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Multisectoral collaboration during public health emergencies: an integrative review

5.1.2e, 5.1.2e, 5.1.2e, 5.1.2e, 5.1.2e, 5.1.2e & 5.1.2e

Introduction

The world continuously deals with public health emergencies of different origins. The COVID-19 pandemic is an example of unprecedented scale which has challenged preparedness and response professionals across the globe. A workshop was organised by the EU SHARP Joint Action Consortium in April 2020, when European public health professionals informally discussed their initial experiences during the first COVID-19 wave. One of the conclusions was that there is a need for clear established processes during cross-sectoral activities (1).

There are two key documents which European preparedness and response professionals should refer to for guidance on how to deal with public health emergencies. The first is the International Health Regulations (IHR) (2005). This is a global legal instrument that was adopted by the World Health Assembly (WHA) in 2005, with the aim of preparing and responding to international public health threats without unnecessary interference with international traffic and trade (2). The second is the Decision 1082/2013/EU. This is a European legal instrument adopted by the European Parliament and the Council in 2013, with a similar aim as the IHR (2005) (3). An all-hazard approach is at the core of both documents, meaning they are applicable to public health emergencies (PHEs) of all origins. Consistent with this approach, the documents emphasise collaboration and interdependence between different sectors.

Although the need for multisectoral collaboration is explicit in the IHR (2005) and the Decision 1082/2013/EU, the documents do not stipulate clear processes for

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multisectoral collaboration during PHEs. It is unclear how preparedness and response professionals at different governance levels should operationalise the concept of multisectoral collaboration in policies as well as preparedness and response plans.

In order to gain more insight into this, we conducted an integrative review to answer the following questions: (1) Which sectors collaborate during public health emergency preparedness and response in Europe?; (2) During which phases of preparedness and response are sectors involved?; and (3) Which tools and instruments can be used for collaboration during preparedness and response?

Method

Literature search

We conducted a systematic electronic search in EMBASE and Scopus databases, covering the period between 2005 and 2020. We chose the year 2005 because that is when the IHR (2005) was adopted. A combination of non-MESH terms referring to public health emergencies, collaboration, preparedness and response were used. The search strategy can be found in Appendix A. Besides this search, we added the two primary preparedness and response instruments, namely the IHR (2005) and the Decision 1082/2013/EU. These were obtained for the WHO and European Union websites. Given the large number of results, we did not perform snowball sampling.

Inclusion criteria

We imported the search results into EndNote and removed the duplicates. Prior to formal screening the authors BV and SK conducted a pilot of the inclusion and exclusion criteria. They screened and discussed the titles and abstracts of 10% of the articles. Articles focusing on preparedness for, and/or response to, public health emergencies of biological, chemical, radionuclear or environmental origins affecting human health were included. Articles focusing on emergencies of other origins or on technical aspects of preparedness and response, such as laboratory techniques and vaccine manufacturing, were excluded. The final criteria can be found in Appendix B. These criteria were used for the title and abstract screening of the remainder of the

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articles, and the following full-text screening. The authors BV and SK screened 25% of the articles independently and compared their results at both stages. They discussed any disagreements until consensus was reached. SK then proceeded with screening the remainder of the articles.

Given the nature of the study and the fact that we aimed to capture as many sectors as possible, we did not put any restrictions on the quality of included articles. Hence, we did not perform any individual quality assessment.

Data extraction and analysis

The data were extracted in three steps. Firstly, we identified all actors named in the articles when describing preparedness and response. We identified references to the words "collaboration", "cooperation", "coordination", and "data sharing". We then noted which actors were involved in these contexts and which actors were linked to each other. Secondly, we identified during which phases the sectors were involved in preparedness and response. We used the seven phases of public health emergency preparedness and response cycle defined by the HEPSA tool (4), namely (a) Pre-event preparations and governance, (b) Capacity building and maintenance, (c) Surveillance, (d) Risk assessment, (e) Risk and crisis management, (f) Post-event evaluation, and (g) Implementation of lessons learned. Lastly, we compiled a list of tools and instruments described in the articles that have been used and can be used to facilitate multisectoral collaboration during preparedness and response. We define tools and instruments in this review as anything actors can use for the multisectoral collaboration during preparedness and response, ranging from written documentation to abstract agencies.

The analysis was also done in three steps. Firstly, we used an iterative process to cluster all actors named in the articles. The list of sectors of economic activities developed by the European Commission (5) was used as a starting point. Secondly, we compared the frequency with which the sectors were involved in different situations. We compared how often sectors were named when describing PHEs of different origins. We also compared how often those sectors were named when

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describing past collaborations or collaborations prescribed in the literature. Moreover, the sectors were allocated to the corresponding phases in the preparedness and response cycle. We then calculated and compared the frequency with which each sector was named in each phase. Lastly, we clustered the tools and instruments according (a) to the level of governance they apply to and (b) whether they are associated to past collaborations or prescribed collaborations.

Results

Literature search

The search strategy resulted in 3067 unique studies. Inclusion- and exclusion criteria were applied to their titles and abstracts, resulting in 1206 articles for full- text screening. The screening of the full texts led to the inclusion of 94 articles. We also added the two key international preparedness and response documents, namely the IHR (2005) and the Decision 1082/2013/EU. The flowchart of the search and selection process is shown in Figure 1. A list of included articles can be found in Appendix D.

