IMPACT OF CLIMATE CHANGE ON DISASTER MEDICAL RESPONSE RESILIENCE

Mariya Georgieva
Department of Epidemiology and Disaster Medicine, Faculty of Public Health, Medical University of Plovdiv, Bulgaria, mari.georgieva@mu-plovdiv.bg
Stoyan Kyurkchiev
Bulgarian Academy of Sciences, National Institute of Geophysics, Geodesy and Geography, Center for Hydrology and Water Management, Sofia, Bulgaria**,** jazon@abv.bg
Elena Valkanova
Department of Epidemiology and Disaster Medicine, Faculty of Public Health, Medical University of Plovdiv, Bulgaria, elena.valkanova@mu-plovdiv.bg
Rumyana Etova
Department of Epidemiology and Disaster Medicine, Faculty of Public Health, Medical University of Plovdiv, Bulgaria, rumyana.etova@mu-plovdiv.bg

Abstract: The climate is an extremely complex system including not only the atmosphere but also the oceans, the Earth's ice cover, land and biomass, the atmosphere being the most dynamic part of the climate system. Based on the accumulated data from measurements of climatic elements, a significant change in the mean temperature on the surface of the Earth is recorded since the end of the 19th century and the beginning of the 20th century. Climate change on a global scale is the cause of the occurrence of various meteorological events with unusual intensity and power. The scale of these events often takes on catastrophic proportions with a pronounced disparity between the available and necessary means and capabilities to deal with the consequences. A key factor in addressing these challenges is good preparedness and high resilience of the civil protection system. The aim of this study is to assess the role and significance of climate change for disaster resilience of medical support. Materials and methods: Documentary, descriptive and comparative methods are used to analyze various meteorological processes, phenomena and changes in recent years and their impact on disaster resilience. Results and discussion: The formation of climatic conditions strongly depends on various external (cosmogenic) and internal (terrestrial, geophysical, geological, geographical, anthropogenic) factors. The changes they cause lead to instability in climate elements, manifesting as extreme events. Fluctuations in the flow of streams and rivers and snowmelt, an increase in the frequency and duration of heavy rainfall or prolonged periods of drought follow. Heavy and intense rainfall causes floods and landslides, while little or no rainfall leads to drought and wild fires. Achievement of resilience to meteorological disasters requires an increase in material, financial and human resources, which are used for prevention and recovery. This represents a serious challenge, considering the significant increase in their frequency. Nowadays it is necessary to anticipate and prepare disaster response means and capabilities that could be utilized in the context of recovery from a previous overwhelming event. Maintaining disaster resilience is possible if the risk of unusual and uncharacteristic events that are made possible due to climate change is analyzed and predicted. Conclusion: The increase in the frequency and intensity of the disasters related to climate change requires an acceleration of recovery and a rapid return to normal functioning, both of the affected and the responsible structures. Proper risk assessment and prevention that take into account the changing factors of the climate and environment will reduce the negative impact on the society and the economy.
Keywords: Climate Change, Disaster Resilience

1. INTRODUCTION

The climate is an extremely complex system including not only the atmosphere but also the oceans, the Earth's ice cover, land and biomass, the atmosphere being the most dynamic part of the climate system. Based on the accumulated data from measurements of climatic elements, a significant change in the mean temperature on the surface of the Earth is recorded since the end of the 19th century and the beginning of the 20th century. Climate change on a global scale is the cause of the occurrence of various meteorological events with unusual intensity and power. The scale of these events often takes on catastrophic proportions with a pronounced disparity between the available and necessary means and capabilities to deal with the consequences. A key factor in addressing these challenges is good preparedness and high resilience of the civil protection system. (Vekilska, 2012, Zahariev and Raykova 1998)

The aim of this study is to assess the role and significance of climate change for disaster resilience of civil protection.

2. MATERIALS AND METHODS

Documentary, descriptive and comparative methods are used to analyze various meteorological processes, phenomena and changes in recent years and their impact on disaster resilience.

