandemic has been observed, including not only earthquakes but also hydrometeorological hazards such as floods and hurricanes. Silva and Paul [5] mention the $M = 6.0$ earthquake near Khoy (Iran) on 23 February 2020, the $M = 5.3$ Zagreb (Croatia) earthquake on 22 March 2020, the $M = 5.7$ Magna earthquake in Utah, and the earthquake swarm that hit Puerto Rico’s southern region in early 2020.

In the case of the earthquake in Iran, the first confirmed COVID-19 case was reported a few days before the event, which could indicate that some cases already existed in the earthquake-affected area, that there were no COVID-19 cases in the affected province prior to the seismic event, and that there were less than 40 cases in the 14 days following the event. Silva and Paul [5] assumed that even if the earthquake’s impact increased the virus’s transmissibility, there were insufficient cases to cause an outbreak.

According to the Croatian Institute of Public Health, 87 COVID-19 cases were noted in the most affected city of Zagreb before the earthquake, and 206 COVID-19 cases were noted in the entire country. In the two weeks that followed, 337 cases were reported in Zagreb. Based on Peitl et al. [28] and Civljak et al. [29], COVID-19 testing was disrupted for hours in hospitals of the earthquake-affected areas, while people left their homes due to widespread unrest and compromised physical distancing measures. The rise in COVID-19 cases could be attributed to the earthquake’s potential disruption of safety measures [5]. They did not, however, mention any other factors that could have contributed to the significant increase in cases in Croatia following the earthquake.

After the $M = 5.7$ Magna earthquake in Utah and the earthquake swarm that hit the southern region of Puerto Rico in early 2020, no significant increase in the number of COVID-19 cases was found, as was the case in Iran. Insufficient pre-existing COVID-19 cases with low potential to trigger an outbreak during the post-disaster period were held responsible for this post-disaster trend [5].

Mavroulis et al. [6] studied how the COVID-19 pandemic evolved in areas affected by disasters caused by hydrometeorological hazards in 2020, such as the Evia flood on August 9 and the Ianos medicanne on September 19. They used publicly available laboratory-confirmed daily-recorded COVID-19 cases in disaster-affected areas for post-processing in selected pre- and post-disaster periods, including one week before the earthquake and three weeks after the earthquake, respectively. Only after the Ianos medicanne there was an

increase in reported COVID-19 cases in the post-disaster period. After the Evia flood, there was no change in the number of cases.

Mavroulis et al. [6] referred to a number of factors related to the pandemic's evolution, as well as disasters and their management plans, which may have influenced the post-disaster evolution of cases. The pre-existing viral load and infection rate in the affected areas, the severity of the disaster effects, and the measures adopted for the effective disaster management of compound emergencies were all shown to have the potential to influence the pandemic's post-disaster evolution in disaster-affected areas.

In conclusion, the post-disaster evolution of COVID-19 in disaster-affected areas is strongly linked to:

1. The pre-disaster viral load and infection rate in the earthquake-affected areas;
2. The demographic characteristics of the earthquake-affected areas, comprising their population density and spatial distribution;
3. The intensity of the generated earthquakes and the triggered effects on public health (casualties and injured people), on nature (primary and secondary earthquake environmental effects) and on building stock (damage to buildings and infrastructures);
4. The need for immediate evacuation without the assistance of emergency responders;
5. The number of evacuees;
6. The number of people involved in managing the disaster during the immediate response phase;
7. The restrictions on movement and access to the affected area before and after the disaster for mitigating pandemic;
8. The level of training and preparedness of the responders and authorities involved in the disaster management;
9. The effectiveness of the measures adopted and amended by the responders and the authorities involved in disaster management.

Taking into account the results of the analysis of the post-earthquake evolution of the pandemic in the earthquake-affected areas and the factors with which this evolution is closely linked, we can argue that these measures—applied by the Civil Protection authorities during the emergency phase and during the preparation of the immediate response actions, with all the adjustments to the new conditions of the parallel occurrence of earthquakes and the pandemic—can be considered effective in limiting the spread of the pandemic in earthquake-affected communities. There was no increase in any of the examined and analyzed cases under consideration in terms of the number of cases during the post-earthquake period.

