INTEGRATING BIOLOGICAL HAZARDS (INCLUDING PANDEMICS) INTO DRR PLANNING

Technical Advisory Document

Team Members
Rajib Shaw, Keio University and Resilience Innovation Knowledge Academy (RIKA)
Ranit Chatterjee, Resilience Innovation Knowledge Academy (RIKA)
Ambika Dabral, Resilience Innovation Knowledge Academy (RIKA)

Advisors
Emily Chan, Chinese University of Hong Kong, China
Antonia Loyzaga, National Resilience Council, the Philippines
Yong-kyun Kim, Ministry of Interior and Safety, Republic of Korea

Table of Contents

1. Background 1
2. Purpose and target audience 1
3. Review of existing risk assessment frameworks and country experiences 2
4. Key sectors relevant for mitigation, transmission and impacts 3
   - 4.1 Sectors that help in mitigation 3
   - 4.2 Sectors that exacerbate transmission of infectious diseases 4
   - 4.3 Sectors impacted 5
     - 4.3.1 Impact on the primary sector 5
     - 4.3.2 Impact on the secondary sector 6
     - 4.3.3 Impact on the tertiary/ service sector 6
     - 4.3.4 Impact on the quaternary sector 7
5. Risk assessment and scenario planning 7
6. Prevention and preparedness 13
7. Integration into DRR strategies 17
   - 7.1 Sendai Framework Priority 1: Understanding disaster risk 18
   - 7.2 Sendai Framework Priority 2: Strengthen disaster risk governance to manage disaster risk 18
   - 7.3 Sendai Framework Priority 3: Investing in disaster risk reduction for resilience 19
   - 7.4 Sendai Framework Priority 4: Enhancing disaster preparedness for effective response, and to build back better in recovery, rehabilitation and reconstruction 19
8. Implication to Sustainable Development Goals 20

List of Figures

Figure 1: Analytical interpretation of risk assessment frameworks and guidance 2
Figure 2: Inferences from dealing with past and current health emergencies 3
Figure 3: Sectors supporting mitigation of a health emergency 4
Figure 4: The sphere of transmission of infectious diseases based on sectors 5
Figure 5: Sectoral impact of a health emergency /biological hazard 21
Figure 6. Sectoral approaches for new and known biological hazard 7
Figure 7: Differentiation of biological hazards for risk assessment ..... Error! Bookmark not defined.
Figure 8: Suggestive scenarios for understanding inter-linkages with other disaster risk 12
Figure 9: Key themes for prevention and preparedness of biological hazards 13
Figure 10: Relevance of recommendations across priorities and targets of Sendai Framework 20

1. Background

The COVID-19 pandemic is the worst biological hazard induced disaster observed in recent memory. Its unprecedented speed and spread have affected most parts of the world. The year 2020, which is supposed to be an important milestone year for the Sustainable Development Goals (SDGs), the Sendai Framework for Disaster Risk Reduction 2015-2030 and the Paris Climate Agreement, is under the shadow of the pandemic. The pandemic has not only impacted economies at every level, but it has also hindered the achievement of the SDGs. Moreover, the cumulative effect of COVID-19 has strongly impacted national and local development planning.

2. Purpose and target audience

The Sendai Framework enhanced the scope of disaster risk management by expanding beyond natural hazards to include biological hazards such as epidemics and pandemics. The Sendai Framework also places strong emphasis on the need to build resilient health systems through the integration of disaster risk management into the provision of health care at all levels and, in particular, "to enhance cooperation between health authorities and other relevant stakeholders to strengthen country capacity for disaster risk management for health."

Biological hazards defined

A "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.

Biological hazards are of organic origin or conveyed by biological vectors, including pathogenic microorganisms, toxins and bioactive substances. Examples are bacteria, viruses or parasites, as well as venomous wildlife and insects, poisonous plants and mosquitoes carrying disease-causing agents. Biological hazards are also defined by their infectiousness or toxicity, or other characteristics of the pathogen such as dose-response, incubation period, case fatality rate and estimation of the pathogen for transmission.

UN General Assembly A/71/644: Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction

To strengthen a systemic approach to planning and coordination, the UN Office for Disaster Risk Reduction (UNDRR) **is issuing guidance notes on integrating risks associated with biological hazards, including pandemics**, into: 1) disaster risk reduction planning at the national and local levels, and 2) UN Sustainable Development Cooperation Frameworks and Common Country Analysis and plans.

This document serves as the Technical Advisory Document to provide a substantive background to inform the development of the two guidance notes. The document: 1) Provides the analytical basis for the identification and analysis of risks associated with biological hazards; 2) Explores and documents the interlinkages between biological hazards and diverse socio-economic sectors to enable prevention and mitigation; and 3) Provides policy options and guidance on implementing integrated risk management of biological hazards in line with the Bangkok Principles.

The current document also **provides a basic review of materials to facilitate the development of the two guidance notes.** This document was produced through 1) Reviewing existing guidelines and supporting documents on disaster risk reduction and biological hazards; and 2) Identifying how risks associated with biological hazards can be mitigated across diverse sectors based on selected past disasters and the COVID-19 pandemic. This Technical Advisory document is accompanied by an Annex.

The target audience of the guidance notes include:

a. National disaster management organizations (NDMOs).
b. Health authorities and other sector planners.
c. UN country teams that contribute to common country assessments and identify priorities for UN cooperation.
d. Local authorities.

3. Review of existing risk assessment frameworks and country experiences

Comprehensive risk assessment of biological hazards forms the basis for effective emergency risk management of health, helps in understanding risk by supporting risk communication and acts a backbone for risk-informed decision making, planning and development. Conducting such an assessment calls for a whole-of-government and whole-of-society approach. As a result of the review of some of the existing risk assessment frameworks and guidance documents (section 3.3 of Annex), Figure 1 summarizes some pertinent considerations regarding the four key components of risk – hazards, exposure, vulnerability and coping capacity, to be analyzed at a given scale (global, regional, national, local) and from a systems perspective (human, ecological, economic, etc.).

Figure 1: Analytical interpretation of risk assessment frameworks and guidance

Analysis of the past cases of pandemics and public health emergencies of international concern (PHEIC) and the experience of countries in managing COVID-19 (section 3.5 of Annex) point towards the need for evidence-based decision making supported by technology and innovations to develop early warning and risk assessment tools (Figure 2). The direct, indirect and wider impacts of a health emergency are sector-specific and vary across economies.

Figure 2: Inferences from dealing with past and current health emergencies

4. Key sectors relevant for mitigation, transmission and impacts

Analysis of past health emergencies shows that the impacts are sector specific and that sectors play different roles in the mitigation and transmission of a health emergency/biological hazard (section 5 of the Annex).

4.1 Sectors that help in mitigation

The role of the ***healthcare*** sector is paramount in mitigating a health emergency (Figure 3). A robust healthcare system is important to monitor, provide early warning, and share critical information. During a health emergency, the sector supports containment efforts by carrying out testing, diagnosis and treatment. It calls for increased production of personal protective equipment (PPE), undertakes research and development of vaccines, manages dead bodies, and mobilizes healthcare workers in both the formal and informal allied healthcare industry.

Non-Governmental Organisations (NGOs) provide an essential backup to the healthcare sector and the government by conducting needs assessments, engaging communities and amplifying their voices.

Public Utility Services help in maintaining hygiene, adherence to government orders and maintaining basic services.

As part of the ***Education*** sector, higher education institutions (HEIs) can support by conducting research on the various aspects of the health emergency and by generating risk awareness.

The ***Information and Telecommunication (IT)*** sector underpins many sectors and can support the different aspects of the response to biological hazards, including medical services, information sharing, data collection, early warning, and risk communication. The sector also powers remote learning modalities, tele-medicine, tele-working and e-commerce.

The ***Financial and Banking*** sector can ensure businesses are able to access financing, reduce economic impact by restructuring loans, and reduces the chance of person-to-person spread by promoting contactless payment.

