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ARTÍCULO ORIGINAL

Territorial risks analysis by transboundary animal diseases in Cuba

María Irian Percedo[I], Isel González[I], Pablo R. Chávez[II,*], Carlos Delgado[III], María Antonia Abeledo[I]

[I]Center of Preparedness for Disasters Reduction in Animals and Plants (CEDESAP), National Center for Animal and Plant Health (CENSA), Collaboration Center for Reduction of the Risk of Disasters in Animal Health. Apdo. 10, San José de las Lajas, Mayabeque, Cuba. E-mail: percedo@censa.edu.cu. [II]Animal Protection, Civil Defense, Cuba. [III]Veterinary Medicine Institute (IMV), Cuba.

ABSTRACT: A methodology for the territorial risk analysis of biological disasters due to transboundary animal diseases (TADs) was developed and conducted in all municipalities in the country. The methodology identifies the relevant places for the potential entry and the following spreading of TADs (objectives with biological risk-OBR), and characterizes the level of their vulnerability (sanitary gaps) as well as that of the local animal populations. The vulnerability of animal populations considers many topics divided into four aspects: structure of animal production, sanitary control, urbanization of animal rearing, and general characteristics of the municipality. In 161 municipalities, 1597 OBRs were identified. Few municipalities were classified at the highest level of risk but sanitary breaches were identified in many of them. The identification of sanitary breaches and the General Index of Biological Risk in each municipality and OBR was usefull for the improvement of the disaster risk reduction plan. The communication of the biological risk is better understood and accepted by the stakeholders through this process. The use of the methodology for developing plans for prevention diseases at local level is discussed.

Key words: risk analysis, transboundary diseases, animal protection, biological disasters, prevention, risk reduction.

El análisis territorial de riesgo para las enfermedades transfronterizas de los animales en Cuba

RESUMEN: Se desarrolló y aplicó en todos los municipios del país una metodología para el análisis territorial de riesgo de desastres biológicos por enfermedades transfronterizas de los animales (ETrans). La metodología identifica los lugares relevantes para la entrada y consiguiente diseminación potencial de las ETrans (objetivos con riesgo biológico-ORB) y caracteriza el nivel de su vulnerabilidad (brechas sanitarias), así como de la población animal local. La vulnerabilidad de la población animal considera varios tópicos divididos en cuatro aspectos: estructura de la producción animal, el control sanitario, la urbanización en la crianza de animales y las características generales del territorio. En 161 municipios evaluados se identificaron 1597 ORB. Pocos municipios fueron clasificados con el mayor nivel de riesgo, pero se identificaron brechas sanitarias en muchos de ellos. La identificación de brechas sanitarias y del Índice General de Riesgo Biológico en cada municipio y ORB fue útil para el perfeccionamiento de los planes de reducción de riesgo respectivos. Este proceso de análisis de riesgo facilita su comunicación, así como su entendimiento y aceptación, por parte de los decisores. Se discute el uso de esta metodología para el desarrollo de los planes de prevención a nivel local.

Palabras clave: análisis de riesgo, enfermedades transfronterizas, protección animal, desastres biológicos, prevención, reducción de riesgos.

***** Chávez, Pablo: He worked in the National Civil Defence when this methodology was developed. Our post-morten recognition.

INTRODUCTION

There is a growing international concern about the situation of disasters affecting the sustainable development of countries, especially poor and developing countries, where the resources available to solve unforeseen problems are more limited.

Animal disease outbreaks pose significant threats to livestock sectors throughout the world, both from the standpoint of the economic impacts of the disease itself and the measures taken to mitigate the risk of disease introduction, and in the developing world, livestock diseases have broader, more nuanced effects on markets, poverty, and livelihoods, given the diversity of uses of livestock and complexity of livestock value chains [1].

The sudden appearance and subsequent spread of exotic animal diseases in a region or country are considered as disaster because they threaten entire animal populations including those in neighboring regions or countries, producing significant environmental changes with serious economic, social, productive, commercial and sanitary repercussions [2]. The transboundary animal diseases (TADs) posed these characteristics and it is required the effort of the regional or global cooperation for its prevention or control [3].