3. RESULTS AND DISCUSSIONS

Climatology is a science studying the set of climate-forming factors and conditions, their geographical distribution and change. The term "climate" is derived from the Greek word "klimatos" meaning "inclination". It was introduced for the first time by the ancient Greek astronomer Hipparchus of Nicaea. Historically, there are many definitions of the concept of climate, but the most widespread and generally accepted one is "Climate is the multi-year mode of metrological weather, characteristic of a given territory depending on the geography and location, solar radiation and atmospheric circulation for a relatively long period of time". According to the World Meteorological Organization, this period is no less than 30 years. The term "weather" defines the physical state of the atmosphere over a given local area at a given moment in time. It is determined by the values of the non-meteorological elements temperature, air humidity, cloudiness, precipitation, wind regimes. Weather is constantly changing but typical recurring conditions are observed over long periods of time in a given area. They characterize the climate of this geographical region (Zahariev and Raykova 1998, Takuchev, 2008, Nikolov, 2011, Vekilska, 2012, Petrova, 2019).

The climate is an extremely complex system including not only the atmosphere but also the oceans, the Earth's ice cover, land and biomass. The atmosphere is the most dynamic part of the system and is in constant contact with all other parts. The climate system is characterized by the elements: temperature, precipitation, sea level, atmospheric pressure, air humidity, wind. An important part of the climate system is the general atmospheric circulation, ocean currents, etc. The formation of climate conditions also strongly depends on the amount of falling solar radiation, the orbital parameters of the Earth and its position in the Solar System, called external space factors. The main geographical factors shaping the climatic conditions over a given territory are: latitude, altitude, orography of the area, the distribution of continents and oceans, ocean currents (Zahariev and Raykova 1998, Nikolov, 2011, Vekilska, 2012).

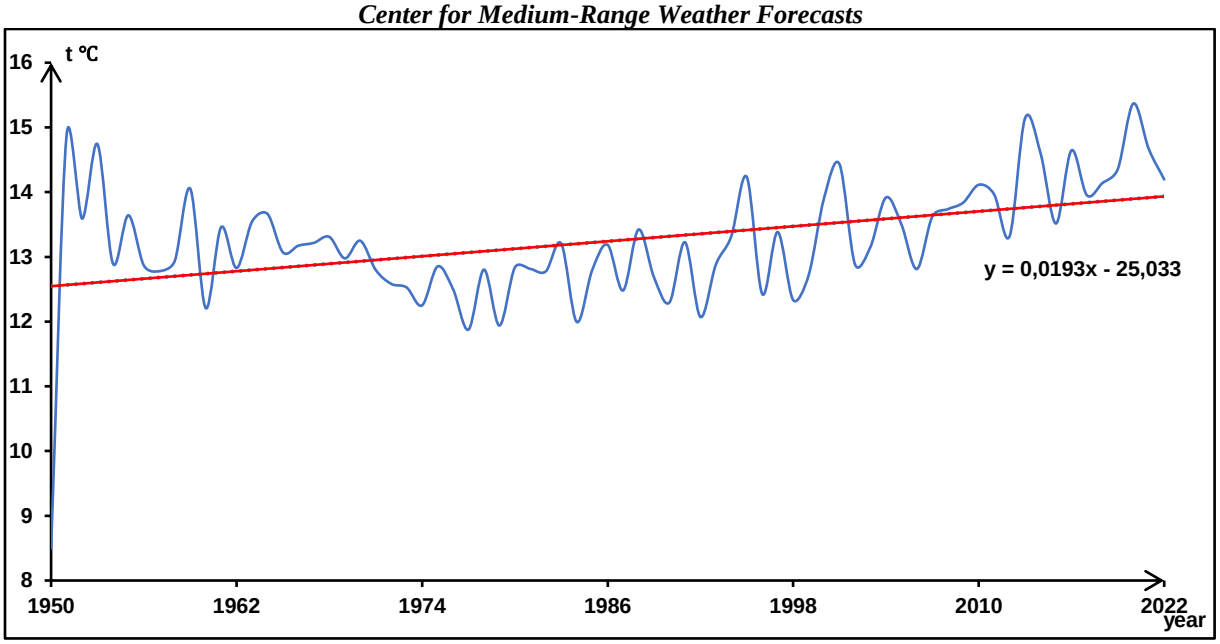
The presence of the earth's atmosphere allows the average temperature on the earth's surface to be +14.8 ℃. Without the existence of an atmosphere, the average temperature of the earth would be -18 ℃, i.e. the greenhouse effect is estimated at about 30 ℃. (Takuchev, 2008) This temperature is not constant during the different geological eras and has changed from 12℃ to 25℃ and according to others 7℃ to 27℃ (Nikolov, 2011). The reasons for these fluctuations in the earth's average temperature throughout its geological development are due to various external (cosmogenic) and internal (terrestrial, geophysical, geological and geographical) causes. External: variations in solar radiation related to the dynamics of the processes taking place in the Sun, changes in the Earth's orbital parameters (tilt of the Earth's axis, eccentricity, precession) and changes in the astronomical characteristics of the Earth's position in the solar system. These major factors directly and profoundly influence the natural course of Earth's climate and leave a lasting imprint on the geologic record. All cosmogenic factors have cyclic progression of varying duration. The so-called "Milakovich Cycles" (tilt of the Earth's axis, eccentricity, precession) have a profound effect on the climate. Internal: land-to-water distribution, volcanic activity, physical characteristics of the Earth's geoid, continental drift, surface change (Zahariev and Raykova 1998, Nikolov, 2011, Vekilska, 2012).

