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REVIEW ARTICLE

A look at biological danger and biosafety in the international health context

Una mirada sobre peligro biológico y bioseguridad en el contexto sanitario internacional

Umolhar sobre o perigo biológico e a biossegurança no contexto da saúde internacional

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ABSTRACT

Introduction: the emergence and re-emergence of pathogens represent a constant threat to the security of humanity, with unpredictable health, social and economic consequences. Added to this is the biological risk present in facilities that use biological agents that are pathogenic to humans, animals and plants. **Objective:** explore information about biological danger and biosafety in the international health panorama, its link with biological emergencies and risk communication for its prevention. **Method:** a descriptive systematic review of 5,097 articles was carried out, based on a meta-analysis in the period 2000 to 2024 (post-covid period). The Sánchez-Meca methodology was used, with the use of Harzing's Publish or Perish 8 software. The academic search engines used were Google Scholar, Semantic Scholar and Crossref. **Results:** it was detected that. There are few studies that reflect the relationship between biological hazards and risks, biosafety, biological emergencies and the leading role that risk communication can play in the international health context. **Conclusions:** the results suggest the need to know biological hazards to implement biosafety measures, preparation and implementation of biological emergency plans, as well as the creation of more effective and efficient risk communication strategies and plans for the protection of the population directly or indirectly exposed to biological risk, as well as socioeconomic goods and services and the environment in general.

Keywords: biological hazard; biological emergency; biosecurity; biohazard communication; biological hazard containment

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RESUMEN

Introducción: la emergencia y reemergencia de patógenos representan una amenaza constante para la seguridad de la humanidad, con consecuencias sanitarias, sociales y económicas impredecibles. A esto se suma el riesgo biológico presente en instalaciones que utilizan agentes biológicos patógenos para humanos, animales y plantas. **Objetivo**: explorar información sobre el peligro biológico y la bioseguridad en el panorama sanitario internacional, su vínculo con las emergencias biológicas y la comunicación de riesgos para su prevención. **Método**: se realizó una revisión sistemática descriptiva, de 5 097 artículos, a partir de un metaanálisis en el período 2000 a 2024 (periodo poscovid). Se empleó la metodología de Sánchez-Meca, con el uso del software Harzing´s Publish o Perish 8. Los motores de búsquedas académicas empleados fueron Google Scholar, SemanticScholar y Crossref. **Resultados**: se detectó que son escasos los estudios que reflejan la relación entre los peligros y riesgos biológicos, labio seguridad, las emergencias biológicas y el rol protagónico que puede desempeñar la comunicación de riesgos en el contexto sanitario internacional. **Conclusiones:** los resultados sugieren la necesidad de conocer los peligros biológicos para implementar medidas de bioseguridad, elaboración e implementación de planes de emergencias biológicas, así como la creación de estrategias y planes de comunicación de riesgos más efectivos y eficaces para la protección de la población expuesta directa o indirectamente al riesgo biológico, así como bienes y servicios socioeconómicos y al medio ambiente en sentido general.

Palabras claves: peligro biológico; emergencia biológica; bioseguridad; comunicación de riesgo biológico; contención de riesgos biológicos

RESUMO

Introdução: a emergência e reemergência de agentes patogénicos representam uma ameaça constante à segurança da humanidade, com consequências sanitárias, sociais e económicas imprevisíveis. Soma-se a isso o risco biológico presente eminstalações que utilizam agentes biológicos patogênicos para humanos, animais e plantas. **Objetivo:** explorar informações sobre perigo biológico e biossegurança no panorama sanitário internacional, sualigaçãocomemergências biológicas e comunicação de riscos para suaprevenção. **Método:** foi realizada revisão sistemática descritiva de 5.097 artigos, baseadaem meta-análise no período de 2000 a 2024 (período pós-covid). Foi utilizada a metodologia Sánchez-Meca, com a utilização do software PublishorPerish 8 de Harzing. Os motores de busca acadêmicos utilizados foram Google Scholar, SemanticScholar e Crossref. **Resultados:** detectou-se que existempoucosestudos que reflitam a relação entre perigos e riscos biológicos, biossegurança, emergências biológicas e o papel de liderança que a comunicação de riscos pode desempenhar no contexto de saúde internacional. **Conclusões:** os resultados sugerem a necessidade de conhecer os riscos biológicos para implementar medidas de biossegurança, elaboração e implementação de planos de emergência biológica, bem como a criação de estratégias e planos de comunicação de riscos maiseficazes e eficientes para a proteção da populaçãodiretaouindiretamenteexpostaao risco biológico, bem como dos bens e serviços socioeconómicos e do ambiente emgeral.