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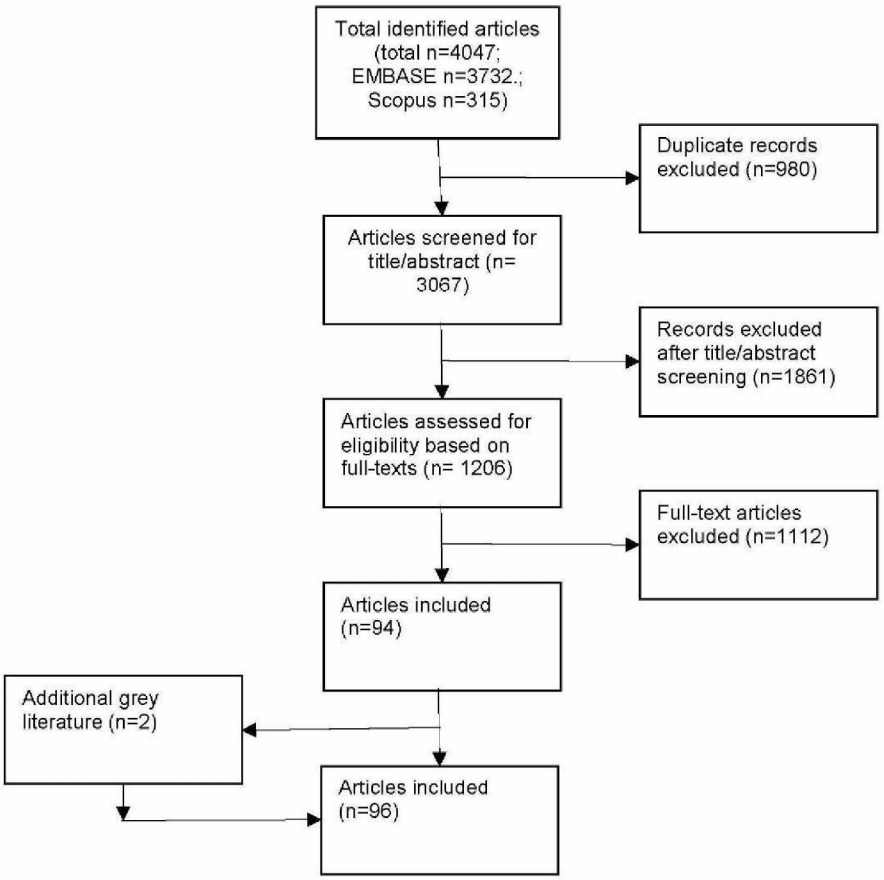

Figure 1 Flowchart of the systematic literature search

The sectors involved in preparedness and response

We modified the Europe Commission's list of sectors of economic activities (5) to define sectors appropriate for this review. The modified list of sectors can be found in Table 1. We altered the boundaries and names of sectors 1, 4, 12, 15, 23, 25, 26 and we added a 28th sectors, namely civil society.

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Table 1 The list of sectors, based on the European Commission's list of economic activities

ID number	Name of the sector
1	Agriculture, forestry, fishery and the environment
2	Arts, entertainment and recreation
3	Hospitality and Tourism
4	Human health
5	ICT service activities
6	Manufacturing of food, beverages and tobacco
7	Manufacturing of textile, apparel, leather, footwear and related products
8	Mining and heavy industry
9	(Human) Transportation and Points of entry
10	Veterinary activities
11	Wholesale and retail trade, renting and leasing
12	(Commercial) business and legal activities
13	Chemical industry
14	Construction
15	Education and academia
16	Energy and water supply, sewerage and waste management
17	Finance, insurance and real estate
18	Manufacturing of consumer goods except food, beverages, tobacco, textile, apparel, leather
19	Manufacturing of electrical equipment, computer, electronic and optical products
20	Manufacturing of fabricated metal products, except machinery and equipment
21	Manufacturing of machinery and equipment, except electrical equipment
22	Manufacturing of transportation equipment
23	Media and communication
24	Personal service-, administrative support service- and security and investigation activities
25	Governance (at international, national and subnational levels)
26	Non-health scientists and experts
27	Wood processing, paper and printing
28	Civil society

There is a large variation in the number of times the sectors are named when describing preparedness and response. Sectors were named a total of 4022 times, with four sectors being named noticeably more often than others. These sectors are 'Governance' (n=1985, 40%), 'Human health' (n=1243, 25%), 'Non-health scientists and experts' (n=566, 11%), and 'Civil society' (n=564, 11%) (Figure 2). Eleven sectors were not named when describing preparedness and response, namely 'Arts,

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entertainment and recreation', 'Manufacturing of textile, apparel, leather, footwear and related products', 'Mining and heavy industry', 'Wholesale and retail trade, renting and leasing', 'Construction', 'Manufacturing of consumer goods except food, beverages, tobacco, textile, apparel, leather', 'Manufacturing of electrical equipment, computer, electronic and optical products', 'Manufacturing of fabricated metal products, except machinery and equipment', 'Manufacturing of machinery and equipment, except electrical equipment', 'Manufacturing of transportation equipment' and 'Wood processing, paper and printing'.

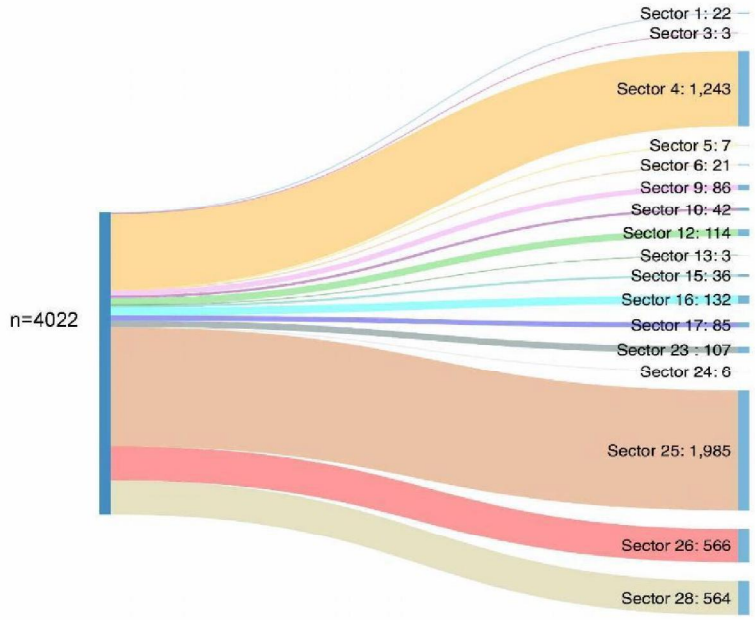

Figure 2 The sectors named when describing preparedness and response. See table 2 for sector names.

Multisectoral collaboration during preparedness and response

When we focus on the sectors involved in *collaboration* during preparedness and response, we see similar results as above. We once again see that the sectors 'Governance' (n=607, 49%), 'Human health' (n=424, 35%), 'Non-health scientists and experts' (n=58, 4%), and 'Civil society' (n 58= 4%) were named most often (Figure 3). As we compare the frequency at which these sectors were named when describing the different origins of the PHEs, one main difference is the high frequency with which

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the sector 'Governance' (n=60, 76%) was named compared to the low frequency with which 'Human health' (n=9, 11%) was named, when describing PHEs of chemical origin.

