Urban planning for health – experiences of building resilience in 12 cities

Second report on protecting environments and health by building urban resilience

World Health Organization
European Region

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Abstract

Urban planning, risk governance and resilience have become increasingly important pathways to promote and protect public health at the local level. Climate change, inadequately planned urbanization and environmental degradation have left many cities vulnerable to disasters. The COVID-19 pandemic has further highlighted the links between health and urban environments, and the relevance of sustainable and resilient planning. Various global frameworks have been established to address sustainable development, urban environments and resilience, and awareness of the local benefits associated with implementation of these global agendas is increasing. The Protecting environments and health by building urban resilience project aims to support local authorities and decision-makers to reflect on the environment and health dimensions of local preparedness and resilience, and to promote the application of urban planning approaches to establish safe, healthy and sustainable cities. This second report of the project presents the findings of semi-structured interviews in 12 European cities on their practical experiences with environmental emergencies and disasters at the city level, and related lessons learned for resilient urban design and infrastructure planning.

Keywords

- Urban planning
- Environment and health
- Emergencies
- Healthy cities
- Prevention
- Resilience
- Preparedness
- Building forward better

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Glossary

For all three project reports and the summary report, the following terminology is used, as defined by the United Nations Office for Disaster Risk Reduction.[1]

Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development.

Hazard is a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Hazards may be natural, anthropogenic or socionatural in origin. Natural hazards are predominantly associated with natural processes and phenomena. Anthropogenic hazards, or human-induced hazards, are induced entirely or predominantly by human activities and choices. Several hazards are socionatural, in that they are associated with a combination of natural and anthropogenic factors, including environmental degradation and climate change.

Mitigation is the lessening or minimizing of the adverse impacts of a hazardous event.

Preparedness is the knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters. Preparedness is based on a sound analysis of disaster risks and good linkages with early warning systems, and includes such activities as contingency planning, the stockpiling of equipment and supplies, the development of arrangements for coordination, evacuation and public information, and associated training and field exercises.

Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.

Vulnerability reflects the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

[1] UNDRR (2021). Understanding disaster risk: terminology [website]. Geneva: United Nations Office for Disaster Risk Reduction (https://www.preventionweb.net/understanding-disaster-risk/terminology, accessed 25 March 2022).

Executive summary

Emergencies can become transformative experiences for cities: an opportunity to rethink, replan and rebuild, and to push for changes that can make them more healthy, sustainable, equitable and resilient. Going back to "normal" may not be good enough – instead, cities should strive to build better urban futures. This report presents the results of a series of interviews with cities in the WHO European Region, which aimed to compile local insights on how to set priorities for becoming more resilient and for preparing for (or responding to) environmental and health crises. Interviews were conducted with local government representatives involved in urban planning, environment or health areas. They focused on how the cities had approached urban planning and infrastructure design as a response to specific disasters – or in a preventive manner for future ones – and how these efforts could contribute to healthier, more sustainable urban futures.

A total of 12 case study cities in 11 countries in the WHO European Region were interviewed using a questionnaire sent in advance. They included three small (<100 000 citizens), five medium (100 000–500 000 citizens) and four large cities (>500 000 citizens). Of these, 10 had experienced at least one emergency event in the last decade, including major floods, forest fires, earthquakes, hurricanes, industrial accidents, power outages, heatwaves and snowstorms. Several cities had experienced multiple disasters at the same time – a trend that is likely to continue in the future. These events caused a broad range of effects, including substantial impacts on health. Thematic analysis was applied to interview extracts to identify common topics, ideas and patterns.

Emergency preparedness is a key element of building the resilience of health systems and other systems, and a central component of emergency management frameworks. The interview extracts were therefore analysed using four distinct but interconnected phases of emergency management frameworks. These include two phases that take place during and after an emergency (response and recovery), and two to be carried out before a new emergency strikes (mitigation and preparedness).

When considering response, the interviews highlighted the fact that cities face a number of challenges with actions taken during an emergency. Some touched on governance, collaboration and communication aspects; for instance, dealing with a lack of information and protocols, collaborating with government bodies at regional or national levels and effectively reaching out to the community during the crisis. Health risk management and giving attention to vulnerable groups were also identified as main challenges during emergency management: unexpected environmental health risks may arise from certain disasters; impacts on mental health may be disregarded initially, leading to a need for greater attention later; and cities may experience a lack of emergency material during critical moments. While early warning and information systems may contribute to mitigating the health and other effects of certain types of event, their spatial scope and accuracy can be limited, and some cities may not have them in place.

The interview results identified some key factors for recovery after the event, including access to financial resources and contingency budgets, insurance coverage, flexibility in local supply and distribution chains and social awareness of the different exposures and health risks of the surrounding environment. In addition, the interviews outlined a number of factors in building resilience that are critical for a full and speedy recovery, including long-term investment in critical infrastructure, transforming the economic model to rely more on sustainable and green industries, and control over development pressure.

When focusing on mitigation and preparedness for future emergencies, the interviews presented a number of lessons the case study cities had learned from the emergencies. These related to urban management and coordination, to physical and structural planning or interventions that contribute to mitigation and, especially, to preparedness. They included improving coordination across levels of government; clearly defining roles and responsibilities; ensuring effective communication with the community; building awareness; increasing emergency training; and creating a favourable environment for consultation, dialogue and public participation. Lessons learned also touched on issues related to the benefits of a "proximity lifestyle", where infrastructure and services are spatially distributed in an equitable manner across neighbourhoods; mobility choices steer towards the promotion of walking, cycling and public transportation (over the use of private cars); and public spaces are designed "for the people".

The interviews highlighted that local production and supply of basic goods and services help cities stay functional during a crisis and make them less dependent on other cities or countries (which may become problematic during an emergency). In particular, local energy sufficiency (including more flexible power systems that include redundancies) is desirable in terms of reducing vulnerability to many types of crises. Lessons learned from past emergency experience also touched on the critical role of urban green infrastructure, given the many hazard mitigation benefits of nature-based solutions and a renewed recognition of the value of urban and periurban green spaces as a consequence of COVID-19-related lockdowns and restrictions.

When considering regulations and urban planning, case study cities pointed to the use of preventive approaches to land use planning that integrate risk maps and implement mechanisms such as buffer zones, preventing building in risk-prone areas and protecting critical green infrastructure. Other factors included mapping and updating the physical infrastructure to better plan for and respond to emergencies (especially vulnerable areas, such as informal settlements), and strengthening regulations to make buildings more resistant to strong winds, seismic events, fires or water damage in case of storms or floods.

Finally, the case study cities highlighted the importance of maintaining a long-term vision when it comes to emergency preparedness and building urban resilience – looking beyond the short-term capacity to cope with the immediate response and recovery to get "back to normal". This entails testing various emergency scenarios and updating risk assessments to include the best available predictions (especially regarding climate change). It also requires evaluation of the local government's response to and management of any emergency, to provide authorities with better understanding, identification and assimilation of the lessons learned, and to foster a faster and more efficient response to future environmental or health threats.

Most of these lessons learned (and many of the actions carried out by the cities in response) are closely linked to healthy urban planning principles. In particular, they focus on promoting active mobility, reducing risk exposure through planning (where green infrastructure plays a critical role) and ensuring local access to basic services. The interviews also revealed three cross-cutting elements – equity, evaluation and learning mechanisms, and compilation of relevant information in advance – that do not seem to be embedded in the planning and preparedness strategies of the case studies.

This report also touches on how cities learn from each other, and in what way (or to what extent) international framework documents (such as the United Nations Sustainable Development Goals, 2015 Paris Agreement and Sendai Framework for Disaster Risk Reduction 2015–2030) affect local authorities' thinking about urban planning, emergency preparedness and urban resilience and their relationship with health in their city. Limitations of the study are presented and discussed, and the main challenges for better integration of health and urban planning are considered further.

Planning has a prevention and risk mitigation role to play; it is a public health intervention that provides mechanisms to transform physical and social environments, reducing harmful exposures and facilitating healthy lifestyles. This report explores this potential through the case studies, considering both urban planning and management (including aspects such as city maintenance, governance, intersectoral coordination and urban and infrastructure design). The report aims to consolidate shared knowledge about the links between urban disaster management and planning and health, and provides 10 key messages extrapolated from the 12 case study city interviews.

Key messages

1. Disaster experience, recovery, prevention and preparedness mechanisms should be used to push for changes that can make cities more healthy, sustainable and resilient.

2. Urban resilience should be thought of as more than just emergency preparedness.

3. Planning requirements should be applied as a tool to prevent the siting of functions and infrastructure in areas at risk of environmental disasters.

4. Authorities should consider how emergencies are/can be interconnected.

5. Horizontal and (especially) vertical communication across different departments and levels of government should be improved.

6. It is important to uphold the public perception that local authorities are executing their mandate for environmental and health protection measures.

7. Cities should collaborate with and learn from other cities.

8. Crisis management should be evaluated to keep learning, improving and planning more resilient, sustainable and healthy urban environments.

9. Local access to basic services should be ensured through equitable distribution and proximity lifestyle paradigms.

10. Health should be better integrated as a cross-cutting element of urban planning.

1. Introduction: the Protecting environments and health by building urban resilience project

1.1 Project context

Climate change, rapid and/or inadequately planned urbanization and environmental degradation have left many cities vulnerable to disasters. In addition, cities increasingly face local emergencies through industrial accidents and system failures, indicating the high degree of interdependencies especially within large cities. Inadequate planning has thus been recognized as a relevant disaster risk factor, affecting urban hazards, exposure and level of vulnerability (UNDRR, 2021).

Disasters and local emergencies have a direct impact on population health, causing injuries, diseases, and mental and psychosocial outcomes. In addition, they may significantly affect the functionality of critical infrastructure, such as health-care facilities or water and energy supply, thereby further increasing existing health challenges due to lack of treatment and care services, with specific impacts for chronic and infectious diseases. Increasing local preparedness for health emergencies should therefore be considered a priority by national governments as well as local authorities (WHO, 2021a).

Cities need to understand what features and processes make them vulnerable to crises and environmental emergencies, and their associated health impacts. They also need to recognize the most effective counteractions to take to reduce risk, prepare and become resilient (WHO, 2020). Reflecting the global relevance of this challenge, various international commitments and agreements have highlighted the need to address disaster risk, emergency preparedness and resilience at urban scale. The Sendai Framework for Disaster Risk Reduction 2015–2030 (United Nations, 2015a) stipulates four action priorities: understanding disaster risk, strengthening governance to manage it, investing in disaster reduction for resilience, and enhancing preparedness for better response – all priorities to protect lives, livelihoods and health. Sustainable Development Goal (SDG) 11 on sustainable cities and communities (United Nations, 2015b) requires increased efforts by cities to adopt and implement policies on disaster resilience, and to establish disaster risk-management schemes. The Paris Agreement (United Nations, 2015c) established – alongside its focus on climate change mitigation – the first universal, legally binding global commitment on climate-change adaptation to strengthen resilience and reduce vulnerability.

Much can be done at the city level by local authorities, planners and managers to translate these global agendas into local action, using urban planning and design as an instrument to reduce risks and vulnerabilities and build resilience – ultimately resulting in the protection of health and well-being (WHO, 2021b). Reflecting this need to localize global commitments, the New Urban Agenda seeks to ensure healthy, resilient and sustainable cities through disaster risk reduction and management, reduced vulnerability, and increased resilience and responsiveness to natural and human-made hazards (United Nations, 2017).

1.2 Project objectives and deliverables

This report is one of the deliverables of the Protecting environments and health by building urban resilience project, led by the European Centre for Environment and Health of the WHO Regional Office for Europe. The project is designed to support local authorities and decision-makers in building urban resilience. The project team compiled local-level experiences and lessons learned in relation to:

- reducing health risks posed by local disasters and emergencies;
- mitigating local vulnerability to associated hazards; and
- identifying local priorities and actions for improving resilience (and health) through urban planning and design, as well as urban infrastructure management.

The project placed focus on availability of data and indicators to support local assessments and decision-making regarding vulnerabilities and resilience needs. Exploring how cities can use urban and infrastructural interventions to reduce local disaster risks, increase preparedness and improve resilience is therefore not only a mechanism to address health protection but also a central component of the broader objective of sustainable, equitable and healthy urban development.

A series of reports sets out the project findings on how urban resilience and preparedness can be improved by city structures and design, and through urban management and monitoring:

- *Urban planning, design and management approaches to building resilience – an evidence review*, which documents urban challenges and implications associated with disasters and extreme events, and identifies associated priorities to prepare for future challenges and increase urban resilience through urban planning, design and management;
- *Urban planning for health – experiences of building resilience in 12 cities*, which summarizes city interviews about their practical experience with local emergencies and disasters, and the local lessons learned for building forward better by reducing risks and vulnerabilities and creating more resilient urban design and infrastructure;

- *Review of indicator frameworks supporting urban planning for resilience and health*, which explores how international monitoring frameworks can be applied at subnational or city level to describe crisis impacts during an emergency situation, and/or to assess vulnerabilities and inform the establishment of more resilient urban settings; and
- *Urban planning for resilience and health: key messages*, a summary report compiling key messages from all three technical reports and providing a condensed briefing for urban decision-makers on how to protect health and well-being through preparedness and resilient urban planning, design and management.

All these reports can be accessed online via the WHO project website.[1]

2. Understanding experiences of building resilience

This report presents the results of a series of interviews with cities in the WHO European Region, which aimed to compile local insights on how to set priorities for becoming more resilient and for preparing for (or responding to) environmental and health crises. Interviews were conducted with local government representatives involved in urban planning, environment or health areas. They focused on how the cities had approached urban planning and infrastructure design as a response to specific disasters – or in a preventive manner for future ones – and how these efforts could contribute to healthier, more sustainable urban futures.

Urban planning and infrastructure design have been demonstrated to have impacts on health, and they are key mechanisms to prepare for future emergencies[2]. Climate change effects, rapid urbanization and environmental degradation have left many cities more vulnerable to disaster or – increasingly – to multiple disasters at the same time (with many cascading impacts on health). Cities need to understand both the features and processes that make them more vulnerable to crises and the associated health impacts and most effective actions to take to mitigate these. Cities that have applied a short-term vision and attempted to save money by not investing in mitigation and preparedness strategies have seen larger longer-term costs. The COVID-19 pandemic has supplied clear evidence of the need to invest in infrastructure, housing and energy, as well as the health sector.

Enabling cities and societies to protect themselves and recover as quickly as possible from future disasters requires paradigm shifts and new collaborations across sectors. Emergencies can become transformative experiences for cities: an opportunity to rethink, replan and rebuild, and to push for changes that can make them more healthy, sustainable, equitable and resilient. As stated in the *WHO Manifesto for a Healthy Recovery from COVID-19 (WHO, 2020),* going back to "normal" is not good enough – instead, cities should strive to build better urban futures.

Today, people expect governments to protect them and their families from external threats to their health and well-being. As outlined in the WHO European Programme of Work, 2020–2025 (WHO Regional Office for Europe, 2021a), this includes reliable risk communication, systematic and comprehensive reviews of management of emergencies (and accountability for the results) and overall creation of an environment that responds to citizens' concerns for safer, healthier and better living for all. The Sendai Framework for Disaster Risk Reduction 2015–2030 (United Nations, 2015a) notes that understanding disaster risk, strengthening governance to manage it, investing in disaster reduction for resilience and enhancing preparedness for better response are all priorities to protect lives, livelihoods and health. Much can be done at the city level by local authorities, planners and managers to build resilience. As the Words into Action guidelines (UNDRR, 2019) point out, impacts of disasters are most immediately and intensely felt at the local level: hazards usually occur locally, local actors are the first responders should a disaster occur, and the local level is where governments and communities can best engage with each other and work together.

The United Nations SDGs call on countries, but also cities, not only to advocate sustainable development but also to become more resilient to future disasters (for which the Sendai Framework provides guiding principles) by working towards good health and well-being, and by addressing global challenges such as climate change and environmental degradation (United Nations, 2015b). This requires alignment with the long-term goal of the 2015 Paris Agreement (United Nations, 2015c) – the first ever universal, legally binding global climate change agreement – of achieving climate neutrality before the end of the century. It also means embracing the New Urban Agenda (United Nations, 2017) planning and construction principles to reduce inequalities and provide access to the benefits and opportunities that cities can offer.

This report shows that cities faced with recent emergencies have much to share about both the challenges experienced during the emergency response and relevant key factors for local recovery. It also demonstrates how cities have used their experience to develop and manage their cities better, setting out what they now do (or are planning to do) differently in terms of urban planning, management, coordination and infrastructure design to become more resilient, and at the same time healthier and more sustainable. Consolidating and sharing this knowledge is a way for other cities to capitalize on the lessons learnt thus far.

[1] Protecting environments and health by building urban resilience. In: WHO/Europe [website]. Copenhagen: WHO Regional Office for Europe; 2022 (http://www.who.int/europe/activities/protecting-environments-and-health-by-building-urban-resilience).

[2] Urban preparedness and establishment of resilient cities are further promoted by the Making Cities Resilient 2030 initiative of the United Nations Office for Disaster Risk Reduction (UNDRR, 2022).

2.1 Conceptual framework

Urban planning has a prevention and risk mitigation role to play, and should therefore be more involved in resilience and emergency preparedness strategies and plans. This report explores the potential of urban resilience and preparedness through interviews with case study cities, considering urban planning and infrastructure design as well as urban management (including aspects such as city maintenance, governance and intersectoral coordination). The lessons learned therefore relate both to urban management and coordination and to physical and structural planning and interventions. While the greatest impacts of emergencies are generally on existing neighbourhoods, understanding the strengths and vulnerabilities of certain urban structures in the face of different emergencies can provide valuable insights for more resilient urban planning of new developments and urban regeneration projects.

Preparedness is the knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters (UNDRR, 2021). WHO's strategic framework for emergency preparedness thus calls for an all-hazards approach and is not limited to supporting health systems (WHO, 2017). It can also be applied to contribute to the resilience of communities – by being better prepared and establishing coping capacities. Preparedness is a central component of emergency management frameworks, which usually define four phases[3] involved in the process (Fig. 1).

Fig. 1. The four phases of emergency management

Source: authors, based on Boston University (2021); Horita et al. (2013); FEMA (2006).

Response is what happens during and right after the event. It consists of protecting life and property through actions such as extinguishing fires, evacuating people, and search and rescue. Urban planning is unlikely to have a direct contribution to emergency response, but urban conditions and design features may have a direct impact on both the spread and distribution of disaster impacts and the corresponding vulnerability of citizens, districts, infrastructures and supply chains. To that extent, lockdown measures as experienced during the COVID-19 pandemic may well be associated with urban planning considerations, especially in relation to decision-making on which public spaces and functions should be fully or partially closed, and in which city districts.

Recovery happens after the emergency and consists of rebuilding and getting "back to normal". This phase is often twofold: immediate recovery, meaning reinstating to a reasonable (though not optimal) level, and full recovery, which could take more time to reach. Full recovery measures are likely to be associated with urban planning: deciding whether certain infrastructures are to be rebuilt as and where they were before, with a different design or functionality, or at a different location.

Mitigation consists of taking measures to prevent future similar emergencies from happening again or to minimize their effects. This can be done through actions such as risk identification, analysis and appraisal, strengthening of building regulations and land use planning and practice, or by implementing technical solutions to make better and more suitable infrastructure (for instance, designing the power grid to avoid bottlenecks

[3] Sometimes a fifth phase – prevention – is added between recovery and mitigation.

in the event of a power outage). From an urban planning perspective, examples of mitigation strategies are incorporating risk maps into land use planning, defining and enforcing buffer zones and restricted areas, securing safe open areas for gathering during evacuation of buildings, producing and sharing spatial data (such as geographical information system (GIS) maps) and implementing nature-based solutions.

Preparedness happens before the emergency takes place and should cover three main components: governance, capacities and resources (WHO, 2017; PAHO, 2019). Examples of preparedness actions are capacity-building, emergency planning and training, provision of equipment and monitoring schemes and creation of early warning tools. From an urban planning and health perspective, preparedness strategies include:

- emergency plans for various types of disasters;
- plans to modify public transportation type/frequency or to define movement flows (as done in some cities during the COVID-19 pandemic);
- plans for temporary accommodation of vulnerable/affected groups in existing buildings or facilities (also needed in many cities during the pandemic);
- plans and provision of space and infrastructure for potential temporary hospitals; and
- design of independent supply chains (considering locations and connections between key production and supply facilities); this would also include locations and plans for efficient distribution of emergency supplies.

Table 1 presents an overview of how urban planning measures may contribute to these different phases. It should be acknowledged, however, that emergency response and management is a multifaceted and complex process that requires multiple collaborations among disciplines and departments.