Palavras-chave: risco biológico; emergência biológica; biossegurança; comunicação de risco biológico; contenção de perigo biológico

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INTRODUCTION

Since ancient times, the emergence of diseases that can lead to health disasters has been a worldwide concern, from those that start in animals (epizootics) with a significant zoonotic potential, to those that appear as a result of undesired events in humans (epidemics) or in plants (epiphytics); in all cases, the consequences are drastic.

The biological hazards facing mankind are dissimilar, considering the wide range of biological agents capable of causing disease in animals, plants and humans, the risk groups to which they belong,[(1)] the biosafety levels of the facilities that make use of them, as well as elements relating to laboratory practices and procedures, safety equipment and facility design.[(2)]

It requires the adoption of biosafety measures aimed at preventing the risks derived from such practices and, thus, reducing the possibility of occurrence of undesirable events that cause significant impacts on animal, plant and human health, which also considers the most recent One Health approach.[(3,4)]

Natural biological threats related to human or directly intentional activities and globalization, characterized by the planetary scope of continuous and large flows of people and other living organisms that transform ecosystems and, therefore, the dynamics and scope of epidemic outbreaks affecting all living beings,[(5)] constitute a serious global concern that must be adequately addressed from a preventive perspective.

The emergence and re-emergence of pathogens constitute a constant threat to the safety of humanity, and the associated health, social and economic consequences are unpredictable. In the last two decades the world witnessed the impact caused by the emergence of two coronaviruses, SARS-CoVen 2002 and MERS-CoVen 2012, which caused outbreaks of severe pneumonias in humans and showed clear pandemic potential. As 2019 drew to a close, the emergence of a third new coronavirus initially nominated2019-nCoV came as a surprise.[(6)]

These are just some of the causes that provoked biological emergencies at the international level, so it was decided to conduct the following research with the aim of exploring information on biohazard and biosecurity in the international health landscape, its link with biological emergencies and risk communication for their prevention.

METHOD

A descriptive systematic review was carried out to identify existing works on biological hazards and biosafety, based on a meta-analysis. The methodology of Sánchez-Meca[(7)] was used and the following steps were considered: information retrieval, compilation, evaluation, analysis-synthesis, integration, synergy, summary and conclusions.

The starting point was the critical analysis of selected scientific articles compiled using Harzing's Publish or Perish 8 software. To identify the articles published on the subject, combinations of search terms (variables to be studied)[8,9] were used, such as: “biological hazards and risks”, “biological safety”, “biological emergencies” and “biological risk communication”.

The data for the meta-analysis were acquired from the academic search engines Google Scholar, Semantic Scholar and Crossref, as well as from specific article explorations using Google as the main search engine.

For the bibliographic analysis, referenced sources were used, including scientific articles and Internet documents, among others. The main criterion for inclusion was scientific articles published in the period 2000-2024. The following indicators were taken into account:

Metrics and statistics:

- Total articles and distribution by search engines in 24years.
- Number of citations.
- Number of citations per year.
- Number of citations per article.
- Number of citations per author.
- Number of articles per author.

The articles compiled, after review according to the different combinations of search terms, were examined and subjected to a selection process in which they were excluded according to the following criteria: repeated, in another format (language other than Spanish, English and Portuguese), no affinity with the subject and out of period. Figure 1 shows the diagram with the main steps of the research.

For data analysis and processing, tools were used to facilitate data collection, processing and visualization, such as: Zotero (bibliographic manager used for the creation and normalization of a database) and Microsoft Excel 2019 (used for the representation of the data obtained through tables and graphs).

RESULTS

At the end of the review process, 5097 articles were evaluated in the period 2000 to 2024. Figure 1 shows the total number of articles evaluated by search engines and variables studied.

Overall, 2,110 articles on biosafety and biological emergencies (41.39%), 1,121 articles on risk communication (21.99%) and 897 on biological hazards and risks (17.59%) were identified.

