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Integrated surveillance and risk assessment for arbovirus infections: recommendations for enhancing One Health in the Mediterranean Region

MediLabSecure Strategic Document 2018

M.G. Dente, A. Ranghiasci,
G. Nacca, S. Declich

EPIDEMIOLOGIA
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Centro Nazionale per la Salute Globale

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In 2007 the public health institutes and ministries of health of the countries of the Mediterranean Basin and Middle East started to collaborate in the framework of the EpiSouth network to strengthen surveillance and control of threats to health. Since then the collaboration has been consolidated and presently also several laboratories are part of the network named MediLabSecure, on the basis of the European project started in 2014 that aimed at enhancing surveillance and control of arbovirus infections. In four years of the MediLabSecure (2014-2017), the studies and the implemented activities provided relevant results and lessons learned reported and discussed in this strategic document. The main objective is to contribute to the strategies for the prevention and control of arbovirus infections with a One Health approach, by focusing on integrated surveillance and multisectoral risk assessments. We propose a conceptual framework to facilitate the description, comparison and assessment of integrated surveillance systems and we provide recommendations to enhance operationalization of One Health strategies in national health policies and regional contexts.

Key words: Arbovirus infections; surveillance; One Health; risk assessment; Mediterranean Region

Istituto Superiore di Sanità
Sorveglianza integrata e valutazione del rischio delle arbovirosi: raccomandazioni per rafforzare le strategie di One Health nel Mediterraneo. Documento strategico MediLabSecure 2018.
Maria Grazia Dente, Alessia Ranghiasci, Gloria Nacca, Silvia Declich
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Nel 2007 gli istituti di sanità pubblica e i ministeri della salute dei paesi del bacino del Mediterraneo e del Medio Oriente hanno iniziato a collaborare, nel quadro della rete EpiSouth, per rafforzare la sorveglianza e il controllo delle minacce alla salute in queste aree. Da allora questa collaborazione si è consolidata e attualmente anche diversi laboratori fanno parte della rete chiamata MediLabSecure sulla base del progetto europeo avviato nel 2014, volto a migliorare la sorveglianza e il controllo delle infezioni da arbovirus. In quattro anni di MediLabSecure (2014-2017), gli studi e le attività implementate hanno fornito risultati rilevanti e lezioni apprese che riportiamo e discutiamo in questo documento strategico. L'obiettivo principale è di contribuire alle strategie per la prevenzione e il controllo delle infezioni da arbovirus con un approccio di One Health, concentrandosi sulla sorveglianza integrata e sulla valutazione multisettoriale del rischio. Proponiamo un quadro concettuale per facilitare la descrizione, il confronto e la valutazione dei sistemi di sorveglianza integrata e forniamo raccomandazioni per migliorare l'operatività delle strategie One Health nei sistemi sanitari nazionali e nei contesti regionali.

Parole chiave: Arbovirosi; sorveglianza; One Health; valutazione del rischio; Regione del Mediterraneo

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LIST OF ABBREVIATIONS

CP	contact points
CCHF	Crimean Congo Haemorrhagic Fever
CVOs	Chief Veterinary Officers
DENV	Dengue virus
ECDC	European Centre for Disease Prevention and Control
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
IZSAM	Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise
MLS	MediLabSecure Project
MRA	Multisectoral Risk Assessment
OIE	The World Organisation for Animal Health
RA	Risk Assessment
RRA	Rapid Risk Assessment
RVF	Rift Valley Fever
SWOT analysis	Strengths, Weaknesses, Opportunities and Threats analysis
WHO	World Health Organisation
WNV	West Nile Virus

PREAMBLE

The rationale for the MediLabSecure project stems from the same considerations as the rationale for all projects under the EU Chemical, Biological, Radiological and Nuclear Risk Mitigation Centres of Excellence Initiative. That is, in the contemporary world no country can isolate itself from threats emanating from the regional and global environment. In order to effectively reduce threats and mitigate risks, the only viable option for countries is to cooperate with each other. Threats do not hand over passports at border checkpoints.

For MediLabSecure the threats in question are vector-borne diseases. Due to well-known factors, the distribution of vectors in the broader Mediterranean region is changing, migrating from south to north. Vector-borne disease outbreaks are becoming common in Europe, and even more novel and unusual outbreaks are anticipated.

The bleak picture I paint is somewhat off the scale, because there are international and national institutions and organisations ensuring that this threat remains under control – Institut Pasteur, Istituto Superiore di Sanità, Centro de Investigación en Sanidad Animal-Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Institut de Recherche pour le Développement, the European Centre for Disease Prevention and Control, the World Health Organisation and national institutions in partner countries for instance.

Their joint efforts need reinforcement, and a strategic document is usually a good starting point for that. Moreover, this strategic document has the privilege of also being a distillate of a ten-year long experience of successes and mistakes, which grants it an additional layer of legitimacy and it should be a reason more for the stakeholders to endorse it and translate it into actions.

As the document rightly underscores, the work is not finished. There are still barriers to data sharing, unclear institutional mandates, and structural elements that impede inter-institutional cooperation. We all need to work harder together to ensure that once the surveillance systems are set up, they actually collect data, analyse it, and disseminate it to relevant parties.

There are two reasons why the MediLabSecure project will continue producing results. First, control of zoonotic emerging viruses improves partner countries' public health systems and increases their resilience. This makes them, their neighbours and their region safer, and that includes the European Union. Second, our partner countries' authorities have recognised that cooperating with each other is a crucial responsibility in today's world. MediLabSecure's success is their success.