Media is important for risk communication, awareness raising as well as supporting tele-education.

The ***Transportation*** sector can provide safe and secure international and local mobility to both healthcare workers and affected populations among others.

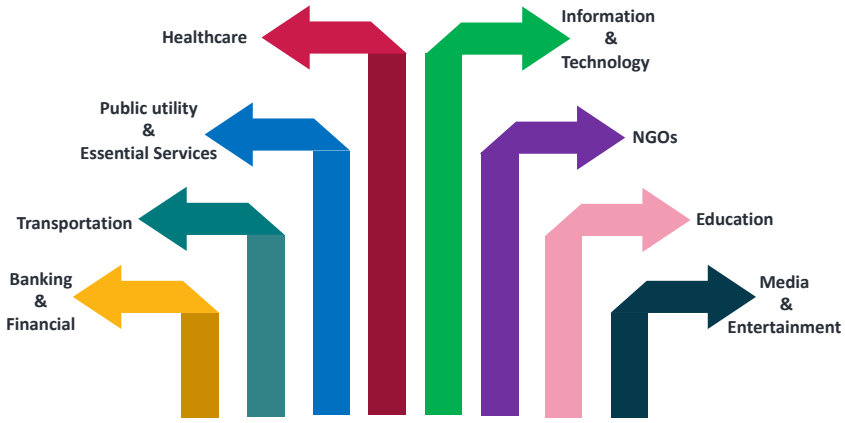


Figure 3: Sectors supporting mitigation of a health emergency

4.2 Sectors that exacerbate transmission of infectious diseases

Transmission can be caused by local to local transmission or by arrivals from international travel. A sectoral transmission may happen among people in a certain sector whose work exposes them to the pathogen or where workers are near infected individuals (Figure 4).

Local transmission may be exacerbated in densely populated cities or by rapid travel (air, water, rail, road) which causes the pathogen to travel faster to distant locations thus putting a higher proportion of the population at risk. The tourism and hospitality sectors also contribute to the spread between cities or by travelers from outside the country. Large sports and cultural events that attract domestic and international visitors can also expose a significant number of individuals to the risk of infection. Locally, schools and universities are possible hotspots of an outbreak as past disasters have shown higher rates of infection in this age group. The HEIs are especially vulnerable to outbreaks due to the high number of international students and faculties.

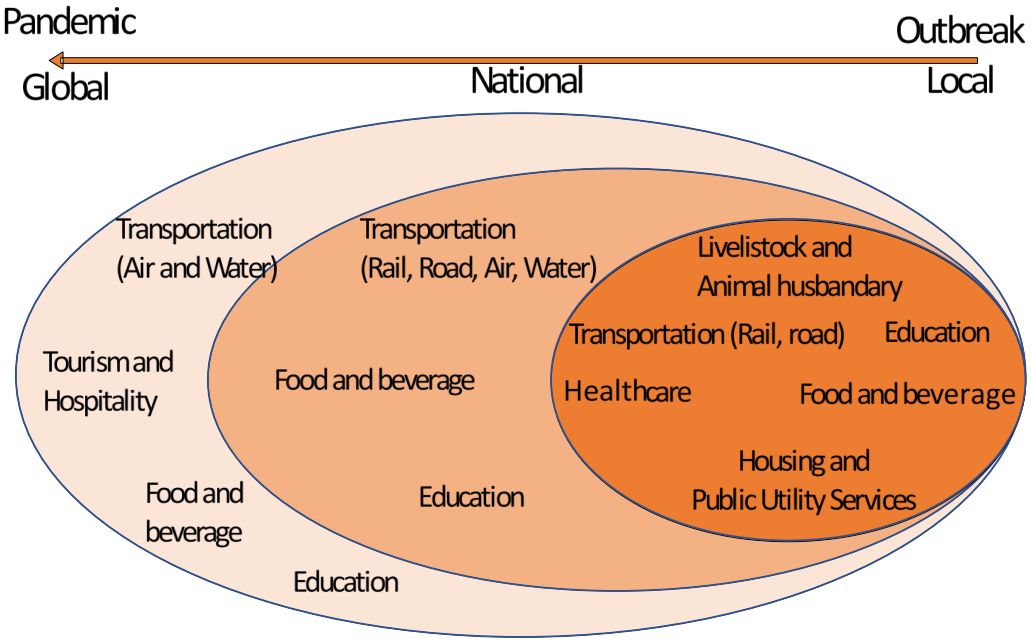


Figure 4: The sphere of transmission of infectious diseases based on sectors

Many of the diseases that originate in animals and can spread to people and cause illness (zoonotic diseases or zoonoses) are caused by viruses, bacterial, parasites, and fungi which spread locally through populations involved in livestock and animal breeding.

Similarly, the healthcare sector has high exposure to infected patients and hence are potent local transmitters themselves. Further, the lack of, or disruptions in, public utility services, like water and solid waste management, may become an important source of transmission. The housing sector, especially informal settlements in developing countries, poses a serious challenge for containing a health emergency due to high population density, lack of essential services, and other predominant socio-economic factors.

4.3 Sectors impacted

A biological hazard can have a differential impact on the primary, secondary, tertiary and quaternary sectors of the economy[1], while having different impacts on the SDGs (Figure 5).

4.3.1 Impact on the primary sector

Primary sectors of the economy, such as agriculture, livestock and mining, can be impacted depending on the geographic location, seasonality and on the nature of the outbreak. Zoonotic

[1] https://en.wikipedia.org/wiki/Three-sector_model

virus borne outbreaks are more likely to impact livestock while restricted mobility and lockdowns imposed by governments can become an impediment for daily wage laborers in the agriculture sector. In addition, the supply chain connecting agriculture products to markets or other dependent industries is also hampered. A pest attack or an extreme weather event may compound the impact on the agriculture sector and agro-based industries thus putting the food security of millions at risk. The mining sector may face issues of absenteeism, restriction in transportation, non-availability of equipment and shutting down of markets.

4.3.2 Impact on the secondary sector

The secondary sector, like the primary sector, will be impacted based on the geographic location, seasonality and on the nature of the outbreak. The manufacturing sector may be hit by absenteeism, lack of transportation, shortages in labour, raw material and equipment, or service disruptions. This sector has a high dependency on critical infrastructure to remain operational and hence any disruption in critical infrastructure may severely cripple the manufacturing sector. Moreover, government restrictions and risk aversion behavior of the public may lead to lower demand for produced goods. On the other hand, pharmaceutical companies and other companies involved in making PPEs and other essential goods stand a high chance of gaining from the sudden rise in demand for certain products.

4.3.3 Impact on the tertiary/ service sector

In a health emergency, the healthcare sector in developed, developing and least developed countries faces a serious challenge of investing in additional workforce, equipment and other resources to ensure operational readiness. At the same time, hospitals experience a decrease in normal patient visits thus straining their regular cash flow. The transportation, tourism and hospitality industries are linked and would be highly impacted due to travel restrictions by government and risk aversion behaviors by people. Lastly, the rise in fake news and cybercrimes can have a negative impact on the media and IT industries.

4.3.4 Impact on the quaternary sector

The education sector has been found to be one of the most frequently impacted sectors. The main reason is the closure of schools and absenteeism of teachers. The propensity of children to some viral infections has led to closure of schools in the past disrupting the academic calendar. This can cause long-term developmental, psycho-social, physical, and emotional complications. Further, a health emergency may expose children to high risk of abuse, neglect, and other issues around child protection. A health emergency may also disrupt the functioning of public utility services due to migration or absenteeism of the workforce, thus impacting the functioning of the other sectors that are dependent on essential services. Further the impact and response by the sector would also vary based on the characteristics of the biological hazards (Figure 5).