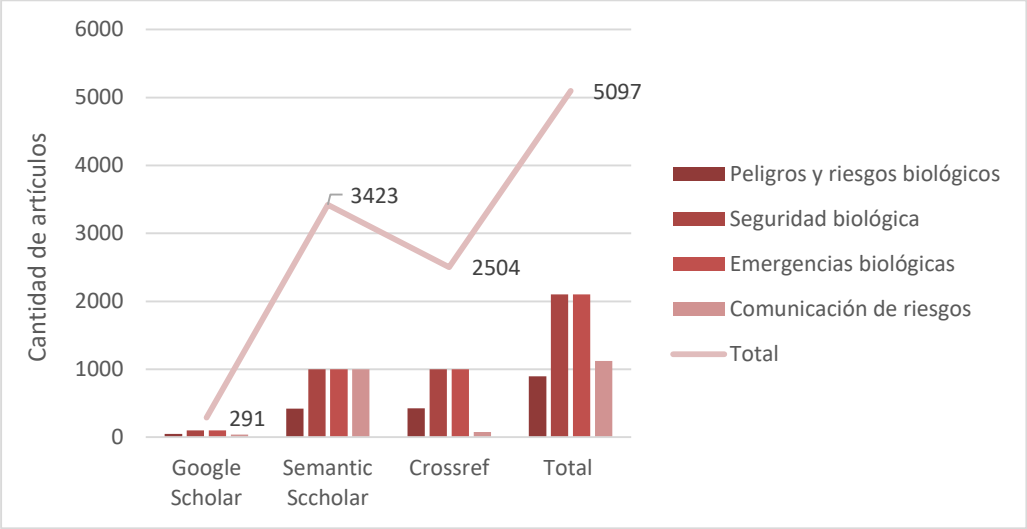

Figure 1: Total number of articles evaluated by search engines and variables studied.

Other metrics identified in the searches are shown in Figure 2.

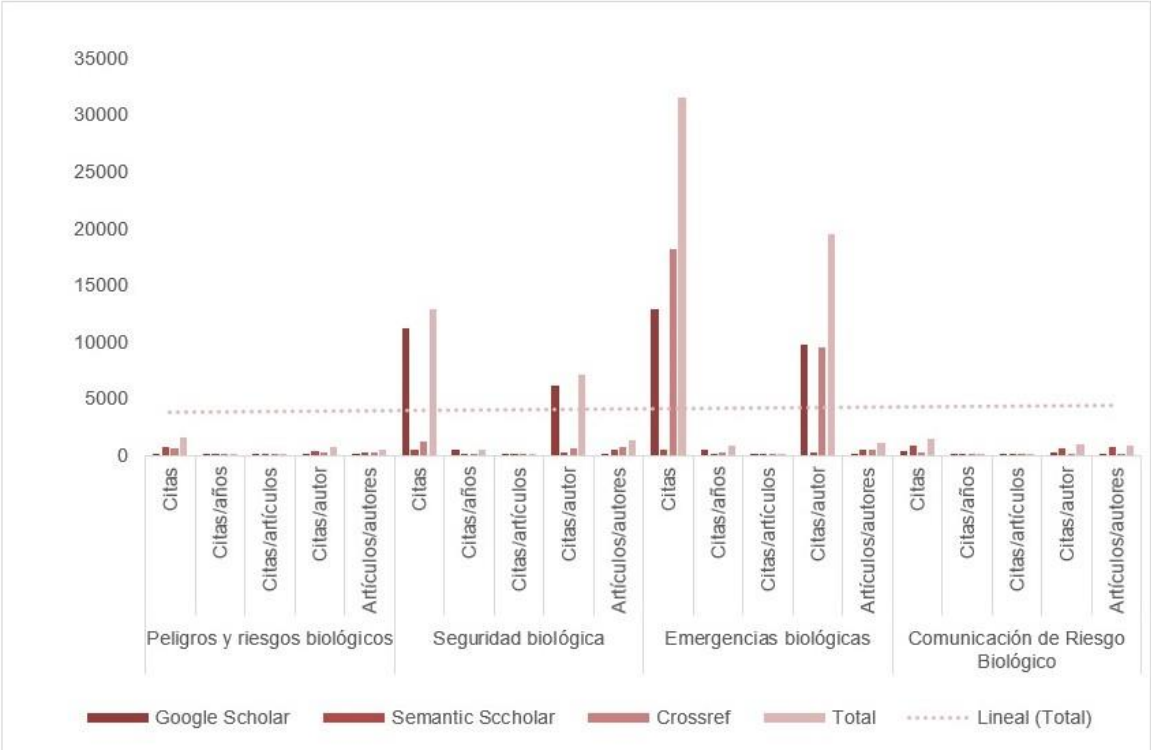

Fig.2. Metric indicators identified in the searches performed.

Of a total of 47,411 citations, the highest number corresponded to the topic of biological emergencies with 66.64%, while the lowest number of citations found was on biohazard communication with 3.00%.

In terms of citations by year, a similar result to the previous metric (citations) was obtained, with a total of 1442.01, the highest number corresponded to the topic on biological emergencies (59.41 %) and the lowest number found was for the variable hazards and biological risks (2.98 %).

A total of 280.31 citations per article were identified, of which the highest number found (52.59%) corresponded to biological emergencies and the lowest number was represented by the variable hazards and biological risks (2.25%).

A total of 28331.06 citations were found by authors; 68.88% corresponded to the variable biological emergencies and 2.67% to biological hazards and risks (the least amount). However, the biosafety variable showed the highest number of articles per author, with 36.20%. The lowest quantities found were biological risk communication and biological hazard and risk with 21.35 % and 13.50 %, respectively.