Table 1. Actions and urban planning measures for the four phases of emergency management

Emergency management phase	Description	Emergency management actions and examples of related urban planning measures
Response	Protecting life and property in an emergency	Evacuation, search and rescue, lockdown, humanitarian aid
		Contribution of urban planning measures: lockdown decisions and response measures based on urban design considerations such as those related to spatial dimensions, function and user groups in the affected areas
Recovery	Rebuilding from an emergency	Damage assessment, rehabilitation, reconstruction, re-establishment of services
		Contribution of urban planning measures: potential redesign and relocation of urban infrastructures and facilities
Mitigation	Preventing future emergencies or minimizing their effects	Risk identification, analysis and appraisal, land use planning, technical prevention
		Contribution of urban planning measures: use of risk maps in land use plans, definition and enforcement of buffer zones and restricted areas, definition of safe open areas for evacuation operations, production and use of spatial data (such as GIS data), implementation of nature-based solutions
Preparedness	Taking action in advance to be ready for an emergency	Capacity-building, emergency planning, training, equipping, monitoring, exercising, early warning
		Contribution of urban planning measures: emergency plans for various types of disasters, emergency plans for public transportation, plans for temporary accommodation, plans and provision of space and infrastructure for tent hospitals, design of independent supply chains (including locations and distribution of emergency supplies)

2.2 Aims and objectives

The ultimate objective of this project was to develop practical understanding of how cities can improve sustainability and resilience – and thereby protect environment and health – through urban planning, management and preparedness. While acknowledging the important role of regional and national organizations (such as national disaster management authorities) in the four phases of emergency management, this report focuses on the opportunities to address these at the local level. In particular, the interviews with case study cities aimed to collect lessons learned on:

- practical challenges and hazards during crisis situations and the associated health risks, and the experiences of addressing these from an urban planning, infrastructure design and management perspective at a local level; and

- implemented or proposed local policies, action plans or interventions to establish better preparedness and more sustainable and resilient urban structures to protect environment and health during local emergencies.

Analysis of the interviews with the case study cities aims and response measures aimed to:

- describe the main challenges and limitations of local emergency response and preparedness;
- identify best practices and lessons learned in the areas of sustainable urban planning, environment and health; and

- highlight priority areas for further improvement of urban preparedness and resilience in order to build urban futures better.

The results should provide a clearer understanding of the links between urban planning, management and health protection, and of how these can be strengthened by the inclusion of health as a cross-cutting and foundational element of urban planning and preparedness strategies.

2.3 Structure of the report

Following this introductory section, section 3 describes how the case studies were selected (3.1) and the questionnaires used (3.2). It sets out how cities were approached and how the interview process was carried out (3.3), and presents the methods used to analyse the interview responses (3.4).

Section 4 gives descriptive data of the case study collection, including cities and event types (4.1), main health impacts of these events (4.2) and information on the case study interviewees (4.3).

The analysis of the interviews is set out in section 5, which also includes descriptive case study profiles of the interviewed cities. This section identifies the main challenges during management of an emergency situation (5.1) and key factors for recovery (5.2). It outlines lessons learned and city responses (5.3), then analyses these through the lens of the four phases of emergency management frameworks (5.4). Lastly, it examines how cities learn from other cities or use international framework documents (5.5).

Section 6 provides discussion of the links between the lessons learned (and city responses) for urban planning and health (6.1), followed by identification of gaps and needs from the interview responses (6.2). It notes the limitations of the study (6.3) and presents further reflection on the main challenges and opportunities for cities to strengthen integration of health and urban planning at the local governance level (6.4).

The 10 key messages extrapolated from the 12 case study city interviews are examined and elaborated on in section 7.

The annexes give finer detail about the project's processes: Annex 1 lists the case studies and interviewees, Annex 2 sets out the results of an overview screening for recent urban disasters and extreme events in the WHO European Region, and Annex 3 provides the two complete interview guides used.

3. Methods

3.1 Selection of the case study cities: eligibility criteria

Cities were selected to be interviewed based on diversity in type of emergency experience, geographical location and size.

- To be eligible, the cities should have experienced at least one of the following emergency events within the last 10 years: weather-related events (flooding, heatwaves, extreme cold, earthquakes, desertification, forest fire, storms and hurricanes), industrial/chemical accidents, power outages, infrastructure failure or pandemics. The COVID-19 pandemic, experienced by all countries in the WHO European Region, was included in a section of the interview guide to compile first impressions, but it was not considered a "past emergency" in terms of eligibility criteria.
- The eligibility criteria stated that the cities selected should be geographically spread across the WHO European Region, setting a maximum of two cities per country, and a minimum of five different countries within the Region. In addition, at least one case study city should be on the Mediterranean.
- The eligibility criteria required examples of various city sizes. A minimum of two small cities (<100 000 citizens), four medium cities (100 000–500 000 citizens) and two large cities (>500 000 citizens) was set.

In addition, two cities with no history of recent disasters were selected to shed light on how they prioritized and embedded preparedness and resilience aspects in their planning approaches, and how they prepared for sustainable and healthy development in the absence of local emergency experience.

3.2 Case study questionnaires

Two interview guides were designed: interview guide A for cities with experience of a specific emergency event and interview guide B for cities without such experience (see Annex 3). The questionnaires included various types of questions to collect information on experiences, lessons learned and measures to prevent future emergencies. Closed questions (for example, Does your city have an emergency preparedness programme?) gave respondents a limited number of possible answers, while open-ended questions (for example, What main lessons learned derived from the management of this emergency?) captured information on the experiences and opinions of the interviewee in their own words. Further, both clarifying and probing questions were used in some cases (for example, Is local government planning in a preventive manner for future similar crises? If so, what exactly is it doing?) to facilitate responses that went into greater detail.

The questions were structured around seven sections, each of which touched on important aspects of emergency preparedness at the city level and the impact of previous environmental emergencies (if any). Table 2 gives an overview of the guides.

Table 2. Structure of the interview guides

Section	**Interview guide A** (city with recent emergency experience)	**Interview guide B** (city with no recent emergency experience)
1	Context	
2	Challenges during emergency response	Governance
3	Lessons learned and key factors for recovery	Capacities
4	Actions taken	Resources
5	Local response to the current COVID-19 pandemic	
6	Local emergency preparedness for previous and future disasters	
7	Useful resources for emergency preparedness and response	

Common elements to both guides were:
- the context surrounding the recent emergency experience in the city (if any);
- the local response to the current COVID-19 pandemic, focusing on what had been done and what had been learned in terms of the relationships between health and urban management, planning and infrastructure design;
- the aspects of local emergency preparedness for previous disasters that had helped the city create a faster and better response to the pandemic;
- the resources (if any) the city had found useful for emergency preparedness and response, and whether the local government had referred to any recent national or international framework documents on the matter, such as the SDGs, the 2015 Paris Agreement, the Sendai Framework for Disaster Risk Reduction 2015–2030 or other health-specific guidelines.

Sections specific to interview guide A related to:
- the main challenges during the emergency response and how the city managed these;
- the lessons learned from management of the emergency and the key factors for recovery (focusing on how these lessons affected or relied on urban and infrastructure design and the connection with health);
- the action taken by the city (through urban planning and infrastructure design) to become more resilient to certain types of emergencies and to promote and protect health and well-being, including local plans and priorities for action.

Sections specific to interview guide B touched upon:
- local governance in relation to local resilience measures;
- local capacities for resilience measures;
- local resources (financial, human, logistics and supply) to establish local resilience measures.

The interview guides were written by project team members at the Urban Planning, Environment and Health Initiative of ISGlobal, and reviewed by WHO. To assess the clarity of the questions and determine the time needed to carry out the interview, a pilot interview was conducted using a preliminary version of interview guide A. Feedback from this resulted in restructuring of some questions and communication with interviewees prior to the interviews.

3.3 Call for cities and interview process

A call for cities to participate in the project was circulated in technical and professional city networks (including the WHO European Healthy Cities Network, United Nations Sustainable Development Solutions Network, United Cities and Local Governments, ICLEI – Local Governments for Sustainability and European Union Missions in Horizon Europe). The call consisted of a summary of the scope and aims of the project. It invited the city networks to contribute and share local experiences and lessons learned in relation to emergency situations and local priorities for improving resilience. The call noted that selected cities would have to identify a suitable person for an interview of around 1–1.5 hours with a WHO consultant. It also asked them to provide local material on priorities, strategies and action plans for becoming more resilient and reducing exposure to environment and health threats related to crisis situations, if available.

In parallel to this call for cities, a list of potential cities to study was created by searching for major emergencies that had occurred during the last 10 years in cities in the WHO European Region. (An overview of these events is provided in Annex 2.) The research team contacted some cities on this list directly to request their participation.

In total, 15 cities expressed interest in participating in the project. These were checked against the eligibility criteria to balance the overall size and geographical representation of the set, and 12 case study cities were selected for interviews (10 with experience of a recent emergency and 2 without). Cities selected were contacted directly and interview arrangements were made.

The relevant interview guide was shared via email with the interviewee at least two days prior to the interview. Given the length of the questionnaires, it was suggested that interviewees should not do extensive preparation, since if any question could not be answered (or answered in full), this would not be a problem. If answers to any of these questions were deemed important, the responses could also be updated afterwards when approving the summary.

Permission to record audio and video of the interview for transcription and analysis purposes only was asked for in writing via email prior to the interview, and interviewees were reminded of this at the beginning of the interview, before starting the questionnaire.

A copy of the notes taken by the research team during the interview was sent to each interviewee for review and approval. If clarifications, corrections and/or additions were made to these notes by the interviewee, these were incorporated into the data before analysis. Recordings were deleted after the interview notes were confirmed and approved by the interviewees.

3.4 Analysis of the interview responses

The main material used for analysis was the notes taken by the research team during the interviews. These notes were not literal transcriptions of the interviewee's responses, although some sections of the interview were transcribed literally if deemed relevant, aided by the audio recordings. After review and approval of the notes by the interviewees, interview extracts were analysed manually using thematic analysis to identify common topics, ideas and patterns. Coding of interview extracts entailed creating a table in which disaster emergency management challenges, factors for recovery, lessons learned and actions implemented were identified and converted into categories.

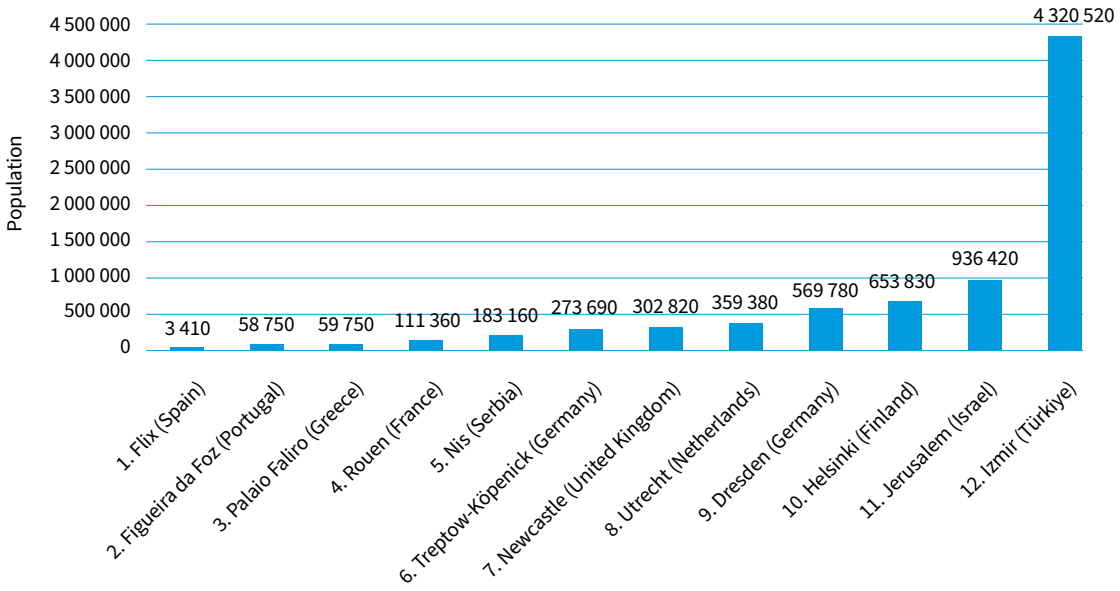
In addition to the notes taken during the interview by the research team, some interviewees voluntarily provided additional material considered relevant to the topic. This included reports, policy briefs, action plans and urban plans created by the local government, as well as links to news pieces about the relevant emergency event. This material was also reviewed and included when considered to add value.

4. Case studies

4.1 Cities and types of emergency events experienced

A total of 12 case study cities from 11 countries in the WHO European Region were interviewed. They included three small (<100 000 citizens), five medium (100 000–500 000 citizens) and four large cities (>500 000 citizens). The smallest city has a population of 3410; the largest has a population of over 4.3 million (Fig. 2).

Fig. 2. Populations of the case study cities



Of the cities selected for interviews, 10 had experienced at least one emergency event (not including the COVID-19 pandemic) in the last decade. Two had experienced one major event, five had experienced two major events and three had experienced three major events. Two cities had not experienced any major emergency or disaster within the last 10 years, and were interviewed instead on how they approached preparedness and resilience in their local planning without specific disaster experience.

Among the emergency events experienced, major floods and forest fires (each occurring in three of the cities) were the most common. Two cities had experienced a major earthquake, one a hurricane, one an industrial accident and one a major snowstorm. The city that had experienced a major snowstorm had also withstood increasingly frequent heatwaves in the last few years, while another city was increasingly affected by droughts. Two cities had experienced an energy outage, although one had a much greater impact than the other. Power outages also happened in several other cities as a consequence of different emergencies, such as hurricanes or forest fires (illustrating the importance of understanding interdependencies and the cascading effects of risk).

In discussions of urban resilience and preparedness for extreme events, the interviewed cities identified water pollution and increasing frequency of heatwaves (each identified by four of the cities) as the most frequent general environmental and/or health concerns. Fig. 3 shows a map of the city locations with details of population size and emergencies experienced.

Fig. 3. Case study cities and types of emergency events experienced

1. **Flix** (Spain)		forest fire		heatwave
2. **Figueira da Foz** (Portugal)		forest fire		hurricane
3. **Palaio Faliro** (Greece)		Earthquake		
4. **Rouen** (France)		industrial accident		
5. **Nis** (Serbia)		flood		
6. **Treptow-Köpenick** (Germany)		power outage		
7. **Newcastle upon Tyne** (United Kingdom)		flood		power outage
8. **Utrecht** (Netherlands)				
9. **Dresden** (Germany)		flood		
10. **Helsinki** (Finland)				
11. **Jerusalem** (Israel)		snowstorm		heatwave
12. **Izmir** (Türkiye)		forest fire	 drought		Earthquake

4.2 Emergency events and impacts on health

Of the 12 case study cities, 10 – excluding Helsinki and Utrecht – had faced disasters in recent years. These events caused a broad range of effects, including substantial health impacts. The earthquake in Izmir (Türkiye) in 2020 had the greatest health impact: it led to 116 fatalities and many more injuries. Moreover, since it occurred during the COVID-19 pandemic, cascading impacts multiplied, making rescue operations and other processes of the assistance chain especially challenging, and significantly increasing the number of infected people in the area after the event.

The next most severe in terms of health impact was the flooding in Dresden (Germany) in 2002, which caused four fatalities and led to the evacuation of 35 000 residents. The reported economic cost of recovery for the city was €1.15 billion.

Two cities experienced unexpected health impacts that are still somewhat unknown because of their potential long-term effects. Citizens in Rouen (France) were exposed to a toxic cloud from a fire in a factory making oil-related products in 2019, and the community in Figueira da Foz (Portugal) was exposed to asbestos from scattered pieces of this construction material in older roofs that flew off during a hurricane in 2018. Although the health consequences of these events are yet to be assessed in

full, they could have significant impacts on health since the whole community was exposed during the emergency in both cases.

Power outages – whether as an initial event or as a consequence of a different disaster – affected the supply of basic goods like water and warm food, and put vulnerable groups (such as people requiring oxygen supply at home) at risk. In some cases, emergency calls were not possible because the power cut affected telephone connections, so the health system could not reach those in need. People were also trapped in elevators or trains, and had to be rescued.

Other events, such as snowstorms and hurricanes, led to direct health risks from accidents while walking on slippery streets, from collapsing trees or from pieces of buildings flying off and breaking windows or hitting people.

Mental health risks were reported as a result of evacuations from homes, as in Newcastle upon Tyne (United Kingdom), which had to organize three evacuations within six months in 2012 because of flooding events and resulting damage to buildings and foundations. In Flix (Spain), people living near the site of the forest fire in 2019 had to be evacuated, and the roads used for evacuation were not always safe for travel because of the high risk of being trapped and exposed to the fire. The Flix case also led to smoke exposure and – if citizens attempted to avoid this by closing doors and windows – to extremely high indoor temperatures in the context of a heatwave. Elderly people with symptoms of respiratory disease and those without air-conditioning in their homes became especially vulnerable.

Across all 12 cities, physical and mental health were increasingly becoming issues of concern in the face of the COVID-19 pandemic. For instance, access to treatment was limited during the most severe phases of the pandemic: hospitals came close to capacity when dealing only with COVID-19 patients, and many of those with existing conditions suffered as a result of postponed treatment. Lockdown measures affected daily life – for example, by reducing opportunities to exercise, socialize and visit open green spaces when access to them was limited. In addition, the great economic impact and increased unemployment rates caused by the pandemic affected household economies and health, and may also exacerbate social inequalities. Further, lockdown measures increased the health risks of groups living in inadequate housing, again exacerbating inequalities and exposing socioeconomically vulnerable groups (such as single-parent households) to a greater health burden (WHO Regional Office for Europe, 2019). Inequalities also arose in access to services and public spaces, making a "proximity lifestyle", where infrastructure and services are spatially distributed in an equitable manner across neighbourhoods (and all its associated health benefits), available only to those living in better areas.

4.3 Interviewees

Interviewees' backgrounds varied depending on the case study. They included urban planners, mechanical engineers, environmental planners, resilience experts, deputy mayors and (in three cases) mayors. The majority of interviews (8/12) were carried out with one interviewee, but two interviewees with different backgrounds participated in four case studies. They were interviewed together in Newcastle upon Tyne (United Kingdom), Palaio Faliro (Greece) and Treptow-Köpenick (a district of Berlin, Germany), and separately in Dresden (Germany). In all 10 cities with recent experience of a disaster, the interview was held with at least one person who was a municipal employee at the time of the event. Annex 1 lists the case studies and interviewees.

5. Semi-structured interviews: experiences, lessons learned and city responses

5.1 Main challenges during management of an emergency situation

5.1.1 Collaboration, communication and decision-making

This subsection examines governance and management challenges experienced by the case study cities during the emergency response and first phase of recovery.

The semi-structured interviews provided considerable detailed information about the main challenges the cities faced during the emergency situations and how these challenges were managed in the **immediate response** to the disaster. They also noted the cascading effects of a disaster – from power outages caused by strong winds impeding effective communication (as in Figueira da Foz, Portugal) to the increased difficulty of protecting health during rescue operations when an earthquake strikes during a pandemic (as in Izmir, Türkiye). Most cities stated that their operational capacity[4] to respond to the emergency was effective and sufficient, and that everyone (including all departments and government bodies) was available to lend a helping hand. This was the case even when the operational action was highly demanding, as with the snowstorm in

[4] The mobilization of resources (human and logistics) to face the immediate response in the event of an emergency.

Jerusalem (Israel). The role of the community, through spontaneous volunteering, also proved instrumental during the emergency response in many cases. Local governments would sometimes rely on the help from the community, or play an intermediary role (for example, building a website through which to manage donations between citizens in Izmir, Türkiye).

Collaboration among different departments **working in partnership** in local government was generally seen as effective and positive, but this was not as evident in the case of collaboration and communication with government bodies at the regional or national levels. For instance, Rouen (France) stated that information management by the state (which took over during the emergency) could have been more transparent and have shown more accountability for the event and its health-related aspects. Not all cities experienced such conflicts, however. For instance, Newcastle upon Tyne (United Kingdom) noted that the city was very used to working in partnerships and coordinates well at all levels. Palaio Faliro (Greece) confirmed that the local government worked closely with regional and national bodies on the technical inspections of buildings after the earthquake, receiving guidelines, instructions and financial support.

In general, local governments confirmed that they had capacities and resources to **reach out to the community** and provide basic goods and services as an immediate response to the situation. Health authorities were present mainly through social services (for instance, relocating people and attending to vulnerable groups). Communication with the community was a different issue: in some cases electricity supply and/or telephone and Internet lines were interrupted, or roads were cut off, and it became difficult to reach citizens to offer information, assess the situation and provide whatever was needed to those most vulnerable or affected by the emergency.

Some experiences showed that the lack of previous similar events led to a **lack of information and protocols affecting decision-making**. This made it difficult for local authorities to make hard decisions at certain points; for example, deciding whether to tell people to stay in their homes or to evacuate them, or assessing what amount of land should be left to burn so that the rest can be secured, as with the forest fire in Flix (Spain). Dealing with changing conditions and expectations was also a challenge for local governments. For instance, one of the main challenges during the emergency situation in Treptow-Köpenick (Germany) was not knowing how long the blackout would last, and therefore not being able to make adequate decisions. At first, the utility company stated that the power failure would be repaired in a few hours. This led to creation of a strategy that had to change when it became clear that power re-establishment would take longer. Dresden (Germany) faced a similar challenge during the response to the flood: a lack of adequate information about how high the water level would rise strongly restricted decision-making. On the other hand, some cities (such as Newcastle upon Tyne, United Kingdom) were confident that they had enough emergency plans and protocols in place to know the key contacts in case of an emergency.

Decision-making is dependent, however, on **risk governance and management capacity**: effective implementation and capacity to act fast and mobilize resources (financial, human, logistics and supply). Jerusalem (Israel) mentioned that one main challenge when facing the effects of the snowstorm was the complexity and tardiness involved in management actions such as contracting suppliers. These processes often entailed long periods of waiting for approval by committees and similar, which were limiting when handling such a time-sensitive situation as an emergency response. Many cities established “emergency task forces” or “crisis management groups” with members across local departments. Some of these (such as Dresden, Germany) also coordinated external support teams coming to the city to help with the crisis response.