The emerge and spread diseases are threats associated to smuggling and other actions that circumvent orderly trade and these have grown as a consequence of the interdependence between globalization and trade. The potential costs of animal disease transmission through infected products are escalating as industries become more concentrated [4], as occur in developed countries [5]. On the hand, in the most of developing countries, there are not the resources and policies for a good governance and the appropriate implementation of sanitary standards [6, 7], while chances for diseases eradication are related to its quickly recognizing before its dissemination; this task may be extremely difficult and costly, or even impossible [8]. The previous studies have shown that the close relationship between Gross Domestic Product (GDP) with the total public expenditures for prevention activities at national level may lead to its significant under funding, most notably in low-income countries [9].

Thus, the research results confirm that emerging infectious disease origins are significantly correlated to the socio-economic, environmental and ecological factors, while the global resources for counter disease emergence are poorly allocated, with the majority of the scientific and surveillance effort focused on countries in the lowest risky areas of the world [10].

However, today more than ever, with the increasing globalization, the world 'developed' and 'developing/ transition' countries are so interconnected that both, TADs effects and the measures to prevent them cannot be viewed in isolation [7].

Nowadays, the transboundary diseases, many of them emerging, re-emerging or zoonotic diseases, are considered as perils of disaster situations due to their impacts; and the international organizations claim to pay attention to them by the governments and the sanitary institutions [11]. As a consequence, the increase of heavy losses due infectious diseases in developed, as well as in resource-poor developing countries, is an important reason for the investment in preventing and preparing for biological emergencies and disasters [3, 4, 7, 12].

To coping TADs, as the same as other perils of disasters, the prospective disaster risk management should be integrated into sustainable development planning, thus the development programs and projects need to be seen in the context of reduction or aggravation of vulnerability and hazard [13]. Also, the planning for effective community risk reduction of biological threats and management emergencies should be risk-based, because the counter measures to prevent the introduction and spread of TADs should be proportionate to the risk assessed [14].

The principles of the methodology developed in Cuba for this purpose and the results of its national implementation are the objectives of this paper.

MATERIALS AND METHODS

A methodology was developed and applied nationally in order to evaluate the risk of introduction and dissemination of TADs in municipalities and country-wide. This allowed to obtain a General Index of Biological Risk (GIBR) for each animal species (bovine, porcine and poultry) at the municipality level. GIBR was calculated by accumulating points based on the evaluation of the following components:

- **Threats**: given by the presence of objectives (places) with biological (sanitary) risk (OBR) that can promote the introduction as well as dissemination of transboundary diseases.
- **Vulnerability of OBR (V_{OBR})**: given by the deficiencies in the sanitary protection (against epidemics) of the objectives with biological risks (OBR), those identified as sanitary gaps (SG).
- **Vulnerability of the animal population (V_{AP})**: given by different factors that make an animal population

of a particular territory to be more exposed to the introduction and dissemination of transboundary diseases. The methodology has been developed for cattle, pigs and poultry, although it can be adapted to other species.

In each territory, a risk analysis is conducted for each animal species in a way that each one has a particular GIBR determined by the peculiarity of its risk factors and the vulnerability of its animal population.

The partial validation of the methodology was made in 1997 (15), and after its integral validation in four municipalities in 1998 (16), it was approved for its introduction in the whole country in 2002 by the Veterinary Medicine Institute, official veterinary services in Cuba. In 2003, the technical staff was trained to apply it in provinces and municipalities. The necessary data for the analysis by veterinarians from IMV at the municipalities is updating annually.

A brief explanation about the criteria used for the evaluation of risks in every municipality is given below.

Evaluation of threat (perils) from the presence of OBR (T).

In every municipality, all types of OBR were identified and grouped (I, II and III) according to whether they were a place of potential introduction and/or dissemination of diseases, or a general epidemiological interest (Table 1). Biological Risk Objectives of group I, except for fishing ports and sport fishing bases, are places where activities of the first barrier of sanitary protection are carried out, in particular the application of external quarantine measures for avoiding exotic disease introduction. The inclusion of fishing ports and sport fishing bases in OBR group I was justified by the possible contact and illegal exchange of animal by-products between fishing boats and international ships. International landing areas are coast zones where potentially dangerous wastes coming from international ships are accumulated. Waste processing plants were included in OBRs of group I because they receive sweepings from ports, and residues from restaurants and hospitals among other wastes, and treat them thermally at high pressure for the production of animal feed.

The industry processing foods from animal origin (group II) include milk pasteurization plants, cheese and ice-cream factories, rustic and industrial slaughterhouses and animal by-product production centers, among others.