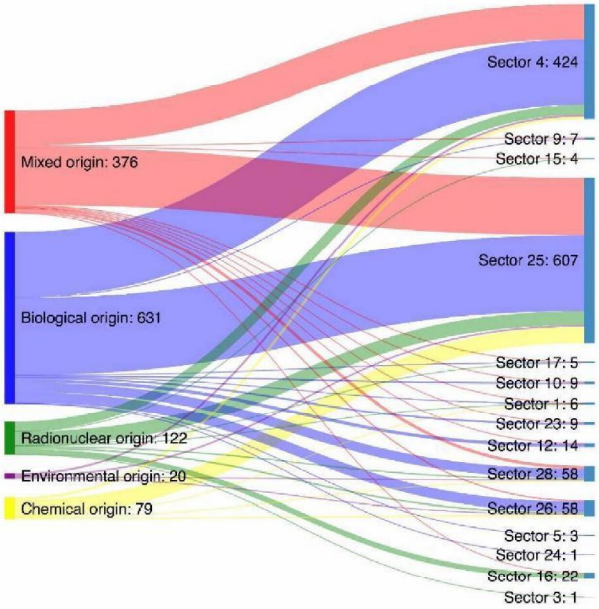

Figure 3 Sectors involved collaborating during preparedness and response. See table 2 for sector names.

Sectors involved in past collaborations and prescribed collaborations

We also compared the frequency at which sectors were named in past collaborations and prescribed collaborations. There are two main similarities. The first is that the sectors 'Governance', 'Human health' and 'Non-health scientists and experts' were named most often, as can be seen in Figure 4. The second is that the sector 'Non-health scientists and experts' was named equally often in both cases (approximately 4%).

A couple of differences can be identified when comparing the frequency at which sectors are named when describing past collaboration and prescribed collaborations. On the one hand the sectors 'Governance' and 'Civil society' were named

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proportionally more often in prescribed collaborations than past collaborations (52% vs 46% and 6.6% vs 2.0% respectively). On the other hand, the sectors 'Human Health' and 'Energy and water supply, sewerage and waste' were mentioned proportionally less often in prescribed collaborations (30% vs 40% and 0.6% vs 3.7% respectively).

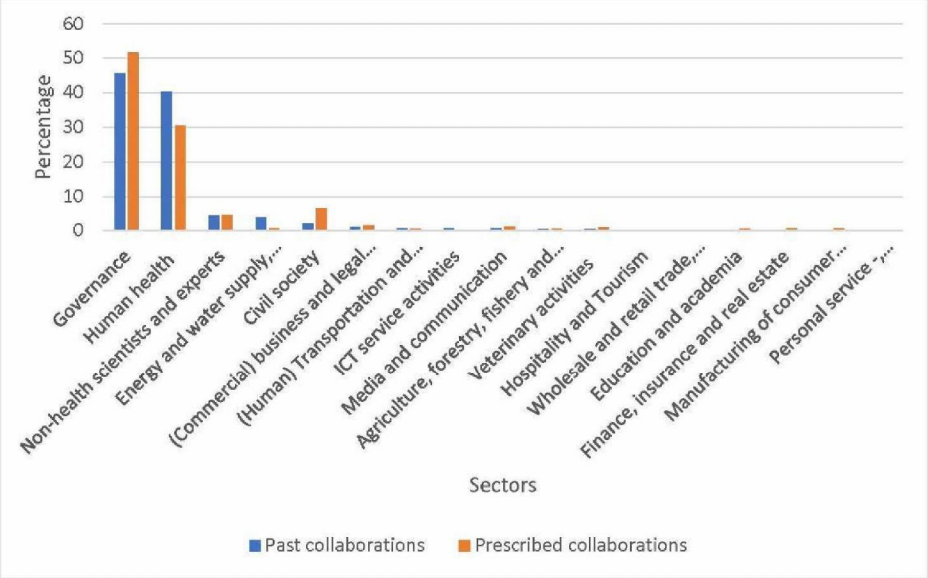

Figure 4 Sectors named in past collaborations vs. prescribed collaborations

When comparing which sectors were mentioned in past collaborations and prescribed collaborations as well as how often they were linked to each other, the following can be seen. A total of 13 sectors were named when describing past collaborations and a total of 15 sectors were named when describing prescribed collaborations (see Figure 5 and 6). The following sectors were named when describing past collaborations: 'Agriculture, forestry, fishery and the environment' (ID 1), 'Hospitality and Tourism' (ID 3), 'Human health' (ID 4), 'ICT service activities' (ID 5), '(Human) Transportation and Points of entry' (ID 9), 'Veterinary activities' (ID 10), 'Wholesale and retail trade, renting and leasing' (ID 11), '(Commercial) business and legal activities' (ID 12), 'Energy and water supply, sewerage and waste management' (16), 'Media and communication' (ID 23), 'Governance' (ID 25), and 'Civil society' (ID 28). However, when describing prescribed collaborations, two sectors were no longer named and three sectors were

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added. The sectors that were no longer named were Hospitality and Tourism (ID 3) and ICT service activities (ID 5). The sectors that were added were 'Education and academia' (ID 15), 'Finance, Insurance and Real estate' (ID 17), and 'Manufacturing of consumer goods except food, beverages, tobacco, textile, apparel, leather' (ID 18), such as vaccines.

Second, 12 of the 13 sectors named when describing both types of collaboration were linked to more sectors when describing prescribed collaborations than past collaborations.