In Treptow-Köpenick (Germany), two emergency coordination teams were established – one at the district and one at the city level (Berlin Senate): both involved a range of municipal departments as well as emergency services, and had direct connections to each other. In general, cities stated that operational departments handling the immediate response would be involved in these crisis management groups, while urban planning would not be involved (or not much).

Emergencies are not isolated events; nor do they occur individually. Some emergencies are **interconnected**, occurring while a different emergency is still taking place (as in the case of Izmir (Türkiye), where an earthquake hit the city during the COVID-19 pandemic). In other cases, an initial emergency can provoke others, amplifying the impact and hindering the city’s capacity to recover quickly. For instance, while the immediate impact of Tropical Storm Leslie in Figueira da Foz (Portugal) in 2018 only lasted around two hours, the interruption of water supply and electricity lasted for several weeks. The power outage was especially severe, since it disabled communication and put a great strain on every household and business affected. In this sense, Helsinki (Finland) is an example of how to mitigate this “snowball effect” of an initial emergency leading to many others. The city decided to put all electricity lines underground, making power cuts very unlikely in the event of strong winds; this strategy is also being implemented in other parts of Finland.

5.1.2 Health risk management and attention to vulnerable groups

This subsection covers various aspects described by the case study cities, including social determinants, axes of inequality, environmental determinants and health outcomes and response.

In cities with recent experience of earthquakes – Palaio Faliro (Greece) and Izmir (Türkiye) – the most vulnerable people were those living in **inadequate buildings**: older homes that did not comply with current structural regulations in case of a seismic event. According to the interviewees, this vulnerability was determined by the year the buildings were constructed, and not by the inhabitants' socioeconomic situation. Nis (Serbia) is another case of vulnerability to environmental emergencies determined by where a person lives: people living in informal housing in suburban areas are those most exposed to the almost yearly flooding events. The lack of effective regulation of these "illegal buildings" adds to the lack of sufficient data (including environmental data such as air pollution levels); this condemns the city to rely on short-term actions instead of long-term structural changes that could prevent future disasters or mitigate their effects.

During the pandemic, the link between health and housing conditions also became more evident in many cities, as people were asked to remain at home in confinement as a health measure. This instruction relies on the assumption that remaining at home offers a protective environment, but this is not always the case. Beyond what is reported by the 12 case studies included in this report, disaster literature identifies certain housing conditions that can affect health. Examples include mould growth after flooding events and its effect on allergies and respiratory health (Barbeau et al., 2010) and ventilation capacities during extreme heat events (Samuelson et al., 2020; Ahmed, Kumar & Mottet, 2021).

Focusing attention on especially vulnerable groups of the community affected by the emergency was often possible thanks to previous **identification and registration** of these people in databases (sometimes for other purposes, such as preparedness for a different type of emergency in Flix (Spain) or health plans that were in place before the emergency happened). Figueira da Foz (Portugal) mentioned how their wealth of GIS data and experience of using GIS tools, formerly devoted to planning and waste management (among other uses), proved helpful in the COVID-19 emergency. During the pandemic, this tool was used to identify socially and/or economically vulnerable people in order to quantify and qualify their location and condition, and to attend to their specific needs, including health needs (showing that an understanding of risks and reliable data can save lives during a disaster).

In general, large cities with more than one level of administration require more exchange and coordination between administrative levels, as some data or resources and capacities may naturally not be available at all levels. For example, Treptow-Köpenick (Germany) did not have adequate local information and registers of certain vulnerable groups, and could not rely on being informed through emergency calls as the communication network was affected by the power outage. This entailed coordination and exchange of relevant information with higher administrative levels, such as the Berlin Senate for the list of residents receiving home care services and relying on oxygen supply.

Each city interviewed experienced a different set of conditions, with particular associated health risks arising during or immediately after the disaster. The earthquake in Izmir (Türkiye) in October 2020 was the only event to occur **during the COVID-19 pandemic**; this made rescue operations and other processes of the assistance chain especially challenging. Many rescuers who went to the city to help the operation became infected, as did many members of parliament who also visited the site to offer their support. Similar effects and limitations would have occurred for any other crisis occurring during a pandemic situation, with special relevance for events triggering a significant number of hospitalizations.

Unexpected environmental health risks arose from certain disasters. This shows a lack of risk assessments to understand potential exposures in the city and an ensuing lack of protocols to address these. For instance, Figueira da Foz (Portugal) found itself with a major problem when many of the roofs that had flown away during the hurricane were found to contain asbestos in their construction materials. The roofs were torn to pieces and dispersed throughout the whole city, and citizens unaware of the risk were exposed, especially when picking them up to help with the street cleaning operation. Despite local authorities giving personal protective equipment (gloves, masks and suits) to as many people as possible, many were put at risk. This created somewhat unknown health risks, since the possible health consequences of exposure to asbestos are known to manifest many years later. Although it was not stated specifically during the interview, it should be noted that this health risk could become even greater if people were to recycle the material for do-it-yourself activities or simply store it for repair work or similar. Another example is the cloud created by the fire in the factory in Rouen (France), when oil-related products were burned and released toxic gases and particles over a vast area. In this case, a registry of people who had been exposed to the cloud was neither available nor established, restricting assessment of the population health impacts of the fire. In both the Portuguese and French cases, information is thus not available on who was exposed and for how long; this makes it especially challenging to assess health risks and evaluate possible connections with future health issues.

Dresden (Germany) noted that the city was not prepared for a flood the size of the one in 2002, as it **lacked emergency material**. This experience triggered preparedness actions that made the impacts of a similar flooding event in 2013 less severe, however. In 2002, no internal knowledge about managing such a situation was available in the city, showing a lack of risk awareness at the time. Sand and sandbags were also lacking; this required the city to procure the materials externally and exposed the city to the risk of delays in protecting local health and infrastructure, given the speed at which the river level rose. Helsinki (Finland) noted that emergency material (mainly medical equipment) stored in a national central security facility was insufficient

and some of it – such as face masks and other personal protective equipment – was outdated, which was an issue when faced with the first wave of the COVID-19 pandemic.

Health consequences mentioned in the interviews were mostly limited to physical health, but emergency events and consequences can have **severe impacts on the mental health** of the communities. This was the case in Newcastle upon Tyne (United Kingdom), where citizens from a particular neighbourhood had to be evacuated from their homes up to three times during six months of 2012 as a result of three major flooding events. This caused great emotional stress and anxiety among these neighbours, with a clearly cumulative effect. The local government employed a consultant expert in community resilience to carry out sessions with the community in order to understand and address this issue. Mental health is also a concern in the context of the COVID-19 crisis. This was mentioned by several cities – especially those experiencing strict lockdowns and restrictions, and those suffering severe economic impacts as a result. Izmir (Türkiye), for example, established a psychological support call centre in March 2020 and received a large volume of calls from the day it launched, indicating the need for such a mechanism within the local community.

5.1.3 Early warning and information systems

Some events, like industrial or technical disasters, cannot be predicted. Some cannot be predicted early or well enough for sufficient preparedness, as with earthquakes or (flash) floods. Nevertheless, others can be forecast. Cities that invest in early warning and information systems have a better chance of mitigating the health and other effects of certain types of events. Conversely, the inability to do so, or a disregard for the potential size and scale of a disaster, can lead to great damage.

It should be noted that there are **limitations to forecasts and early warning systems**. Having a forecast system in place does not always provide full security. Figueira da Foz (Portugal) provides an example of an inaccurate warning, as the city was not aware of the scale and strength of Tropical Storm Leslie in 2018. Meteorological forecasts predicted that the storm would enter from Lisbon, so that city was prepared for the event: everything was closed and people stayed at home. Figueira da Foz, 200 km north of Lisbon, ended up being more affected, however. Unfortunately, a show with 1000 people attending was taking place at the time the storm entered this coastal municipality from the sea. Dresden (Germany) highlighted that some flood monitoring and warning systems were in place during the 2002 flooding event, but not an early warning system able to predict the length of the flooding period and the maximum level to be expected, which is crucial information for decision-making for emergency response and management.

Most disaster events experienced by the case study cities could not be fully addressed by **local or city-scale early warning systems**. For the required level of detail, earthquakes and temperature extremes are best forecast at a national or regional level (although earthquakes are often local too, in terms of identifying the epicentre where the main damage could occur). Flooding may be local but should be harmonized for all relevant cities along the river, and may thus be handled at regional, county or state level as well. Notably, although early warning systems at the local scale might be effective and desirable (especially multi-hazard early warning systems, which are particularly relevant in the context of cascading impacts), it may not be cost-effective for municipalities to create such structures independently in their jurisdiction areas. Thus, while local mandates and accountability for forecasting and early warning may be specific to local conditions, they might go beyond local capacities (an issue to be considered when planning risk governance).

Thanks to collaborative efforts between local authorities and the environmental agency, following the experience of several floods in the same area in 2012, Newcastle upon Tyne (United Kingdom) is now able to predict when a flood is coming. This has allowed the city to put in temporary barrier solutions (which take about a day to deploy and a day to take down), that have worked several times since then. In addition, the city has implemented nature-based solutions such as water retention parks and green walls, as well as a "surface water drainage first" policy to favour on-site runoff surface water management. In the case of Dresden (Germany), since the flood in 2002 that hit the city when it was unprepared (and thus provided significant learning opportunities), much has been done in terms of better forecasting and modelling systems for the River Elbe. This made the impacts of the 2013 flood less severe and showed that preparedness for this type of emergency had improved. The city has also established a groundwater surveillance system and tide measurement systems in smaller water bodies.

5.2 Key factors for recovery

Recovery[5] from an emergency can depend on the type and scale of the event, but a few recurring key factors emerged from the interviews as critical for a full and speedy recovery.

The case study city interviews revealed the many challenges faced during and after the emergency. They also revealed that many cities had some level of structural awareness and resulting **preparedness**. Dresden

[5] As noted earlier, recovery consists of two phases: immediate recovery, meaning reinstating to a reasonable (though not optimal) level, and full recovery, which could take more time to reach. The key factors described in this section refer to full recovery.

(Germany) had sandbags (although not enough) to contain the flood water, and had not allowed building in flood plain areas of the city. Treptow-Köpenick (Germany) had access to lists of people needing power for oxygen machines, although these were kept at a higher administrative level (requiring coordination and exchange between levels, which was especially challenging during the power outage as telephone connections were affected). Figueira da Foz (Portugal) had a storm warning system, although it was not sufficiently accurate. In Izmir (Türkiye) and Palaio Faliro (Greece), earthquake experience had already improved building codes to some extent, preventing much damage in those built in the last few decades. It should therefore be acknowledged that, while there is room for improvement in emergency preparedness in these cities, the health and environmental impacts of the case study events could have been much worse if these measures had not been put in place.

Costs of recovery can be significant, requiring substantial **financial resources and contingency budgets**. For instance, the flooding event in Dresden (Germany) in 2002 caused an estimated cost of €1.15 billion to the city, mostly due to damage to buildings and infrastructure (€390 million for residential buildings, €220 million for transport infrastructure and €190 million for public facilities), but also including €2.7 million for environmental damage remediation. The importance of quick access to sufficient financial resources can be a determining factor for a fast and full recovery after a disaster, as noted by Figueira da Foz (Portugal), Izmir (Türkiye) and Palaio Faliro (Greece). For example, while in Figueira da Foz (Portugal) the hurricane in 2018 destroyed many buildings throughout the city, these structures could be repaired fairly quickly as the local government had enough money to spend on repairing public buildings and rebuilding those of people who were not covered by insurance and could not afford it. Access to national and international financial aid was also key in some cases, as in Izmir (Türkiye), for example, when rebuilding after the earthquake.

Repairing the damage to both public and private property is not always in the hands of the owners or of the local authorities. With the flooding events in Newcastle upon Tyne (United Kingdom), local authorities had to work intensively to discern and organize a set of mixed situations among the people affected, figuring out their tenancy status and what levels of **insurance** they had in each case. Local authorities in Figueira da Foz (Portugal), after the experience of the hurricane and tropical storm, made it mandatory for all buildings (especially those owned by entities) to have insurance for this kind of situation. Insurance requirements were not limited to buildings but also applied to cars, as many were lost during these events.

Not all infrastructure can be repaired quickly. The forests lost in recent fires in Flix (Spain) and Figueira da Foz (Portugal) have not yet recovered and will probably never be the same. This requires planning beyond the budget for immediate response and recovery, to consider **long-term investment** in transforming the economic model to rely more on sustainable and green industries, which may in due course be a key factor in preventing or recovering from future emergencies. This was an aspect mentioned in the contexts of the industrial model in Rouen (France), the need to transform the agricultural sector and become less dependent on water in Izmir (Türkiye) and the complex issue of unattended and unused cropland in Flix (Spain).

The COVID-19 pandemic offers another example of the need to invest in long-term infrastructure, including but not limited to the health sector. In terms of health-care facilities, the pandemic (and, for example, the vaccination strategy) has shown cities how logistics and scale may need to be adapted, depending on the crisis, and how having pre-existing systems that are flexible is important. But the effects of the pandemic also continue to affect cities in other sectors, such as public transport and the use of public space. A preparedness framework that considers the interconnections between sectors and is able to envisage spending on healthy and sustainable infrastructure as an investment (and not only a cost) is beneficial.

In the long term, **social awareness** of the surrounding environment, different exposures and their health risks has also arisen as a key factor for full recovery. Flix (Spain), Izmir (Türkiye) and Rouen (France) all stated the importance of society being aware of the needs and risks of their territories. Flix (Spain) highlighted the importance of raising awareness of how shopping habits can both help local brands (like small-scale farmers) and help protect rural areas by increasing their value. Izmir (Türkiye) noted that conscious exploitation of agricultural areas, adapted to current needs but also to future conditions (such as higher temperatures or availability of water – both with health implications) would benefit the land and the community. For Rouen (France), improving industrial culture and awareness of the environment is indispensable, since it is clear that public acceptance of environment-related impacts of industry is changing. To achieve this, the local government is seeking to raise awareness among the population of the industries located in the city and the associated environmental and health risks, using a specific communication strategy, mainly through public magazines and social networks. In parallel, industries are also trying to communicate more and more effectively on what they produce and what they emit.

Control of development pressure and **compliance with risk prevention regulations in urban planning** can be difficult. Most cities are under strong pressure for urban growth and development – particularly for residential housing, as in Helsinki (Finland), Utrecht (Netherlands), Newcastle upon Tyne (United Kingdom) and Jerusalem (Israel). This can mean that local authorities often have to challenge developers to ensure inclusion of public space interventions with demonstrated benefits for health, such as sufficient open and green space, walkways and cycle lanes. Cities in which risk maps are incorporated into urban masterplans – as in the case of Helsinki (Finland) – however, are likely to avoid much damage in the case of an emergency. In this regard, Figueira da Foz (Portugal) has recently developed a fire risk map and has also predicted areas that will probably be affected by

water rise in the next century, ensuring that further building development is not allowed in those areas. Dresden (Germany) decided not to rebuild some larger infrastructure on the same site after the 2002 flood, as it was a major obstacle for surface flow and limited the flood channel. In addition, the city developed a masterplan on flooding preparedness (formally adopted in 2010), which lists regulatory and technical measures to be implemented in various urban districts, depending on their flood risk level. On the other hand, cities like Nis (Serbia) face complex issues of informal settlements, which often do not comply with risk prevention regulations (such as distance from the river shoreline). The urban planning mindset and practice is still far from considering the open space around a building as a vital part of the health, safety and well-being of citizens.

When supply and distribution of basic goods and services are affected as a consequence of an emergency, having a strong, self-sufficient and **flexible local supply and distribution chain** in the city is a key factor to be able to distribute different products to the community, and especially to vulnerable groups. For instance, Izmir (Türkiye) has in place a community milk distribution system through a local chain, and this proved useful during emergencies, as it could be modified to distribute food, drugs or other kinds of assistance to the most vulnerable groups. Similar solutions were adopted by cities like Figueira da Foz (Portugal) and Palaio Faliro (Greece). Local supply can also fail due to power outages, as in the case of Treptow-Köpenick (Germany) and (briefly) in the transportation system of Newcastle upon Tyne (United Kingdom) and other regions of the country. In the case of Treptow-Köpenick (Germany), while water supply was simple to arrange and was provided quickly, warm food supply only reached households at the same time as the power supply was restored.

5.3 Lessons learned and city responses

This subsection presents the main lessons the case study cities learned from the emergencies they faced in the last decade, or are currently facing in relation to the COVID-19 pandemic, and gives examples of actions taken in response. The lessons learned relate to urban management and coordination, as well as to physical and structural planning or interventions. Reflecting both these dimensions, the lessons and city responses are structured into five main concepts: coordinate and communicate; go local; go green; rethink, rebuild and regulate; and maintain a long-term vision.

5.3.1 Coordinate and communicate

Improved communication between the local authority and citizens, the private sector and/or other government authorities at various levels was highlighted by most cities – Figueira da Foz (Portugal), Flix (Spain), Rouen (France), Dresden (Germany), Nis (Serbia), Newcastle upon Tyne (United Kingdom) – as a way to improve both crisis management and emergency preparedness efforts. In various cases, however, the local emergencies also led to identification of a need for better internal coordination and communication within the local authority and its different departments.[6]

The first lesson learned within this concept relates to **coordination across levels**. Stronger and more transparent vertical coordination and collaboration, especially among national, regional and local authorities across different sectors, was mentioned as a possible pathway to achieve more effective and efficient coordination across government levels. This is especially relevant in larger cities, where there is a central city government as well as partly independent districts with their own local authorities.

In Flix (Spain), coordination was considered to have been a strong point in the management of the emergency in 2019, although it was also identified as an important point to be strengthened for the future. During the Treptow-Köpenick (Germany) blackout, district authorities did not have adequate information and registers of residents; they had to coordinate with the Berlin Senate to gain access to the list of people who needed energy supply to run oxygen machines. After the event, the district of Treptow-Köpenick started working with housing agencies and using information in buildings to reach out to private residents. Rouen (France) is establishing an industrial platform that brings together several high-risk industries in the area to help them with coordination of their developments and associated risks.

The next lesson learned within this concept relates to **definition of roles and responsibilities**. Responsibilities and tasks among the different technical groups involved in emergency management – and associated departments – should be clear. Their roles and mandates should be understood, and the integration of actors and service providers and related information flows should also be clear so that the process runs smoothly. People in charge of these responsibilities may change, so it is important to refresh information and make sure that every person involved is up to date on the emergency procedures. Overall, collaborations among different departments (such as urban planning, housing and health) during non-emergency times can enhance coordination during disaster situations. This is why it is so important that these institutions are identified and engaged in risk planning in the city.

[6] Section 5 of the first report on protecting environments and health by building urban resilience (Urban planning, design and management approaches to building resilience – an evidence review) reflects event-specific strategies supporting governance, communication and public engagement in relation to urban preparedness and resilience.

In Figueira da Foz (Portugal), for example, each department involved in the Civil Protection Commission has a representative who attends its meetings and transmits the messages to others. In Helsinki (Finland), a risk crisis management leadership team is in place, with clear established lines of command. Whenever a major emergency occurs, the mayor takes command; if an emergency is minor, a department director may head the response. Moreover, depending on the type of emergency, the city's Risk and Safety Management Department may be involved. Other cities have established similar mechanisms and crisis committees, which have generally discussed allocation of roles and responsibilities in extreme events, and can be revived as required.

The next lesson learned within this concept relates to **communication with the community**. The case study interviews highlighted a need for public authorities to communicate in a responsible and transparent way, using evidence-based information and ensuring that vulnerable or affected groups are not excluded. Effective local leaders should anticipate people's need for information and not just react to social media news and concerns expressed by the general public. This is especially true given the growing sensitivity of the local population: in recent years, tolerance of environmental and health risks has evolved, and what might have been considered satisfactory previously is no longer accepted. The interviews also emphasized that the method of handling these issues is a crucial part of ensuring trust in a local government. Public perception that local authorities are executing their mandate for environmental and (especially) health protection measures is vital, even if, as in most cases, health competencies are not local. To ensure that communication with the community is logistically possible in all circumstances, precautionary measures should be considered for events that affect or disable standard communication channels and mechanisms – especially when the energy supply is affected. In such cases, information chains need to be organized differently.

Newcastle upon Tyne (United Kingdom), reflecting on the crisis management of the 2012 flood, realized that a lot of time had been spent talking to residents, but there had not been enough communication with business owners – who had also been affected by the event – to understand their biggest needs. In Dresden (Germany), action has been taken to improve communication, including provision of publicly accessible data for the local community and local businesses in a website that provides guidance and information on risk and prevention measures and information about actions and regulations the municipality is implementing. In Treptow-Köpenick (Germany), during the local energy outage, a 24-hour staff presence was established in many public facilities such as fire stations and public transport hubs to enable direct contact with the community within short distances.

The next lesson learned within this concept relates to **building awareness**. As noted in the previous subsection, tolerance of environmental and health risks has evolved, and citizens are less accepting of certain issues. Several cities mentioned the importance of building social awareness of the surrounding environment and health risks. Local governments should therefore seek to increase and promote information for the population and to include health impacts more directly in such communications.