At this point, it should be mentioned that these cases may be considered as ideal, as there was no increase in viral load and no increase in infection rate or infection outbreak in the earthquake-affected communities during the pre-earthquake period. However, even in these cases of pre-existing low viral load and low infection rates, the measures adapted to the new specific conditions of the simultaneous occurrence of earthquakes and the pandemic can be characterized as beneficial and effective, as they helped to maintain the low viral load in the post-earthquake period, and in some cases to further reduce it. In any case, they did not lead to an increase in viral load in the earthquake-affected communities.

In view of the latter finding, it can be said that strict compliance with the above adapted measures would have beneficial effects, even in more unfavorable conditions formed by the parallel occurrence of these hazards. Of course, in any case of a parallel occurrence of geological and biological hazards which requires the application of emergency measures to manage the impact on the local population, the applied measures should always be tailored to the type and characteristics of the natural hazard, the epidemiological characteristics, the physiographic and demographic characteristics of the affected area, the characteristics of the affected population and, most importantly, the conditions created by the synergy and the interaction of the aforementioned factors.

6. Proposal of Multi-Hazard Measures for Managing Earthquake Disasters Amid a Pandemic

Based on the good practices and lessons learned from the immediate response of the Civil Protection services for the management of earthquake emergencies in Greece during the pandemic, in this section we share multi-hazard approaches that must be adopted and applied during earthquake emergency responses not only during the current pandemic, but also during future biological hazards with similar characteristics.

The proposed approach constitutes a combination of the aforementioned measures with similar measures that have been applied so far to effectively manage the impact of concurrent crises formed by the simultaneous occurrence of natural and biological hazards, including earthquakes and floods amid the pandemic (e.g., [4,30–32]), and aims to effectively deal with the adverse conditions created when disasters and crises collide to improve disaster management and preparedness in the future.

These approaches comprise:

- Measures for first responders and staff involved in the emergency response phase and increasing the type and number of emergency shelters to limit transmission risk among the affected population;
- Pandemic mitigation measures for accommodated staff and visitors in emergency shelters;
- Administrative and engineering controls in emergency shelters, including changes to facility layouts and supply distribution practices;
- The designation of isolation facilities to separate suspected cases;
- Remote psychological support.

The proposed measures are summarized in Table 2.

Table 2. Multi-hazard measures during the emergency response phase amid the pandemic.

Proposed Measures during the Emergency Response Phase Amid an Evolving Biological Hazard	
Measures for first responders and staff involved in the emergency response phase	<ul style="list-style-type: none"> • Screening for infectious disease before being transferred to the disaster-affected area; • Rapid diagnostic tests for COVID-19 detection before engaging in emergency response operations and activities; • Regular assessment of the clinical condition of the staff; • Regular screening of temperature during operations; • Mandatory use of mask indoors and outdoors; • Regular hand washing with soap and clean water or the regular use of alcohol-based hand sanitizer; • Covering the mouth and nose with a tissue, sleeve or flexed elbow when coughing or sneezing and throwing tissue into closed bin after use; • Regular disinfection of equipment and surfaces heavily used and often touched; • Maintaining physical distance; • Avoiding places of overcrowding; • Seeking immediate medical care in cases of infection symptoms among the staff; • Activation of an emergency response plan in the case of the detection of infection symptoms among the disaster-affected population; • Isolation of members of teams and staff of Civil Protection authorities who have even mild symptoms or who are expecting test results and have mild symptoms, or who do not have symptoms but have been in contact with a confirmed case.
Avoidance of overcrowding in emergency shelters	<ul style="list-style-type: none"> • Increasing the number of emergency shelters of the same type; • Using different facility types as emergency shelters.

Table 2. Cont.