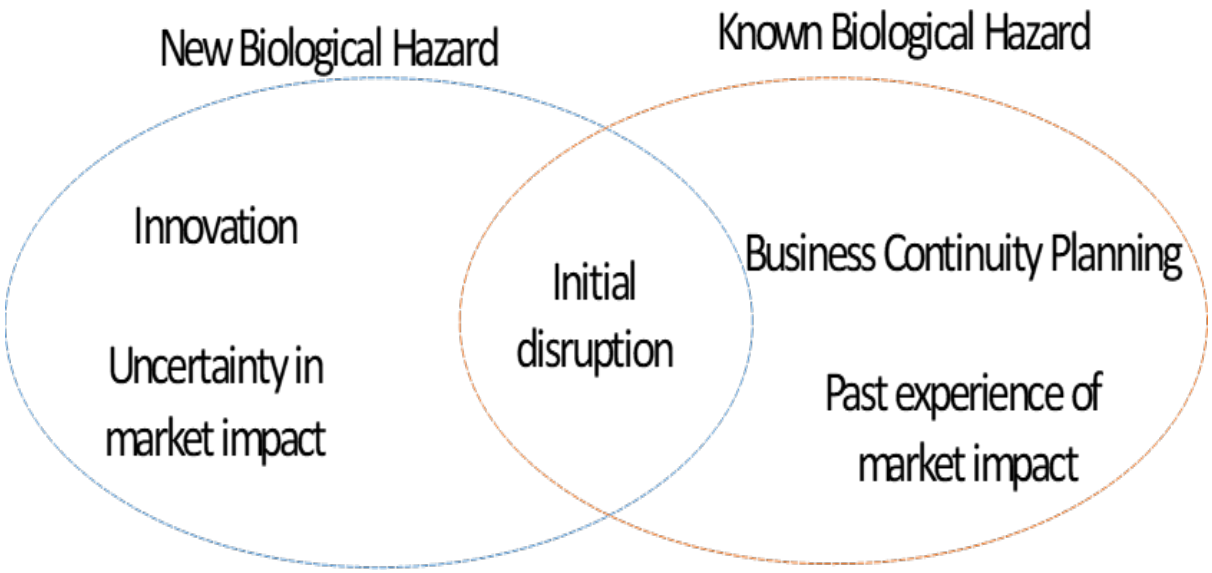


Figure 5. Sectoral approaches for new and known biological hazard

5. Risk assessment and scenario planning

To better understand the dynamics of biological hazards, it is important to assess the risk components, as outlined in Section 3, individually and their mutual interplay and interaction. The following key considerations need to be included while planning to undertake risk assessment of biological hazards:

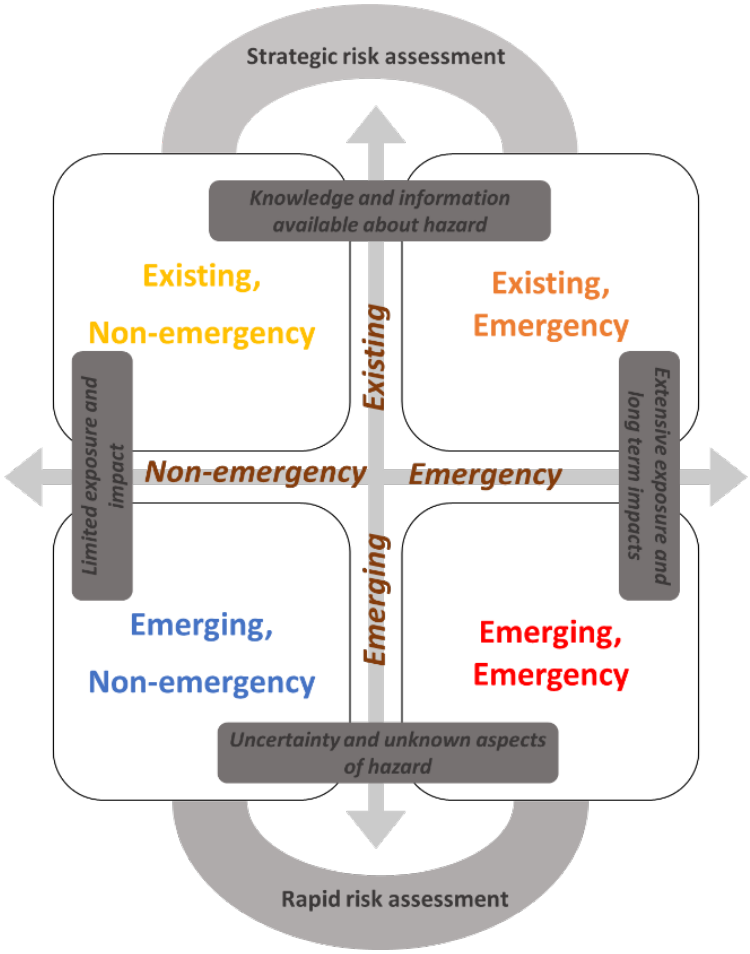
a. Identifying biological hazards

Risk assessments form the basis for planning and implementation through analyzing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment. This includes analysis of historic and present risk components, and also the potential emerging risks in the future. It is important that risk assessment exercises are comprehensive and multi-sectoral to capture the

full spectrum of risks, including that of biological hazards, and also to analyze their interconnected and cascading nature to inform policy actions.

b. Categorizing biological hazards for risk assessments

Biological hazards, for the purpose of risk assessment and management, can be differentiated into existing and emerging hazards based on knowledge about them. While all biological hazards can induce emergency situations of varying nature, duration and severity, based on their potential to cause epidemic/ pandemic/ PHEIC, they can be differentiated into non-emergency and emergency biological hazards (Figure 6).



Risk assessment of existing biological hazards including those with potential to result in an emergency (for example, diseases like malaria, cholera, etc.) can be effectively undertaken due to availability of ample knowledge on aspects of causes, nature of transmission, treatment protocols, potential impact, etc.

Based on this, it is possible to undertake strategic risk assessments and pro-active planning for prevention, preparedness, public health interventions, capacity building and monitoring. However, In the case of emerging biological hazards, it can be quite challenging to conduct an assessment due to their uncertain, ambiguous and unknown nature.

Despite these challenges, the **Words into Action Guidelines: National Disaster Risk Assessment, 2017 (Biological Hazards Risk Assessments)** underscore that an estimated 75 percent of emerging infectious diseases of humans that have evolved from exposure to zoonotic pathogens warrant risk assessments for health threats at the interface between animal, human and ecosystem. The guidelines note three approaches of assessing the risks of biological hazards catering to three different purposes:

1. ***Strategic risk assessment*** which caters to pre-event phase and aids in planning for prevention, preparedness, capacity development and medium- to longer-term risk monitoring and evaluation.
2. ***Rapid risk assessment*** is used for planning response interventions based on risk associated with detected events

3. ***Post-event assessment*** is used for planning recovery, updating and strengthening the overall risk management system.

Subsequently, conducting a strategic-level risk assessment would not be practical once an outbreak emerges and instead, only a rapid risk assessment may be feasible to inform immediate prevention and mitigation measures. Further, non-emergency and emergency-causing biological hazards vary in their impact on different sectors and hence have a different scale of exposure. While, exposure to the former is mostly limited to affected individuals, households, communities, and occupations, exposure to the latter is often vast in spread and duration.

c. Dynamic nature of risk assessment of emerging biological hazards

The uncertain, ambiguous and unknown nature of emerging biological hazards along with their tendency to re-emerge as subsequent waves (which often behave differently from the previous waves) makes them dynamic events which are dependent on various factors that can propagate or contain the spread.

This calls for conducting a rapid risk assessment which is dynamic in nature to understand both the spatial and temporal dimensions of the hazard, its factors and diverse impacts across sectors and social groups. A rapid risk assessment will aim to capture the evolving circumstances and hence the changing level of risk for an individual, community and for different sectors over different phases of the transmission of the hazard, thereby bringing agility to risk-informed decision making. To capture this dynamic nature, assessment of emerging biological hazards is crucial as it guides other factors in risk assessment like potential exposure, vulnerable sectors and social groups and required capacity.