DISCUSSION

The World Health Organization (WHO) defines biological agents as microorganisms, viruses, biotoxins, particles or other infectious material, and asea of natural or genetically modified origin, which may cause infection, allergy, toxicity or otherwise pose a hazard to humans, animals or plants.[3]

A similar concept is set out in Directive 2000/54/EC on the protection of workers from risks related to exposure to biological agents, which defines them as microorganisms, including those that have been cell cultures and human endoparasites, which may be capable of causing any infection, allergy or toxicity.[10] Meima, et al.[11] define a microorganism as a microbiological entity, cellular or non-cellular, capable of replication or of transferring genetic material. Montaño, et al.[12] define microbial diversity, in a broad sense, as the variety of microorganisms and their diverse adaptation mechanisms.

Royal Decree 664/1997, of May 12, 1997, on the protection of workers against risks related to exposure to biological agents at work, in Article 2 defines biological agents as microorganisms, including genetically modified organisms, cell cultures and human endoparasites, susceptible to cause any type of infection, allergy or toxicity, while microorganisms are defined as any microbiological entity, cellular or not, capable of reproducing or transferring genetic material.[13,14]

Miranda (2024)[15] refers that biological agents comprise microorganisms such as bacteria, fungi and/or viruses, including genetically modified germs, human endoparasites such as helminths and protozoa and cell cultures. These infectious agents are characterized by developing adaptability, and consequently infection, to the changes that occur in the environment, which gives them resistance to grow in any environment.

In Cuba, biological agents are considered as viable microorganisms or their products, prions and other organisms that cause or may cause diseases to humans, animals and plants, as established in the current legislation on biological safety.[16]

Decree Law 190/1999 on Biological Safety in Cuba defines organisms as any biological entity genetically modified or exotic to the country, capable of reproducing or transferring genetic material. It establishes that the facilities are laboratories that carry out biotechnological, diagnostic, research, production and teaching activities, as well as the premises and areas in which the biological risk is present. It recognizes as use the use, manipulation, storage, transportation and control of biological agents and genetically modified or non genetically modified organisms.[16]

Biosafety, according to WHO, is defined as the principles, technologies and containment practices applied to avoid unintentional exposure to biological agents or their accidental release.[3] Meanwhile, in Cuba it is defined as the set of scientific-organizational measures, including human and technical-engineering measures, including physical ones, aimed at protecting the worker of the facility, the community and the environment from the risks involved in working with biological agents or the release of organisms into the environment, whether genetically modified or exotic; minimizing the effects that may occur and rapidly eliminating their possible consequences in case of contamination, adverse effects, leaks or losses.[16]

The international health context today gives biosecurity a special nuance. The World Health Assembly has taken significant steps to improve the International Health Regulations (IHR), through agreements adopted (key amendments) in June 2024, to strengthen preparedness, surveillance and response to public health emergencies, including pandemics [17] and thus ensure that countries have robust systems for the protection of global health.

Thus, WHO notes the importance of biosecurity in preventing and controlling the spread of infectious diseases, especially in outbreaks such as COVID-19 and Ebola.[18] Measures include surveillance and early detection (improving surveillance systems to detect outbreaks quickly), coordinated response (strengthening countries' response capacity and international coordination) and health equity (ensuring that all countries, regardless of their resources, can respond effectively to health emergencies).

The need for preparedness for the emergence of new pandemics is evident, for example, health systems in Latin America will face future health emergencies, including the resurgence of some infectious diseases, the effects of climate change on health, and the spread of misinformation about health.[19] The future will bring other pandemics and large-scale health emergencies; therefore, it is important to strengthen health systems that are more resilient and prepared for future pandemics, based on the lessons learned from COVID-19: collaborative surveillance, community protection, safe and scalable care, access to countermeasures, and emergency coordination.[20]

It also requires the development of vaccines and treatments (investing in research and development to be prepared for new pathogens), strengthening of health systems (improving global health infrastructure to manage future crises) and international cooperation (fostering collaboration between countries to share information and resources); strategies that are essential to protect global health and mitigate the impact of future pandemics, with biosecurity taking on a leading role.

Key aspects of biosafety, One Health and biohazards

WHO defines hazard, in the case of laboratory biosafety, as a biological agent that could cause adverse effects in humans (including such personnel), animals or the environment.[3] Hazard is usually associated with risk, however, both terms are different; the dictionary of the Royal Spanish Academy (RAE) defines it, in its broadest sense, as risk or imminent contingency of some evil happening,[21] while the WHO refers that this does not become a risk until the probability of causing damage and its consequences are taken into account.[3]

In terms of biosafety, the authors of this work define biological hazard as that caused by the presence of biological agents capable of causing infectious diseases in animals, plants and/or humans, whether viruses, bacteria, fungi or parasites.