After the industrial accident of 2019, Rouen (France) is seeking to improve knowledge of and pride in its industrial history among the local community, in collaboration with companies in the industrial area of the city. Izmir (Türkiye) is working on raising awareness of the increasing droughts and how to adapt to predicted water scarcity in the future as an effect of climate change. This is especially relevant in the agricultural sector, and includes promoting new technologies and less water-demanding crop choices. Flix (Spain) highlighted the importance of building social awareness of how shopping habits can have an effect on the use and protection of rural areas that are becoming increasingly vulnerable to forest fires.

The next lesson learned within this concept relates to **training**. Another way to work towards emergency resilience and healthy cities at a local level and to build awareness in the community is by training people to deal with such events. Repeated occurrence of crisis situations makes the local community increasingly aware of the related risks and the need for preparedness; this may also make them more open to receiving relevant information and training.

Some cities, including Figueira da Foz (Portugal) and Palaio Faliro (Greece), have implemented training programmes in schools to teach students how to respond to some of the most common disasters in the area. Treptow-Köpenick (Germany) states that, as well as a frequent scheme of emergency drills, public authority staff have benefited from courses and workshops offered by the German Federal Office of Civil Protection and Disaster Assistance, which provides documents and seminars on disaster prevention and management and related framework competence.

The final lesson learned within this concept relates to **consultation, dialogue and public participation**. Providing space and opportunities for consultation and dialogue with citizens can be a way to identify and address the health impacts and concerns of the local population. Moreover, citizens usually have plenty to contribute about lessons learned. Certain kinds of public consultation formats, such as neighbourhood assemblies, have been strongly affected by the COVID-19 pandemic – especially in smaller towns where this was a common and popular way for the local government and community to connect.

Rouen (France), Dresden (Germany) and Izmir (Türkiye) provide space for public dialogue and consultation, where the mayor frequently meets with citizens or community representatives. In Jerusalem (Israel), a

"neighbourhood urban planner" moderates communication between the municipality and the community in every neighbourhood. Many of these consultation and participation formats can also support urban planning and local decision-making processes; for example, through participatory assessment approaches, such as environmental or health impact assessments. Figueira da Foz (Portugal) and Rouen (France) have adapted to the pandemic situation and are now communicating by social media or holding virtual sessions in which citizens can ask about different topics.

5.3.2 Go local

The first lesson learned within this concept relates to a **proximity lifestyle**. The COVID-19 pandemic – as well as limitations and restrictions caused by other crisis situations – has been an opportunity for local governments (and the community in general) to reflect on how the structure, design and management of the city, as well as the local use of public space, is interconnected with health and well-being. Healthy and sustainable communities are foundational motivations for the proximity city concept, which also indirectly enhances urban resilience. Research has shown that compact cities that include local access to basic services and green space through active mobility and in an equitable way are beneficial for health, well-being, social cohesion and sustainability (see, for example, Lennon (2020)).[7]

Newcastle upon Tyne (United Kingdom) and Utrecht (Netherlands) are working on creating neighbourhoods using the "15-minute city" concept. In fact, Utrecht's aim is for a 10-minute city, where everyday needs and amenities are accessible within a short walk or bicycle ride, reducing the level of local dependency on private cars and buffering the impact if part of the city is not functional.

The next lesson learned within this concept relates to **mobility choices**. Investment in cycling to create local mobility was identified by many cities as relevant for its environmental and health benefits. Cities are still mainly dominated by cars, although efforts to increase cycling infrastructure are steps in the right direction. How to share public space (and keep it public) has much to do with mobility infrastructure and choices, and interviewees noted that local authorities should clearly set their priorities in this regard.

In Newcastle upon Tyne (United Kingdom), the COVID-19 pandemic accelerated implementation of various services and infrastructures related to an active mobility model that considers health and planning together, such as cycling and walking paths, closing residential streets and car-free zones at schools for drop-offs. These were all changes the city wanted to make, and the pandemic became an opportunity to implement them quickly, with temporary measures that will probably become permanent. Figueira da Foz (Portugal) has provided a local public bike network to avoid crowded buses. The increasing trend of cycling has even reached problematic levels in the city of Utrecht (Netherlands) where, in the last 20 years, the use of bicycles has enormously increased to the point of having to manage congestion points and excessive occupation of available public space. In Dresden (Germany), the pandemic experience increased walking and cycling, but local infrastructure cannot support this everywhere; this is an aspect that will be considered in future transport planning.

The next lesson learned within this concept relates to **key elements and human scale**. Overall, most interviews mentioned a new recognition of the value of key elements that make a healthy and enjoyable proximity lifestyle (such as green and walkable spaces or local stores and services). In addition, most interviewees mentioned the need to make public spaces "for the people", in terms of both proximity (so that people can easily manage the distances to serve their daily needs) and giving more public space to pedestrians (versus cars) to promote safer and healthier environments. As a result, some of the temporary solutions applied during the COVID-19 pandemic (especially those where pedestrians are favoured over cars) will probably become permanent.

Urban and periurban green spaces are now much more visited and valued by the community in the cities of Jerusalem (Israel), Helsinki (Finland), Utrecht (Netherlands) and Flix (Spain). Newcastle upon Tyne (United Kingdom) is promoting safe pedestrian paths (some through public parks) so that children can walk to school on their own.

The next lesson learned within this concept relates to **distribution of services**. A proximity lifestyle entails effectively distributing services throughout cities. This model does not necessarily match the traditional urban morphology of downtowns, where most services and public transportation lines are concentrated and pass through the city centre. In this sense, cities that aim to provide an urban landscape that facilitates a safe and healthy proximity lifestyle are now giving consideration to the spatial distribution of infrastructure and services.

[7] Subsection 6.5 of the first report on protecting environments and health by building urban resilience (Urban planning, design and management approaches to building resilience – an evidence review) also touches on urban distances to services and similar as a consequence of urban form and design.

Case study profiles of interviewed cities

View of the smoke cloud caused by the fire

View of the landscape after the forest fire

Case study city 1: Flix (Spain)

Population: 3410
Type of emergency: heatwave and forest fire (2019)

Brief description of the event
In the last days of June 2019, in the context of a heatwave with temperatures up to 44 °C and strong winds, the self-combustion of a dung heap on a farm caused a forest fire that devastated over 6000 hectares (4000 of which belonged to the municipality of Flix). There were no fatalities, but some inhabitants of the town had to be evacuated and relocated until conditions were safe. The community in the urban core was confined at home and advised not to open doors or windows because of the risk of smoke inhalation, especially at night. During the heatwave, indoor temperatures in certain homes were extremely high. It took 10 days to extinguish the fire completely, and great tranches of cropland were lost. Electricity supply and telephone connections were cut in some places and only re-established after several weeks.

Additional environmental challenges
In addition, since 2004, Flix has been managing water pollution in its reservoir from former chemical discharges – monitoring for potential environmental and health risks.

View of damaged trees and houses after Storm Leslie

View of an electricity pylon bent by the winds of Storm Leslie

Case study city 2: Figueira da Foz (Portugal)

Population: 58 750
Type of emergency: hurricane and fire (2017), tropical storm (2018)

Brief description of the event
In October 2017, after a very dry summer, Hurricane Ophelia caused multiple fires in the central region of Portugal. This led to devastation of about 5000 hectares in Figueira da Foz and a total of 70 deaths (although none was in the municipality itself). This spontaneous phenomenon lasted about a day and a half, but it was so widespread throughout the region that firefighters and rescue teams from other municipalities nearby were prevented from helping. Communication systems were affected, making contact with the community almost impossible, and the electricity supply was unavailable for up to a week in some areas.

In October 2018, Tropical Storm Leslie brought the highest wind speed ever registered in the country. The storm lasted about two hours, but water supply, electricity and communications were interrupted for weeks. In total, over 100 000 trees fell and blocked roads; about 3000 houses were damaged; and most industries in the area had to stop activity because warehouse roofs had blown off and windows had been broken. An important health risk arose from this event in Figueira da Foz, since the whole community was exposed to asbestos from the many older rooftops flying off in pieces.

Cracks in structural elements of school buildings in Palaio Faliro after the earthquake in 2019

Case study city 3: Palaio Faliro (Greece)

Population: 59 790
Type of emergency: earthquake (2019)

Brief description of the event
In July 2019, several cities in Greece experienced an earthquake that had a strong impact on buildings and infrastructure. In Palaio Faliro, this event damaged a large number of buildings. There were no fatalities in the city, and the road infrastructure was not strongly affected, but most older buildings (which were not as prepared for seismic activity as the more recent ones) showed large cracks in their structural elements. Technical inspection of all buildings (public and private) was carried out by local authorities in line with the national guidelines of the Department of Natural Disaster Recovery. This began the day after the earthquake occurred and took approximately 2–3 weeks to complete. The emergency response also required housing assistance and financial support for people evacuated from their homes.

Additional environmental challenges
Another environmental and health concern in Palaio Faliro is river pollution resulting from an oil leak in 2017. Since that year, work carried out to address this issue has found cases of illegal disposal of household sewage and petroleum products from road drains in this river, which flows directly into the sea.

Case study city 4: Rouen (France)

Population: 111 360
Type of emergency: industrial accident (2019)

Brief description of the event
Rouen is located in the industrial valley of the River Seine. In September 2019, a large fire occurred in a factory making oil-related products (Lubrizol, established in the city in 1956). Although the fire was put out rapidly (within about 24 hours) and no fatalities occurred, the toxic products released gases and particles. These created a large cloud, 22 km wide and 6 km tall, which had a significant environmental impact and created a strong perception of environmental and health risks. The economic damage was significant – especially for agriculture-related services, as the surrounding region of Normandy is an agricultural one, but also for tourism (which has not yet been able to recover because of the outbreak of the COVID-19 pandemic in 2020). Further, the social impact was very high: strong concern was raised among the community about the potential long-term effects on health from exposure to the cloud – not only from breathing contaminated air but also from consumption of potentially contaminated water and food.

Additional environmental challenges
The city of Rouen has also faced issues with water quality in the River Seine in recent years. Many studies have shown that leaks of certain products in previous decades (many of which can now be found in the river sediment) could still be causing environmental impacts.

Case study city 5: Nis (Serbia)

Population: 183 160
Type of emergency: floods (almost every rainy season)

Brief description of the event
The frequent flooding of the River Nisana during the rainy season causes great disruption in the city of Nis, especially in suburban areas where informal housing (including about 60 000 units in the city) is widespread. These buildings do not comply with urban planning zoning and regulations, and they are often not a safe distance from the river. This makes them especially vulnerable to the health and environmental risks of flooding events and to material damage, as such buildings are often not protected by insurance, given their informal status. Flooding events usually last around 3–7 days and often cause temporary interruptions of electricity and drinking-water supplies. No fatalities due to these events have been registered in recent years, but material damage in houses (especially to underground floors) can be substantial.

Additional environmental challenges
Other environmental and health concerns that affect Nis are water pollution from the river and air pollution. While the first is being managed and does not affect the drinking-water supply, the second is yet to be addressed. Levels of air pollutants get worse every year due to the growth and development of the city; however, the associated health risks are yet to be determined.

Emergency service vehicles during the night of the power outage

A section of the damaged power cable

Case study city 6: Treptow-Köpenick (Germany)

Population: 273 690
Type of emergency: energy outage (2019)

Brief description of the event
On 19 February 2019 at 14:00, two power lines were damaged during construction work on a local bridge in the district of Treptow-Köpenick, Berlin. Several parts of the district had no power supply for 30 hours, affecting around 30 000 households and 2000 local businesses; this became the longest power failure in Berlin since the Second World War. The power outage affected two hospitals and interrupted public transport lines. It also stopped water supply and sanitation services and affected cooling chains and food storage in fridges and freezers in businesses and private households. In buildings, elevators became stuck, and people had to be rescued. Heating systems were also unable to function, but due to the relatively limited time period and the mild winter temperatures, this did not cause a direct health threat. No charging of mobile phones was possible in disconnected areas, and citizens residing in private homes who needed an oxygen supply had to rely on battery power. As public buildings and services were also affected, various emergency response mechanisms had to be re-established – the local authority crisis response team lost energy supply and had to be moved to another location.

Case study city 7: Newcastle upon Tyne (United Kingdom)

Population: 302 820
Type of emergency: flood (2012) and power outage (2019)

Brief description of the event
Several flooding events throughout early and mid-2012 caused great damage in Newcastle upon Tyne. Rainstorms overwhelmed the River Tyne and the underground railway, affecting buildings throughout the city but especially in a neighbourhood called Newburn, where a culvert had collapsed in the spring. A storm in September ("Thunder Thursday") caused buildings in Newburn to collapse and almost washed away the foundations of a block of flats. A landslip also affected a road and some businesses. The service water system could not cope with the amount of water (around 40 ml of rainfall in 20 minutes), and flooding was extensive. During all these events, people were evacuated from their homes (some had to leave up to three times in six months). There were no fatalities, but the housing damage was significant, and the recovery took about two years. After the emergency, the community showed symptoms of stress and emotional ill health due to the cumulative effect of these events.

In August 2019, a lightning strike overpowered the electricity network across the country. The power outage lasted a matter of seconds or minutes, but it disrupted the whole transport infrastructure. Newcastle was particularly affected by an interruption to the airport's electricity supply, as generators there took longer than expected to start up.

Case study city 8: Utrecht (Netherlands)

Population: 359 380
No recent local emergency experience

View of the river shore

Utrecht has not experienced any major environmental or health emergencies in the last 10 years (excluding the COVID-19 pandemic). However, since 60% of the country is below sea level, the risk of sea level rise – one of the impacts of climate change – means that coping with water is going to become an increasingly pressing issue; this also affects urban planning in Utrecht. Another effect of the worldwide environmental crisis is the increasing frequency of heatwaves in the city, including an especially strong one in the summer of 2020, which coincided with the pandemic.

View of the green spaces along the river

Under the motto "Healthy urban living for everybody", Utrecht is developing its Urban Plan Strategy 2040, which aims to create a 10-minute city (one in which most services required for daily life are accessible to citizens within a short walk or bicycle ride) and is based on two pillars: green structure and the public transport system. This strategy touches on issues of inclusiveness through access and proximity to local services, public spaces and affordable housing. The city is also working on producing risk maps (such as ones showing potential flood-risk areas) to improve urban resilience by testing various emergency scenarios; this has become especially important following the experience with the COVID-19 pandemic, which highlighted a lack of preparedness for unexpected emergency scenarios.

erial view of the flooded area around the opera house by the River Elbe

View of the flooded central train station by the River Weisseritz

Case study city 9: Dresden (Germany)

Population: 561 942
Type of emergency: floods (2002, 2013)

Brief description of the event
In August 2002, an unprecedented flooding event in Dresden affected all local water bodies and systems for over 10 days. The River Elbe and smaller rivers and water systems rose to levels never observed before and caused an extreme rise in groundwater level. The event caused four fatalities, and 107 000 residents (20% of the local population) were directly affected by either flooding or groundwater level rise. Around 35 000 residents had to be evacuated, including patients and staff of some hospitals and nursing homes. The wider impacts of the flood also indirectly affected the whole city by interrupting public transport, water supply and sanitation, the sewerage system and energy supply, among others. Energy outages and overburdening of the system had an impact on information technology infrastructure and telephone communication. After the flooding ceased, it was another 1–2 weeks before services became functional again, and in some areas full performance only returned to standard levels after months. Environmental damage largely resulted from broken oil tanks from oil-fired heating systems, leading to water pollution.

Another significant flooding event of the River Elbe occurred in June 2013, but this was better managed, benefiting from better preparedness in the city.

Aerial view of Helsinki

Day-care group visiting one of Helsinki's parks

Case study city 10: Helsinki (Finland)

Population: 653 830
No recent local emergency experience

Helsinki has not experienced any major environmental or health emergencies in the last 10 years (excluding the COVID-19 pandemic). However, the city has historically been exposed to flooding and stormwater events, which have triggered establishment and use of preparedness strategies and contingency plans for flood protection. Preventive measures are incorporated into land use planning and practice – for example, by making stormwater management a mandatory part of the development plan in new areas.

In addition, several studies concerning sea level rise and climate change (including the heatwave in 2018, which was especially strong) have increased awareness of environmental and health risks in emergency and contingency planning. For instance, power cuts in Helsinki are now very unlikely because all electricity production is within the city limits and all electricity lines have been put underground. Nevertheless, extreme cold weather continues to be a major issue the city has to address every year, even though buildings are well prepared for cold weather.

Views of a main road in Jerusalem on the third day after the snowstorm in 2013

Case study city 11: Jerusalem (Israel)

Population: 936 420
Type of emergency: snowstorm (2013)

Brief description of the event
In December 2013, Jerusalem experienced a heavy snowstorm that left many parts of the city isolated: some areas had no access to public transport or electricity supply for up to two days. Thousands of trees fell, and many roads were closed. The city could not function for over four days, and the process of reactivating public transport services (especially bus services) was very complex because of all the snow that needed to be cleared. Direct health risks were mainly accidents caused by walking over snow and ice or by trees coming down. Despite early warnings, the expected scale and consequences of the event were greater than anticipated. It was also considered especially odd since it occurred in December, while snow usually falls in the months of January of February (and does not arrive every year).

Additional environmental challenges
Jerusalem has also experienced increasingly frequent heatwaves in recent years, and temperature records have been broken. These events have raised concern about the effects of climate change on the urban environment, and given rise to dilemmas such as whether to allow enough tree canopy in the streets to keep neighbourhoods cooler in the summer and reduce the "urban heat island" effect or to trim the branches of all trees to mitigate the consequences of another potential snowstorm.

View of one of the collapsed buildings during the 2020 earthquake

A warehouse where supply of basic goods was managed during the event

Case study city 12: Izmir (Türkiye)

Population: 4 320 520
Type of emergency: earthquake (2020), forest fire (2019)

Brief description of the event
In October 2020, the city of Izmir was shaken by an earthquake measuring between 6.6 and 7.0 on the Richter scale. A total of 116 people lost their lives; many more were injured; and many buildings collapsed – especially in one district, where the buildings were older and less prepared structurally for seismic events. Several thousands of citizens were evacuated and offered temporary accommodation, while the response and immediate recovery required the efforts of not only local authorities but also the community through volunteering. The fact that this emergency occurred during the COVID-19 pandemic made rescue operations and other processes of the assistance chain especially challenging, as this increased the health risks to rescuers in particular and to the community in general.

In 2019, the city experienced the largest forest fire of recent history, which affected several villages and led to the loss of many large wooded areas. Luckily, no casualties resulted from the fire.

Additional environmental challenges
Izmir is also facing increasingly frequent and concerning droughts, which significantly affect its current agricultural economy and practices.

Utrecht (Netherlands) is creating secondary transportation and service "nodes" in the urban fringe to better distribute services and ease congestion downtown. Treptow-Köpenick (Germany) also indicated that future energy supply grids should have smaller dependent sections, ensuring that the affected area is smaller and more manageable in the event of a power outage.

The next lesson learned within this concept relates to **local production and supply**. Going local also refers to the use and promotion of local markets, modifying the production and supply chain to support local producers and reduce dependency on imported goods. The COVID-19 crisis led to more people ordering supplies and food online instead of going to stores in person; this triggered much reflection on the resilience of physical stores and forced local stores and markets to update their supply formats.

In Figueira da Foz (Portugal), distribution of basic goods through local markets proved to be helpful during the responses to both the storms and the COVID-19 pandemic. Izmir (Türkiye) also used existing local distribution networks to provide basic goods to those most affected by the earthquake, and local production was promoted during the pandemic through a network of volunteers collaborating with local farmers. Palaio Faliro (Greece) created a "Care at home" programme during the pandemic to provide vulnerable people with food so that they did not need to leave the house. This programme also included, for instance, a book-sharing initiative, since public libraries were closed.

The final lesson learned within this concept relates to **energy safety and sufficiency**. Power systems need to be more flexible and include redundancies: they should be designed in a way that clearly defines smaller dependent sections that are manageable in the case of a power cut. Local energy sufficiency is also desirable in terms of vulnerability to multiple types of crises.

Helsinki (Finland) produces its electricity within the municipality boundaries; the goal for Utrecht (Netherlands) in the coming years is to do the same, but within the regional boundaries. In Helsinki, all power lines are underground; this reduces the possibility of experiencing power outages due to strong winds or stormwater flooding – all risks that are expected to increase in the future.

5.3.3 Go green

The first lesson learned within this concept relates to **recognizing the value of urban and periurban green spaces**.[8] The environmental and health benefits of urban green spaces are well documented (e.g. Gascon et al., 2016), and some cities have already taken action to enhance communities' exposure to nature. In this sense, a renewed recognition of the value of urban and periurban green spaces as a consequence of COVID-19-related lockdowns and restrictions is seen as a positive context and mindset in which to push for a number of actions. These might include planning that incorporates more multifunctional green space in urban contexts, preserves existing green spaces (or spaces of opportunity) despite building development pressures, and grasps the multiple benefits of nature-based solutions, all of which are particularly relevant when facing the effects of climate change.

Flix (Spain), Jerusalem (Israel), Utrecht (Netherlands) and Helsinki (Finland) are promoting access and itineraries around nearby natural spaces. Rouen (France) is opening spaces like schoolyards during summertime to be used by citizens when schools are closed.

The next lesson learned within this concept relates to **nature-based solutions**. Also known as green and blue infrastructure, or natural infrastructure, nature-based solutions are sustainable planning, design, environmental management and engineering practices that weave natural features or processes into the built environment to build more resilient communities (FEMA, 2021). These practices can be applied to a community's built environment or to its natural areas, and they have many hazard mitigation benefits (such as retention areas to protect from flooding). It is important to protect these areas through land use regulations, restricting the location of infrastructure in these areas and maximizing their benefits.