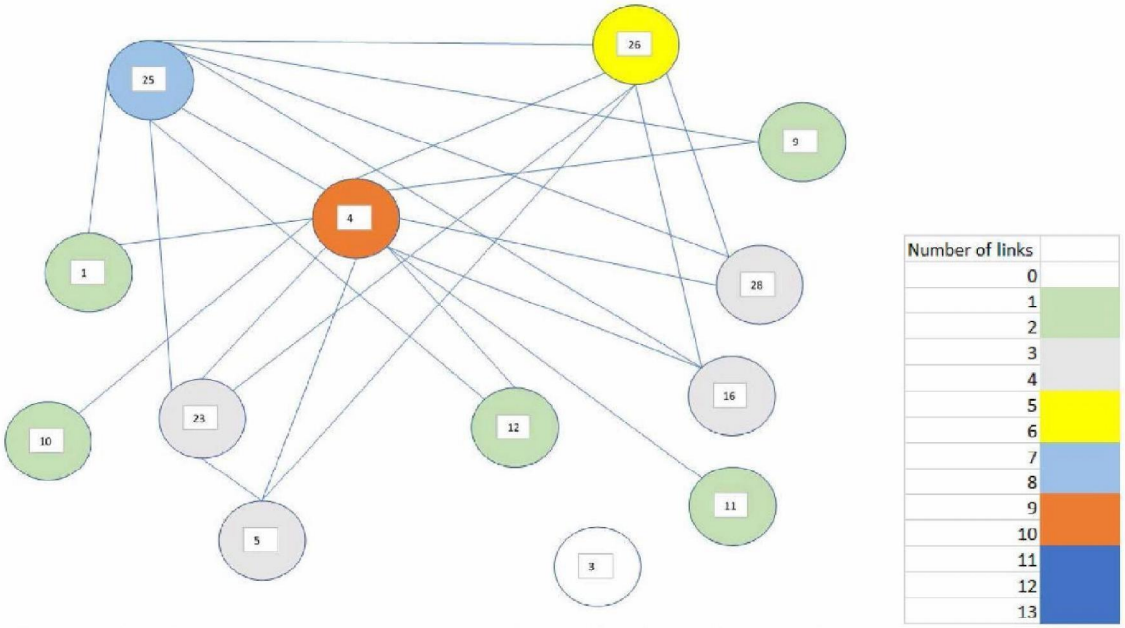

Figure 5 Sectors named in past collaborations. See table 2 for sector names.

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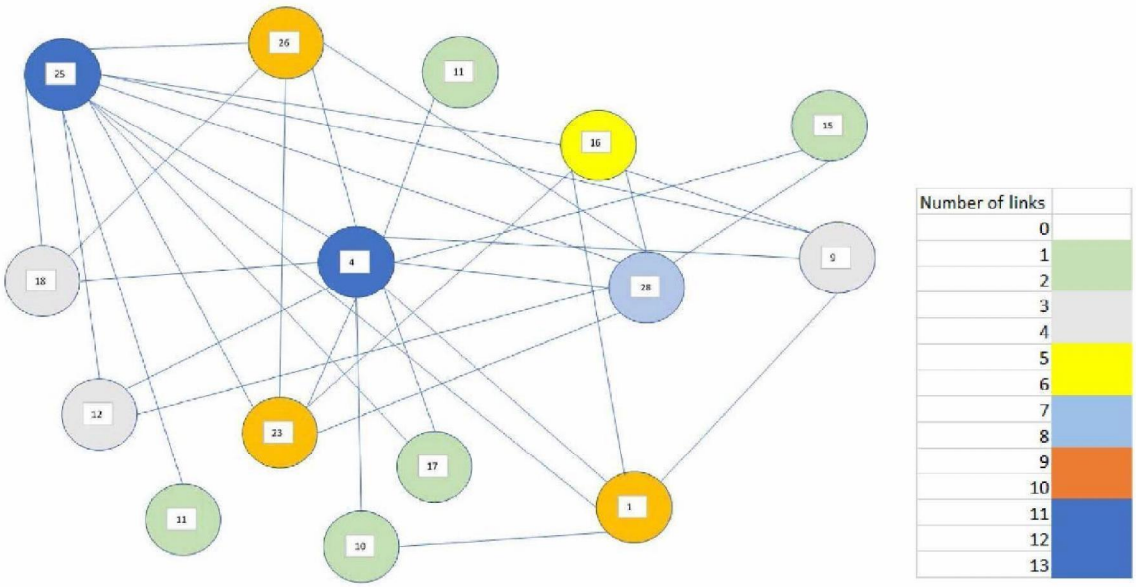

Figure 6 Sectors named in prescribed collaborations. See table 2 for sector names.

Sectors involved during the phases of preparedness and response

Sectors were named most frequently when describing activities in the phases 'Governance', 'Surveillance' and 'Risk assessment', as shown in Table 2. The sectors 'Governance' and 'Human health' were named most often. All sectors were mentioned less often when describing the 'Post-event evaluation' and 'Implementation of lessons learned' phases.

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Table 2 Sectors named in the phases of preparedness and response

	Governance	Capacity building and maintenance	Surveillance	Risk assessment	Risk and crisis management	Post-event evaluation	Implementation of lessons learned
Agriculture, forestry, fishery and the environment	2	0	2	1	0	0	0
Arts, entertainment and recreation	0	0	0	0	0	0	0
Hospitality and Tourism	1	0	0	0	0	0	0
Human health	110	4	94	16	160	9	0
ICT service activities	0	0	1	0	1	0	0
(Human) Transportation and Points of Entry	3	1	0	2	1	0	0
Veterinary activities	3	0	3	2	1	0	0
Wholesale and retail trade, renting and leasing	1	0	0	0	1	0	0
(Commercial) business and legal activities	6	0	4	0	3	0	0
Education and academia	3	1	0	0	0	0	0
Energy and water supply, sewerage and waste management	16	2	0	0	4	0	0
Finance, insurance and real estate	3	0	0	0	2	0	0
Manufacturing of consumer goods except food, beverages, tobacco, textile, apparel, leather	1	0	1	0	1	0	0
Media and communication	0	0	6	0	4	0	0
Personal service -, administrative support service- and security and investigation activities	0	0	0	0	1	0	0
Governance	184	6	128	21	195	6	2
Non-health scientists and experts	11	1	6	8	18	6	0
Civil society	10	0	16	4	17	4	0

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The tools and instruments for collaboration during preparedness and response

A list of the tools and instruments identified that have been used to facilitate collaboration during preparedness and response or that should be used for this purpose was compiled. This list is shown in Table 3.