It can be present not only in hospital facilities, where the presence of pathogenic microorganisms is evident, but also in laboratories of veterinary medicine, plant health, entomophagous and entomopathogenic reproduction centers (CREE), drug and vaccine production centers; also in genetic engineering and biotechnology laboratories, for the diagnosis and confirmation of infectious diseases, food quality, water and liquid and educational waste, as well as in farms for animal breeding and reproduction, fish breeding-breeding-breeding-reproduction and marketing stations, meat and dairy products processing industries for marketing and human and animal consumption.

If a deeper analysis is carried out, it could be said that biological hazards exist even in hairdressing-barbering/manicure-pedicure services and even in public transportation, taking into account the characteristics of the biological agents and their propagation forms, the potential presence of susceptible hosts and the appropriate environmental reservoirs. These three elements form what is known as the epidemiological triangle. The interaction between them determines the emergence and spread of infectious diseases.[22]

It is appropriate to place in the international health context the importance of biosecurity for the protection and conservation of workers, the community and the environment in a broader sense, and its close link with the current One Health approach, which recognizes that human, animal and environmental health are interconnected. This approach promotes interdisciplinary and multisectoral collaboration to address health risks that arise at the interface between humans, animals and the environment.[23,24]

In Cuba, One Health is the strategy for achieving optimal health of people, animals, plants and the environment (through prevention, control and rapid response to any hazard), through intersectoral and multidisciplinary collaboration, from the community to the national level, to maximize the rational use of all resources available in the country, while ensuring the harmonious and sustainable development of society.[25]

There is a close relationship between biosecurity and the One Health approach by promoting zoonosis prevention,[26] surveillance and response (can serve as an early warning system for human outbreaks and provide a faster and more effective response),[17] risk reduction management (globalization, climate change and urbanization can facilitate the spread of diseases)[17] and international cooperation (to share information, resources and best practices).[27] Biosecurity is a key component of the One Health approach.

Key issues to consider include existing national and international rules and regulations, prevention and control measures, public health impacts, as well as training and awareness.[17] Biological hazards can have a significant impact on public health in a variety of ways ,for example, biological agents such as viruses, bacteria and fungi can cause outbreaks of infectious diseases; such was the case of the Ebola outbreak in West Africa between 2014 and 2016 with a devastating impact, thousands of deaths and great stress on local health systems; the most notable outbreaks occurred in Guinea, Sierra Leone and the Democratic Republic of Congo.[28]

Global transmission of pathogens is another impact that biohazard can have on people's health, i.e. pathogens can spread rapidly between countries and continents, which is how the COVID-19 pandemic was able to have a global impact, affected millions of people and caused an unprecedented health crisis.[29,30,31]

Inappropriate use of antibiotics and other antimicrobials has led to the development of resistant bacteria, which makes it difficult to treat common infections and can lead to outbreaks of multidrug-resistant infections.[32] In addition, the biohazard impacts the economy and society, causes overload on public health systems, can lead to the emergence of zoonoses and health inequalities.[33] However, one of the common gaps in biosecurity work is not paying enough attention to effective communication between different stakeholders.[18]

Prevention and control measures are essential to minimize the risks associated with biological hazards.[34] These may include personal hygiene and work environment, hence the importance of implementing adequate antisepsis and disinfection policies, as well as the correct selection and use of personal and collective protection equipment; a key point is also the implementation of biosafety protocols for each operation involving biological risk, equipment handling, waste management, access limitations to facilities with biological risk, among others.

It is necessary, mandatory and relevant to implement medical surveillance programs that include vaccination schedules for the immunization of personnel directly or indirectly exposed to biological risk, pre-employment, periodic and reincorporation medical examinations, as well as the establishment of environmental education programs on biological safety to prepare workers and the community.[31,35,36]

In a general sense, biological hazards pose a significant threat to public health through multiple pathways. Adequate preparedness and response, along with international cooperation, are essential to mitigate these risks, while also considering the One Health approach.

To achieve the purposes of safeguarding health, it is valid to consider the basic principles of biosafety: practices and procedures, safety equipment and the design of facilities, not to mention key aspects such as safety organization, management of hazardous biological waste, and the transport of samples or substances that may contain pathogenic biological agents.[2,3]

The exploration of biohazard and biosafety in the international health context offers vital contributions to the community. By increasing awareness of associated risks and safe practices, it educates and empowers professionals and citizens while promoting responsible behaviors. In addition, highlighting gaps and areas for improvement encourages the updating of policies and protocols, as well as improving preparedness for biological incidents. Addressing biohazards and biosecurity not only improves infectious disease response and prevention, but also fosters international collaboration, which is essential for coordinated global management of biological threats.