The massive emergence of various measuring instruments in the last 150–200 years has allowed scientists to conduct accurate measurements and accumulate a large database on climate and its changes. This circumstance made it possible to better understand and analyze the processes taking place in the atmosphere, the formation of the climate and its natural course. Based on the accumulated data from measurements of climatic elements, a significant change in the average temperature on the earth's surface began at the end of the 19th century and the beginning of the 20th century. Strong industrial development in combination with deforestation led to an increase in the Earth's average temperature by 0.6 ℃ during the 1930's in the northern hemisphere (Vekilska, 2012). Earth's average temperature rose by about 1.09°C between the end of the 19th century and the past decade, 2011–2020. The warming was more substantial over land (1.59°C) than over oceans (0.88°C) (IPCC, 2021). The main anthropogenic factors influencing the climate are: changes in the gas and aerosol composition of the atmosphere, changes in the structure, characteristics and properties of the underlying surface, thermal effects on the atmosphere, human economic activity (Zahariev and Raykova 1998, Vekilska, 2012).

Instrumental metrological monitoring in Bulgaria, which started at the end of the 19th century, allowed the registration of the warming that began in the 20th century on the territory of the country (Zahariev and Raykova 1998, Vekilska, 2012). In terms of climate, the city of Plovdiv falls according to the genetic classification of

Nojarov in a transitional subtropical to temperate and transitional oceanic-continental climate. (Nojarov, 2017) Based on the processed data from The European Center for Medium-Range Weather Forecasts, for the period 1950–2022, an average annual temperature of 13.240C was determined for the region of the city of Plovdiv.(Ecmwf, 2023) Climatic changes have a reflection in the average annual temperatures for this part of the country. For the interval 1950–2022, a general rise in the average annual air temperature for Plovdiv and its surroundings by 1.33 ℃ was found.

Figure 1. Trend for average annual air temperature in Plovdiv for 1950-2022 based on data from The European Center for Medium-Range Weather Forecasts



The recent decades climate change led to increasing both number and frequency of disasters thus increasing the challenges for communities to deal with them. The communities must be well prepared and able to recover from sudden and unexpected changes caused by disasters and less vulnerable to achieving high resilience. Most of the researchers agree that the answer to the challenges is to create a global concept of disaster resilience, which is based on humanitarian support to vulnerable nations and the delivery of health services in case of a disaster. (Bonanno et al., 2010, Martin-Breen, Anderies, 2011, Ostadtaghizadeh et al., 2015, Ager et al., 2015, Department for International Development, 2011, Fiddian-Qasmiyeh, Ager, 2013, Kieny et al., 2014, Kruk et al., 2015, UNICEF, 2011)

For the first time "disaster resilience" as a term was used at the World Conference for Disaster Reduction in 2005. At that conference, a new concept for disaster response arising from the increasing challenges that disasters pose to affected countries and communities. (Cimellaro et al., 2010, Шишманова, 2004) The concept of "resilience" comes from the Latin language, where "resiliere" means "to go back". According to different dictionaries resilience is defined as "ability to quickly recover from adversity, endurance" or "the ability to recover from or adjust easily to misfortune or change." (Ranjan, Abenayake, 2014, Oxford Dictionaries, Merriam-Webster Dictionary) According to the United Nations Office for Disaster Risk Reduction disaster resilience is the ability of a system, community or society exposed to hazards to resist, adapt to, transform and to recover adequately, efficiently and in a timely manner. (UNISDR, 2009) The Organization for Economic Co-operation and Development defines it as the ability of individuals, communities, organizations, and countries potentially exposed to hazards to cope with them by adapting and change or resistance, in the long term. (Combaz, 2014)