Proposed Measures during the Emergency Response Phase Amid an Evolving Biological Hazard	
Mitigation measures in emergency shelters	<ul style="list-style-type: none"> • Minimum staff needed for the shelter operation; • Screening for symptoms by the medical staff of the shelter; • Training for the detection and reporting of symptoms, infection prevention and control within the facility; • Training for applying pandemic mitigation measures within the emergency shelter; • Using face masks while staying in the emergency shelter, especially during interaction with the disaster-affected people; • Regular hand washing with soap and clean water or the regular use of alcohol-based hand sanitizer; • Using disposable gloves; • Implementing all appropriate measures for the management of a person living in the shelter and suffering infection; • Immediate evaluation of accommodated people by responsible medical staff; • Maintaining an appropriate physical distance between all people in the shelter, including staff, disaster-affected people and visitors.
	<ul style="list-style-type: none"> • Screening temperature before entering emergency shelters; • Using face masks throughout their visit to the emergency shelter; • Maintaining appropriate physical distance; • Regular hand washing with soap or alcohol-based hand sanitizer; • Avoiding visiting when feeling ill or if they have symptoms of infection;
Administrative and engineering controls in emergency shelters	<ul style="list-style-type: none"> • Configuration of the emergency shelter spaces in order to maintain physical distance between the affected people: <ul style="list-style-type: none"> ○ Individual rooms; ○ Separate areas; ○ Large facilities; ○ Guidance for spacing.
	<ul style="list-style-type: none"> • Shelter equipped with adequate handwashing stations with clean water, soap and disposable towels or alcohol-based hand sanitizer for use prior to entering food lines; • Packaged meals prepared and served by staff wearing masks and disposable gloves throughout the preparation and serving of meals; • Each family should consume meals in places that have been predetermined, maintaining physical distance; • Individual and disposable serving items; • Continuous and regular cleaning and disinfection of the used surfaces.
	<ul style="list-style-type: none"> • Limiting interaction of families with other groups of residents and staff; • Avoiding sharing emergency supplies; • Restriction of entrance to non-essential visitors; • Restriction of entrance to volunteers; • Restriction of mass gatherings; • Designation of outdoor spaces for religious services and communal meetings.
	<ul style="list-style-type: none"> • Facilities equipped with beds, oxygen cylinders and equipment for monitoring temperature and oxygen levels; • Access to health assessment, medical care and counseling for the isolated person if needed.

7. Discussion

Many of these measures were proposed and implemented during the emergency response phase after earthquakes generated in the early stages of the pandemic. In this phase, the conditions were unprecedented and difficult for all involved in managing the effects of the pandemic and in dealing with the parallel occurrence of disasters induced by geological and biological hazards. However, the measures were effective as they were reverently applied by the majority of the affected population. Furthermore, their implementation was strictly monitored by Public Health organizations and Civil Protection authorities. It is significant to note that, in the early stages of the pandemic, effective medical means to combat COVID-19 infection and disease, such as antiviral drugs and COVID-19 vaccines, were either non-existent or under development.

After 2 years of the pandemic—marked on the one hand by numerous human losses worldwide, but on the other hand by the discoveries of COVID-19 vaccines and antiviral drugs and extensive vaccination coverage in a large part of the world—it can be said that strict compliance with the above adapted measures would have beneficial effects, even in more unfavorable conditions formed by the parallel occurrence of these hazards. These harsh conditions could be attributed either to single events or to a synergy of events and triggering factors. Characteristic examples of such events and factors could include the occurrence of earthquakes during the winter period, the triggering of earthquake environmental effects and building damage in densely populated urban areas, the creation of large numbers of displaced residents in need of immediate accommodation in emergency shelters and camps, and increased viral load and infection rate resulting in COVID-19 outbreaks and clusters in the pre-disaster period in the areas of interest.

In the case of the relaxation of control measures and a subsequent increase in viral load and infection rate, the majority of these measures should be reapplied at least for the disaster-affected areas, and necessarily for all affected residents and participants in the emergency response zones, among whom interaction cannot be avoided.

8. Conclusions

The COVID-19 pandemic has caused unprecedented global disruption. The disease and the resulting mitigation measures have brought societies and many public services to a halt. Such disruptions also have an impact on disaster risk reduction and disaster risk management. Earthquakes, on the other hand, do not wait for the virus to vanish. From the initiation of the pandemic, earthquakes have struck many countries around the world. One of them was Greece.

The earthquake in Epirus (northwestern Greece) occurred on 21 March 2020, at the start of the country's first wave of the pandemic and two days before the imposition of the first national lockdown. The Samos earthquake occurred on 30 October 2020, just before the peak of the second wave of the pandemic in the country and 7 days before the imposition of the second national lockdown. In 2021, two destructive earthquakes struck Greece: the Thessaly earthquake on 3 March, during the third pandemic wave, and the Crete earthquake on 27 September, during the fourth pandemic wave.