The Threat (T) existing in every municipality was classified by the kinds of Group I OBRs and number of Group II OBRs present; and a threat-level value ranging from 1 (low) to 4 (very high) was assigned (Table 2). International ports and airports and the international land border were considered to pose great risk in a municipality (very high or high). Two to four is the most common number of Group II OBRs in municipalities; therefore five as a cut-off were used, assuming that municipalities with higher than this number would be at greater risk for disease spread.

Evaluation of OBRs municipal vulnerability (V_{OBR}).

The sanitary gaps existing in OBRs identified in every territory were characterized according to the protection criteria previously established for each kind of OBR (14). From the perspective of vulnerability, Group I, II and III OBRs were assigned 5, 3 and 1 points, respectively, for each sanitary gap detected. The total points accumulated from all existent gaps was considered as the measure of an individual OBR's vulnerability. The sum of the total «vulnerability» points

TABLE 1. Group classification of the Objectives with Biological Risk./ *Clasificación por grupos de los Objetivos con Riesgo Biológico.*

Group I. Places of potential introduction of transboundary diseases		
• International airport	• International port	• International post office
• International tourism area	• Animal quarantine centre	• International garbage landing site
• Migratory birds settling	• Landing area for illegal immigrants	• Land border (Guantánamo)
• Fishing port	• Sport fishing base	• Commercial free zone
• Plant processing residues for animal feeding		
Group II. Places of potential dissemination of transboundary diseases		
• Veterinary diagnostic laboratory	• Industry processing foods from animal origin	
• Animal research center	• Veterinary clinic	
• Veterinary biologics production center		
Group III. Other places of epidemiological importance		
• Wildlife area (and zoo)	• Sanitary landfill	

TABLE 2. Scoring system to evaluate threat according to Objectives with Biological Risk present in the municipality./ *Escala para evaluar la amenaza según los Objetivos con Riesgo Biológico existentes en el municipio.*

Type of OBR	Threat (Points)			
	Very high (4)	**High** (3)	**Medium** (2)	**Low** (1)
Group I	International port, airport, and/or international land border	International port, airport, and/or international land border	OBRs present, but not including international port, airport or international land border	OBRs present, but not including international port, airport or international land border
Group II	There are 5 or more OBRs	There are less than 5 OBRs	There are 5 or more OBRs	There are less than 5 OBRs

of all OBRs existent in each municipality was calculated (V_{OBR}), expressing the overall vulnerability of that municipality. From threat perspective, each Group I, II or III OBR was assigned 10, 5 or 3 points, respectively. The sum of the total «threat» points of all OBRs existent in each municipality was calculated (OBR_T), expressing the overall threat in that region. The V_{OBR} was divided by OBR_T and categorized. Points were subjectively assigned (1 low, 2 medium, 3 high and 4 very high), to each V_{OBR}/OBR_T category in order to estimate the average vulnerability of OBR in the municipality (14).

Evaluation of vulnerability of animal population (V_{AP}).

Several aspects, listed below, were considered in order to analyze the vulnerability of animal populations (V_{AP}) by individual species (bovine, porcine, poultry).

The V_{AP} was ultimately determined by summing the points assigned to each aspect. The points assigned to each category of each aspect appear in parentheses.

I. Structure of animal production in the municipality.

a) Density of animal population. Points were accumulated from the number of geographical sub-quadrants (1 Km^2) categorized by SIVE (System of Information and Epidemiological Surveillance, in Spanish), as very high, high and medium animal density in each municipality (Table 3) [16]. The points accumulated according to the animal density scale are shown in Table 4.

b) The predominant economical productive sector. Four types were considered: I) Backyard breeding (15 points); II) Not specialized (10 points); III)

TABLE 3. Animal density scales according the national epidemiological surveillance system in Cuba./ *Escala de densidad animal según el sistema nacional de vigilancia epidemiológica en Cuba.*

ANIMAL DENSITY (1 Km^2)

By Species	VERY HIGH	HIGH	MODERATE
Bovine	> 600	301-600	101-300
Porcine	>10000	5001-10000	1001-5000
Poultry	>80000	30001-80000	15000-30000

TABLE 4. Scale for the evaluation of animal density in the municipality./ *Escala de evaluación de la densidad animal en el municipio.*