According to Manyena resilience can be described as the ability of a system or society exposed to danger to adapt and survive through change and self-improvement or as a process of being able to deal with emergency events that present danger and have the prerequisites for vulnerability. Bruneau defines the concept as reduced probability of system failure, reduced consequences due to failure, and reduced system recovery time. (Cimellaro et al., 2010, Samsuddin et al., 2018, Winderl, 2014) Other researchers believe that by promoting the complex adaptive systems approach, the ability of the system or process to deal with shock or stress is the meaning of resilience. Department for International Development states that the ability of countries and communities to manage emergencies by

sustaining or transforming without compromising long-term perspectives can be described as resilience. In the global plan for disaster risk reduction, the Hyogo Framework for Action the term is defined as "the ability of a system, community or society potentially exposed to hazards to adapt by resisting or changing, to achieve and maintain an acceptable degree of functioning and structure". (Ager et al., 2015, Department for International Development, 2011, Fiddian-Qasmiyeh, Ager, 2013, Kieny et al., 2014, Kruk et al., 2015, UNICEF, 2011, Combaz, 2014) Bulgarian Red Cross represents it in the following way "the ability of people, communities, organizations or countries exposed to disasters and crises and the related vulnerabilities, to: anticipate, mitigate, cope with, recover from disaster damage without jeopardizing their long-term prospects'. (Bulgarian Red Cross)

According to Ranjan and Abenayake, a sustainable community should be considered from a physical, social, economic, organizational, and environmental perspective. Physical resilience consists of the type of construction, age of buildings, critical infrastructure, possibility of access and evacuation, possibility of shelter, possibility of transport and communications. Social sustainability includes population, education, and non-profit organizations. Economic resilience includes income, property value, employment, size of business, housing capital. Environmental sustainability consists in the possession of natural resources. Organizational disaster resilience includes government organizations, municipal services, health facilities. (Ranjan, Abenayake, 2014)

In the event of a disaster, medical facilities are an essential element of disaster medical support as they are the primary health care providers. The life and health of the population, subjected to the negative impact of the damaging factors, depends on the proper and continuous functioning of medical facilities in case of a disaster. (Pourhosseini et al., 2015, Farah B. et al., 2023) Disaster resilience of health institutions is their ability to withstand and respond to disasters, maintain their functionality in crises and be able to recover to their original state or adapt to a new one after a disaster has occurred. A medical facility is defined as disaster-resistant when its infrastructure (buildings, electricity and water supply, type of structure, etc.) is resilient, sufficient material-technical and medical resource provision is available, as well as sufficient in number and with the necessary knowledge and emergency response skills medical personnel. (Cristian, 2018, Khalil et al. 2022) The resilience of medical facilities to disasters can be seen as a combination of two main elements - static and operational. Static represents "structural" and "non-structural" components such as building stock, equipment, and utilities. Functional (operational) includes "functional" or "operational" components such as human resources, planning and management processes. (Fallah-Aliabadi et al. 2020, Li et al., 2021)

Aditya V. Bahadur, Maggie Ibrahim and Thomas Tanner (2010) research resilience to climate change and disasters. They define ten main characteristics of a resilient systems – diversity, effective governance, capable of change, involving community, “planning for failure”, equity, social values, dynamic, adaptive, cross-scalar. (Bahadur, 2010) Achieving and maintaining climate change resilient healthcare system that possesses these features has its challenges.

Rising temperatures and heat waves are the most prominent climate change related event. Prolong periods of heat as well as extremely high temperatures are expected. (Ebi, 2021) They could affect negatively many people and this will increase the demands for healthcare provision. Allowing high indoor temperatures in the healthcare facilities will affect the personnel and the patients and is a risk for their wellbeing. Maintaining comfortable and safe conditions in hot environment has financial cost. Effective institutions including healthcare facilities, that can withstand the financial burden, have an advantage. Improvements in this direction are directly related to the general quality of healthcare and should be a priority even when there is no impending calamity.

Changes in temperature and precipitation result in droughts which are among the expected climate related disasters. Clean water is essential for the provision of healthcare. Backup to all essential elements for disaster medical support, including water supply, would make the system much more viable.