A rapid risk assessment requires a diverse team of epidemiologists, virologists, biotechnologists, health practitioners, decision analysts, DRR experts, etc. who can provide information on critical factors like medium of transmission (air borne, water borne, surface transmission, soil borne, human to animal, animal to human, etc.); incubation period; rate of transmission, recovery and mortality; phases of transmission, if any (like appearance of disease, cluster transmission, community transmission, etc.); differential impact of hazard based on age group, gender, prevailing health conditions (if any); occupational linkages (if any); chances of reoccurrence in a recovered person; possibility and frequency of mutation; existence of a detection protocol, known treatment, vaccines, etc.

d. Linkages with integrated surveillance systems for capturing the dynamic nature

Existing integrated surveillance systems can play a critical role in capturing the transmission pathways - the dynamic spatial and temporal spread of an emerging biological hazard and assist in rapid and dynamic assessment of the hazard. Such an integrated system should not only be limited to disease surveillance but should also include hospital surveillance, laboratory surveillance, veterinary surveillance, community surveillance and external surveillance.

e. Assessing direct exposure of transmission of biological hazards

Direct exposure to biological hazards often occurs through its transmission within a geographical area and can be assessed based on factors affecting the transmission (as identified during hazard assessment). This varies from hazard to hazard as different biological hazards follow different mediums of transmission and impact different sections of the community differently (depending on age group, comorbidity, pregnancy, linkages with specific occupations, etc.).

Various factors like immunity status of the exposed population, dosage and duration of exposure play critical roles in identifying populations at risk of exposure of transmission. Depending on the phases of transmission of the biological hazard, direct exposure may vary over time and intensity and thus may require scenario planning and modelling for anticipating/ extrapolating the exposure.

f. Assessing multi- and cross-sectoral dimensions of exposure of biological hazards

While direct exposure to a biological hazard can be understood in terms of its transmission, indirect exposure to a biological hazard is not limited to its mode of transmission. Indirect exposure of individuals, organizations, may also vary according to the nature of strategies deployed to contain and manage the transmission of the biological hazard. For example, a strategy involving the complete lockdown of an area would impact the exposed population and sectors very differently from a strategy with a partial lockdown and continuation of essential services.

A scenario planning exercise that tests possible strategies for the different phases of transmission and subsequent waves of transmission can help officials anticipate areas, populations and sectors at risk of exposure (including implications of the exposure on urban, geographically isolated and disadvantaged areas). Based on the results of these exercise, and guided by the hazard assessment, multi-sectoral inter- and trans-disciplinary teams should be able to estimate potential exposure of individuals, organisations, and systems to prioritize geographical areas, sections of society, sectors, infrastructure and services under short-, medium- and long-term scenarios.

g. Assessing vulnerability to biological hazards and systemic risk

Assessing the vulnerability of exposed populations, sectors and systems to biological hazards requires consideration of their various underlying characteristics which may vary from one biological hazard to another. Broadly, among others, these characteristics are:

- ***Health-linked*** (like co-morbidity, previous outbreaks);
- ***Occupation-linked*** (like high exposure of transmission to certain occupations like first responders and care givers, with human-animal interface);
- ***Public health-linked*** (like nutritional aspects, water and food systems, disposal of waste);
- ***Triggered by prevailing socio-economic conditions*** (like living conditions, overcrowding, employment status, practices of social stigma, respect for human rights, sustainability of income sources, status of social and financial protection systems);

- ***Linked to behavioral aspects*** (compliance with regulations/ measures, proper hygiene practices, and safety precautions);
- ***Environment-linked*** (whether favorable for the growth of the biological hazard and its transmission).

Thus, unlike other hazards where vulnerable groups and sectors are often pre-identified and known (like older persons, persons living with disabilities, children, women, marginalized minorities, LGBTIQs, etc.) the impact of biological hazards on different groups can vary and thus it might difficult to identify vulnerable groups in advance. These vulnerable groups and sectors may vary based on the strategies deployed for containment and management of the hazards and along different phases of transmission. Therefore, these groups should be assessed for short-, medium- and long-term impact scenarios.

h. Evaluating existing capacities for prompt response and early recovery

Capacity assessments should identify and assess existing resources and plans, infrastructure and services critical for identifying, responding to and managing the biological hazard such as specialised hospitals, diagnostic facilities, testing facilities, treatment capacity, availability of PPEs, trained and equipped essential service providers, existing protocols, public awareness and behavioral aspects, etc. Critical appraisal of these resources should be done to identify the gaps and bottlenecks (including those related to the production and supply of essentials like PPEs, ventilators, etc.) that can prevent the implementation of an effective and efficient response during the management of the disaster.

Scenario planning (corresponding to different phases of transmission) can help in assessing the effective capacities of the resources needed for different phases of transmission and subsequent waves of transmission. Scenario planning should also consider aspects such as the ability of critical and essential services to operate with limited human and technical resources and partially disrupted supply chains; current and expected production and supply of essential material; ability of sectors to adapt to alternate or virtual functioning, capacity of ICT infrastructure to support virtual operations in remote and rural locations; capacity of local communities (socio-economically and psychologically) to sustain themselves during restricted mobility, and capacity of academic and research institutions to conduct research.

i. Understanding the interplay of multi-hazard risks through scenario planning and network modeling

Tools like scenario planning and network modelling may be undertaken to understand and assess the possible inter-linkage of the risk of biological hazards with that of other natural or human induced hazards. Figure 7 suggests three such possible scenarios for risk assessment- A: Standalone occurrence of a biological hazard induced disaster; B: Natural/ human-induced disaster leading to biological hazard induced disasters (malaria outbreak in aftermath of floods) and C: Sequential or simultaneous occurrence of biological hazard induced disaster with natural/ human-induced disasters.

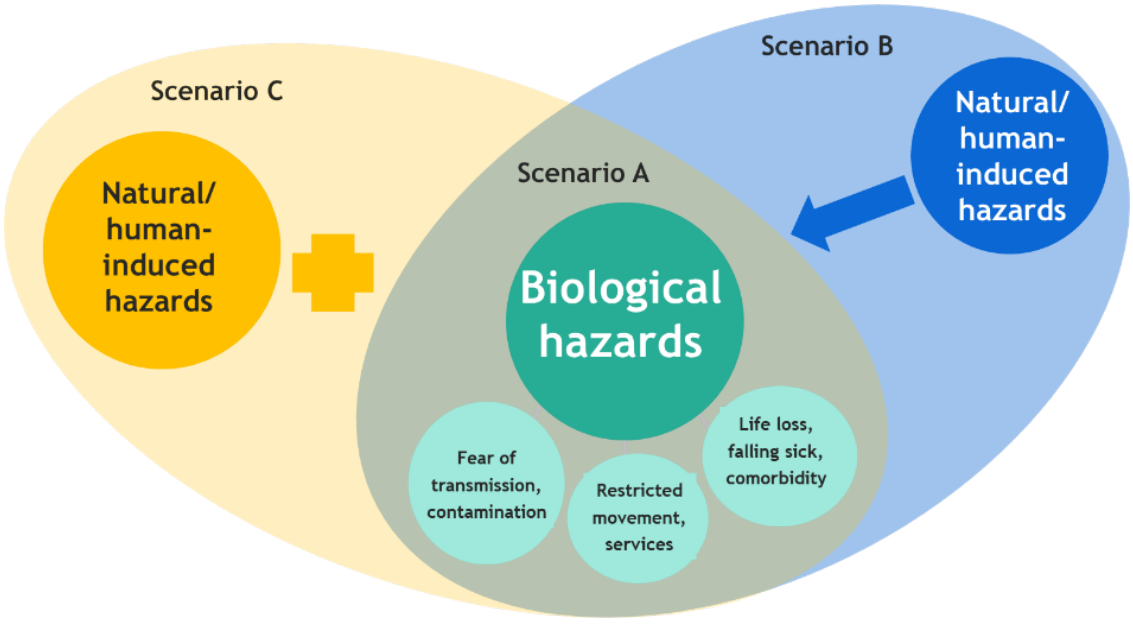


Figure 7: Suggestive scenarios for understanding inter-linkages with other disaster risk