SPECIES	BOVINE					PORCINE AND AVIAN				
ANIMALDENSITY SCALE (Points)	1 (2)	2 (4)	3 (8)	4 (12)	5 (16)	1 (2)	2 (4)	3 (8)	4 (12)	5 (16)
Very high	1-5	6-10	11-15	16-20	> 20	1-2	3-4	5-6	7-8	> 8
High	2-8	9-17	18-25	26-33	> 33	2-3	4-5	6-7	8-9	> 9
Moderate	5-20	21-40	41-60	61-80	> 80	2-5	6-7	8-9	10-11	> 11

Owner cooperatives (8 points); IV) Specialized (6 points). The assignment of points was subjectively based on several aspects, including biosecurity, level of diagnostic activities and access to veterinary services and control of animal movement, all of which increased in the same order as the different production types are cited above. The points assigned are lower while the level of the biosecurity increases.

c) Main purpose of animal production. This was evaluated only when the intensive production sector with large scale production and a defined purpose predominate in the municipalities. Those systems with greater systematic entry of animals in the production flow (as fatteners and open production systems) were considered more vulnerable, as they provide greater probabilities of entry of diseases into herds as well as less sanitary stability of population with respect to endemic diseases in the territory (Table 5).

d) Main movement flow of animals in animal production. This refers to the movement (transit) of animals to meet the production objectives of their husbandry in the territory. This can be: movement out of the territory (0 points); movement within the territory (3 points); movement into the territory (5 points). There is a greater probability of the introduction of a new disease and epidemiological instability of animal population when animals are introduced into the territory.

II. Sanitary control of animal population. For each aspect, control is defined as satisfactory (S), deficient (D) or regular (R). In case of «Satisfactory» it does not sum any point (0).

a) The level of veterinary diagnostic. This includes necropsies, sample submissions to labs and the completion and reporting of the diagnostic work done in the labs. R (6), D (8)

b) Quality of biosecurity. Taking into account the external and internal barriers and environmental sanitation evaluation in production facilities. R (8), D (10)

c) Animal movement control. It considers the evaluation of the fulfillment of sanitary certification for animal movement within and between municipalities and the violations detected. R (3), D (5)

d) Delivery of relevant and updated information on sanitary control to Municipal Office of IMV. R (2), D (3)

e) Speed of notification to the municipal IMV of high morbidity and/or mortality cases. R (3) $\leq$ 48 hours, D (5) > 48 hours

f) Veterinary coverage provided by local veterinary services. R (2) D (4)

g) Staffing completeness of the official veterinary structure in the municipality (% of the stipulated personnel employed). R (2) From 80-89 %, D (4) Less than 80%

III. Aspects related to ownership of animals in urban areas

a) Approximate estimate of animal population in urban areas. This is a relative evaluation of the livestock existence (cattle, pigs, chicken) in the cities and surrounding areas for backyard production. Low (2), Medium (3), High (5).

b) Vector and pest control in urban communities. R (3), D (5).

c) Systematic collection of garbage and wastes in the community. R (3), D (5)

IV. General characteristics of the municipality.

a) Ratio of rural to urban areas. Regions with a predominance of rural areas are considered more vulnerable. Rural/urban: $\leq$ 0.6 (1), 0.7 - 0.9 (2), $\geq$1 (4)

b) Accessibility into the territory. Municipalities with good transportation infrastructure (highway, freeway, trains etc.) are considered more vulnerable because they facilitate disease dissemination through the movement of people and vehicles linked to animal production. For

example, the intensive production of dairy cattle or fatteners will require a viable infrastructure facilitating the link between primary production and industry.Good (4), Average (2), Poor (1)

c) Predominant landscape. Mountainous rural regions are considered more vulnerable due to the difficulty of surveillance and routine control measures, above all when the animals are scattered within small and isolated production sectors. Flat terrain (1), Mixed (2),Mountainous (4)

The points assigned for each aspect listed above (from I to IV) were summed within each species (bovine, porcine, poultry), in order to determine their population vulnerability (V_{AP}) in each municipality. The following categories were then assigned 1, 2, 3 or 4 points respectively: Low (≤41 points), Medium (42-53), High (54-64) or Very high (>64).

Evaluation of the General Index of Biological Risk (GIBR)

The points from the final evaluation (Very high, High, Medium or Low) of each GIBR component (T, V_{OBR} and V_{AP}) were summed. The points summed from all components were categorized as: Low (3 - 4 points), Medium (5 - 7), High (8 - 10) or Very high (11 - 12).