High temperatures increase evaporation which could cause torrential rainfall and flooding. Frequency and intensity of these events are expected to increase. (Ebi, 2021) The challenges that arise are the loss of functioning hospitals if they are flooded, the need for evacuation of the patients and staff, worsened epidemiological conditions. To mitigate this, high level of diversity seen as large number of entities performing different functions, is associated with resilience. In disaster scenario it is much easier to recruit existing capacities than to create new once. An important factor is the ability to maintain quality of the provided care.

Wildfires are among the expected climate related disasters. (Ebi, 2021) Air pollution, need of evacuation, and large number of casualties requiring specialized treatment are some of the problems that are expected. Hospital evacuation is a challenging procedure to organize and execute. Effective governance is of great essence. The acute and urgent nature of required actions mandates competent and decisive management. It should be based on the real situation and should consider the actual demands.

Climate change and associated events can result in compound disasters – two or more extreme events occurring simultaneously. Examples include extreme heat and drought, extreme heat and fire. Another possibility is the same

or different event affecting the same territory, for example two consecutive floods or flood after hurricane. (Ebi, 2021) Diversity in planning, response and recovery is considered beneficial. Raising preparedness for various scenarios increases the chance to comply with the actual disaster conditions. Climate change modifies the possible events and triggers unusual and novel challenges which make diverse planning even more important.

Ability to accommodate uncertainty and accept change is another characteristic of the resilient system. Flexibility and adaptive capacity require certain level of autonomy on all levels of the healthcare. This poses the question for the qualification and training not only of the managing bodies but of all medical professional that could potentially be involved.

All disasters, including climate related once, stretch medical capacities because of the large number of affected casualties. Community involvement in disaster relief is inevitable in overwhelming events according to researchers. Volunteers usually are involved, but utilizing large number of civilians has also proven to be beneficial to expand the capability for emergency response and improve resilience. (Selwyn, 2024) Bystanders provide first aid, but also could be involved in public health initiatives.

5. CONCLUSIONS

The increase in the frequency and intensity of the disasters related to climate change requires an acceleration of recovery and a rapid return to normal functioning, both of the affected and the responsible structures. Proper risk assessment and prevention that take into account the changing factors of the climate and environment will reduce the negative impact on the society and the economy. Improving general healthcare quality is a prerequisite for disaster resilience and should be prioritised by the healthcare providers.

REFERENCES

Векилска Б. (2012). Обща климатология. Университетско издателство „Св. Климент Охридски“, София, с. 394

Захариев В., и Б. Райкова. (1998). Климатология и Хидрология I част. Център по дистанционно обучение. Нов Български Университет, София, с.196

Николов Т. (2011). Глобални изменения на климата в историята на Земята. Академични издателство „Проф. Марин Дринов“, София, с. 391

Петрова М. (2019). Климатология. Учебно помагало. Университетско издателство „Св. Св. Кирил и Методи“, Велико Търново, с. 193

Такучев Н. (2008). Климатология, Хидрология и Агрометеорология. Издателство РИК „Искра-М-И“, Стара Загора, ISBN 978-954-9383-48-5, с. 461

IPCC. (2021). Climate Change 2021. The Physical Science Basis Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. ISBN 978-92-9169-158-6, p. 40

Nojarov P. 2017. Genetic climatic regionalization of the Balkan Peninsula using cluster analysis. Journal of Geographical Sciences, 27(1), pp. 43-61.

The European Center for Medium-Range Weather Forecasts - https://www.ecmwf.int

Bonanno G. et al. (2010). Weighing the costs of disaster: consequences, risks, and resilience in individuals, families, and communities. Psychol Sci Public Interest. Available on: http://www.psychologicalscience.org/journals/pspi/pspi_10_4.pdf

Martin-Breen P, Anderies J. (2011). Resilience: a literature review. New York (NY): The Rockfeller Foundation. Available on: http://www.rockefellerfoundation.org/blog/resilience-literature-review

Ostadtaghizadeh A. et al. (2015). Community Disaster Resilience: a Systematic Review on Assessment Models and Tools. PLOS Currents Disasters, 1.

Ager A. et al. (2015). Health service resilience in Yobe state, Nigeria in the context of the Boko Haram insurgency: a systems dynamics analysis using group model building. Conflict and Health, 9.