Table 3 Tools and instruments (to be) used for multisectoral collaboration during preparedness and response

Past collaborations	Prescribed collaborations
International tools and instruments	
International actors and institutions	
The World Health Organization (6-9)	The World Health Organization (6-8, 10-16)
National IHR Focal Points (NFP) (7, 17, 18)	National IHR Focal Points (NFP) (14, 18, 19)
The European Union (EU) (20)	The European Union (3, 21, 22)
The European Commission (20)	The European Commission (3, 20)
European Centre for Disease Prevention and Control (20)	European Centre for Disease Prevention and Control (20, 22)
European Union (UN) Health Security Committee (HSC) (3, 22)	EU Health Security Committee Health Security Committee (HSC) (3, 22, 23)
	International Atomic Energy Agency (IAEA) (15, 16)
	The United Nations (UN) global health apparatus could act as a hybrid multistakeholder global health body (13)
	The need for escalation processes defining the roles and transfer of control of emergencies between different organizations such the WHO and the United Nations (UN) (13)
	The need for a clear line of command within the United Nations (UN) system to coordinate global response, for example a High-level Council on Global Public Health Crises within the UN General Assembly (13)
	The WHO and UN should establish a Commission on a Global Health Risk Framework (14)
	The WHO should use a High-Level Panel on Global Response to Health Crises (14)
	The need to designate an authority equivalent to the European Centre for Disease Control responsible for chemical public health events (24) This could be a network led by civil protection representatives or health representatives (25)
	Proposed joint WHO-World Trade Organization (WTO) dispute commission (26)
European Medical Corps (EMC) consisting of emergency medical teams, mobile laboratories,	European Medical Corps (EMC) consisting of emergency medical teams, mobile laboratories,

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medical evacuation capacities and logistic support (27) International and national emergency medical teams (I-EMTS and N-EMTS) (6)	medical evacuation capacities and logistic support (27) International and national emergency medical teams (I-EMTS and N-EMTS) (17)
Legislations and formal agreements	
International Health Regulations (3, 7, 18, 20, 28, 29) Article 45 of the IHR to facilitate the sharing of information and reporting of potential PHEICs (14)	International Health Regulations (3, 6, 7, 14, 18, 21, 30-40) IHR Core Capacities (41)
World Health Assembly Resolutions 54.14 and 55.16 (14)	World Health Assembly Resolutions 54.14 and 55.16 (14)
	IHR Monitoring Framework (14)
	WHO Constitution (17)
WHO's 2016 Research and Development (R&D) Blueprint to prevent epidemics, with one of the focuses being improving coordination (6)	WHO's 2016 Research and Development (R&D) Blueprint to prevent epidemics (6, 13, 42)
	Global Health Security Agenda (GHSA) (43)
	The need to establish common Global Health Security Agenda (GHSA) and World Organisation for Animal Health's (OIE) Performance of Veterinary Services (PVS) pathways for One Health strategies (14)
	The need to establish common Global Health Security Agenda (GHSA) and World Organisation for Animal Health's (OIE) Performance of Veterinary Services (PVS) pathways for One Health strategies (14)
Decision 1082/2013/EU Articles 15(b) and Article 11 (21)	Decision 1082/2013/EU (3, 11, 22, 25, 31) Predecessor Decision 2119.98/EC (3)
	(Article 168 of) The Treaty on the Functioning of the European Union (TFEU) (3)
	The Schengen Agreement (7)
	Council Decision 2005/386/JHA (44)
	Pandemic Influenza Preparedness (PIP) framework (14)
Longstanding bilateral agreements concerning the exchange of information between border control authorities (11)	
Joint Radiation Emergency Management Plan of International Organizations (Jplan-2010) (45)	Joint Radiation Emergency Management Plan of International Organizations (Jplan-2010) (15, 16, 45)
International Action Plan for Strengthening Response to Radiation Emergencies (15)	International Action Plan for Strengthening Response to Radiation Emergencies (15)
	EU CBRN Action Plan (23)
	Convention on Early Notification of a Nuclear Accident (15)
	Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (15)
Material Transfer Agreement (MTA) (33)	
	International agreements regarding the sharing of data and viruses such as the Nagoya Protocol (14)

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	Agreements concerning the sharing of viruses and reciprocal obligation to make vaccines and medicines affordable (14)
Global Vaccine Action Plan (46)	Global Vaccine Action Plan (21)
Doha Declaration, with World Health Organization (WHO) and World Trade Organization (WTO) (26, 46)	
Standing international agreements between different international organisations such as the WHO, International Atomic Energy Agency (IAEA), the World Meteorological Organization (WMO), the Food and Agriculture Organization (FAO), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO), the European Commission, the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) (47)	Standing international agreements between different international organisations such as the WHO, International Atomic Energy Agency (IAEA), the World Meteorological Organization (WMO), the Food and Agriculture Organization (FAO), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO), the European Commission, the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) (47)
Common protocol framework for laboratories for communication and reporting during an emergency (16)	Common protocol framework for laboratories for communication and reporting during an emergency (16)
	The 1992 Convention of Transboundary Effects of Industrial Accidents could be used (23, 24)
	The need to harmonize legislative approaches to infectious diseases across countries (20) The need to find a legal framework to increase the willingness of stakeholders to cooperate and coordinate health preparedness programs (40)
	The need for certification guidelines for points of entry (2)
	National policies and guidelines should formalise linkages (43)
Networks and platforms	
International Health Regulations (IHR) network (47)	
EU/EEA (8)	
WHO Europe region (22)	
WHO Global Outbreak Alert and Response Network (GOARN) (18)	
WHO Early Warning Alert and Response Network (EWARN) (48)	WHO Early Warning Alert and Response Network (EWARN) (48)
Early Warning and Response System of the European Union (EWRS) (49)	Early Warning and Response System of the European Union (EWRS) (3, 8, 21-23, 49, 50)
	UN Global Health panel (13)
	(Already) available partnerships between the UN system and the WHO (13)
	International structures such as the Global Health Cluster and the Inter-Agency Standing Committee (13)
	The need to establish the Internally Displaced Persons Surveillance System (48)
Network for the epidemiological surveillance and control of communicable diseases (3)	Network for the epidemiological surveillance and control of communicable diseases should be used (3, 22)