Infectious diseases and biosafety

Infectious diseases, since ancient times, continue to be a very important public health problem,[37,38] as is the recent case of the disastrous consequences, at international level, caused by the SARS-CoV-2 coronavirus, the cause of covid-19,[29] and the impacts caused are still being felt.

The pandemics experienced transformed the societies in which they appeared and, quite possibly, have changed or decisively influenced the course of history.[37,38] In all cases it was necessary to adopt measures to curb contagion at the same time that research was conducted to discover what caused the diseases and deaths, including the use of personal protective equipment and isolation of sick personnel, among others.[38]

Some diseases or infections caused by the presence or occurrence of biohazards may be transmissible, meaning that they pass easily from person to person after dissemination; some may do so only when the disease is present in certain forms (e.g., pneumonia vs. bubonic plague); and others are generally not transmitted from person to person (e.g., respiratory anthrax).[38]

Depending on the severity of the disease and the number of people affected, diseases caused by a biohazardous agent may cause a surge in health care and require the appropriate application of control measures to contain the spread of disease.

Accidental or intentional release of a biohazard that threatens public health and the environment may include :[39]

- Releases in facilities (including laboratories) that handle or store biohazardous materials.
- Releases during transportation of biohazardous materials.
- Discovery of unidentified or unknown biohazardous materials.
- Suspected or confirmed terrorism involving the release of biohazardous materials (bioterrorism).

Internationally, local agencies, including Local Health Departments (LHD), Environmental Health Departments (EHD), law enforcement, fire protection agencies (Fire Departments) and local emergency managers have primary responsibility for responding to emergencies involving biohazards in accordance with local plans and procedures. Activities should prioritize containment, management and clean-up of the biohazard, in addition to protection, triage and treatment of people and the environment.[40,41]

Activities may include the deployment of public health personnel, creation of isolation centers, location and creation of cemeteries, acquisition and distribution of personal and collective protective equipment, creation of centers for medical diagnosis, activation of prevention systems. Actions are prioritized and stratified according to the level of biohazard and the magnitude of the incident.[42]

Biosafety and biosecurity are fundamental to the protection of human health from biological risks and agents, because these disciplines enable a safe and targeted response to disease, to be carried out based on scientific evidence, to limit the spread and consequences of infectious diseases.[43]

With the wide range of agents involved and the variety of sectors affected, it is urgent to raise awareness and establish emergency plans for incidents, accidents or breakdowns involving pathogenic biological agents in biohazardous facilities, or an outbreak of a zoonosis in the agricultural or health sectors.[12]

Linking the emergence of infectious diseases to biosecurity is crucial to understanding and mitigating the risks associated with these biological hazards. Implementing biosecurity practices not only prevents the spread of pathogens, but also protects public health, reduces the incidence of outbreaks and limits their negative impacts.

This knowledge enables the community to adopt effective preventive measures, as well as to improve preparedness and response to health emergencies. It also fosters greater responsibility and awareness of the appropriate use of antibiotics, thereby reducing antimicrobial resistance. Biosafety education empowers professionals and citizens, promoting safe behaviors that are essential to maintaining collective health in an increasingly interconnected world.

Biological emergencies and emergency plans

Biological emergencies are considered to be those situations caused by the occurrence of events that may result in damage with immediate or delayed adverse repercussions on the environment in general, the population and workers in particular, due to the escape or release of organisms.[2]

In the context of this work, the authors consider a biological emergency as a legally established situation resulting from the occurrence of unforeseen events or accidents that threaten human, animal or plant health, derived from the presence of infectious biological agents (escape, release, introduction, dissemination and/or transmission), products that may contain them or fragments with genetic information.

Biological emergencies are nowadays addressed through a combination of biosecurity strategies and comprehensive approaches such as One Health, starting with surveillance and early detection,[20] rapid and coordinated response (... includes the deployment of rapid response teams, establishment of quarantines and implementation of infection control measures),[19] as well as the development of vaccines and treatments.[44]

It is necessary to establish biosafety protocols in biohazardous facilities that also include cybersecurity measures and confidential information handling, as well as recommendations for emergency situations such as wars and natural hazard disasters; measures that are essential to prevent the accidental or intentional release of pathogens.[45] Creating a culture that includes continuous training of personnel and the adoption of standardized procedures for handling pathogens is essential for risk prevention.[19]

In Cuba, there is an approved legal regulatory framework that addresses the issue of biological emergencies for risk prevention. Such is the case, for example, of Resolution 199/2020 "Biological safety regulations for the use of biological agents and their products, organisms and fragments of these with genetic information".[2] It establishes the biological emergencies to be considered:

a) Accidental ingestion, cuts or burns.
b) Accidental ingestion of potentially hazardous material.
c) Emission of aerosols outside the biological safety cabinets.
d) Breakage and spillage of containers with cultures on surfaces, equipment and personnel, as well as during transportation out of the facility, in any proportion.
e) Breakage of tubes or other containers with presumably dangerous contents or in centrifuges lacking safety devices, postal packages and biological safety cabinets.
f) Escape or dissemination of biohazardous animals or plants from the areas to which they have been confined.
g) Epidemics, epizootics and epiphytes, produced by release from the facility or release areas.
h) Fires, floods or other natural catastrophes;
i) Accidental or intentional releases of biological agents, with emphasis on those of risk group 2 and above;
j) Theft, robbery or disappearance of biological agents or sensitive information related to them, with emphasis on those of risk group 2 and above.
k) Other situations that may arise.