The use of nature-based solutions was mentioned in most interviews, whether as a means to manage surface water with stormwater parks and rainwater harvesting in Newcastle upon Tyne (United Kingdom), by promoting green roofs in new developments in Utrecht (Netherlands) or by preserving and protecting the dunes in coastal areas in Figueira da Foz, (Portugal). Jerusalem (Israel), however, finds itself with a dilemma over whether to allow enough tree canopy in the streets to keep neighbourhoods cooler in the summer and reduce the "urban heat island" effect (especially in the light of the city's increasingly frequent heatwaves) or whether to trim the branches of all the trees to mitigate the consequences of another potential snowstorm like the one in 2013.
The next lesson learned within this concept relates to **access and equity in the distribution of urban green spaces**. The benefits of proximity and access to and use of green spaces are well known, and it seems that their value is increasing significantly in post-lockdown times. As a result of the COVID-19 crisis, local access to these spaces has become more relevant. The pandemic also revealed the importance of having equally distributed green spaces among city neighbourhoods and of preserving the ones already there (despite ongoing development pressures).

[8] Subsection 6.8 of the first report on protecting environments and health by building urban resilience (Urban planning, design and management approaches to building resilience – an evidence review) summarizes the benefits of urban nature for urban sustainability, health and resilience.

During the COVID-19 pandemic, in some cities, citizens were unable to visit parks and playgrounds for periods of time, including Dresden (Germany), Figueira da Foz (Portugal), Flix (Spain), Nis (Serbia), Rouen (France) and Utrecht (Netherlands). Some still have access limitations in place. Other cities, including Helsinki (Finland), never restricted access to green public spaces, whereas some – including Jerusalem (Israel) and Newcastle upon Tyne (United Kingdom) – had intermediate restrictions. For example, in Jerusalem, natural spaces and playgrounds were kept open, but only within a 1 km range of people's homes, while national parks were closed during the lockdown.

The final lesson learned within this concept relates to **green infrastructure and public health**. The importance of nature within urban areas as a way to minimize the health impact on the local population in future emergencies (and in everyday life) was mentioned by many cities, which were already working on the issue via different approaches.

Newcastle upon Tyne (United Kingdom) is investing in green infrastructure and including walkways and cycle lanes for active transport within this as a public health strategy. Jerusalem (Israel) has an urban natural sites masterplan, which is trying to define which areas can or cannot be built on in order to reduce ecological damage. Izmir (Türkiye) has a green infrastructure plan and a green action plan (related to climate change) that aim to increase and improve green areas within the city.

5.3.4 Rethink, rebuild and regulate

The first lesson learned within this concept relates to a **healthy urban planning approach**. Several cities have implemented (or intend to implement) changes or new approaches related to urban planning and/or infrastructure design, using lessons learned from past events in order to be more prepared for future events.[9]

Jerusalem (Israel) underlined the importance of addressing these issues within a city model of "healthy urban planning" and as part of a sustainable development plan. Three other cities –Dresden (Germany), Nis (Serbia) and Izmir (Türkiye) – mentioned the importance of urban plans and building design to be more protected from and resilient to future emergencies.

The next lesson learned within this concept relates to **staying functional**. Interviews showed how the case study cities tried to remain functional during the crisis, maintaining service provision and public services and trying to reduce public life as little as possible. In this sense, their experiences reveal how building forward better to be resilient and functional, even in extreme events, may require planning ahead for redundant structures and including a "plan B" for key services (see, for example, Sharifi & Yamagata (2018)).

Reinstating public transport services in Jerusalem (Israel) after the 2013 snowstorm was a main priority for the local government. These efforts showed how challenging this could be (especially with buses) with the current street layout. Izmir (Türkiye) modified its pre-existing local supply network to deliver basic goods (such as food or medicines) to those most affected by the earthquake in 2020. After the power outage in Treptow-Köpenick (Germany), the city secured a local authority facility with an independent power supply. After the hurricane in 2017 and storm in 2018, Figueira da Foz (Portugal) implemented a system of independent emergency power supply and satellite communication between villages.

The next lesson learned within this concept relates to **buffer zones and restricted areas**. A strategy mentioned by most cities interviewed was restricting buildings in areas that may be prone to natural or environmental risks or located in proximity to certain hazards. In particular, the use of buffer zones to separate uses (such as industry from housing, or buildings from water bodies or forests) is an effective strategy to reduce the vulnerability of both buildings and people in the event of an emergency (including industrial accidents, fires, storms and water level rise) (see, for example, King et al. (2016)).

In Rouen (France), the industrial accident accelerated changes to an urban project that was being developed: this will now set a larger buffer zone between the industrial and residential areas. Figueira da Foz (Portugal) also added buffer zones between houses and trees near forests to prevent forest fire risk, and building is no longer allowed near the beach or in places at risk of damage during storms. Case study cities with flood experience, such as Dresden (Germany), Nis (Serbia) and Newcastle upon Tyne (United Kingdom), and those without recent flood experience but acting in a preventive manner, such as Helsinki (Finland) and Figueira da Foz (Portugal), used planning tools to ban buildings in flood-risk areas.

The next lesson learned within this concept relates to **strengthening building regulations**. Building regulations should be updated, taking into consideration how older buildings can be more vulnerable to strong winds and seismic events, and how certain materials can affect health and the environment negatively. Siting and design decisions may also be key to preventing water damage from storms or floods. In addition to drafting stricter regulations, a necessary part of implementation is carrying out inspections to see whether regulations are actually being followed.

[9] Subsections 6.5 and 6.6 of the first report on protecting environments and health by building urban resilience (Urban planning, design and management approaches to building resilience – an evidence review) discuss challenges and responses to support urban resilience through the design of urban and building infrastructure.

In addition to buffer zones and restricted areas, Figueira da Foz (Portugal) has implemented new building regulations to improve resistance to wind. Use of plain continuous roofs in the city is no longer permitted (only those with tiles are now acceptable), as Tropical Storm Leslie demonstrated that plain roofs are more prone to fly away in strong winds and more likely to cause greater damage. Inspections also became more frequent and rigorous; for example, the capacity of construction materials to resist strong winds (especially roofs) is now checked, and new construction in flood-risk areas is impeded. Moreover, the priority for local authorities in the city is repairing and rebuilding, not building new houses. Stricter building regulations have been implemented in both cities with previous experience of earthquakes – Palaio Faliro (Greece) and Izmir (Türkiye) – to improve the structural soundness of buildings in these seismic areas. In Dresden (Germany), practical interventions and legal/regulatory interventions were implemented in order to include preventive actions related to urban design, building design and siting, so that the city infrastructure is better prepared and less exposed in future flooding events.

The next lesson learned within this concept relates to **strengthening land use planning and practice**. Land use planning can become a crucial mechanism for building resilient and healthy cities for the future, especially when using predictive approaches and integrating risk maps. By preventing building in risk-prone areas and protecting key green infrastructure (among other measures), life and property can become less vulnerable to the impacts of emergency events, and cascading effects can be significantly reduced. In this sense, it is crucial that cities map and update vulnerable areas and informal settlements (which are unplanned) with the use of community agents, to support risk assessment, evacuation and response in case of emergency.

Helsinki (Finland) is an example of effective and rigorous land use planning and practice. The masterplan covers the whole city and includes detailed plans for smaller areas, from suburban districts to single blocks – sometimes even just buildings or building sites. Stormwater management is always part of the plan in new areas. Similarly, in Newcastle upon Tyne (United Kingdom), new developments must accommodate not only runoff water coming from the site but also additional water that may have to be managed during a future flooding event. Developers are forced to take a predictive planning approach to adapt to what climate change might bring. Buildings located in flood-risk areas of Nis (Serbia) must be adapted to accommodate recurring floods by, for example, not building underground, elevating the ground floors or implementing water management and drainage solutions in the surrounding areas. However, the problem of informal settlements that do not comply with any land use planning or risk prevention legislation in these suburban areas limits the actions available to the city for immediate response and repair.

The next lesson learned within this concept relates to **improving infrastructure design**. Improving infrastructure design (for water management, communication or energy supply, among others) is key for urban resilience in general. It can significantly reduce the city's vulnerability to the impacts of emergencies by mitigating potential cascading effects.

Dresden (Germany) has rebuilt and expanded its canalization and sewer systems in order to increase its capacities – action that resulted in a general urban resilience measure. The city also noted that using ecological management and local options to provide buffers for flooding in smaller water bodies is an investment that would reduce the effects of similar floods in the future. In Treptow-Köpenick (Germany), the power outage triggered changes to the independence of power supplies in order to try to avoid possible bottlenecks for both the city and the local authority (which now also has a facility with an independent energy supply). In Figueira da Foz (Portugal), each local settlement within the municipality now has a generator, and someone in each village has been designated to have a phone with satellite connection; this ensures connection and communication with state bodies in case of power outage. In Flix (Spain), lessons learned from the forest fire led to a redesign and upgrading of the road network, making it wider at some points so that emergency vehicles can access all areas easily.

The next lesson learned within this concept relates to **mapping data**. Precise and updated mapping of the physical infrastructure is a great resource that enables local authorities to respond to emergencies effectively and efficiently, and to work towards preventing them.

In Palaio Faliro (Greece), local authorities have created a map where every potential safe open space is identified and categorized as areas for people to gather when evacuated from buildings or for emergency vehicles to be located during rescue operations. In Newcastle upon Tyne (United Kingdom), an underground digital map was developed, since the city has sewage infrastructure and former coalfields dating from the nineteenth century, of which existing maps are often wrong or imprecise. Figueira da Foz (Portugal) mentioned how their wealth of GIS data and experience of using GIS tools, formerly devoted to planning and waste management (among other uses), proved helpful in the COVID-19 emergency. During the pandemic, this tool was used to identify socially and/or economically vulnerable people in order to quantify and qualify their location and condition, and to attend to their specific needs in the most efficient way possible, also considering many other aspects of the city's systems. Dresden (Germany) also developed detailed GIS maps for flooding information, which are accessible to all citizens.

The next lesson learned within this concept relates to **emergency material**. Procurement and storage of emergency material is extremely important during an emergency response. When a city depends entirely on such material being sent from other cities or countries, delays and other potential problems put the community at greater risk. Cities may need to consider storing at least some specific emergency materials or devices, and should

conduct periodic inventories, depending on the local risk profile.

In Dresden (Germany), emergency material (such as salt, sandbags, face masks and machinery) had to be brought from other cities for the 2002 flood. This led to improvement in procurement and storage of such material, which mitigated the effects of the 2013 flood. Helsinki (Finland) has a national central security supply, where emergency material (mainly medical equipment) is stored. In March 2020, however, it was found that face masks and other personal protective equipment needed during the first wave of the COVID-19 pandemic were insufficient and some were out of date. The city's hospital logistics supply system has been changed so that these are brought to the hospital every day instead of materials being stored there, as this was not efficient from an economic point of view.

The final lesson learned within this concept relates to **emergency drills**. Emergency drills and exercises strengthen emergency response plans, establish routines and collaboration, and teach the community what to do (or not to do) when an emergency happens.

Only a few cities were already performing emergency drills, and they were mentioned as an aspect to be improved by others, including Treptow-Köpenick (Germany) and Flix (Spain). Helsinki (Finland) practises emergency drills on climate change and related emergencies for city management leaders, exemplifying the greater awareness now of environmental risks in emergency and contingency planning.

5.3.5 Maintain a long-term vision

The first lesson learned within this concept relates to **emergency preparedness**, which is not solely operational. Operational capacity is the mobilization of resources (human and logistics) to face the immediate response in the event of an emergency. Emergency preparedness is often reduced to operational capacity and readiness, thereby disregarding mitigation and prevention efforts needed to prepare for similar events and become more resilient. There is a need for a long-term vision in emergency preparedness matters – beyond the short-term capacity to cope with the immediate response and recovery to get "back to normal".

In Treptow-Köpenick (Germany), emergency plans and communication flows have been set up, which may also be useful for other emergency situations. Flix (Spain) has been promoting, through fiscal benefits, associations of owners who are in charge of a forest property, in order to avoid abandoned lands that may be a possible source of future fires.

The next lesson learned within this concept relates to **risk identification and "scenario-based" thinking**. As part of risk identification, scenario-based thinking imagines "impossible" scenarios and ensures that local governments know where the main risks lie, who and where most vulnerable groups are, and what cascading effects could be set off. This helps them prepare to address or minimize these impacts effectively. In terms of knowing what first steps to take, this testing of various emergency scenarios (which should be imagined with the participation of vulnerable groups) could be a useful tool in creation of emergency plans and resilient urban planning at a local scale.

In Utrecht (Netherlands), municipalities have their own risk exercises, which are prepared for various different scenarios. The city noted, however, that more work should still be done on this. In Helsinki (Finland), preparedness and contingency planning is being undertaken, taking into account several different risks. A flooding event in 2005 pushed the city to include sea level rise and climate change topics in its planning, and now other climate-related emergencies are included in emergency practices and drills for city management leaders.

The next lesson learned within this concept relates to **climate change adaptation in urban settings**. Many emergencies experienced by the case study cities are closely linked to climate change. Cities need to update their risk assessments in line with the best available predictions and implement adaptation strategies and plans that reduce their vulnerability in the future (see, for example, Sharifi (2021)).[10]

Most cities stated that climate change adaptation was among their main priorities when thinking strategically about the future of their city. Figueira da Foz (Portugal) focused on the increasing risk of hurricanes and sea level rise; Izmir (Türkiye) placed emphasis on water scarcity; Jerusalem (Israel) acknowledged the increasing frequency and severity of heatwaves and snowstorms; and Newcastle upon Tyne (United Kingdom) highlighted heavy rains and stormwater management, among others. In some cases, however – as in Helsinki (Finland) – interviewees felt that this might have been put on hold because of the pandemic; although climate change adaptation was acknowledged in policies, a sense of urgency was lacking in terms of direct action.

The next lesson learned within this concept relates to **drafting and approval of urban and land use plans**. Efforts to address the long-term vision of emergency preparedness are also needed in drafting and approval of spatial or technical plans, to ensure that they contribute to disaster risk prevention and urban preparedness. Allocation of critical infrastructure or functions in vulnerable and disaster-prone areas should be prevented, and

[10] Subsection 6.1 of the first report on protecting environments and health by building urban resilience (Urban planning, design and management approaches to building resilience – an evidence review) discusses climate change adaptation as one of the most important cross-cutting issues for urban resilience.

other infrastructure may require specific features and criteria to be approved. Land use planning and zoning approaches can therefore be the foundation of a long-term vision for better resilience.

Examples of this are the masterplan on flooding preparedness, the sustainable and resilient mobility planning and environmental impact assessments in Dresden (Germany); the surface water management plan in Newcastle upon Tyne (United Kingdom); the recent emergency plan in Palaio Faliro (Greece); the transportation masterplan, urban sites masterplan and city model for healthy urban planning in Jerusalem (Israel); and the green action plan and COVID-19 resilience action plan in Izmir (Türkiye). Utrecht (Netherlands) is working on an urban strategy plan to 2040, using long-term vision that has not been triggered by any recent emergency. This nevertheless includes mechanisms to coordinate and link health, environment and urban planning dimensions in future planning by the city. Nis (Serbia), on the other hand, notes that the lack of a long-term vision among local authorities in emergency preparedness (which is generally reduced to the short-term, operational aspect) hinders integration of health and environmental impacts in urban planning. Nor is urban planning considered an overarching issue that should include health and environmental concerns and criteria.

The final lesson learned within this concept relates to **evaluation**. Interviews revealed the need to evaluate local governments' response and management continually and, therefore, to keep learning from past experiences. Evaluation of the emergency response and management should be performed after any event, as this provides local authorities with better understanding, identification and assimilation of the lessons learned, and can therefore foster a faster and more efficient response to future environmental or health threats.

Some interviewees – including Dresden (Germany), Figueira da Foz (Portugal), Flix (Spain), Palaio Faliro (Greece) and Rouen (France) – stated that an evaluation of the response to the COVID-19 crisis was already (or would shortly be) under way. Others – including Helsinki (Finland), Izmir (Türkiye), Jerusalem (Israel), Newcastle upon Tyne (United Kingdom), Nis (Serbia) and Utrecht (Netherlands) – were unsure, however, or mentioned that it is still too early to learn and that this might take years. In Dresden (Germany), various departments are evaluating COVID-19 management; other cities, like Rouen (France), have established a citizen committee to do this. Both internal evaluation and public consultation should become part of a learning process, also acting as an exercise in institutional commitment and accountability.

5.4 Links between lessons learned and the four phases of emergency management

As set out in subsection 2.1, emergency management can be broken down into four distinct but interconnected phases: two that take place during and after an emergency (**response** and **recovery**), and two to be carried out before a new emergency strikes (**mitigation** and **preparedness**).
Expanding on the sustainable urban management and planning contributions to emergency preparedness and urban resilience (necessarily working in conjunction and synergy with other sectors), the lessons learned from recent emergencies in the case study cities (detailed in subsection 5.3) are listed in Table 3 and assigned to one or more emergency management phase.

Table 3. Responses/actions mentioned during the interviews and how they relate to the four emergency management phases

Lessons learned	How urban management and planning can be integrated with other sectors to develop healthier and more resilient environments, and ensure that cities are less vulnerable							
	During		**After**		**Before/in preparation**			
	Response How sustainable urban management and planning interventions can make cities more resilient and reduce emergency impacts		**Recovery** How urban design considerations can help to build forward better after extreme events		**Mitigation** How urban planning and infrastructure design considerations can minimize the effects of emergency impacts		**Preparedness** How urban planning interventions and management considerations can prepare cities for emergencies and make them more sustainable	
	Implementation pathway	Case study	Implementation pathway	Case study	Implementation pathway	Case study	Implementation pathway	Case study
1. Coordinate and communicate								
Coordination across levels	Emergency management	1, 2, 4, 5, 7, 9					Vertical and horizontal coordination	1, 2, 4, 5, 7, 9
Definition of roles and responsibilities	Roles, mandates, information flows	2, 6, 7, 9, 10					Integration of actors, updating procedures	2, 6, 7, 9, 10
Communication with the community	Consultation	4, 5	Consultation	7	Data sharing	9	Instructions, assistance	4, 5, 9
Building awareness					Change of habits	1, 6, 12	Population capacity-building	1, 6, 12
Training							Awareness raising	2, 3
Consultation, dialogue and public participation			Government involvement	4, 9, 12	Outreach, identifying stakeholders	1, 2, 4, 7, 11	Including citizens in planning	1, 4, 11
2. Go local								
Proximity lifestyle					Local access to services, infrastructure	7, 8	Local access to services, infrastructure	7, 8
Mobility choices					Infrastructure, services, management	2, 7, 8		
Key elements and human scale					Healthy urban planning	1, 8 10, 11	Healthy urban planning	1, 8 10, 11
Distribution of services					Periurban areas	8		
Local production and supply	Basic products supplied by local production, supply to vulnerable groups	2, 3, 8, 12	Supply chain independence	2, 3, 8, 12			Supply chain independence	2, 3, 8, 12
Energy safety and sufficiency	Communication lines with emergency services	2, 6			Flexibility, redundancies, independence	1, 6, 8, 10		

Table 3. contd

Lessons learned	How urban management and planning can be integrated with other sectors to develop healthier and more resilient environments, and ensure that cities are less vulnerable							
	During		**After**		**Before/in preparation**			
	Response How sustainable urban management and planning interventions can make cities more resilient and reduce emergency impacts		**Recovery** How urban design considerations can help to build forward better after extreme events		**Mitigation** How urban planning and infrastructure design considerations can minimize the effects of emergency impacts		**Preparedness** How urban planning interventions and management considerations can prepare cities for emergencies and make them more sustainable	
	Implementation pathway	Case study	Implementation pathway	Case study	Implementation pathway	Case study	Implementation pathway	Case study
3. Go green								
Recognizing the value of urban and periurban green spaces					Health and environmental benefits	1, 4, 7, 8, 10, 11	Health and environmental benefits	1, 4, 7, 8, 10, 11
Nature-based solutions	Surface water management	7, 9, 10			Preservation, promotion, management, distribution	2, 7, 8, 11	Preservation, management, distribution	2, 7, 8, 11
Access and equity in the distribution of urban green spaces					Health and environmental equity	1, 4, 7, 8, 10, 11	Health and environmental equity	1, 4, 7, 8, 10, 11
Green infrastructure and public health					Strategies, plans, interventions	4, 5, 7, 9, 11, 12	Strategies, plans, interventions	4, 5, 7, 9, 11, 12
4. Rethink, rebuild and regulate								
Healthy urban planning approach					Resilience, sustainability	4, 5, 9, 11, 12	Protection	6, 9, 12
Staying functional	Transportation and local supply network modification	11, 12			Power supply independence	2, 6		
Buffer zones and restricted areas					Risk prevention	2, 4		
Strengthening building regulations					Risk prevention, inspections	2, 5, 9, 12	Adaptation	3, 4, 5, 9, 12
Strengthening land use planning and practice					Risk prevention	7, 10		
Improving infrastructure design					Risk prevention	2, 6, 9	Adaptation	1

Table 3. contd

Lessons learned	How urban management and planning can be integrated with other sectors to develop healthier and more resilient environments, and ensure that cities are less vulnerable							
	During		**After**		**Before/in preparation**			
	Response How sustainable urban management and planning interventions can make cities more resilient and reduce emergency impacts		**Recovery** How urban design considerations can help to build forward better after extreme events		**Mitigation** How urban planning and infrastructure design considerations can minimize the effects of emergency impacts		**Preparedness** How urban planning interventions and management considerations can prepare cities for emergencies and make them more sustainable	
	Implementation pathway	Case study	Implementation pathway	Case study	Implementation pathway	Case study	Implementation pathway	Case study
4. Rethink, rebuild and regulate contd								
Mapping data	Response strengthening	2, 3			Prevention, prediction	2, 3, 7, 8, 9	Adaptation	2, 3, 7, 9
Emergency material	Response strengthening	9, 10					Supply provision	9, 10
Emergency drills	Response strengthening	1, 6					Population capacity-building, awareness	1, 6, 10
5. Maintain a long-term vision								
Emergency preparedness (not restricted to operational capacity and readiness)	Operation	5, 11	Recovery	5, 11	Prevention	5, 11	Preparedness	5, 11
Risk identification and "scenario-based" thinking	Response strengthening	2, 3, 7			Risk & vulnerable groups prediction	2, 3, 7, 8, 10	Prevention, emergency planning	2, 3, 7, 8. 10
Climate change adaptation in urban settings					Prediction	2, 7	Adaptation	2, 4, 5, 7, 10, 11, 12
Drafting and approval of urban plans					Planning updates	3, 7, 8, 9, 11, 12	Planning updates	3, 7, 8, 9, 11, 12
Evaluation	Learning/capacity-building	1, 2, 3, 4, 9	Learning/ capacity-building	1, 2, 3, 4, 9	Learning/ capacity-building	1, 2, 3, 4, 9	Learning/ capacity-building	1, 2, 3, 4, 9

Notes: 1 – Flix; 2 – Figueira da Foz; 3 – Palaio Faliro; 4 – Rouen; 5 – Nis; 6 – Treptow-Köpenick; 7 – Newcastle upon Tyne; 8 – Utrecht; 9 – Dresden; 10 – Helsinki; 11 – Jerusalem; 12 – Izmir.