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	The Epidemic Intelligence Information System (EPIS) platform (22)
Connecting Organizations for Disease Surveillance (CORDS) (6)	
Establish surveillance mechanisms for sharing biological samples (7)	
Surveillance platforms such as The European Surveillance System (TESSy), WHO regional platform EuroFlu and WHO global platforms FluNet and FluID (8) European Influenza Surveillance Network (EISN) (8)	ECDC Vector-borne disease surveillance feedback system process (51) Surveillance platforms such as The European Surveillance System (TESSy), WHO regional platform EuroFlu and WHO global platforms FluNet and FluID (8)
WHO-REMPAN (Radiation Emergency Medical Preparedness and Assistance) network (15)	WHO-REMPAN (Radiation Emergency Medical Preparedness and Assistance) network (15, 20)
European Commission's European network of biological and retrospective dosimetry (RENEB) (9)	
Radiation emergency medicine global networks such as the Radiation Emergency Medical preparedness and Assistance Network (REMPAN) and the Biological Dosimetry Laboratories Network- BioDoseNet (45)	Radiation emergency medicine global networks such as the Radiation Emergency Medical preparedness and Assistance Network (REMPAN) and the Biological Dosimetry Laboratories Network- BioDoseNet (45)
European Information Network on Drugs and Drug Addiction of the European Monitoring Centre for Drugs and Drug Addiction (ECDMMA) (44)	European Information Network on Drugs and Drug Addiction of the European Monitoring Centre for Drugs and Drug Addiction (ECDMMA) (44)
REITOX (**R**éseau **E**uropéen d'Information sur les Drogues et les **Tox**icomanies) (44)	REITOX (**R**éseau **E**uropéen d'Information sur les Drogues et les **Tox**icomanies) (44)
	Realizing the European Network in Biodosimetry (RENEB) (9)
The global web-based open-source information system platform District Health information System 2 (DHIS2) (52)	The global web-based open-source information system platform District Health information System 2 (DHIS2) (52)
Cross-border collaborative programmes such as Flu-Zone (37)	
	Rapid Alert System for Food and Feed (RASFF) (24)
	Rapid Alert system for Chemical Health Threats (RASCHEM) (23, 24)
	Industrial Accident Notification (iAN) system (24)
	e-Major Accident Reporting System (e-MARS) (24)
	Rapid Alert System for non-food consumer products (RAPEX) (24)
	Internet Surveillance Report Programs (ISRP) such as Global Public Health Information Network (GPHIN) or ProMED (33)
	It is suggested to have a pyramid structure of European and national risk assessors' forums linked to existing international and national networks of emergency responders and experts (25)
	The need to establish the Internally Displaced Persons Surveillance System (48)
Activities	

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Regular teleconferences (29) Regional teleconferences organised by WHO/Europe/ EC and ECDC (8)	Teleconference with health officials and ministers (7)
Joint evaluation of IHR capacities (32)	
Coordination meetings (8); international consultations and activities (8); Joint Annual influenza surveillance meetings (8); Regular meetings (37)	Coordination meetings (8); international consultations and activities (3, 8); Joint Annual influenza surveillance meetings (8)
Having personnel whose job specifically include communicating with their counterparts across the border (11)	
Exercises, workshops and training initiatives such as the EU Pandemic Influenza Workshop (20, 22)	Inter-country workshops organised by WHO/Euro and the ECDC (8) Large scale exercises involving collaboration and the sharing of best practices should take place (11) Consistency in training across public health professionals (23) Exercises, workshops and training initiatives such as the EU Pandemic Influenza Workshop (20, 22)
	Open simulations of the effectiveness of the PIP framework organised by the WHO (14)
	Meta leadership summit (11)
	European Union (EU) Health programmes (23)
Research project such as EU Joint Action Healthy Gateways (22)	Research projects and programs (23), such as EU Joint Action Healthy Gateways (22)
	The need for Civil society shadow reporting when emergency committees make decisions (14)
	WHO's Health Emergencies Programme with the aim of establishing a coordinating body for disease outbreaks with one workforce, one set of rules and processes and one clear authority (12)
Other	
	The need for permanent mechanisms for the coordination of chemical cross-border threats (23)
Euroregional website developed to provide information for health processes (37)	
Interpersonal relationships, such as contacts and friendship (9)	
	A centralised repository of chemical, biological, radiological (CBR) related information (23)
	The need for the relevant sectors' data collection and information technology systems to relate to each other (21)
	The need for public health surveillance systems that communicate information and exchange data with each other (36)
	Pre-determined systems for sharing resources and communicating between neighbours (25)
	The need to clarify responsibility and have the associated accountability and enforcement mechanisms (6)

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	One-World, One-Health (OWOH) international initiative (37)
	Maritime National Single Window prototype system of the European Commission by the European Maritime Safety Agency (22)
	Context of 'One Health' approach (11)

National tools and instruments	
National actors and institutions	
Focal point for information in each relevant institution for information and data transfer (21)	Focal point for information in each relevant institution for information and data transfer (21)
	The need to nominate a coordinator and contact points for relevant points of entry, public health and other sectors (2)
Human Animal Infections Risk Surveillance (HAIRS) group in the UK which draws in experts from the medical and veterinary sectors (53)	
	Governmental papers which set out the governments' work with key EU agencies (22)
	The need for legal framework that delineate mechanisms for effective epidemic management (54)
Legislations and formal agreements	
	National frameworks such as the British Department of Health's National Framework (55)
Greek agreements made between relevant actors involved in the preparedness and response to emergencies during the 2004 Summer Olympics, such as the Cooperation Agreement, Declaration of Intent and the Memorandum of Understanding (56)	
	National preparedness and response plans putting coordination structures in place for cross-sectoral incidents (3)
	The need to have a national risk communication strategy and operational plan than include all stakeholders (32)
	Pre-determined hospital plans should be determined (49)
Networks and platforms	
A central location such as an emergency operation centre (52) Health situation rooms, also known as strategic command centres (57)	A central location such as emergency operations centre (EOC) (18, 43, 52)
Strong operational, coordination and communication systems (58)	
Activities	
Other	
Structures that ensure a coordination and effective flow between national policy and implementation at level (11)	
Personal relationship between those in different sectors at the local level (11)	Personal relationship between those in different sectors at the local level (11)

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Discussion

The aim of this review was to answer the following research questions: (1) Which sectors collaborate during public health emergency preparedness and response in Europe?; (2) During which phases of preparedness and response are sectors involved?; and (3) Which tools and instruments can be used for collaboration during preparedness and response?