The risk involved in each of scenario varies. For example, in Scenario B, critical response agencies would have been already damaged/ disrupted or overwhelmed due to the previous disaster. Similarly, in Scenario C, the risk to response personnel and the affected population in relief camps is enhanced due to the possible transmission of biological hazards in a crowded setup or in a flooded area (in case of water-borne disease outbreak). This calls for consideration of the possibility of cascading and sequential/ simultaneous disasters while assessing all components of risk- hazard, exposure, vulnerability and coping capacity so that risk-informed response planning and management can be undertaken.

j. Understanding the role of collaboration for undertaking risk assessments of biological hazards

Risk assessments of biological hazards are based on the availability of accurate and trusted data, information, knowledge and expertise in multiple sectors. In addition, this data and expertise must be shared across sectors and geographical boundaries. Thus, as a precursor for undertaking risk assessments, the following factors need to be institutionalized and strengthened:

- Active collaboration between disaster risk management organizations/ DRR platforms with all key sectors like health, public health, food systems, transportation, etc. which have a critical role to play in the prevention and mitigation of biological hazard risk and/ or in exacerbating the transmission.
- Inter-ministerial cooperation and collaboration.
- Identification and liaison with sectoral expertise including those on human rights, gender and disability/chronic illness.
- Greater integration of science-policy-practice through seeking inputs from different disciplines.
- Robust mechanism of data management and inter-sectoral information sharing.

6. Prevention and preparedness

With the evident impact that biological hazard induced disasters can have on the normal functioning of the society and on almost all sectors of economy, it is pertinent to envisage and include them in not only in DRR planning but also in sectoral and overall development planning. Therefore, instead of just preparing to respond and recover from biological hazards, each sector should examine its functions from a disaster risk management perspective whereby it identifies the underlying vulnerabilities; its infrastructure and supply chains exposed to risk; and work towards risk prevention, mitigation, management and building overall resilience. To achieve this, the following key themes (Figure 8) can be considered:

a. Understanding non-linear transition of biological hazards from one phase to another

Biological hazards, particularly pandemics, do not often follow a linear path from response to recovery and tend to re-emerge as subsequent waves whose impact can be very different from that of the previous one. With the onset of each subsequent wave, the recovery phase returns to the response phase until the development of a vaccine or immunity in the community. This should be acknowledged and reflected in sectoral planning and response strategies, not only to support early and better recovery, but also so that the first wave of occurrence (even in case of emerging hazards) could be utilized as a potential early warning for subsequent waves. In this manner, efforts towards the prevention, mitigation and preparedness of future waves can be undertaken in advance.

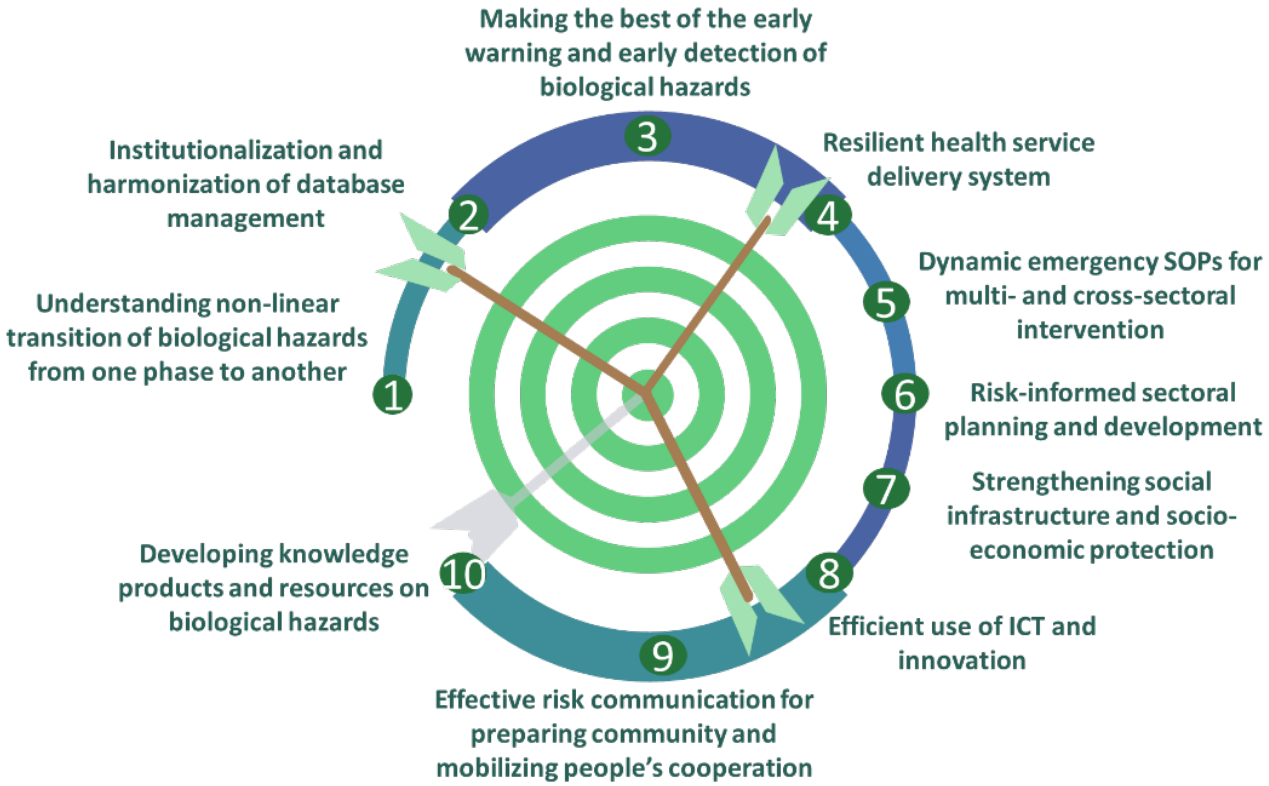


Figure 8: Key themes for prevention and preparedness of biological hazards

b. Institutionalization and harmonization of database management

Depending on the intrinsic nature of the biological hazard, it tends to have differential impacts on different demographic groups (like older persons, pregnant women, persons with co-morbidity, etc.). Accurate and trusted baseline data including geo-spatial and multi-temporal data, data on exposure, vulnerability and capacity; data on pre-disaster health and socio-economic indicators of the population become key to removing the conditions that give rise to biological risks in the first place. Harmonization and inter-operability of data and information among and within countries and regional partners can play huge role in improving the effectiveness and appropriateness of targeted DRR actions.