Urban planning interventions, related to the planning itself and/or to local planning policies;

Internal coordination and logistic interventions by local authorities;

"Soft" aspects (communication, participation, awareness, training, incentives).

This table is not exhaustive and only presents an overview of how the actions raised by the 12 cities can be categorized.

5.5 Use and impact of international framework documents, and the role of city-to-city learning

The interviews carried out in this project aimed to understand whether – and how – cities create their plans and policies to become more healthy, sustainable and resilient. Questions probed whether the cities had learned from previous experiences; whether they used specific documents and guidelines; and whether certain international framework documents (such as the SDGs, the Paris Agreement or the Sendai Framework for Disaster Risk Reduction 2015–2030) affected how they thought about and took action on health, environment and planning.

Cities mostly referred to regional and (especially) national guidelines that were to be followed on emergency preparedness planning, noting the need for frequent updates of these guidelines. In several cases, climate change adaptation strategies also travelled vertically from national or regional levels to the local mandate for implementation.

In terms of international framework documents, the 2030 Agenda for Sustainable Development with its **SDGs** (United Nations, 2015b) is the best known and most used by local governments. All interviewees except one were familiar with the SDGs, and most were able to identify the goals that their city was prioritizing. For example, Utrecht (Netherlands) is focusing on the SDGs most related to environmental, social and health objectives, all of which are highly relevant for "healthy urban living". Flix (Spain) is focusing mainly on the energy and climate-related goals, through the Covenant of Mayors for Climate Efficiency and Sustainability. Newcastle upon Tyne (United Kingdom) is planning to use some of the SDG measures as the framework for recovery work, and the city asked a local university to help locate its position on various of the indicators for these goals. Other cities stated that SDGs were mostly used as strategic frameworks at higher government levels rather than as technical guidance documents (and they are therefore not embedded in practical guidance).

Most cities were also aware of **the 2015 Paris Agreement** (United Nations, 2015c), but used it as a background document to create an supportive atmosphere for climate work – as in Helsinki (Finland) – or as a political or strategic document – as in Treptow-Köpenick (Germany). Newcastle upon Tyne (United Kingdom) mentioned that the Paris Agreement provided a framework for its Net Zero Newcastle: 2030 Action Plan, which sets a target of becoming a carbon neutral city by 2030, and noted that the local authority leadership had grasped the agenda and was focusing on climate change. Other cities indicated that this document was not used much at a local level but was in use at higher government levels.

The **Sendai Framework for Disaster Risk Reduction 2015–2030** (United Nations, 2015a) was the least known of the international frameworks. Only those interviewees with a more technical role in urban resilience were familiar with the document – such as Newcastle upon Tyne (United Kingdom) and Helsinki (Finland) – and an assessment of its impact on local actions is thus not possible. Those who confirmed that they were familiar with it highlighted the fact that it was probably not used enough in their countries, and Newcastle upon Tyne (United Kingdom) added that it could offer a different perspective to the way they were framing resilience, by bringing together sustainability, climate change and disaster.

Overall, the results suggest that these international frameworks and commitments play an important supportive role and provide an overall policy context to reorienting urban planning schemes to address and implement urban sustainability, preparedness and resilience. However, with the increasing specificity of the frameworks, streamlining across municipality departments seems to decrease, and awareness is mostly limited to the relevant departments in charge of the subject. Practice guidance and broader positioning may be necessary to make such international agreements applicable and relevant at a local scale and across all sectors of local government.[11]

In relation to the discussion on the most applicable sources of information and guidance to support sustainable and resilient urban planning schemes, a few cities indicated that they used examples of other cities (**peer-to-peer exchange**) to learn from and better prepare for future disasters. Helsinki (Finland) mentioned very helpful and productive cooperation and exchange of experiences both between Finnish cities and occasionally with some cities in other countries. Similarly, Dresden (Germany) indicated that exchanges of information with other flood-prone cities were actually more relevant than theoretical guidance and standards. Utrecht (Netherlands) noted that this was not done enough, but could be very beneficial. Considering the many city networks, international conferences and forums that aim to share experiences and promote collective learning on urban issues among cities, it seems that there could be significant opportunities in utilizing urban networks and exchanges to support local planning, with a focus either on resilience and preparedness or on overall sustainable and healthy cities.

[11] See *Review of indicator frameworks supporting urban planning for resilience and health*, the third report on protecting environments and health by building urban resilience, for an overview of the applicability of urban indicator frameworks.

6. Discussion

The previous section described both what cities were considering (key factors for recovery, lessons learned from the emergency event, and the urban management and planning changes and design modifications planned or implemented already) and how they were planning to approach these issues (challenges, solutions and technical aspects of resilient and sustainable urban planning and infrastructure design). The focus of this project is on resilience to emergencies and crises, but the results show how cities are also preventing emergencies (for example, through flood alleviation) and implementing strategies that will increase resilience to lower-level everyday challenges. Investment in such changes is worthwhile as an overall strategy, beyond times of crisis.

6.1 Implications of lessons learned (and city responses) for urban planning and health

The environment is an important health determinant, estimated to account for almost 20% of all deaths in the WHO European Region (WHO Regional Office for Europe, 2021b). People place great value on living in safe and supportive communities, where the social and physical environment favours physical, psychological and social health and well-being (WHO Regional Office for Europe, 2021a). Urban planning is a public health intervention that provides mechanisms to transform the physical and social environments, reducing harmful exposures and facilitating healthy lifestyles. It can become crucial in reducing both health risks during extreme events and the associated burden on the health system. The case studies show how emergencies often became opportunities for areas or departments of local government to push harder for changes that were already in the making. These events, strongly etched in the memory of the community, can act as live examples of the potential effects of (for example) climate change, convincing decision-makers of the need for investment in adaptation and mitigation strategies for the city, and motivating stronger collaboration between urban planning, environment and health areas to work on these strategies together. Several responses to the lessons learned (described in subsection 5.3) have clear links to protecting and promoting health through urban design. Three main categories emerged: promoting active mobility, reducing risk exposure through planning, and ensuring local access to basic services.

Public health interventions and policies **promoting active mobility** are related to multiple health and environmental benefits (Koszowski et al., 2019). Although most cities report that cars still dominate public spaces, many cities are making changes to their urban and transport planning to facilitate active mobility, mostly by increasing pedestrian-only areas, increasing and improving cycle lanes, and providing public bicycle networks. In addition, the change from the use of private cars to a more sustainable transport mode reduces fossil fuel consumption and emissions, thereby contributing to reducing air pollution, noise and heat. Moreover, active mobility has positive effects on transport planning, since these transport modes do not take up as much public space as cars. The reallocation of public space previously occupied by motorized vehicles can mean increases in green infrastructure, spaces for social interaction and other activities that foster health. Active mobility increases physical activity levels, which is another key public health benefit.

Facilitating active mobility among citizens is related to urban planning and access to basic services at a reasonable walking or cycling distance. A city that provides basic everyday services for the community at a distance that can be covered by walking or cycling from any home (15 minutes is considered a reasonable maximum time frame by many plans) – and provides adequate and safe infrastructure to facilitate these healthy transport modes – can promote physical and mental benefits.

Regarding the spatial distribution of infrastructure and services, Utrecht (Netherlands) is planning to create “nodes” in the urban fringe that will facilitate access to public transportation (and promote its use) without the need to travel downtown where all public transport connections are currently concentrated. Urban green infrastructure is also closely linked to active mobility patterns. Cities like Newcastle upon Tyne (United Kingdom) are incorporating walkways and cycle lanes to green infrastructure and creating nature-based solutions as public health interventions.

Health can be protected by actions and interventions to prevent exposure to certain risks, thereby **reducing risk exposure by planning**. One of the most obvious measures is guaranteeing physical distance or restricting the allocation of infrastructure in certain areas. This may include buffer zones between residential and industrial areas in case of industrial accidents, as in Rouen (France), or between houses and trees in case of forest fires, as in Figueira da Foz (Portugal) and Flix (Spain). It might also involve restrictions on building near the beach in case of storms or hurricanes, as in Figueira da Foz (Portugal), or in flood-risk areas, as in Dresden (Germany), Helsinki (Finland) and Nis (Serbia). These preventive measures reduce the risk of death, injury and material damage, as well as other associated health risks that may come from affected buildings and infrastructure. For instance, flooding events can lead to vector-borne diseases and faecal–oral transmitted diseases if sewage waters mix with drinking-water.

Buffer zones and restricted areas often come with (or from) strengthening of land use regulations and increased inspection efforts to enforce them. Efforts to ensure compliance with land use plans and regulations, which have already considered disaster risk prevention, are therefore efforts to protect both health and property.

Greening cities and opening up densely populated neighbourhoods are other ways to reduce risk exposure. Green spaces are related to health through various pathways, including air quality, noise and temperature reduction benefits as well as mental and physical benefits for the community. Such nature-based solutions can also become mitigation strategies in the event of heavy rains, water level rise or heatwaves. Treptow-Köpenick (Germany), one of the largest and least dense Berlin districts, observed fewer COVID-19 cases than the more central and densely populated districts. In addition to other factors, this may be related to the urban design, which includes large natural areas and might have favoured more outdoor activities and facilitated social distancing.[12]

Lessons learned regarding urban greening – closely related to making public spaces for people – are not new, but they were highlighted during the COVID-19 pandemic, which was an emergency European cities were not prepared for. In this sense, risk identification and scenario-based thinking could become useful tools for creation of both emergency plans and resilient urban planning at a local scale, potentially reducing or avoiding associated health impacts.

Ensuring local access to basic services helps to promote a healthier (and more equitable) society. This includes access to electricity, water and sanitation, but also to safe and adequate housing and health care. In addition, growing evidence points to other amenities such as green spaces being critical when it comes to its positive effect on health and well-being. This is something that was clear for most interviewees, whose cities were pushing for different plans and strategies to increase and improve green infrastructure in their cities, including Jerusalem (Israel), Izmir (Türkiye), Newcastle upon Tyne (United Kingdom), Helsinki (Finland) and Utrecht (Netherlands). Moreover, it seems that the COVID-19 pandemic helped to highlight the importance of having high-quality, local and accessible green spaces to become a healthier (and more sustainable and resilient) city.

Proximity and equitable distribution of basic services (including health care) may facilitate faster responses during emergency situations, thereby potentially minimizing health impacts. Also, infrastructure design in which certain risks have been accounted for allows greater flexibility in adapting to or mitigating the impact of a future emergency. In terms of access to electricity supply, for example, Treptow-Köpenick (Germany) indicated that future energy supply grids should have smaller dependent sections, ensuring that – in the event of a power outage – the affected area is smaller and more manageable for local authorities (especially in terms of providing basic needs and attending to vulnerable groups with higher health risks). For example, as noted earlier, power cuts can have a wide array of consequences and potential health impacts. In addition to telecommunication connections being compromised (and emergency calls limited or impeded), people being trapped in elevators or in public transportation and people who require oxygen supply at home having to rely on batteries, power cuts can compromise water purification plants, as happened recently in Texas (United States of America), with a serious potential impact on human health.

Another basic need is safe and adequate housing. In addition to buffer zones and restricted areas, cities with seismic risk, such as Palaio Faliro (Greece) and Izmir (Türkiye), are seeking to ensure the structural soundness of buildings in the event of an earthquake by strengthening building regulations. This not only reduces material damage but, more importantly, greatly reduces the risk of collapse and potential injuries and deaths. Promoting housing adequacy to cope with emergencies through stricter building regulations was also implemented by Figueira da Foz (Portugal). In addition to these considerations for safer housing when faced with earthquakes or strong winds, adequate ventilation has proved critical in the cases of COVID-19 and other airborne diseases, while improving energy efficiency in homes can help mitigate extreme indoor heat and cold, which is associated with increasing risk of respiratory and cardiovascular conditions (WHO, 2018).

Table 4 shows a selection of relevant responses to lessons learned (described in subsection 5.3) by the case study cities that are most strongly associated with the three main sustainable urban planning categories described above, showing how these planning interventions can make cities not only more resilient but also more sustainable and healthy.

[12] Interviewees from Treptow-Köpenick considered that it was too early to respond to questions on impacts, actions taken and lessons learned from the COVID-19 experience, however. A thorough review of the experiences is required before policies that may affect urban planning and design can be formulated.

Table 4. Responses to lessons learned and how they relate to healthy urban planning

Responses to lessons learned	Promoting active mobility	Reducing risk exposure through planning	Ensuring local access to basic services
Coordinate and communicate			
Coordination across levels	✔	✔	✔
Definition of roles and responsibilities		✔	✔
Communication with the community	✔		✔
Building awareness	✔	✔	
Consultation, dialogue and public participation	✔	✔	✔
Go local			
Proximity lifestyle	✔		✔
Mobility choices	✔	✔	✔
Key elements and human scale	✔	✔	✔
Distribution of services	✔		✔
Local production and supply		✔	✔
Energy safety and sufficiency		✔	✔
Go green			
Recognizing the value of urban and periurban green spaces	✔		✔
Nature-based solutions		✔	
Access and equity in the distribution of urban green spaces	✔	✔	✔
Green infrastructure and public health	✔	✔	✔
Rethink, rebuild and regulate			
A healthy urban planning approach	✔	✔	✔
Staying functional		✔	✔
Buffer zones and restricted areas		✔	
Strengthening building regulations		✔	
Strengthening land use planning and practice	✔	✔	✔
Improving infrastructure design	✔	✔	✔
Mapping data		✔	
Emergency material			✔
Maintain a long-term vision			
Emergency preparedness (not restricted to operational capacity and readiness)		✔	✔
Risk identification and “scenario-based” thinking		✔	✔
Climate change adaptation in urban settings	✔	✔	
Drafting/approving urban and land use plans	✔	✔	✔
Evaluation	✔	✔	✔

6.2 Gaps and needs

Interviews revealed how three cross-cutting elements – equity, evaluation and learning mechanisms, and compilation of relevant information in advance – do not seem to be embedded in planning and preparedness strategies. Although these issues might have been mentioned or tackled in part by some cities, in general they were not addressed in the responses, and few examples were given of specific plans or actions where these elements were considered central.

Equity in emergency preparedness plans (or in urban planning in general) was not strongly considered and/or explained by the interviewees. While the issue of equity might be implicit when talking about equally distributed services (medical, public transport and so on) and green spaces throughout the city – as in the cases, for example, of Jerusalem (Israel) and Utrecht (Netherlands) – usually no examples of specific plans or actions were provided.

This is a complex issue, as diverse events may lead to different people being vulnerable. While flooding events may affect those with limited mobility, a forest fire might have a greater impact on someone with asthma, while a snowstorm could affect someone with cardiovascular symptoms and without heating in the house. Mental health impacts can also vary greatly. Some cities provided experiences where equity (and/or gender, ethnicity, human rights, social inclusiveness or disability) were taken into account. During the emergency response, Dresden (Germany) mentioned that the focus was on people with disabilities and functionally limited residents, while Newcastle upon Tyne (United Kingdom) acknowledged the added difficulty (and perhaps also health risk) of evacuating people from their homes when residents suffered some kind of mental illness. In Treptow-Köpenick (Germany), during the power outage, the focus was on people requiring an oxygen supply at home.

In Helsinki (Finland), the interviewee mentioned that, while equity, gender and accessibility are always considered in the masterplan for the city, some smaller plans for specific areas dealing with particularly diverse populations (compared to the rest of the city) have given greater attention to the matter of inclusiveness. In Izmir (Türkiye), when a residential building is structurally compromised, or is located in a seismic risk area and is not to code, much effort is put into demolishing and rebuilding in the same place, thereby keeping citizens in their environment and not relocating them to other areas of the city, even though this might well be faster and cheaper. This, according to the interviewee, is motivated by the fact that people do not want to leave their living environment, and it is considered by local authorities and made compatible with much-needed urban regeneration in certain neighbourhoods.

The most explicit example of equity acknowledged in relation to urban design was provided by Rouen (France), which planned to move the location of an area to welcome les gens du voyage[13] because it was located in an industrial area. As noted by the interviewee, "no human being should be treated differently when it comes to industrial security. [...] It's a question of dignity." This city has also taken specific action to address gender equality – for instance, by working on female representation in the public space (through the renaming of streets and schools, replacing some statues, art choices in the street, or education).

Despite these valuable examples, the interviews overall revealed that attention to disability issues was the aspect that seemed most developed and most easily linked to urban and building design, while equity (including gender equity) was less visible in the discourses and less implemented in specific actions. Since cities can increase inequities, thereby negatively affecting not only health but also resilience and sustainability, this is an important gap for consideration.

The analysis of the interviews revealed that most cities do not have defined **evaluation and learning mechanisms** in place to learn from their experiences in emergency management, or to learn from experiences in other cities. Despite the many tools and indicators available at an international level,[14] these were rarely mentioned by interviewees as helpful mechanisms at the local level to measure the impact of the emergency and recovery experience. Dimensions to describe the quantitative impact of the disaster experience were most often limited to cost and economic data and to general health system indicators (such as the number of deaths or hospitalizations), but did not provide information that could help to improve urban resilience or overall emergency management performance. Treptow-Köpenick (Germany) highlighted that, apart from numbers of affected people and institutions, indicators to assess the impact were mostly related to economic damage, as many businesses registered and claimed compensation in the case of the power outage. However, performance indicators for the emergency event did not come up during any of the interviews, or interviewees were not aware of them. Newcastle upon Tyne (United Kingdom) stated that one thing they had learned from responding to COVID-19 was that "we don't use data enough within the resilience sphere. But now we do."

There was mention of external evaluations in the case of monitoring pollutants in Rouen (France) and in Flix (Spain), and support from universities and research institutes for Newcastle upon Tyne (United Kingdom) and Helsinki (Finland). As stated by Finland, "these are different communities which should definitely work together".

[13] A French term meaning "travellers", which refers to citizens who have a traditional way of life originally based on mobility and travel (living in campers or house trailers), even though many of them are now sedentary rather than nomadic.

[14] See *Review of indicator frameworks supporting urban planning for resilience and health*, the third report on protecting environments and health by building urban resilience, for an overview of the applicability of urban indicator frameworks.

Nis (Serbia) mentioned the need for this kind of close collaboration with research centres; for example, to gain better understanding of air quality levels and associated health risks, which are becoming a significant concern in the community. This would be very helpful to assist local authorities in keeping their citizens better informed, and to be able to design plans and actions targeted to address the issue. These responses showcase the need to have stakeholder engagement from different sectors when planning for resilience, incorporating these actors at the beginning of the process so that they can bring these insights and tools into the planning process and consequently into responses.

Emergency drills and simulation exercises are also tools to improve resilience. Despite their usefulness as learning strategies that strengthen emergency response plans and teach the community what to do (or not to do) in case of an emergency, few cities reported doing them in a frequent and disaster-specific manner. Treptow-Köpenick (Germany) and Flix (Spain) mentioned this as an aspect to be improved. An example of a city where awareness and environmental risks seems to be strong in emergency and contingency planning is Helsinki (Finland), which practises emergency drills on climate change and related emergencies for city management leaders.

It was often considered too soon to evaluate and extract lessons learned from management of the COVID-19 pandemic. However, some interviewees stated that there was already (or would be shortly) an evaluation of the response to COVID-19 crisis management. For instance, in Dresden (Germany), various departments are evaluating this, while others like Rouen (France) have established a citizen committee for reflection.