Department for International Development. Saving Lives, Preventing Suffering and Building Resilience, The UK Government's Humanitarian Policy (2011). London: Department for International Development. Available on: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/67468/The_20UK_20Government_s_20Humanitarian_20Policy_20-_20September_202011_20-_20Final.pdf

Ebi KL, et al. (2021) Extreme Weather and Climate Change: Population Health and Health System Implications. Annu Rev Public Health. Apr 1;42:293-315.

Fiddian-Qasmiyeh E, Ager A. (2013). Local faith communities and the promotion of resilience in humanitarian situations: a scoping study. Oxford: Joint Learning Initiative on Faith and Local Communities and RSC

Working Paper. Available on: https://www.rsc.ox.ac.uk/files/files-1/wp90-local-faith-communities-resilience-2013.pdf

Kieny M. et al. (2014). Health-system resilience: reflections on the Ebola crisis in western Africa. Bull World Health Organ., 92:850.

Kruk M. et al. (2015). What is a resilient health system? Lessons from Ebola. Lancet, 385(9980):1910–2.

UNICEF (United Nations Children's Fund). (2011). Fostering Resilience, Protecting Children: UNICEF in Humanitarian Action. Available on: http://www.unicef.org/hac2011/hac_lead.html

Cimellaro GP et al. (2010). A Framework for analytical quantification of disaster resilience. Engineering Structures, 32(11):3639-3649.

Cimellaro GP, Reinhorn AM, Bruneau M. (2010). Seismic resilience of a hospital system. Struct. Infrastr. Eng., 6:127–144.

Шишманова М. (2004). Устойчивост и уязвимост на съвременния град. Управление и устойчиво развитие, 11.

Ranjan E, Abenayake C. (2014). A Study on Community's Perception on Disaster Resilience Concept. Procedia Economics and Finance, 18:88 – 94.

Merriam-Webster Online Dictionary. Available on: https://www.merriam-webster.com/dictionary/resilience

Oxford Dictionaries. Available on: https://en.oxforddictionaries.com/definition/resilience

UNISDR (United Nations Office for Disaster Risk Reduction). (2009). Terminology on Disaster Risk Reduction. Available on: https://www.undp.org/content/dam/unct/bih/PDFs/UNISDR%20Terminology%20%20English.pdf

Combaz E. (2014). Disaster resilience: Topic guide. Birmingham, UK: GSDRC, University of Birmingham.

Samsuddin N. et al. (2018). Disaster Preparedness Attributes and Hospital's Resilience in Malaysia. Procedia Engineering, 212:371–378.

Winderl T. (2014). Disaster resilience measurements: Stocktaking of ongoing efforts in developing systems for measuring resilience. United Nation Dev. Program. pp. 1–59. Available on: https://www.preventionweb.net/files/37916_disasterresiliencemeasurementsundpt.pdf

Bulgarian Red Cross. Available on: http://www.redcross.bg/resilience.html

Pourhosseini SS, Ardalan A, Mehrolhassani MH. (2015). Key Aspects of Providing Healthcare Services in Disaster Response Stage. Iran J Public Health, 44(1):111-8.

Farah B, Pavlova M, Groot W. (2023). Hospital disaster preparedness in sub-Saharan Africa: a systematic review of English literature. BMC Emerg Med, 23:71. https://doi.org/10.1186/s12873-023-00843-5

Cristian B. (2018). Hospital Resilience: A Recent Concept in Disaster Preparedness. J Crit Care Med (Targu Mures), 4(3):81-82.

Khalil M, Ravaghi H, Samhouri D, Abo J, Ali A, Sakr H, Camacho A. (2022). What is "hospital resilience"? A scoping review on conceptualization, operationalization, and evaluation. Front Public Health, 14; 10:1009400.

Fallah-Aliabadi S, Ostadtaghizadeh A, Ardalan A. et al. (2020). Towards developing a model for the evaluation of hospital disaster resilience: a systematic review. BMC Health Serv Res, 20, 64.

Li L, Liao S, Yuan J, Wang E, She J. (2021). Analyzing Healthcare Facility Resilience: Scientometric Review and Knowledge Map. Front Public Health, 9:764069

Selwyn E. M. (2024). 50 - Role of Bystanders in Disasters, Ciottone's Disaster Medicine (Third Edition), Elsevier, Pages 330-336

Bahadur, A., Ibrahim M., Tanner T.(2010). The Resilience Renaissance? Unpacking of Resilience for Tackling Climate Change and Disasters, Brighton: IDS SCR Working Paper.