Moreover, in a post-outbreak scenario, such databases can be useful not only for undertaking rapid risk assessments but also for promptly reaching out to the most vulnerable to provide social protection cover and emergency relief and to plan targeted response and early recovery. They can also help strengthen understanding of the underlying causes of vulnerabilities to inform future risk management of biological hazards. Institutionalization of inter-operable sector-specific database management aids in the development of effective sectoral strategies to mitigate short, medium and long-term impacts on certain sections of society such as migrant populations, daily wagers, persons with disabilities, the poor, orphans, SMEs, local businesses, etc.

c. Making the best of the early warning and early detection of biological hazards

Emerging biological hazard induced disasters often catch nations off-guard. Even when detected in some other part of the world, there is a tendency not to perceive the risk of its transmission within one's geographical boundaries. This often becomes a foregone opportunity of early warning and prevention of transmission. Strengthening bilateral, regional and global inter-governmental forums for proactive trans-boundary information sharing and active cooperation (research, response, funding, managing borders, etc.) can be a key for the early identification and mitigation of conditions in which biological hazards emerge and spread. At the same time, this cooperation is essential to limit the geographical spread of the biological hazard. Similarly, detection in any sub-national unit should serve as an early warning and trigger the activation of emergency standard operating procedures (SOPs) in the rest of the nation.

d. Resilient health service delivery system

Based on the critical role the health sector plays in mitigating and responding to biological hazards, one of the key priorities should be developing a resilient health service delivery system. This includes both public and private health service providers and primary/ community health care units. Key features of such a system include a) a health information system that enables surveillance, documentation, data analytics and communications; b) health service delivery infrastructure that includes a network of screening and testing facilities and laboratories, isolation and quarantine units, clinics, specialised hospitals and treatment facilities, and post-recovery monitoring facilities; c) emergency response/ surge capacity that includes qualified medical professionals, technical personnel, public safety and security personnel, stockpiles of

PPEs and specialised medical instruments, equipment, medicines and vaccines, especially due to the delocalization of production to distant regions; and d) disaster resilient infrastructure and supply chains.

e. Dynamic emergency SOPs for multi- and cross-sectoral intervention

Biological hazards differ from the other hazards in that some can have a long duration and thus could directly and indirectly impact almost all sectors of economy and all sections of the society, though to varying degrees. When managing biological hazards, officials should seek the support of relevant sectors; for example, reaching out to the manufacturing sector to meet increased demand for production of essential medical supplies and PPEs. This calls for a 'beyond health sector' approach of preparedness to ensure prompt response and early recovery. Thus, SOPs for managing biological hazards should be developed in a participative manner to cover multiple needs and impacts.

However, due to various uncertain, ambiguous and unknown elements involved with biological hazards, the SOPs should be dynamic and apply differently to different biological hazards. SOPs for existing biological hazards can be developed based on past experiences and lessons learnt while SOPs for emerging biological hazards can be developed with the help of scenario planning for worst cases, including but not limited to, the occurrence of cascading, sequential and simultaneous disasters.

f. Risk-informed sectoral planning and development

Conducting a multi-sectoral multi-hazard risk assessment through scenario planning can play a tremendous role in bringing together representatives of different sectors to undertake risk-informed sectoral planning and development. Such planning would aid in establishing vertical (intra-sectoral and between national and sub-national) and horizontal (inter-sectoral) linkages in the overall framework of disaster risk reduction and sustainable development. Pre-disaster multi-sectoral and cross-sectoral exposure and vulnerability assessments could aid decision making at various levels and provide better visibility to localized conditions and their implications in the national risk assessment.

Guided by the risk assessment, land use and land cover planning, baseline datasets, planning and development at all levels will aid in reducing underlying vulnerabilities and exposure of each sector and the overall population. This contributes to reducing the realization of existing risks; addressing existing systemic risks; and preventing and mitigating the conditions that could give rise to biological hazards and their propagation. Risk reduction measures could include, but are not limited to, improving urban planning to avoid overcrowding of settlements, strengthening rural infrastructure, developing skills of the workforce, preventing occupational hazards, incorporating a culture of preparedness and safety in sectors, and developing disaster resilient infrastructure, services and supply chains, etc. .

For preparing sectors for the management of residual risk, each sector should undertake sectoral contingency and continuity planning, identify strategies to adapt to alternate means of

functioning/ service delivery/ business and build capacities down to the lowest administrative unit. The adopted alternate strategies should be sensitive to aspects of workforce welfare compliance with labor and safety laws, and other relevant regulations

g. Strengthening social infrastructure and socio-economic protection

Robust social infrastructure and services, including those dedicated to health, public health, nutrition, education, and social and financial protection, etc., play a crucial role in reducing the vulnerability of the exposed population and in ensuring efficient management of biological hazard induced disasters. In the absence of efficient and inclusive socio-economic protection, such disasters would only increase the existing social and economic vulnerabilities. Guided by socio-economic vulnerability assessments and baseline data, investments in strengthening social infrastructure and expansion of the coverage and efficiency of socio-economic protection systems to cover all vulnerable groups can reduce their exposure to biological and other hazards.

Moreover, it is important to strengthen informal support networks which in many societies are the default system for coping, while also expanding social protection to marginalized communities.

h. Efficient use of ICT and innovation

The unknown and uncertain aspects of biological hazards, which make them different from other hazards, can be addressed by innovative use of information and communications technology (ICT), including new and emerging technologies duly contextualized to local needs and challenges. ICT has an immense potential in supporting the management of different aspects of biological hazards, including prevention, mitigation, emergency warnings, early detection, risk communication, dissemination of safety measures active surveillance, exposure tracing, rapid testing and treatment, assessing individual's exposure and risk, and delivery of essential services, etc. Further, during lockdowns and restrictions on mobility, ICT allows for remote functioning of governance structures, services and businesses like tele-medication (of non-emergency patients/ patients in remote locations), remote education, teleworking, continuity of businesses, etc. In addition, ICT based media can provide a platform for ensuring social cohesion even at times of physical distancing and restricted mobility.

In the backdrop of this, there is a need to strengthen the ICT infrastructure, even in geographically isolated and disadvantaged areas, to ensure no region is without such services. In addition, it is essential to also mitigate the existing divides of digital literacy, gender inequality and poverty which act as structural barriers to equal and easy access of vulnerable groups to ICT infrastructure and services. Because of this increased dependency on digital infrastructure, there is a need for enhanced considerations of aspects of cyber security and data protection.

i. Effective risk communication for preparing communities and mobilizing cooperation

The nature of biological hazard induced disasters is such that the public has a far greater role to play than in other disasters. In fact, the key to 'breaking the chain of transmission' is active cooperation of the public. This underscores the need for a 'whole of society' approach to DRR as

the public must be made more aware and educated about the impending risk. Risk communication is a two-way process and thus it is pertinent to understand and sensitively address disaster risk perceptions, knowledge, attitudes and socio-economic and cultural practices of different parts of society. For effective risk communication, it is also crucial to engage with the communities in their local languages so that minority groups like indigenous communities, migrants and refugees are not left out. Guided by these principles, government, civil society organisations, NGOs, and the private sector should collaborate to communicate with their employees, partners, and the public in general. Active participation and strengthening of local level governance and local stakeholders, including community and religious leaders, are critical in this regard.

Communication on preventive practices such as wearing of masks, safe coughing etiquettes, personal hygiene, and appropriate disposal of PPE and other waste products, cooperation with essential service providers, avoiding panic buying and hoarding, preventing stigmatization of affected or exposed persons or occupations, etc. should be made part of daily life. Risk communication in advance of a disaster is also important to make the public understand the potential consequence of their actions to prevent the creation of new risks and to mitigate the existing ones.

j. Developing knowledge products and resources on biological hazards

Biological hazards also differ from other hazards in the limited availability of knowledge products, well-documented sectoral best practices, cross-sectoral learning, lessons learnt globally, case studies on the management of cascading and simultaneously occurring disasters, etc. The production of these knowledge products can assist the administration and sectoral stakeholders to undertake more realistic scenario planning and develop effective strategies. Effective guidelines, sectoral do-s and don't-s, material demonstrating desirable community behaviors (informed by community practices, innovations and limitations) can become effective tools for risk communication and raising awareness and enhancing the culture of responsible behavior and preparedness.