Since each animal species (bovine, porcine and poultry) had its unique V_{AP}, they were also assigned a corresponding IGBR. In the same sense, the values of the Threat (T) and V_{OBR} can be different in IGBR evaluation for each animal species.The ORB´s considered cannot be the same for each one. For example, if the slaughterhouse is only used for poultry, ORB is not to be considering for the evaluation of the Threat and V_{ORB} for bovine or swine population in the municipality.

The methodology is supported by a computerized system (ACCESS) with its user manual [18].

RESULTS AND DISCUSSION

Results of the biological risk territorial analysis were obtained from 161 municipalities (95.3 % of the total). One-thousand five-hundred ninety-seven ORB were identified; 737 (46.2%) were places of potential introduction of transboundary diseases, 622 (38.9%) were places that can contribute to disease dissemination, and 238 (14.9%) were places of epidemiological importance in cases of disease emergencies (i.e., wildlife areas, such as zoos, and dumping places or sanitary landfill).

Dumping places are very important due to the increase in food animal rearing in urban areas. Therefore, in addition to the potential presence of exotic pathogens in animal-origin food residues, domestic wastes may contain feces and other solid residues from backyard animal rearing, which can also be sources of endemic pathogens.

Table 6 summarizes the evaluation of the General Index of Biological Risk in municipalities for bovine, swine and poultry. It is important to note that the labels for these categories contribute to establish the relative risk of municipalities within their province in order to prioritize planning activities. For instance, the designation Very High means that the municipality needs more attention because it has higher conditions for the disease introduction and spread than those designed as Medium or Low. For each species, the majority of municipalities presented a GIBR between High and Medium; though porcine and poultry have relatively more municipalities classified as Medium (as opposed to High) than bovine. This is a result of the intensive production practices of porcine and poultry industries, which favors the most rigorous application of biosecurity measures and other kinds of controls. Also, the control or preventive program for classical swine fever (CSF) and avian influenza (H5N1), respectively, have an impact in these better evaluations than in bovine. On other hand, bovine operations tend to be semi-intensive or extensive with minor biosecurity practices.

For all species, very few municipalities obtained Very High values of GIBR. This indicates that there are very few municipalities having both conditions, the OBRs of greater danger (airports, ports and land borders) and Very High or High vulnerability values, in either OBRs or animal populations.

TABLE 6. Evaluation results of the General Index of Biological Risk (GIBR) by animal species in municipalities./ *Resultados de la evaluación del Índice General de Riesgo Biológico (IGRB) por especie animal en los municipios.*

Species	Number (%) of Municipalities in GBRI categories.			
	Very high	High	Medium	Low
Bovine	7 (4.3)	67 (41.6)	63 (39.1)	24 (14.9)
Porcine	5 (3.2)	56 (32.3)	73 (45.3)	27 (16.7)
Poultry	9 (5.6)	52 (32.3)	71 (44.1)	29 (18.0)

It is important to note that in those municipalities with Very High GIBR, sanitary gaps in the protection of international ports and airports were not detected. Adequate measures for counteracting risks are guaranteed in all of these kinds of OBRs in Cuba, as they are subjected to systematic inspection by the national and local sanitary authorities.

The risk analysis is a decision support tool for the control and prevention of animal diseases [19]. So, in order to provide the basis for designing and implementing appropriately resourced prevention strategies, the risk analysis should provide an estimate of introduction risk degree of the target disease(s), the more likely mechanisms and entry portals of them in the country and the potential seriousness of its consequences [14]. The territorial risk analysis follows these objectives for the improvement of reduction risk program at local level as a task of the official veterinary services.

This methodology enables making a detailed analysis of the different factors that significantly influence in the origin, course and development of an epidemic in any territory. More than having a qualitative or quantitative evaluation of risk, it allows the identification of problems leading to greater vulnerability in front of a transboundary disease spreading and its disastrous consequences. Thus, the assessment of the TADs risk impact does not rest alone on the GIBR qualification.

The disaster reduction plan for animal production to cope all perils (biological, natural and technological) should be made by the veterinary services for each farm and ORB. Therefore, the methodology is useful for the identification of TADs risks introduction/ dissemination and respective counter measures for its inclusion in the plan of each ORB and a broader level as a municipality/province.

As have been recommended, risk evaluations should include all components that allow the planners to identify sensitive determinants and feasible measures to apply, in order to reduce perils or vulnerability, i.e. to develop a plan for risk reduction [20].