To begin with, there was variation in the number of times sectors were named within the literature. This was the case when describing both preparedness and response in general and when describing collaboration during preparedness and response. Approximately 40% of the sectors were not named at all while three sectors were named noticeably more often than the others in all circumstances. These sectors were 'Governance', 'Human health' and 'Non-health scientists and experts'. Reasons for why these sectors were named most frequently could be that they are the most prominent sectors, they are present most often, they are most visible during public health emergencies (PHEs) or a combination of these factors. It was not possible to pinpoint a specific reason within this study. Also, the absence of certain sectors when describing collaboration, irrespective of the origin of the public health emergency (PHE), points out the necessity to evaluate the concept of multisectoral collaboration during public health emergencies. The literature's lack of specification of when and how specific sectors have added value in collaboration during public health emergencies (PHEs) also makes it difficult to interpret why the sector 'Civil society' was named proportionally more frequently when describing prescribed collaborations than past collaborations.

When comparing the frequency at which sectors were mentioned across the seven phases of preparedness and response, it is important to keep in mind that very few articles focused on the 'Post-evaluation' and 'Implementation of lessons learned' phases. Hence, it is not surprising that this review's results show that the sectors were named at a higher frequency during the 'Governance', 'Surveillance' and 'Risk and

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crisis management' phases. This shows that there is room for more attention for sectoral involvement and collaboration during the different certain phases of the PHE.

Lastly, the compiled list of tools and instruments described in the literature demonstrates there are multiple tools and instruments that have already been used to facilitate multisectoral collaboration. There are, however, also several tools and instruments that have been named when describing prescribed collaborations but have not been mentioned as being already used. Some authors described a need to develop certain tools and instruments. Although this list is quite extensive, it is not complete. During a workshop with European public health officials within the context of the EU Joint Action SHARP (1), the participants shared many more national tools and instruments than mentioned in the literature. This can be because most of the articles had international perspectives and few articles focused on national responses to cross-border crises.

One of the strengths is the unprecedented all hazard approach to reviewing multisectoral collaboration during preparedness and response. This approach is in line with the International Health Regulations (2005) and the Decision 1082/2013/EU. Another strength is the extensiveness of the review, with many published articles focusing on public health emergencies of different origins, being included.

Yet, it is uncertain whether the sample of included articles reflects reality. Most of the articles focused on public health emergencies of biological origin (51%) and mixed origin (30%). This seems disproportionally high. However, it is difficult to confirm this as there is not a European system which records PHEs of all origins for all European countries. Moreover, the term multisectoral collaboration was not strictly defined. This allowed us to capture a wide range of sectors, achieve a broad overview and sub-analyses (not presented in here) showed similar results across the chosen terms. Nonetheless, we cannot exclude the possibility that some sectors could have been named more often if we had included other terms.

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Further research should elaborate on the concept multisectoral collaboration and aim to provide criteria that determine when collaboration is appropriate and advantageous, as well as when collaboration with specific sectors is of added value. More literature is needed to appreciate the specific roles, tasks and the trade-offs of certain sectors collaborating during preparedness and response. It will be also be beneficial to investigate the possible negative consequences of not providing the necessary sectors a seat at the table. This will help European preparedness and response professionals establish clear processes for collaboration during cross-sectoral activities.

Conclusion

In conclusion, the results of the literature review suggest that there are three sectors which are considered most important, present and/or visible during collaboration during public health emergency preparedness and response. These sectors were also named noticeably more often in three of the seven preparedness and response phases. Furthermore, there is variety of international and national tools and instruments than can be used to facilitate multisectoral collaboration during preparedness and response. Yet, more research is necessary to have a better understanding of multisectoral collaboration during preparedness and response as well as the possible impact of clear established processes for multisectoral collaboration.

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Appendix A

EMBASE search strategy performed on the 12-03-2020

#32 'international health regulation'/exp OR 'international health regulat*':ti,ab OR 'ihr':ti,ab OR '1082/2013/eu':ti,ab OR 'decision 1082*':ti,ab

#31 sector*:ti,ab OR 'discipline*':ti,ab OR 'actor*':ti,ab OR 'stakeholder*':ti,ab OR 'stake-holder*':ti,ab OR 'interoperable':ti,ab OR 'inter-operable':ti,ab OR 'stakeholder'/exp OR 'stakeholder engagement'/exp

#30 'hospital*':ti,ab OR 'police*':ti,ab OR 'fire fighter*':ti,ab OR 'fire service*':ti,ab OR 'fire brigade*':ti,ab OR 'ambulance*':ti,ab OR 'agriculture*':ti,ab OR 'government*':ti,ab OR
military:ti,ab OR army:ti,ab OR 'civil service*':ti,ab OR media:ti,ab OR 'ngo*':ti,ab OR 'private sector*':ti,ab OR 'voluntary sector*':ti,ab OR 'third sector*':ti,ab

#29 'collaborat*':ti,ab OR 'communicat*':ti OR 'coordination*':ti OR (((international OR national OR local OR municipal OR 'government*' OR city OR council OR region* OR global) NEAR/5 (cooperation OR communication OR coordination OR collaboration OR management OR engagement)):ti,ab)

#28 'one health'/exp OR 'one health':ti,ab

#27 'intersectoral collaboration'/exp OR 'intersectoral collaborat*':ti,ab OR 'intersectoral coordin*':ti,ab OR (((interdisciplinary OR 'inter-disciplinary' OR intersectoral OR 'inter-sectoral' OR 'multi-institution*' OR 'interorgani?ation*' OR 'inter-organi?ation*') NEAR/5 ('communication*' OR 'cooperation*' OR 'collaboration*' OR 'coordinat*' OR 'management*' OR 'engagement*' OR team)):ti,ab)

#26 'interdisciplinary communication'/exp OR 'interdisciplinary communication*':ti,ab OR 'interdisciplinary team'/exp OR 'interdisciplinary team*':ti,ab

#25 'multidisciplinary team'/exp OR multidisciplin*:ti,ab

#24 'multi institut*':ti,ab OR multiinstitut*:ti,ab

#23 'multihospital system'/exp OR multihospital*:ti,ab OR 'multi hospital*':ti,ab

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#22 (regional*:ti OR national*:ti) AND network*:ti OR ((regional* NEAR/2 network*):ti,ab) OR ((national* NEAR/2 network*):ti,ab)