Knowledge management, including the development of knowledge products, is a continuous process in general. However, in aftermath of biological hazard induced disasters, the World Health Organization (WHO) recommends conducting an After Action Review within three months of the official declaration of the end of the emergency.[2]

7. Integration into DRR strategies

Effective and relevant risk management of biological hazards changes with the advancement of science, clinical medicine and public health practices and policy. The latest technical guidelines

[2] http://www.euro.who.int/__data/assets/pdf_file/0009/393651/who-guid-aar-eng.pdf?ua=1

and research findings to support planning may be found WHO's Health-Emergency Disaster Risk Management (Health-EDRM)[3]. The following are some further recommendations for the integration of biological hazards into DRR strategies:

7.1 Sendai Framework Priority 1: Understanding disaster risk

1. Conduct integrated risk assessments: For seasonal biological hazards like water-borne diseases, a comprehensive multi-hazard and multi-sectoral National Risk Assessment (NRA) needs to be conducted. The assessment should include exposure, vulnerability and capacity analyses as part of an integrated policy approach[4]. The cascading effect of different disasters should also be considered, keeping in mind a systemic risk approach. A health risk assessment needs to be an integral component of the risk assessment whenever risk informed public health management is required. For responding to an epidemic or pandemic, an early stage risk assessment and scenario planning incorporating the impacts on different sectors would be required. Real time location-based risk maps should be maintained for enhanced coordination among the different actors. Data sharing and big data analysis also becomes crucial for this step.

2. Enhance capacities and knowledge management: Capacity development for integrated risk assessment at the national to local level is important. Disciplinary divergence (wherever possible) and multi-disciplinary collaboration are key to producing an integrated risk assessment. Higher education / research capacities need to be strengthened, and trans-disciplinary to multi-disciplinary innovative research should be promoted. Moreover, the recording of health-related disaster losses in a national disaster loss database is essential. A capacity assessment is required for the response and recovery phases, particularly for worst case scenarios, which identifies roles and responsibilities within the coordination mechanism. The establishment of incubation centers in universities or research institutions with direct links to the field practices would be useful.

7.2 Sendai Framework Priority 2: Strengthen disaster risk governance to manage disaster risk

3. Revising regulations, legislations, policies: Several countries have different regulations for health emergencies and disasters. It is important to identify synergies between the health emergency and disaster risk management regulations, and where applicable, review laws specific to pandemics to determine implications for disaster risk management. The revision of regulations or legislation related to disaster risk management should be considered to enhance the scope to include biological hazards. The relevant policies and plans also need to be customized.

[3] https://www.who.int/hac/techguidance/preparedness/health-emergency-and-disaster-risk-management-framework-eng.pdf?ua=1

[4] Words into Action Guidelines: National disaster risk assessment, UNDRR, 2017: https://www.undrr.org/publication/words-action-guidelines-national-disaster-risk-assessment

4. Enhance science-based governance and decision making: Science-based, data-centric decision making is considered important for early identification of hotspots, to provide policy makers with the appropriate advice, and to address collateral hazards. Inclusion of a multi-disciplinary scientific community in national platforms for DRR is important to ensure different perspectives are brought in for decision making. This will aid in the development of an integrated risk assessment, scenario planning, forecasts of the spread of the epidemic, etc.

7.3 Sendai Framework Priority 3: Investing in disaster risk reduction for resilience

5. Introduce fiscal boosting and social protection: Epidemic and pandemic outbreaks affect wide sectors of society and put both lives and livelihoods at risk, which also impedes development. Fiscal boosting is an important tool for enhancing not only economic recovery, but through a proper social protection measures, can also enhance social safety nets. Existing tools and methods for registering the most vulnerable groups should be adapted to be quickly adjusted and used to identify priority groups for support.

6. Enhance business resilience: Keeping with a whole-of-society approach, public-private partnerships and business-to-business cooperation are important elements to ensure the continuity of supply chains. This assumes higher significance in the context of supporting small and medium enterprises (SMEs), including those which operate in the informal sector and hence are often left out of social and economic assistance packages.

7.4 Sendai Framework Priority 4: Enhancing disaster preparedness for effective response, and to build back better in recovery, rehabilitation and reconstruction

7. Robust and integrated early warning systems: Early warning is key to responding to any type of hazard, and biological hazards are no exception. A proper early warning system for biological hazards can be developed only when there is a robust public health system in place, which detects any biological hazards before outbreaks occur. This issue needs to be incorporated in development planning as well. Like with natural hazards, a key to early warning is end-to-end communication, where last mile communication is crucial. It is also important that the biological hazard early warning system be integrated into the existing early warning system for natural hazards.

8. Introduce Business Continuity Planning and adaptive strategies: Since epidemics and pandemics are often long lasting, proper business continuity planning for core impacted sectors / ministries is critical. These plans should be developed in advance or at an early stage of the event. Moreover, emergency operation centers should be optimized. Where possible, protocols should be adapted based on lessons from previous disasters while

integrating the particularities of the biohazard. Crisis leadership in both the public and private sectors are important. As the situation changes over time, it will be important have an adaptive strategy that can synchronize with the scenario planning.

9. Impact management versus impact reduction (examine root causes) and resilience: While most epidemic / pandemic responses focus on impact management it is equally important to look at root causes and enhance impact reduction. Risk reduction approaches need to be the core of the response mechanism, as well preventative risk reduction in non-emergency decision making and investment. Volunteers, civil society organizations and structures at the decentralized level that are working directly on awareness raising and response should be trained regularly to work under the conditions of pandemics/epidemics to ensure their safety and continuity of operations. Lessons from past biological hazards need to be taken into account and capacity might need to be strengthened to introduce new institutional arrangements to transform the risk profile.

		Target 1: #Mortality	Target 2: #Affected people	Target 3: Economic losses	Target 4: Critical infra	Target 5: #countries with N/L strategies	Target 6: Internaitonal Cooperaiton	Target 7. EWS and informaiton
Priority 1	1.Integrated risk assessment	◎	◎	○	◎	○	△	○
	2. Capacity and knowledge management	○	○	△	◎	◎	◎	◎
Priority 2	3. Regulation / legislation	◎	◎	◎	◎	◎	△	○
	4. Science based governance / decision	◎	◎	○	◎	○	△	◎
Priority 3	5. Integrated EWS	◎	◎	◎	◎	△	○	◎
	6. Fiscal boositng and social protection	△	◎	◎	◎	○	◎	△
Priority 4	7. BCP and adaptive strategies	○	◎	◎	○	◎	△	◎
	8. Impact management vs impact reducion	○	◎	○	○	◎	○	◎

◎ Highly relevant ○ Relevant △ Less relevant

Figure 9: Relevance of recommendations across priorities and targets of Sendai Framework

8. Implication to Sustainable Development Goals

The COVID19 pandemic will have a lasting impact on all aspects of development planning in the years to come. The pandemic brought into light the need for effective risk management to safeguard development and the implementation of the SDGs, the Sendai Framework, Paris Agreement, and New Urban Agenda as well as other global, regional and national frameworks.

At the time of writing this report, there is still a very uncertain future ahead of us. A continuation of the pandemic will lead to a protracted global economic slowdown that will have implications on the gains and future progress to be made for targets of 2030 Agenda for Sustainable Development (Figure 10) [5,6] .