Considering Greece's single-hazard management plans, the multi-hazard approach needed to manage geological hazards (earthquakes and related phenomena) in the midst of an evolving biological hazard (COVID-19 pandemic) has been a challenge for all involved in the scientific community and for Civil Protection personnel. This challenge arose from the fact that many actions, particularly during the first hours of the emergency response, required direct communication, contact, and interaction with the disaster-affected population. SAR operations, the establishment of emergency shelters following the disaster, the contribution of volunteer teams, the distribution of emergency supplies, post-event building inspections, hazard mitigation during the emergency response phase, psychological support, and awareness and education activities during the aftershock period were all included in these actions.

New approaches were used to carry out all of these actions in the case of the earthquakes studied in Greece since the initiation of the COVID-19 pandemic. The main focus of these approaches was on individuals and the community and taking preventive measures against the spread of the novel virus, particularly by maintaining physical distance and avoiding overcrowding, as well as proper mask use and hand hygiene. Considering the post-disaster trend of daily cases and the pandemic's evolution in the affected regional units, it is possible to conclude that the multi-hazard approach to managing the negative effects of the earthquakes and subsequent seismic effects amid the evolving pandemic in the earthquake-affected areas was effective. As a result, we regard the actions taken by the relevant authorities as good practices and important lessons learned for the management of natural hazards and related disasters in the context of an evolving biological hazard.

The synergy of several factors and the characteristics of the affected areas and those affected resulted in this effectiveness. The epidemiological characteristics of the affected areas, such as the low viral load and infection rate in the affected communities, the demographics of the affected areas, such as the low population density, the sparse distribution of residential areas in the affected regional units, and the accessibility to the areas during the emergency phase, as well as the implementation of pandemic mitigation measures, were among these factors.

We propose an approach that could significantly contribute to the safety of staff and affected people in various phases of emergency response after an earthquake disaster amid the evolving pandemic, keeping in mind the lessons learned from the emergency response for the studied earthquakes' management. Individual and collective protection measures for emergency responders and staff before and during their involvement in the affected area, measures to reduce the risk of transmitting the virus to the affected community, and measures to limit the spread of the virus inside shelters are all part of this strategy.

This strategy can be used not only in the event of a destructive earthquake during a pandemic, but also whenever a disaster caused by a natural hazard has a significant impact on the built environment, particularly buildings and infrastructure, necessitating the establishment of emergency shelters until normalcy is restored. It can also be used in seismically similar areas with similar building vulnerability and susceptibility to earthquake-triggered effects. The evolving pandemic and its consequences may exacerbate the effects on public health and lengthen the time it takes to restore normalcy in affected areas if individual and collective pandemic mitigation measures are not followed during an emergency.

The simultaneous occurrence of a natural disaster and an evolving biological hazard (a pandemic) exposes the shortcomings of single-hazard approaches to disaster management and emphasizes the need for a multi-hazard strategy. Every phase of the disaster management cycle, specifically mitigation, preparedness, response, and recovery, should use a multi-hazard strategy. Despite the difficulty of comprehending the interactions between different types of hazards and multi-hazard assessments, the adaptation of general risk management plans and the adoption of multi-hazard approaches involving multi-stakeholder participation are critical, as the frequency and severity of extreme events rise due to the interaction of several factors and the collision of disasters and crises. National, regional, and local government bodies, as well as volunteer teams and the armed forces, should collaborate with scientists who specialize in natural and technological hazards, related disasters, and all types of crises in order to provide the Civil Protection authorities with more knowledge, experience, and expertise. Innovative technology services and tools to support the Civil Protection mission are important results of scientific and operational synergy.

Despite the ongoing mass vaccination campaigns, it is possible that virus transmission will remain high in the coming months. To avoid a resurgence of the pandemic, it is critical for stakeholders and decision-makers to ensure that disaster management approaches take this risk into account. Multiple ongoing disasters and crises are extremely difficult to manage, but adopting the best practices that have emerged in this field is critical.

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