According to the regulation, emergency plans consist of prior knowledge of the possibility of accidents or catastrophes occurring in the facility, and include actions, insurance and organization of measures to reduce their consequences to minimum levels; they are part of the entity's disaster plan and are applicable to all extraordinary situations, accidents or when an organization goes beyond the framework for which it was intended.

It is also stipulated that emergency plans must include, among others, the following aspects:

a) Biological risk assessment.
b) Safety measures against natural disasters.
c) Measures applicable in case of accidental exposure including decontamination.
d) Emergency medical treatment for exposed and injured persons.
e) Medical, veterinary or plant health surveillance for exposed persons, animals and plants, and their preventive treatment.
f) Epidemiological, epizootiological and phytosanitary investigation, as appropriate.
g) Evaluation of the possible areas of affectation, both inside and outside the facility.
h) Identification of human resources and the responsibilities of each one of them.
i) Identification of personnel and exposed populations.
j) List of medical and medical-veterinary facilities where infected or exposed persons are treated or isolated.
k) Means and routes for transportation of exposed or infected persons.
l) Designation or location of emergency equipment.
m) Control of access to the facilities, stocks and related sensitive information, as well as the selection of personnel.
n) Method of contacting the National Civil Defense General Staff, Ministry of Science, Technology and Environment, and any other emergency services that may be required.
o) Any other indicated by the head of the entity.

Knowing what biological emergencies are and having plans for their prevention and control is essential to protect public health and ensure a rapid and effective response to infectious disease outbreaks. Biological emergencies can arise from the accidental or intentional release of pathogens, which can trigger large-scale health crises.

Well-structured plans can not only identify and contain risks quickly, but also minimize the impact on the population and the health system. These plans include action protocols, biosecurity measures and communication strategies, which are essential elements for coordinating efforts and ensuring a comprehensive and effective response. In short, preparedness and planning are key pillars to face and mitigate the consequences of biological emergencies.

General considerations on the communication process

Communication is the exchange of information between two or more people for a specific purpose, using a common system of signs. There is communication when there are at least three elements, sender/s, receiver/s and message. The latter can be: verbal, visual, gestural, organoleptic..., and all this operates according to a code, and by means of the use of a support through which the message is emitted and received. Basically, it consists of the transmission of a message from one person or group to another, which requires the existence of a willingness to interact between both parties, that is to say that a process of mutual and reciprocal influence is created, through the exchange of thoughts, feelings and reactions that are manifested through the feedback that is established between the communicating parties.[46]

Communication is the process by which we transmit and receive data, ideas, opinions and attitudes to achieve understanding and action. Etymologically it comes from the Latin "communicare" which translates as "to put in common, to share something". Communication is a basic element that generates sociability. It is through it that man is nurtured and preserves his character as an eminent being of coexistence, promotes social solidarity and the cooperative spirit among groups.[47,48]

Biological risk communication

Risk communication in its theoretical-practical evolution has been influenced by different theories, models and approaches coming from Sociology, Psychology, Economics, Social Education, among the most referenced in the scientific literature and of greater impact on health practices oriented to the prevention of health risks, with fundamental perspectives of analysis such as the psychological, scientific-economic, sociological or sociocultural paradigm and Peter Sandman's model, analyzing the relationship between communication and risk from the objective and/or subjective nature that is established between the two.[49]

Risk communication is a scientifically based discipline that faces the dilemma that exists between risks that kill people and risks that alarm them, these are often completely different and people respond only to the risks they perceive.[49,50]

It refers to the real-time exchange of information, recommendations and opinions between experts and/or officials and people facing a threat (risk) to their survival, health or economic or social well-being. It gives great importance to dialogue with the affected populations since the ultimate goal is that everyone exposed to a risk is able to make informed decisions in the face of an emergency or disaster and mitigate the risks of the hazard (risk), such as the outbreak of a disease, through protective and preventive measures and actions. It therefore requires an understanding of stakeholders' perceptions, concerns and beliefs, as well as their knowledge and practices. And to be effective, it must be able to identify and manage rumors, as well as misinformation and other communication challenges from the outset.[50]