Overall, the interviews did not reveal the existence or development of structured mechanisms either to evaluate the management of past emergencies or to learn from past experiences and share these with others. Internal evaluation and public consultation should become part of a learning process, as this also serves as an exercise in institutional commitment and accountability. In the light of the analysis of the interview results, such structured learning and evaluation could provide relevant insights and tap into local preparedness planning potential. Improved engagement with networks of cities – locally, regionally or internationally – could be another opportunity for an exchange of lessons learned on urban planning, enabling collective learning and collaboration.

A key aspect of emergency preparedness is **compilation of relevant information in advance**: having the right information to respond and manage disaster effectively and efficiently. This requires an acknowledgement that diverse events will raise different needs, and vulnerable groups may differ depending on the context and type of event. Interviews revealed that many cities had to compile relevant information and registries from scratch; for example, establishing:

- which facilities have emergency power supply, or who has a list of people requiring medical care at home;
- which open areas are safe for people who have been evacuated from buildings during an earthquake to gather in; and
- which installations or plants need to be protected or shut off during flooding to avoid major environmental disaster.

Searching for this information may be much more difficult when a disaster strikes because communication is compromised, among other variables. Hence, relevant information should be compiled before an event takes place, setting up internal structures and procedures that anticipate what type of information and exchange is needed for different scenarios. This includes mechanisms for effective information-sharing among different sectors and actors.

Relevant information for emergency response may not even be available (or not at the required level), and will therefore have to be created. This was the case in Newcastle upon Tyne (United Kingdom), where dealing with the damage from the flood and underground water rise was especially challenging because of the lack of precise underground information (with a nineteenth-century sewage infrastructure and pits from former coalfields). Ongoing development of an underground digital map will provide much-needed information not only for emergency preparedness but also, in general, for building with increased awareness of potential risks.

While emergency drills and simulations may help to identify needs for information, pulling them together in advance entails significant administrative work and scenario-based thinking – especially intersectoral preparedness work on collaboration and information flows. Being able not only to consider a broad range of crises but also to speculate that different emergencies might occur simultaneously or have cascading effects, where some emergencies cause others, should also be part of scenario-based thinking and preparedness plans.

Finally, part of this preparedness work of compiling relevant information in advance could identify where urban planning features can support resilience and decrease vulnerability. For instance, it could assist in ensuring availability of sufficient open safe areas for evacuation, guaranteeing that roads are adequate for emergency vehicles to pass along (especially evacuation routes) and preventing flood-risk areas from being built on.

6.3 Limitations of the study

6.3.1 Case study selection

Several limitations related to case study selection should be acknowledged. In terms of diversity in city sizes, smaller cities in general proved harder to contact, and it was more difficult to find a representative to conduct the

interview in English. The research team was able to offer interviews in German for Dresden and Treptow-Köpenick (Germany) and in Spanish for Flix (Spain), but could not offer other languages that could have been useful, especially in eastern European cities in the WHO European Region.

Eastern European cities may also have been under-represented due to a lack of international media coverage (with information published in English) reporting on events occurring in those countries. Since these cities rarely appeared in the reviews of literature on disasters in recent years, this limited their inclusion in the project.

Approaching potential interviewees also varied depending on the country and the mechanism in place to approach local officials. In some cases, official requests and approval had to be issued through one or more departments/bodies (sometimes national bodies). Given the very limited time frame, this more complex procedure was not always possible, so cities in such countries were less likely to be represented in the final selection.

6.3.2 Interview guides

Two interview guides were prepared for the project: **interview guide A** for cities with specific disaster experience and **interview guide B** for cities without specific disaster experience (see Annex 3). These questions were meant to be used as a preliminary guide, which would be adapted to the local situation and assist with development of the conversation to collect experiences and lessons learned effectively. Interview guide A proved to be more adequate for natural or environmental disasters, as some questions were not applicable for events such as power outages or other infrastructure failures. Interview guide B started from the premise that no major event had happened in the last decade. However, both cities interviewed with this questionnaire – Helsinki (Finland) and Utrecht (Netherlands) – mentioned recent and increasingly concerning experience of heatwaves, showing that no city is probably entirely free of some kind of extreme weather event, even if it is not considered "major". Conversation about the heatwaves arose spontaneously during the interviews, so less information was captured about these events.

Applicability of certain questions (especially those on lessons learned and drafting or approval of new legislation or strategic plans) was also dependent on the year in which emergency events took place in each city. Analysis shows that the time factor necessarily determined whether the local authorities had been able to:

- evaluate the response to the emergency;
- reach full recovery;
- implement mitigation measures; and
- draft and approve new plans and strategies to become more resilient.

In some cases, such as Figueira da Foz (Portugal), less than two years had passed between the hurricane and the COVID-19 outbreak. This had a strong impact on the city's capacity to recover fully, and much-needed preventive measures for future similar disasters had been postponed. Conversely, Dresden (Germany) had experienced a catastrophic flood event in 2002 and another significant flood in 2013; this gap provided sufficient time to plan and implement a range of strategies and interventions for urban planning and preparedness.

Closely related to this last point, section 5 of both interview guides was focused on the effect of COVID-19 on the city. This covered not only impacts and actions taken regarding urban design or infrastructure but also lessons learned from the experience and how it might motivate a more integrated collaboration between health and urban planning. Especially for the latter category, early ideas and hopes were shared, but interviewees frequently stated that it was "too soon to know", since cities were still facing the immediate response. More time will be needed for a proper evaluation of how the crisis has been managed and what can be learned from it to inform urban planning and design.

6.3.3 Interview process and format

Interviewees' backgrounds varied depending on the case study. They included urban planners, mechanical engineers, environmental planners, resilience experts, deputy mayors and, in three cases, the city's mayor. This diversity in interviewees' backgrounds and positions could have determined their capacity to answer certain questions, or the level of detail that they could provide – especially for those questions requiring a more technical view of a certain area (such as public health).

This limitation was reduced in cases where two interviewees with different (and complementary) backgrounds participated – together in Newcastle upon Tyne (United Kingdom), Palaio Faliro (Greece) and Treptow-Köpenick (Germany), and separately in Dresden (Germany) – but the majority of interviews were carried out with only one interviewee. Overall, interviewees were highly capable of providing valuable answers to nearly all the questions asked. In this regard, sharing the questionnaire beforehand proved helpful, as it provided time for interviewees to check specific data or consult with colleagues from other departments, if deemed appropriate. It was also positive in terms of establishing trust and transparency between interviewer and interviewee.

The interviews were conducted using an online meetings platform. Effective communication was thus dependent on sufficient Internet connection for all parties. This generally worked well; however, in some cases the platform of choice was temporarily out of service or malfunctioning, or firewall software would impede the connection of some interviewees to certain platforms. Although all problems of this sort were solved, in some cases it delayed the starting time of the interview, meaning that it either took longer than the 1.5 hours scheduled or required

interviewers to ask questions in the last sections more quickly. This proved the need to have a "back-up" link to a different platform prepared beforehand, to avoid spending interview time on technical issues.

The same process, format and method of conducting and analysing the interviews was applied to each case study. There was, however, great heterogeneity in both the content and extent of the "raw data" extracted from each interview. The number of questions that could be answered and the detail provided in the answers depended largely on the interviewees' backgrounds and positions. In general, those interviews conducted with two interviewees were longer, and more information was provided. Some topics prompted follow-up questions from the interviewer (for example, if a new policy or action plan was being drafted or approved, this might have led to further questions on goals and guiding principles), while others did not.

All these variables, in addition to different communication styles among interviewees and possible language barriers, led to disparities in the length and richness of the interview content. Despite a conscious effort to represent all the case studies in the analysis fairly, inevitably some are referred to more than others in the analysis and discussion sections.

6.4 Towards a better integration of health and urban planning

Urban planning in cities has experienced (and is experiencing) vast changes to ensure and promote the health and well-being of its citizens. Most of the interviewees believed that increased awareness of urban resilience as a mechanism for local implementation of sustainable development will encourage or strengthen integration of health and urban planning at the local governance level.

Most interviewees stated that it may be too early yet to understand how the COVID-19 pandemic experience will affect local planning. Nevertheless, most cities expected that it would indeed affect local planning priorities and the overall mindset, leading to better integration of health in how people think of and design cities.

6.4.1 The main challenges for better integration of health and urban planning

The most common challenge the cities interviewed cited was that health competencies were fixed at either regional or national authorities. This requires collaboration and communication among different government levels (vertical communication), which can be more challenging than interdepartmental collaboration (horizontal communication) within local government. Nevertheless, the interviews provided interesting examples of how, in some cases, health and urban planning can be integrated locally when thinking of the urban design of the city. Flix (Spain) has created health plans for specific populations at a local level, although it lacks a comprehensive strategy that includes the community as a whole. For example, after an intensive participatory process, a sectoral health plan focused on elderly people led to the installation of "health parks" – green spaces adapted for elderly people and people with reduced mobility.

Newcastle upon Tyne (United Kingdom) expressed optimism about the deliberate move of public health officials in the United Kingdom from the National Health Service into local authorities in 2012 (as part of the Health and Social Care Act). This allows more local influence on health policy and interventions. Moreover, public health authorities in Newcastle upon Tyne are pushing for a shift from "treating" people with (for example) obesity to funding population-level interventions such as parks or cycleways to primary schools. The money spent in treating this kind of widespread illness is being redirected towards health creation and promotion at the population level. Alongside this, the urban planning and design of the city is encouraging and facilitating the practice of physical exercise, thereby encouraging healthier lifestyle options for the community.

Figueira da Foz (Portugal) noted that the COVID-19 emergency triggered legislation changes so that some health competencies were transferred from the national government to municipalities. This has given local authorities greater responsibilities to include health plans for their communities; it is hoped that this will strengthen the health perspective in other areas of urban planning and emergency preparedness strategies.

Common to these examples is the focus on urban settings as a mechanism to promote health and well-being by supporting healthy and active lifestyles and enabling a good quality of life, rather than an emphasis on health care and treatment. Similarly, local action can be adapted to benefit especially disadvantaged population groups.

6.4.2 How cities can become more healthy, sustainable and resilient

In the light of the experiences shared, it is clear that there is still a long way to go in terms of integrating health and urban planning. As stated by Utrecht (Netherlands), what is usually referred to as "soft additions" to urban planning (such as incorporation of environmental and health perspectives) should really be a primary part of their main strategies. These cross-cutting links are stronger in cities where the local authority has an official mandate to embed health objectives in urban planning, including explicit competence supported by staff with public health expertise.

In addition to including public health considerations in urban planning (including assessing health impacts at the population level), taking into account health-care facilities and health-sector activities in urban planning and design can be crucial during emergency preparedness and response (ASPR, 2016). Health-care facility mapping should be included when conducting disaster risk assessments. Incorporating regional health-care facility emergency planning efforts into overall emergency efforts could be an asset, particularly in rural areas, where primary health centres or regional

hospitals could be key infrastructure to be taken into account. For example, this has proved instrumental in efficient COVID-19 vaccination rollouts. Jerusalem (Israel) mentioned how the success of vaccination campaigns in Israeli cities could be connected to urban planning, because services are distributed and not concentrated: "When you are distributing institutional and public spaces [throughout the city], everything is more resilient and you can operate more efficiently". A major theme for sustainable, healthy and resilient cities thus seems to be the average distance between and ease of access to basic services and amenities. This is a key element of urban planning and obviously has an impact on local dependencies and vulnerabilities when cities are affected by extreme events and restricted functionality.

Building resilience is about breaking silos and creating collaborative environments. The case studies describe how embedding health in local urban planning has certain limitations, however – not just because of the health competencies issue described above but also in terms of certain infrastructure being owned, managed and/or designed by regional or national bodies. Newcastle upon Tyne (United Kingdom) described this issue during one of the flood events, where after the collapse of a culvert it became very hard to tell who was liable and responsible for its repair.

Finally, all actions that contribute to achieving universal health coverage, in accordance with the United Nations 2030 Agenda for Sustainable Development, through well planned primary and community health-care facilities at the local level are also a way to strengthen emergency preparedness and response, leading ultimately to more resilient cities and societies.

7. Key messages and conclusions for healthy and resilient urban planning

This section examines and elaborates on the 10 key messages extrapolated from the 12 case study city interviews. While it should be acknowledged that the sample is limited (and thus not representative or exhaustive), these messages consolidate shared knowledge about the links between urban disaster management and planning and health. The relevant lessons learned are indicated below each key message (see subsection 5.3 for further details).

1. Disaster experience, recovery, prevention and preparedness mechanisms should be used to push for changes that can make cities more healthy, sustainable and resilient.

Although changes may be pending, recent emergencies provide powerful examples of the potential effects of infrastructure failure or climate change, and can catalyse paradigm shifts. This can help to convince decision-makers of the need for investment in adaptation and mitigation strategies for the city, and motivate stronger collaboration between urban planning, environment and health areas to work on these strategies together. Disasters can also make more visible the interconnectedness among different sectors such as public spaces and health. Natural disasters in some cities have facilitated more systemic thinking, the rationale to prepare for climate change and better long-term planning and infrastructure management.

Lessons learned that support this key message are coordinate and communicate; go local; go green; rethink, rebuild and regulate; and maintain a long-term vision.

2. Urban resilience should be thought of as more than just emergency preparedness.

Emergency preparedness is the ability to respond quickly and effectively to emergencies. Resilience is the planning, coordination and mitigation that allows the city to respond to a disaster, to learn and adapt, and to become better. Building resilience to disasters is therefore not just ensuring the capacity to respond technically to an immediate crisis. It also includes more strategic processes for mitigation, prevention and preparedness that involve actions such as risk identification, analysis and appraisal; land use planning; capacity-building; training; and exercising. This is most effective if done through a holistic approach with collaborations across sectors and levels.

Lessons learned that support this key message are coordinate and communicate; rethink, rebuild and regulate; and maintain a long-term vision.

3. Planning requirements should be applied as a tool to prevent the siting of functions and infrastructure in areas at risk of environmental disasters.

Urban and land use planning can apply preventive approaches to implement buffer zones and prohibit siting of infrastructure and critical functions in risk-prone areas. Planning regulations can also be applied to protect critical green infrastructure, which itself is a measure of urban preparedness and resilience. Cities should also strengthen building regulations to make building stock more resistant to strong winds, seismic events, fires or water damage in case of natural disasters.

Lessons learned that support this key message are go green; rethink, rebuild and regulate; and maintain a long-term vision.

4. Authorities should consider how emergencies are/can be interconnected.

Being able to contemplate the full range of crises, and considering that they could occur simultaneously (as with the COVID-19 pandemic) will help cities be better prepared and mitigate the cascading effects that some emergencies may cause. Practising "scenario-based thinking" – testing various emergency scenarios – is a useful tool for creation of emergency plans and resilient urban strategies that contemplate a broader range of social, health, environmental and economic impacts. This is especially relevant when considering the effects of climate change on cities.

Lessons learned that support this key message are rethink, rebuild and regulate; and maintain a long-term vision.

5. Horizontal and (especially) vertical communication across different departments and levels of government should be improved.

Cities will become better at facing future emergencies if communication and collaboration is fluent and transparent among different government bodies and areas. This cannot be something that occurs only during an emergency; rather, it should be an ongoing practice that builds institutional capacity and shapes resilience.

Lessons learned that support this key message are coordinate and communicate; and maintain a long-term vision.

6. It is important to uphold the public perception that local authorities are executing their mandate for environmental and health protection measures.

People increasingly hold their local authorities accountable for effective protection from environmental and health risks. This can be strengthened by improving communication with the community, creating the environment and putting mechanisms in place to facilitate consultation and participation, being rigorous and transparent with the information provided, and being accountable for the longer term. Consistent, clear communication is fundamental to successful emergency management, especially when the public is required to take specific action or modify behaviours.

Lessons learned that support this key message are coordinate and communicate; rethink, rebuild and regulate; and maintain a long-term vision.

7. Cities should collaborate with and learn from others.

Cities can benefit from better collaboration and collective learning. This can be done bilaterally (via peer-to-peer exchange, nationally and internationally) and through city networks that can act as effective facilitators of this exchange of collective knowledge and experiences.

The lesson learned that supports this key message is coordinate and communicate.

8. Crisis management should be evaluated to keep learning, improving and planning more resilient, sustainable and healthy urban environments.

Evaluation and learning mechanisms are key. This can be done by using tools and indicators (useful in all stages of emergency management), and/or by working closely with research institutions or other external bodies that can evaluate impact, management and performance of past events (and perhaps predict future ones). In addition, spaces for reflection on past experiences and identification of lessons learned should be done both internally (within the local government) and with the community. Localization of indicators, especially for health, can be useful to monitor short-term and long-term progress.

Lessons learned that support this key message are coordinate and communicate; rethink, rebuild and regulate; and maintain a long-term vision.

9. Local access to basic services should be ensured through equitable distribution and proximity lifestyle paradigms.

The more independent neighbourhoods are, the less vulnerable and dependent a city is when it comes to partial functional or management failures. Distribution of services and amenities provides redundancy in urban structures and services (including public transportation networks), and it is very likely to support equity (another co-benefit for healthy and sustainable urban planning). While this will not work when a whole city is affected, the more independent districts are, the more resilient they are and the more likely to be able to support other districts if extreme events take place. In this sense, building forward better to be resilient and functional, even in extreme events, may require planning ahead for redundant structures and having a "plan B" for key services.

Lessons learned that support this key message are go local; go green; rethink, rebuild and regulate; and maintain a long-term vision.

10. Health should be better integrated as a cross-cutting element of urban planning.

Health should be better integrated into urban planning, and should be seen as a key public health intervention. Rather than a "soft addition", health is a fundamental aspect of urban strategies to build forward better, with direct and indirect impacts on livelihoods, well-being and sustainable development. Frameworks such as Health in All Policies provide guidance tailored for cities to make health and well-being cross-cutting.

Lessons learned that support this key message are go local; go green; rethink, rebuild and regulate; and maintain a long-term vision.

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Annex 1

List of case studies and interviewees

#	City (Country)	Population	Event	Year	Interviewee	Position
1	Flix (Spain)	3410	Forest fire River pollution	2019 2004 – present	Francesc Barbero	Mayor of Flix
2	Figueira da Foz (Portugal)	58 750	Forest fire Hurricane	2017 2017 and 2018	Ana Carvalho	Deputy Mayor, City of Figueira da Foz
3	Palaio Faliro (Greece)	59 790	Earthquake Water pollution	2019 Continuous	Maria Anna Skolinou Ioannis Arkoumanis	Mechanical Engineer, City of Palaio Faliro Vice Mayor for Health and Social Services
4	Rouen (France)	111 360	Industrial accident	2019	Nicolas Mayer-Rossignol	Mayor of Rouen and President of Métropole Rouen Normandie
5	Nis (Serbia)	183 160	Flood Air pollution Water pollution	Annual, during rainy season Continuous Continuous	Tanja Obradović	Chief Urban Planner, City of Nis
6	Treptow-Köpenick (Germany)	273 690	Energy shortage	2019	Oliver Igel Bernd Geschanowski	Mayor of Treptow-Köpenick District District Councillor on Health and Environment
7	Newcastle upon Tyne (United Kingdom)	302 820	Flooding Power outage	2012 2019	Tom Warburton Helen Hinds	Director of City Futures, Newcastle City Council Head of Resilience Planning, Newcastle City Council
8	Utrecht (Netherlands)	359 380	No recent disaster	–	Joost van Faassen	Strategic urban planner, City of Utrecht
9	Dresden (Germany)	556 780	Flooding	2002, 2013	Frank Frenzel Freya Trautmann	Environmental Department, City of Dresden Dresden City, Department of Health and Prevention
10	Helsinki (Finland)	653 830	No recent disaster	–	Susanna Kankaanpää	Environmental Planner, City of Helsinki
11	Jerusalem (Israel)	936 420	Snowstorm Heatwave	2013 Frequent	Miri Reiss	Local Healthy Cities Coordinator, Environment Department, City of Jerusalem
12	Izmir (Türkiye)	4 320 520	Earthquake Forest fire Drought	2020 2019 Continuous	Onur Eryüce	Counsellor to the Mayor of Izmir Metropolitan Municipality

Annex 2

Cities in the WHO European Region with selected recent emergency events

Note: This list results from a preliminary search for major emergencies in the last 10 years in cities in the WHO European Region, and is therefore not exhaustive. It does, however, provide a general overview of the type of events, and indicates that emergencies are a relevant urban challenge across the WHO European Region. Cities interviewed for this project are marked in grey.