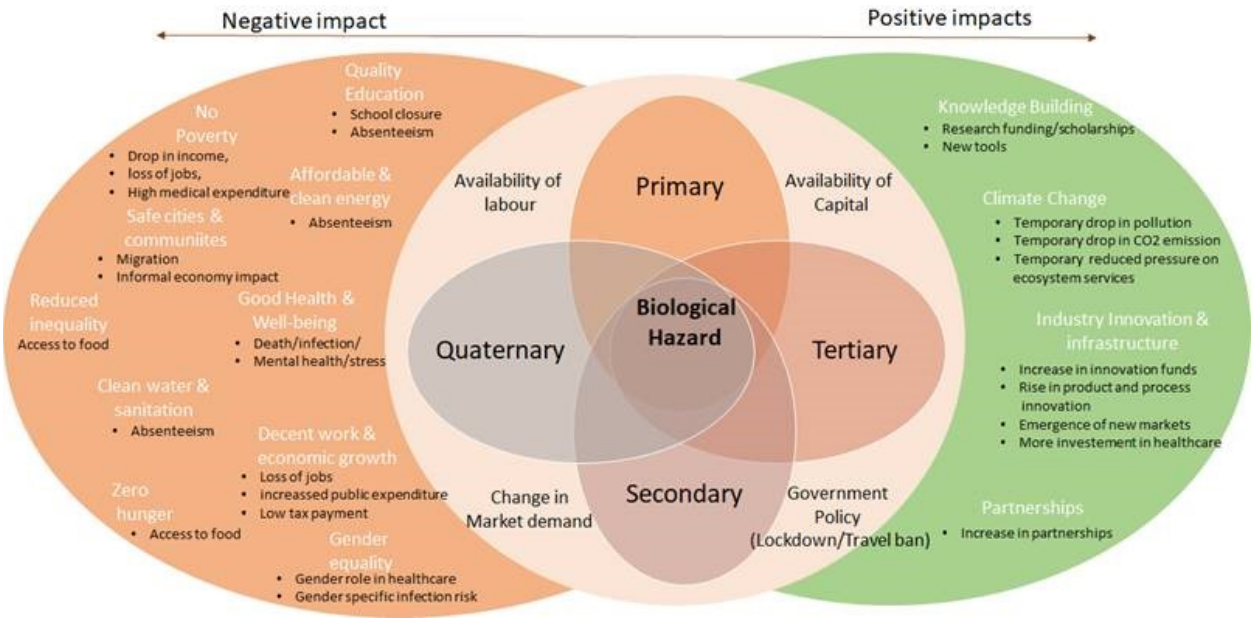


Figure 10: Sectoral impact of a health emergency /biological hazard

The COVID-19 pandemic will push marginalized communities at higher risk of poverty and thus make the achieving of the targets set by ***Goal-1 of No poverty*** challenging. However***,*** a renewed focus on increasing access to basic healthcare for the poor and marginalized communities could improve responses to a future biological hazard. Moving forward, there is a need to focus on creating better access to healthcare and education for the poor and vulnerable populations.

Achieving Goal 2, of Zero hunger is strained due to the impact on primary and secondary sectors. Pest infections, loss of labor force and a breakdown in supply chains could impact agriculture production and lead to a rise in food prices. This would have its an impact on achieving ***Goal 3 of good health and well-being*** by pushing down the nutritional levels in marginalized communities and increasing their risk of malnutrition. Furthermore, lockdowns and the closure of schools in countries with school feeding programs would become an impediment for achieving zero hunger and promoting good health and well-being among school children.

[5] https://unsdg.un.org/sites/default/files/2020-03/SG-Report-Socio-Economic-Impact-of-Covid19.pdf
[6] https://www.researchgate.net/profile/Fatima_Alharmoodi

Moreover, higher mortality and infection rates would make the targets of ***Goal 3 of good health and well-being*** more difficult to achieve. Increasing healthcare coverage and health insurance, especially for people at high risk, to increase access to a vaccine will be of prime importance. Increasing the quantity and quality of health care professionals in high risk zones of biological hazards can prepare the government to respond better to future threats. The inclusion of health indicators in the UNDRR Disaster Resilience Scorecard for Cities [7] and in sustainable city planning under New Urban Agenda will help address health risks through effective city planning, building regulations and investment in resilient healthcare infrastructure.

Access to ***quality education under Goal 4*** may be temporarily impacted by the lockdowns. While digital platforms have shown promise, high levels of digital divide in developing and least developed countries demonstrate that an alternate approach needs to be developed.

Working on improving access to c***lean water and sanitation under Goal 6*** would be an imperative step to preventing future biological hazards and for ***making cities and communities safer under Goal 11***. Furthermore, the need to develop assessment tools, vaccines and promote future research to manage health emergencies comes out as an important area of focus.

Loss of jobs and a rise in unemployment due to the economic slowdown will possibly not only stress the targets set by ***Goal -8 of Decent work and economic growth*** but will also impact ***Gender equality under Goal 5*** and ***Goal 10 on reducing inequality***. Supporting women business owners and providing better access to technology and information would be significant step to reduce these gaps. There will also be a need to promote Business Continuity Planning (BCP) in the tourism sector and to support the informal sector by improving the access of micro, small and medium-sized enterprises to financial services.

Past cases of health emergencies have failed to account for indirect and wider economic impacts in needs assessment and recovery planning. There is a need to understand the overall economic impact to formulate effective recovery policies. This would be an important step in reducing inequalities and would ensure decent work and growth among marginalized and high-risk populations. Ensuring a decent and safe work environment for frontline workers and healthcare personnel has also emerged as an area which needs a detailed look. Preparation of migration policies based on existing trends for biological hazards may prepare the national and local governments in effective response.

Biological emergencies and outbreaks comprise a mix of health, social security and developmental challenges. Like a war, an outbreak has long term impacts on access and availability of food, mental and physical wellbeing and livelihoods. Hence, the whole-of-society approach needs to be imbibed when responding to and planning for recovery from a health emergency. Specifically, for livelihoods, both formal and informal sectors are affected, though the extent of uncertainty may vary. In the formal sector, pay cuts and layoffs become common following an outbreak while in the informal sector, access work is not guaranteed and hence it

[7] https://www.unisdr.org/campaign/resilientcities/toolkit/article/disaster-resilience-scorecard-for-cities

affects food security and wellbeing, which could push marginalized populations to poverty. The rise in public debt, inability to settle loans, reduction in tax revenue, slow growth, low inflation and reduced access to capital for investment are common issues across all the sectors (IMF, 2020).

The COVID-19 lockdowns, however, have had many positive impacts on ***Goals 13, 14 and 15*** on ***combating climate change***, ***life below water and life on land*** in different countries by reducing air and noise pollution levels, healing of the ozone layer and lessening pressure on ecosystem services[8]. Further, studies have established health benefits for vulnerable groups due to the reduction in pollution levels[9]. A challenge for the post lockdown period when production levels rise to make up the loss will be how to sustain these benefits? Further, developing climate models to identify future pandemic risk due to changes in climate conditions and identifying specific geographies will be of importance to plan for future health emergencies.

The recovery from past outbreaks and pandemics have shown that an overburdening of the ecosystem services occurred due to increased production for economic gain to make up for losses. Ecosystem services have a more or less constant regeneration cycle which is disrupted by this sudden surge in demand, thus tipping the threshold of regeneration. Issues of overfishing and clearing of forests could disturb life under water and on land. The increase in production and travel in the aftermath of the health emergency may also increase air and water pollution levels which might impact the health and wellbeing of people with pre-existing respiratory comorbidities. Further, changes in climatic conditions (temperature, humidity, precipitation, sea level sensitivity) will act as a risk multiplier to other non-communicable and infectious diseases and biological hazards, based on their seasonality and return period[10]. For instance, a decrease in public utility services, like solid waste collection and cleaning of drains may lead to an increase in breading of mosquitoes putting countries identified as dengue hotspots at a higher risk of an outbreak.

Lastly, the COVID-19 pandemic recovery is a chance to recover better while leaving no behind. An inclusive long-term recovery plan for the various impacted countries needs to take a holistic approach to address existing gaps and work towards a sustainable society. A biological hazard like the COVID-10 pandemic, is an opportunity to strengthen ***Partnerships under Goal 17*** to develop warning mechanisms and to reduce gaps in data sharing and accuracy for effective evidence-based policy and decision making. The role of science and technology and multi-stakeholder partnerships are of importance in such a case. Better global partnerships and effective risk governance need to be brought into the core of preparedness and response for future health emergencies. Furthering the Health Emergency Disaster Risk Management (HEDRM) Framework may support a coordinated response across various linked sectors rather than straining one particular sector.

[8]https://reader.elsevier.com/reader/sd/pii/S0048969720323305?token=89FE7A972FD31F7D4D66865EFE9ABB1BA2A519D6C2087C3A4E9D9087E3ABA922F8CC22CEB0FD1230F451DF309529B542

[9] https://read.oecd-ilibrary.org/view/?ref=126_126460-1tg1r2aowf&title=From-containment-to-recovery_Environmental-responses-to-the-COVID-19-pandemic

[10] https://www.who.int/globalchange/publications/climatechangechap6.pdf