Communication is a constitutive extension of health processes, it is present in emergency situations and is related to the risk of communication and people's perception of the hazards to which they may be exposed.[51]

Effective risk communication is an indispensable element of outbreak management. When there is an actual or potential threat to the public's health, treatment options and resources may be scarce, and direct interventions may take time to organize; hence, communicating advice and guidance is often the most important public health tool of risk management. Foresightful communication encourages the public to adopt protective behaviors, facilitates more rigorous surveillance measures, decreases confusion, and enables better use of resources, all of which are necessary to deploy an effective response.[52]

Three fundamental principles underlie risk communication:[53]

- Perceptions are realities: what is perceived as real, even if it is not true, is real for the person and real in its consequences. The aim is not only to anticipate responses to stressful or crisis situations, but also to circumstances which, although they may be described as "phantom" epidemics, can generate "real" epidemics of fear, particularly during emergencies and crises.
- The aim is to establish credibility and trust: it must be kept in mind at all times that both conditions must be increased and maintained so that messages are taken as serious and worthy of attention by the population.
- Effective risk communication is a technical skill: it requires a great deal of knowledge, organization, planning, openness and practice.

The types of communication can be a function of the topic in question, such that one can speak of:

- Communication for care: focuses on risks for which both the risk and the way to deal with it have already been well determined through scientific research that is accepted by the majority of the audience; for example, informing about risks of smoking or unprotected sexual behavior.
- Communication for consensus: aims to inform and encourage groups to work together to reach a decision on how a risk can be managed (prevented or mitigated); for example, between citizens and the owner of a landfill facility to determine together how best to dispose of hazardous waste.
- Crisis communication: takes place in the face of a sudden and extreme hazard, e.g., an industrial site accident, a dam failure or a disease outbreak, and plays a key role in addressing how to deal with the situation.

The World Health Organization (WHO) defined seven outbreak communication planning steps for national public health authorities that represent the general areas of work that are critical to strengthening the public communication capacity necessary to manage infectious disease risks: assessment, coordination, transparency, listening to the public in outbreak situations, communication evaluation, development of an emergency communication plan, and training.[52]

Risk information should be carefully organized and presented, particularly when there is a crisis. This type of communication can be included both during and after the emergency event. Public demand for information may be much greater than that offered by the authorities, so ways must be sought, both in terms of messages and delivery, to meet the needs of the audience without being overly reassuring to the exposed population (whether workers or the general population in the face of an epidemic/pandemic) with too little or too much information.[53,54]

International biohazard communication is a crucial component for the management of health emergencies and the prevention of the spread of infectious diseases; it refers to the real-time exchange of information, recommendations and opinions between experts and/or officials and people facing a threat (risk) to their survival, health or economic or social well-being. The International Health Regulations (IHR) establish the need to inform and educate the public and health professionals about biological hazards and prevention measures.[17]

Currently, the World Health Organization (WHO) provides guidelines and support to countries to develop risk communication policies, strategies and plans, including training of key personnel and training of journalists on how to report health emergencies.

Biohazard communication strategies are in place that include transparency and clarity, community participation and use of multiple channels, such as the media, social networks, traditional media and digital platforms, to reach different audiences.[55]

Moreover, in addition, simulation exercises are conducted to test and improve national risk communication systems that help identify areas for improvement and strengthen response capacity. The importance and necessity of cooperation between countries and international organizations to share information and resources, including the creation of communication networks and collaboration in research and development of best practices, should not be overlooked.[55]

Risk communication and biosafety are intrinsically linked and are critical in today's international health context. Accurate and timely dissemination of biohazard information enables health authorities and the public to take appropriate preventive measures, minimizing the risk of exposure and spread of infectious diseases. Effective communication ensures that biosecurity protocols are understood and followed correctly, strengthening the coordinated response to health emergencies.

In addition, transparency and clarity in communication promote public trust, which is essential for compliance with biosecurity measures and for international collaboration in biothreat reduction management. Integrating risk communication with biosecurity strategies is vital to protect global health and effectively address contemporary health challenges.

CONCLUSIONS

Few studies were identified that reflect the relationship between biological hazards and risks, biosecurity and biological emergencies for prevention, preparedness and effective response to biological threats, and natural, accidental or deliberate asean. It also highlights the fundamental role that risk communication can play in the international health context.

The study made it possible to understand that risk communication plays a decisive role in the management process for reducing the risk of health disasters (to cite one example). Knowledge of biological hazards facilitates the implementation of biosecurity measures, as well as the elaboration and execution of emergency plans that include biological ones, with the protection of the population exposed, directly or indirectly, to biological risk. It also contributes to safeguarding socioeconomic goods and services and the environment in general. The creation of more effective and efficient risk communication strategies and plans will be fundamental to face these challenges.

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