City/region (Country)	Size (Approximate population)	Type of event	Year	Brief description
Earthquakes				
Durrës (Albania)	Medium (175 000)	Earthquake	2019	In September 2019, an earthquake measuring 6.4 on the Richter scale – the most powerful in 30 years – caused damage to 500 buildings and strongly affected the coastal city of Durrës.
Zaqatala (Azerbaijan)	Small (21 000)	Earthquake	2012	In May 2012, an earthquake measuring 5.6 on the Richter scale hit the area of Zaqatala, affecting over 3000 houses and public buildings.
Palaio Faliro (Greece)	Small (60 000)	Earthquake	2019	An earthquake in Greece in 2019 strongly affected buildings and infrastructure, causing structural cracks in a large number of buildings in Palaio Faliro.
Samos (Greece)	Small (33 000)	Earthquake	2020	In October 2020, an earthquake measuring 7.0 on the Richter scale hit the Greek island of Samos, leaving many buildings severely damaged or collapsed, and causing two fatalities and 19 minor injuries. This earthquake also affected the province of Izmir (Türkiye).
Finale Emilia (Italy)	Small (15 100)	Earthquake	2012	In May 2012, an earthquake measuring 6.1 on the Richter scale struck northern Italy, mainly affecting the Emilia-Romagna region, causing the collapse of several structures and causing 27 fatalities.
Izmir (Türkiye)	Large (4 300 000)	Earthquake	2020	In October 2020, Izmir was shaken by an earthquake measuring between 6.6 and 7.0 on the Richter scale. There were 116 fatalities; many people were injured; and many buildings collapsed.
L'Aquila (Italy)	Small (70 000)	Earthquake	2016	In August 2016, an earthquake measuring 6.2 on the Richter scale hit central Italy. Seven strong aftershocks had magnitudes of 4.0 to 5.5. At least 250 people were killed and many more were injured.
Zagreb (Croatia)	Large (807 000)	Earthquake	2020	In March 2020, an earthquake measuring 5.3 on the Richter scale hit various cities in Croatia. It was the strongest earthquake in Zagreb since 1880, and caused considerable damage in the historical city centre.
Weather extremes				
Dijon (France)	Medium (157 000)	Heatwave	2003, 2019	In 2003, Europe suffered from its hottest summer since at least 1540. France was one of the countries most affected, with 13 802 heat-related deaths during the heatwave. Dijon, Le Mans and Lyon were among the cities most affected. In July 2019, these cities were also affected by two heatwaves and recorded temperatures of 45.9°C (the highest ever recorded), leading to over 1500 fatalities.
Le Mans (France)	Medium (264 000)			
Lyon (France)	Large (1 610 000)			
Bucharest (Romania)	Large (1 830 000)	Heatwave	Several occasions	In recent years, Romania has experienced several heatwaves which also hit the capital, with at least two fatalities in 2017.
Jerusalem (Israel)	Large (936 000)	Snowstorm Heatwave	2013 frequent	In December 2013, Jerusalem experienced a heavy snowstorm that left many parts of the city isolated; some areas had with no access to public transportation or electricity supply for up to two days. The city is also experiencing increasingly frequent heatwaves.
Wroclaw (Poland)	Large (643 000)	Extreme cold	2017	During January 2017, a period of exceptionally cold and snowy winter weather occurred in eastern and central Europe. During the first week, 46 people (mainly homeless people or migrants) died from cold in Poland when temperatures fell below −20 °C. Wroclaw was also affected by smog caused by the cold weather, with air quality in the area dropping to critical levels.

Moscow region (Russian Federation)	Large (12 000 000)	Heatwave/ drought	2010	In July and August 2010, a heatwave and drought were caused by record high summer temperatures; these also caused wildfires in various regions. Mortality rates increased in Moscow, and tens of thousands of deaths were caused nationally.
Tabernas (Spain)	Small (3700)	Desertification/ drought	Recent years	Tabernas is part of Almeria province, of which 35% is at risk of desertification. Tourism and agriculture require water, and this leads to overexploitation of aquifers. In this way, degradation of the land is generated and the desert advances.
Izmir (Türkiye)	Large (4 300 000)	Drought	Continuous	Izmir is facing increasingly frequent and concerning droughts that strongly affect its current agricultural economy and practice.
Industrial accidents				
Palaio Faliro (Greece)	Small (60 000)	Oil leak	2017	An oil leak caused river pollution in Palaio Faliro, and work to address this identified other environmental concerns in the area.
Ajka (Hungary)	Small (30 000)	Toxic sludge	2010	In 2010, the collapse of a waste repository dam where a bauxite processing factory operated caused a leak of millions of tonnes of toxic red sludge, which flooded near the town of Ajka. As a result, 10 people died, 150 were injured and 400 had to be evacuated from the area. The natural environment and animals living in the surrounding area were also affected.
Rouen (France)	Medium (111 000)	Industrial accident	2019	In September 2019, a factory of oil-related products in Rouen was subject to a big fire, in which toxic products released gases and particles that created a large cloud and caused great environmental impacts and potential health risks. In addition, a leak of chemical products into the River Seine in previous decades could still be causing environmental impacts in the river.
Flooding				
Vlore (Albania)	Medium (130 000)	Flooding	2015	Heavy rainfall during February 2015 caused major flooding in Vlore and southern parts of Albania in general. Some 42 000 people were affected, houses were damaged, and 17 000 acres of farmland flooded. The government declared a state of emergency for the worst affected areas.
Atbasar (Kazakhstan)	Small (30 000)	Flooding	2017	In May 2017, Kazakhstan suffered several floods caused by rain and snow melt; these led to damage, especially in northern regions. Around 10 000 citizens had to be evacuated, and some had to stay in temporary shelters for over a week. In the city of Atbasar, a dam ruptured, flooding more than 400 homes.
Farkadona (Greece)	Small (13 400)	Flooding	2018, 2020	In recent years, Farkadona has suffered several flooding events. These included one in September 2020, which affected thousands of people in Thessalia and other parts of Greece, and another in March 2018, caused by an overflow of the River Pinios and its tributaries.
Newcastle upon Tyne (United Kingdom)	Medium (300 000)	Flooding	2012	Several flooding events in 2012 caused great damage in Newcastle upon Tyne. Rainstorms overwhelmed the River Tyne and the underground railway, especially affecting Newburn neighbourhood.
Ljubljana (Slovenia)	Medium (280 000)	Flooding	2010	In September 2010, Slovenia experienced heavy rains throughout the country, causing several rivers to flood. The capital (Ljubljana) was among the areas most affected. Electricity was shut down as a preventive measure, leaving 3000 people in the dark for several days.
Nis (Serbia)	Medium (183 000)	Flooding Water pollution	Annual During the rainy season	The flooding of the River Nisana during the rainy season frequently causes material damage and temporary interruptions to electricity and drinking-water supply in the suburbs of the city of Nis. The city is also affected by water pollution from the river.
Lviv (Ukraine)	Large (720 000)	Flooding	2020	In June 2020, western regions of Ukraine – including Lviv – were affected by floods. Three fatalities were reported; more than 2500 people were evacuated; and approximately 14 000 houses were damaged. Roads and bridges were also damaged.

Dresden (Germany)	Large (557 000)	Flooding	2002, 2013	In August 2002, an unprecedented flooding event in Dresden affected all local water bodies and systems for over 10 days, causing four fatalities and affecting 107 000 residents. Another major flood took place in 2013, although the impacts of this were less severe thanks to better preparedness.
Service failures				
Newcastle upon Tyne (United Kingdom)	Medium (300 000)	Power outage	2019	In August 2019, a national power outage disrupted the whole transport infrastructure and temporarily interrupted Newcastle Airport's electricity supply.
Bucharest (Romania)	Large (1 830 000)	Heating system failure	2019, 2020	In November 2019, owing to broken pipes in the centralized heating system, some residents of Bucharest did not receive hot water for several days. In February 2020, two of Bucharest's six districts were left without hot water and central heating after a failure of the heating distribution network.
Treptow-Köpenick (Germany)	Medium (273 700)	Energy shortage	2019	In February 2019, two power lines were damaged during construction work on a local bridge in the district of Treptow-Köpenick. This caused a power outage that affected several parts of the district, which were left without power supply for 30 hours.
Fires				
Izmir (Türkiye)	Large (4 300 000)	Forest fire	2019	In 2019, the city experienced the largest forest fire of its recent history, affecting several villages and leading to the loss of great expanses of trees. Luckily, there were no casualties.
Attica region (Greece)	Large (3 800 000)	Fire	2018	During the European heatwave of 2018, a series of wildfires in Greece affected the coastal areas of Attica in July, causing more than 100 fatalities and affecting or destroying multiple vehicles and buildings.
Moscow region (Russian Federation)	Large (12 000 000)	Peat fires	2010	Wildfires broke out across the Russian Federation, primarily in the west and around the capital, in summer 2010. They started burning in late July for around two months. The fires were associated with record high temperatures and drought. The smoke from the fires and the ongoing heatwave put stress on the health-care system, and the fires affected crop production and destroyed houses and infrastructure.
Flix (Spain)	Small (3400)	Forest fire	2019	In the context of a heatwave, self-combustion of a dung heap on a farm caused a forest fire that devastated 6000 hectares.
Pedrógão Grande (Portugal)	Small (4000)	Fire	2017	In June 2017, a huge forest fire of unknown cause – preceded by a heatwave – started in the area of Pedrógão Grande, causing at least 64 fatalities and 135 injuries.
Figueira da Foz (Portugal)	Small (59 000)	Forest fire	2017	In October 2017, Hurricane Ophelia caused multiple fires in the central region of Portugal, which ended with 70 fatalities overall and burned 5000 hectares in Figueira da Foz.
Storms and hurricanes				
Beja (Portugal)	Small (36 000)	Subtropical storm	2018	Subtropical Storm Alpha was the first recorded subtropical cyclone to make landfall in Portugal. Beja was one of the cities that also suffered from a tornado, which is associated with supercell thunderstorms.
Figueira da Foz (Portugal)	Small (59 000)	Hurricane Tropical storm	2017 and 2018	In October 2017, Hurricane Ophelia caused major damage in Figueira da Foz. In October 2018, Tropical Storm Leslie brought the highest wind speed ever registered in the country and affected water supply, electricity and communications for weeks.
Timişoara (Romania)	Medium (306 000)	Storms and winds	2017	In September 2017, a storm produced heavy winds that damaged buildings and trees in Timişoara. Eight people lost their lives and over 60 were injured. Power lines were cut for several days, leaving households without electricity supply.
Funchal (Portugal)	Medium (112 000)	Hurricane	2018	In October 2018, Tropical Storm Leslie brought the highest wind speed ever registered in Portugal. In the Madeira archipelago, including Funchal, local authorities closed beaches and parks, and several flights were cancelled.

Annex 3

Case study questionnaires

Interview guide A (for cities with a specific urban disaster experience)

Introduction (3–5 minutes)

1. Identification of emergencies with environmental impact and main impact on the city (5–10 minutes)

a. What recent (within the past 10 years) natural and/or environmental emergency (or emergencies) has your city experienced? Please describe it briefly.
b. Was this emergency limited to an area or neighbourhood, or did it affect the city as a whole? Were other cities nearby also affected?
c. Was it the first time an event like this had happened in the city, or had it happened before?
d. How long did this emergency last?
e. Were basic services and infrastructure affected by this emergency? If so, how?
f. What impacts did this event have in terms of loss of life, health and environmental damage, economic, social and cultural impacts and so on? Were impacts lasting and significant?
g. Is this emergency event connected to other emergency events or vulnerabilities? For example, did one event affect or initiate another?

2. Practical challenges and crisis management (10–15 minutes)

a. What were the main challenges (environmental, technical and management) during the emergency situation? How were these managed – what departments were involved and how was the response coordinated? Were any major obstacles or problems encountered?
b. What were the health risks for the community, and how were they managed?
c. Were coordination mechanisms in place between urban planning, environment and health departments during the response? If so, were they effective? If not, do you believe that this would have been helpful for better emergency management?
d. Did the city receive support (financial, human, logistics and supply)? If so, from where? Was this support considered sufficient? If not, what aspect was lacking most?
e. Were any groups especially vulnerable to this emergency? If so, please describe them.
f. How was communication handled for this emergency? Was there a lead authority? If so, who was it? What mechanisms or channels were used? What information/instructions were given to people, and in what way – for instance, were media campaigns, guidelines or similar designed to reach the public? Was there a local community response?
g. Were early warning and information systems in place before the event?
h. Were there problems with supply and distribution of basic goods and services to the local population during the emergency? If so, were these affected by the urban design and structure? How was this addressed during the crisis?

3. Lessons learned and how they relate to urban planning and infrastructure design (10 minutes)

a. What main lessons can be learned from the management of this emergency?
b. What would you say were the key factors for full recovery (meaning getting "back to normal")? How long did this take?
c. Do any of these lessons have to do with urban planning and/or infrastructure design? Does the municipality have the mandate to work on all the factors that caused the crisis, or are some factors dependent on higher levels (such as the regional or national level)?
d. If supply and distribution of basic goods and services to the local population during the emergency were affected by the city's urban design and structure, what future changes can be made to avoid this situation next time?
e. What aspects of urban crisis management could be improved and become more effective, including in terms of collaboration between different local departments in high-pressure situations?
f. Were any indicators used to measure the impact of the emergency and recovery?

4. How urban planning and infrastructure design has been (or will be) changed to become more resilient. Plans and priorities of action (15 minutes)

a. Do you believe this recent emergency has led to long-term adjustment of local planning and infrastructure design in the city, or affected planning objectives?
b. As a consequence of the experience, what changes have been made (or are planned) on local planning and infrastructure design to avoid such situations and minimize the health impact on the local population in the future in terms of technical solutions, specific policies and regulations and similar? How has the overall mindset been changed?
c. Did this emergency (and especially the health impact of the event) affect how the city thinks about upgrading or building new infrastructure in general? What are the priorities for upgrading and/or building new infrastructure after the emergency experience?
d. Is local government planning in a preventive manner for future similar crises? If yes, by doing what exactly?
e. Are environmental impacts and health impacts considered together in local planning? If so, how will these aspects be strengthened in urban planning processes to avoid future problems?

f. Do urban planning, environment and health departments work together successfully in the drafting of these policies and practices triggered by the crisis? If not, what are the bottlenecks? Are there any conflicts between the different departments that may affect intersectoral collaboration?
g. Are gender, equity, ethnicity, human rights and disability issues accounted for in the planning and design of urban systems and infrastructure? If so, in what way? Please provide some examples.
h. Do you monitor environmental pollutants? If so, has your city assessed the health impact of environmental pollutants?
i. Are interventions and modifications in the public space considered as part of an urban strategy to increase resilience and quality of life for the citizens? If so, what interventions/modifications?
j. In what sense is the urban planning and infrastructure design better prepared for future emergencies? Do you think the city is well prepared now, overall, to face a new similar disaster, reducing or mitigating its consequences?
k. (If not yet mentioned during the interview) Does the city have formally approved plans or strategies related to emergencies and emergency response?

5. How the city has faced/is facing the COVID-19 pandemic (10 minutes)

a. What were the impacts and actions taken regarding urban planning or infrastructure when facing the COVID-19 pandemic? For instance, were there changes in the public transport service (such as increasing frequency or prioritizing certain modes)? Were new buildings created (such as temporary housing or hospitals), existing buildings modified or tactical urbanism to reconfigure public space, to address the spread of the virus and reduce its impacts? How were access restrictions to public spaces managed?
b. Can any lessons be learned from this experience that may affect future planning? What lessons can be adapted in the future, for instance, in terms of public transport services; distribution of products and services across the city; securing safe public indoor spaces in restaurants, shops or schools (or perhaps promoting outdoor schooling such as “forest schools”); or trying to keep public spaces such as parks and playgrounds open?
c. Do you believe this experience will motivate more integrated collaboration between health and urban planning? How?
d. To your knowledge, will the city’s response to the COVID-19 pandemic be evaluated and adapted to become more resilient to future environmental or health threats, using pre-defined indicators and standardized tools and processes and reporting accordingly?
e. Has the city conducted a public consultation about the lessons learned from COVID-19 and those changes the public wishes the city to keep or develop or change?

6. Intersection of emergencies (10 minutes)

a. Your city may have implemented urban design changes and interventions on local supply and distribution chains as part of sustainable and resilient planning in general, or as a reaction to recent crises. If so, did any of these interventions prove useful when facing the COVID-19 pandemic or other emergencies? Did any aspects of emergency preparedness (such as operational readiness, coordination between departments or access to contingency funding) make your response to the COVID-19 emergency more efficient and effective?
b. Could lessons learned from the COVID-19 experience also affect urban planning dimensions in the future – for instance, by assuring larger and more equally distributed open spaces, parks and playgrounds throughout the city or in terms of attending to the needs of the most vulnerable groups.
c. Many elements of emergency preparedness are common to all disasters. Apart from disaster-specific plans (for the initial emergency – the focus of this interview), do you believe that your city’s emergency preparedness follows an all-hazard approach?
d. Has the city established surveillance and warning systems?
e. Does your city have a health plan?

7. Use and impact of national and international framework documents (5 minutes)

a. Which type of guidance has your office/department found useful (if any) in terms of emergency preparedness planning and implementation?
b. Is your office/department familiar with the Paris Agreement, the SDGs or the Sendai Framework for Disaster Risk Reduction 2015–2030? If so, are any of these framing or impacting the city, thinking about health, environment and planning?
c. Is there anything else you would like to add?

Interview guide B (for cities without a specific urban disaster experience)

Introduction (3–5 minutes)

1. Identification of emergencies with environmental impact and main impact on the city (5 minutes)

a. To the best of our knowledge, your city has not registered any major natural or environmental emergency in the last decade. Is this the case?
b. Does your city have an emergency preparedness programme? If so, do you believe it has helped prevent or reduce the consequences of any emergencies?
c. All cities are at risk of facing various types of emergencies. Is your city at higher risk of a certain type? If so, which and for what reason?
d. Is there a history (prior to the last decade) of disasters or crises affecting your city? If so, please describe it.

2. Local resilience measures: governance (10 minutes)

a. Is planning for future emergencies considered a priority by both local government and the local community? Is this also the case for regional/national government?
b. Has your municipality invested in resilience planning schemes? If so, what priorities are there for this investment?
c. Has your city implemented any local resilience measures in the last decade in terms of urban planning and infrastructure design? Please describe them.
d. Have specific policies, legislation and/or action plans been drafted for this? If so, do urban planning, environment and health departments work together successfully in the drafting of these policies, action plans and interventions?
e. Do these policies, legislation and/or action plans consider environmental and health impacts together?
f. Do these policies, legislation and/or action plans account for gender, ethnicity, disability issues or human rights?
g. In particular, how does this planning account for equity and attend to the needs of especially vulnerable groups?

3. Local resilience measures: capacities (10 minutes)

a. Are risk assessments carried out for different types of potential emergencies? If so, have the health implications of these risks been assessed?
b. Is this used as the basis to determine priorities for emergency preparedness?
c. Are surveillance and early warning systems in place? Have they proved effective in recent years? If so, please describe how.
d. Does your city have a health plan?
e. How is risk communication designed in your city? Is there a lead authority? Who is it? What mechanisms or channels are used? What information/instructions are given to people, and in what way – for example, are media campaigns or guidelines designed to reach the public?
f. How are emergency preparedness plans assessed and strengthened? For instance, are interim solutions tried out to assess their potential as long-terms measures that increase resilience to future emergencies? Are exercises/simulations carried out in a preventive manner? Are there pre-defined indicators and standardized tools and processes to assess and report on this?

4. Local resilience measures: resources (10 minutes)

a. Do you believe sufficient funding is available to support your preparedness efforts?
b. Where does it mainly come from – for example, domestic or international sources?
c. Is contingency funding devoted to emergency response?
d. Are sufficient human resources available to support your preparedness efforts?
e. Is the health system strong enough to support a future crisis?
f. In what way and to what extent is the community involved in the successful outcome of emergency preparedness plans in your city?
g. What measures have been taken to prevent health and safety supply shortages in case of emergency?
h. In what way do these measures affect urban planning and infrastructure design?

5. How the city has faced/is facing the COVID-19 pandemic (10 minutes)

a. What were the impacts and actions taken regarding urban planning or infrastructure when facing the COVID-19 pandemic? For instance, were there changes in the public transport service (such as increasing frequency or prioritizing certain modes)? Were new buildings created (such as temporary housing or hospitals), existing buildings modified or tactical urbanism to reconfigure public space, to address the spread of the virus and reduce its impacts? How were access restrictions to public spaces managed?
b. Can any lessons be learned from this experience that may affect future planning? What lessons can be adapted in the future, for instance, in terms of public transport services; distribution of products and services across the city; securing safe public indoor spaces in restaurants, shops or schools (or perhaps promoting outdoor schooling such as “forest schools”); or trying to keep public spaces such as parks and playgrounds open?
c. Do you believe this experience will motivate more integrated collaboration between health and urban planning? How?
d. To your knowledge, will the city’s response to the COVID-19 pandemic be evaluated and adapted to become more resilient to future environmental or health threats, using pre-defined indicators and standardized tools and processes and reporting accordingly?
e. Has the city conducted a public consultation about the lessons learned from COVID-19 and those changes the public wishes the city to keep or develop or change?

6. Intersection of potential emergencies (10 minutes)

a. Your city may have implemented urban design changes and interventions on local supply and distribution chains as part of sustainable and resilient planning in general, or as a reaction to recent crises. If so, did any of these interventions prove useful when facing the COVID-19 pandemic or other emergencies? Did any aspects of emergency preparedness (such as operational readiness, coordination between departments or access to contingency funding) make your response to the COVID-19 emergency more efficient and effective?
b. Could lessons learned from the COVID-19 experience also affect urban planning dimensions in the future – for instance, by assuring larger and more equally distributed open spaces, parks and playgrounds throughout the city or in terms of attending to the needs of the most vulnerable groups.
c. Many elements of emergency preparedness are common to all disasters. Apart from disaster-specific plans (for the initial emergency – the focus of this interview), do you believe that your city's emergency preparedness follows an all-hazard approach?
d. Were hazard-specific plans learned from other cities or based on other cities' experience with disasters? If so, please provide some examples.

7. Use and impact of national and international framework documents (5 minutes)

a. Which type of guidance has your office/department found useful (if any) in terms of emergency preparedness planning and implementation?
b. Is your office/department familiar with the Paris Agreement, the SDGs or the Sendai Framework for Disaster Risk Reduction 2015–2030? If so, are any of these framing or affecting the city's policies, thinking about health, environment and planning?
c. Is there anything else you would like to add?

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