Many specialists of different disciplines at municipality and province level intervened in the risk analysis process and approved the final report for each territory. As recommended, this process uses science-based evidence through multidisciplinary approach to assist in making decisions for animal health policy [4, 14].

In Cuba, the plans for dealing with natural, technological and sanitary (biological) disasters in all sectors are guided by the Civil Defense [21, 22, 23, 24], and the Agricultural Ministry within the sector [25, 26].

On the other hand, Cuba has a surveillance system with a comprehensive and current data base [17], which includes accurate data for the risk analyses from essentially every single animal production unit in each municipality. The methodology for biological risk analysis is geared towards veterinary service at the municipal level, which is the primary technical-administrative level of IMV. It provides a tool for the basic evaluation of diverse risk factors that facilitate the introduction and dissemination of TADs.

The methodology has greatly improved the planning of measures to prevent disease emergencies in Cuba, and it is particularly useful because it pays attention to the threats and vulnerability conditions in every municipality. Throughout many years ago, the progressive application of this methodology has been incorporated in the surveillance system and its results are considering also disaster reduction program elaborated at the local level.

The territorial risk analysis is only possible to be made by the veterinary services at the same level, never by the province or national specialists whom do not know the particular characteristics of each municipality. The strengthening of veterinary services at the municipal level has aided these activities in a more effective manner which includes the participation from key people in all sectors involved with animal production.

FAO was committed to develop a system approach to assist countries to attain compliance with international animal health standards and improve trade opportunities [7]. In this sense, the territorial analysis of biological risk could offer performance indicators related to the principal compliance sanitary barriers to avoid the introduction and dissemination of diseases into any territory, and it facilitates the improvement of the prevention measures against these threats and trade opportunities.

To coping disasters situations, communication among the different actors in the community is a strategic aspect, because they should know and have an adequate perception about the risks they are facing. Their support is a key for success the mitigation programs [13, 20].

Ways to facilitate communication and to sensitize all stakeholders to the importance of planning measures for mitigating future events that can affect animal protection should include education about biological risk evaluation activities geared directly or indirectly to animal health in various places or about indicators of the danger of introduction and dissemination of severe diseases, including zoonosis.

In this context, the results of the municipal risk analysis are also useful to sensitize the community sectors involved in the disaster reduction activities.

The methodology applied in Cuba has many contact points with the recently guide proposed for the prevention and control of diseases which considers the concepts as risk-based and people-centered control of disease risks in livestock value chain [14].

Nowadays it is accepted the planning of strategies to reduce risks (risk management) as a result of knowledge of the usual patterns of movement of animals, products, materials, people and vehicles (productive fluxes) combined with risk analysis to better understand how disease could spread if introduced into the system at different places [14]. So, the strategy to coping avian influenza in Asia was strengthened with these guidelines to use science-based evidence by a multidisciplinary approach which contributed to a better understanding of the disease transmission risks, drivers and impacts (27).

The territorial based-methodology bases are similar of those and its application was useful to improve and support diseases prevention program at local level. So, the Veterinary Services need to define the major issues to coping TADS for requesting a higher priority in the national budget allocation, and/or sustained external support.Thus, the risk analysis results can help the Veterinary Services to identify the priorities and can be able to effectively address these challenges. In Cuba there is investment in the development of capabilities for disaster preparation from threat, vulnerability and risk planning and identification process (28).

Taking into account many similarities in the animal production systems in the Caribbean countries, the Cuban experience with this methodology was shared with the Epidemiology Working Group (EWG) of CaribVET, the network of animal health in the region. For its use in other countries the methodological manual, with the software for database management and the user´s manual, were translated into English for the training of the EWG members (29).

Recently, the necessity of increasing the participation of the veterinary authority in the national platform for disaster reduction was analyzed since the prevention stage, particularly in the perils, vulnerability and risk analysis (30). Also, it is better to work on risk reduction rather than on risk management because of the significant benefits from the improved prevention and control measures outweigh the cost of investment (7, 11).

The risk analysis territorial-based methodology considers the introduction and spreading disease prevention in a broad sense. It takes into account the TADs general characteristics in order to have a better target and improve the sanitary defenses at national levels as an effective way to cope these threats of biological disasters.

So, the methodology has been updating since 2012 with some changes in the territorial analysis of perils. Additionally, the major exotic and endemic diseases for our country were considered, specifically those with potential emergence due to climate changes.

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