#21 'natural disaster'/exp OR 'natural disaster*':ti,ab OR 'geographic and geological phenomena'/exp OR 'severe weather'/exp OR 'flooding'/exp OR 'wildfire'/exp OR 'seismic flooding*':ti,ab OR ((environmental* NEAR/5 (accident* OR disaster* OR indicent* OR event* OR emergenc*)):ti,ab)

#20 ammonia*:ti OR caprolactam:ti OR cyclohex*ti OR oil:ti

#19 'chemical accident'/exp OR ((chemical NEAR/5 accident*):ti,ab) OR ((chemical NEAR/5 hazard*):ti,ab) OR ((chemical NEAR/5 disaster*):ti,ab) OR ((chemical NEAR/5 contamination*):ti,ab) OR ((chemical NEAR/5 incident*):ti,ab) OR ((chemical NEAR/5 event*):ti,ab) OR ((chemical NEAR/5 emergenc*):ti,ab) OR ((chemical NEAR/5 intoxicat*):ti,ab) OR ((chemical NEAR/5 poisoning*):ti,ab) OR bhopal*:ti,ab OR seveso*:ti,ab OR 'probo koala*':ti,ab OR ('kolontar*':ti,ab AND 'sludge*':ti,ab)

#18 'radiation accident'/exp OR 'radiation accident*':ti,ab OR 'radioactive contamination'/exp OR 'radioactive contamination*':ti,ab

#17 kyshtym*:ti,ab OR 'windscale*':ti,ab OR 'environmental impact'/exp OR 'meteorological phenomena'/exp

#16 'nuclear accident'/exp OR 'nuclear accident':ti,ab OR 'nuclear hazard:ti,ab' OR 'nuclear disaster*':ti,ab OR chernobyl*:ti,ab OR fukushima*:ti,ab

#15 'zoonosis'/exp OR zoono*:ti,ab

#14 'food poisoning'/exp OR 'food borne*':ti,ab OR 'food poisoning*':ti,ab

#13 sars:ti OR mers:ti OR ebola*:ti OR h1n1*:ti OR 'influenza a virus (h1n1)'/exp OR 'ebolavirus'/exp OR 'middle east respiratory syndrome coronavirus'/exp OR 'sars coronavirus'/exp

#12 'epidemic'/exp/mj OR epidemic*:ti OR epidemy:ti OR epidemia:ti OR pandemia:ti

#11 'pandemic'/exp/mj OR 'pandem*':ti

#10 'biological accident'/exp OR 'biological accident*':ti,ab OR 'biological hazard*':ti,ab OR 'biological disaster*':ti,ab

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#9 'health hazard'/exp/mj OR 'health hazard*':ti OR 'health accident*':ti OR 'health disaster*':ti

#8 #5 OR (#6 AND #7)

#7 'emergency'/exp OR emergenc*:ti,ab OR 'public health disaster*':ti,ab OR 'public health catastroph*':ti,ab

#6 'public health'/exp OR 'public health*':ti

#5 'public health emergen*':ti,ab

#4 #1 OR #2 OR #3

#3 'disaster planning'/exp OR 'planning*':ti OR plan:ti OR plans:ti OR 'framework*':ti OR 'countermeasure*':ti OR 'counter-measure*':ti OR 'coping*':ti OR 'guarding*':ti OR 'protective action*':ti

#2 (respon*:ti,ab OR recover*:ti,ab OR resilien*:ti,ab) NOT 'dose respon*':ti,ab

#1 preparedness*:ti,ab OR prepar*:ti,ab OR 'mobili?ation*':ti,ab OR 'surge capacity*':ti,ab

Scopus search strategy performed on the 12-03-2020

#5 4 or 5

#4 2 and 3

#3 1 and 3

#2 TITLE ((biological* OR chemical* OR radiological* OR radiation* OR radioactiv* OR environmental*) W/1 (accident* OR incident* OR disaster* OR outbreak* OR hazard* OR contaminat* OR intoxicat* OR poisoning*))

#1 TITLE (preparedness) OR TITLE (response*)

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Appendix B

Inclusion and exclusion criteria

	Inclusion criteria	Exclusion criteria
Focus	Published after 01-01-2005	Published before 01-01-2005
	New, unexpected or (re-) emerging diseases or situations which (threaten to) overwhelm (inter)national capacities	Public health emergencies due to a deliberate human action (i.e. terrorism) Public health emergency due to chronic infectious diseases (i.e. e.g. HIV, TB)
	Acute public health emergency of biological (infectious, zoonotic or food safety related), chemical, radionuclear of environmental origin[1]	Public health emergency of origin other than biological, chemical, radionuclear or environmental
	Preparedness for, and/or response to, acute public health emergencies due natural causes or non-deliberate human action is the central theme	Biological response (e.g. immunological response)
	The aim and/or objectives must be specifically about, or	Sole focus on a technical area of public health

[1] See appendix C for definitions

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	elaborate on, one of the following subjects: - The (potential) role(s) of (a) specific actor(s) - The (potential) action(s) of (a) specific actor(s) - The expectations of (a) specific actor(s) - Any form of interaction between specific actors	preparedness and/or response such as vaccination production or laboratory tests Focus on trainings and/or exercises
	Any governance level of preparedness and response (i.e. local, national and international)	Outbreaks constrained to the hospital setting
	Focus on human health	Threats to animals, property or the environment but not to humans
Publication/literature type	No restrictions	
Study Design	No restrictions	
Languages	English	
Access	Available through the National Institute for Public Health and the Environment in the Netherlands or the Vrije Universiteit Amsterdam.	

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Appendix C

Key definitions

Biological hazards include infectious, zoonotic or foodborne-related disease.

Chemical hazards include toxic substances used in various sectors which can lead to disease due to exposure or contamination.

Radionuclear hazards include nuclear power plant, transportation and occupational accidents (in settings with radiation sources such as health care facilities, research institutions, and manufacturing operations, naturally occurring or human included.

Environmental hazards include natural disasters and severe weather conditions, naturally occurring or human induced.

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Appendix D

Included articles

Abramowitz SA, Hipgrave DB, Witchard A, Heymann DL. Lessons From the West Africa Ebola Epidemic: A Systematic Review of Epidemiological and Social and Behavioral Science Research Priorities. The Journal of infectious diseases. 2018;218(11):1730-8.

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