This document just shows the shortest path to it.

Eddie Maier
Head of Sector for Chemical, Biological, Radiological and Nuclear Threats
DG for International Cooperation and Development
European Commission

FOREWORD

MediLabSecure had the explicit objective to enhance laboratories and health institutions' capacities as well as to strengthen surveillance systems of emerging and re-emerging zoonotic arboviruses in the Mediterranean and Black Sea regions. As implementing organizations, the Institut Pasteur, the Institut de Recherche pour le Développement (IRD), the Instituto Nacional de Investigacion y tecnologia Agraria y alimentaria (INIA) and the Istituto Superiore di Sanità (ISS) succeeded in creating a network encompassing 55 laboratories in animal and human virology, medical entomology and 19 public health institutions in 19 non-EU countries. These partners had the opportunity to fulfil some of their core missions which are public health, research, technology transfer and to share knowledge in the field of diagnosis, biosafety, vector control, quality management and risk assessment.

Defined as "a coordinated, collaborative, multi and trans-disciplinary and cross-sectoral approach addressing potential or existing risks that originate at the animal–human–ecosystems interface" (from "One Health in a world with climate change" by Black & Butler published in 2014 in the journal *Scientific and Technical Review of the Office International des Epizooties*), the One Health approach is a major keystone to reach MediLabSecure objective. This approach is actually advocated through collaboration between working groups and sectors within the project and is also a priority for the Institut Pasteur and the Institut Pasteur International Network.

Indeed, global ecosystem change leads to the migration of populations of animals and vectors and thus encroachment of habitat of different species. The Institut Pasteur promotes Public Health projects where the relationships between humans, animals and ecosystems must be considered in order to improve the overall understanding of diseases and to implement adapted control strategies. In this sense, MediLabSecure is a spearhead project since this network proves to be a fruitful framework to implement inter- and trans-sectoral activities oriented towards the One Health approach such as MediLabSecure situation analysis on integrated surveillance studies in some representative countries and Multisector Risk Assessment exercises.

Based on these activities, the Istituto Superiore di Sanità (ISS), leading the working group on Public Health, provided their expertise in delivering this Strategic Document in which some recommendations have been able to be issued with the enlightened support of mobilized experts. These recommendations should be concretely initiated in the future in the MediLabSecure network which undoubtedly represents a breeding ground to enhance with a One Health approach the risks' mitigation of health emergencies.

Last but not least, on behalf of the Institut Pasteur as coordinating organization and the project team, we thank the European Commission's Directorate-General for International Cooperation and Development for their decisive support to implement these activities through the European Union Chemical Biological Radiological Nuclear risks mitigation Center of Excellence Initiative (EU CBRN CoE).

Marc Jouan
International Vice-President
Institut Pasteur

PREFACE

MediLabSecure is an initiative aimed at reinforcing preparedness to threats to health in 19 countries of the Mediterranean Basin and Black Sea Region.
A priority for the Region is the prevention and control of arbovirus infections, both for the possible impact on the national systems (including, but not only, the health system), and for the relevance of choosing appropriate and long-term strategies.

In this context, MediLabSecure effort is focusing on the laboratory and public health capacity of the countries involved with a One Health approach that is enhancing collaboration between the relevant sectors (human, animal, entomological, environmental).
In fact, the impact of a specific pathogen/disease should be assessed considering all kind of national attackable resources (human, animal, environmental) that should be intersectorally preserved.

For this, One Health, which rely on a strong and coordinated collaboration between different disciplines, can be particularly relevant especially if we will be able to operationalize and embed it in the national health systems.
This approach will contribute to the valorization of the available resources and will enhance synergies with the Sustainable Development Goals Agenda.

The Istituto Superiore di Sanità (ISS) is honored to take part in MediLabSecure, which is the consolidation of ten years of ISS collaboration with the countries of the Mediterranean Region aimed at strengthening the national and regional health systems capacity in terms of preparedness and response to threats to health.

Since the beginning, the ISS has given particular attention to the strategies adopted: addressing "regional" priorities; promoting networking and cross-countries collaboration; valorizing national capacities and resources.

The present strategic document develops on the results of studies and activities implemented in the last four years with MediLabSecure partners and presents recommendations for future actions shared with the countries and the international organizations involved in this effort.

Stefano Vella
Head of the National Center for Global Health
Istituto Superiore di Sanità

INTRODUCTION

The Istituto Superiore di Sanità (ISS) started to collaborate with the countries of the Mediterranean Basin and Middle East more than ten years ago with the EpiSouth Network.

Doing activities with a network of countries is quite challenging, you need to identify shared and common aims and work towards them with strategies relevant for the consolidation of the network.

We, and our partners, learned a lot by sharing successes and constrains (1) and we recognised that the pros are by far more than the cons. For this, we consolidated the network collaboration and since the 2014 we are contributing to the MediLabSecure Project (MLS) (2014-2018).

Since the starting of this collaboration, we deemed relevant to report and discuss the results and lessons learned of the studies and activities implemented in the framework of these projects in Strategic Documents.

These documents are prepared by the Network members who took part in the studies and activities, are finalized with the help of subject matter experts and they include recommendations on the way forward.

Since 2007, we have released seven strategic documents on several issues addressed by the Network's activities.

We mention here, as an example, the Episouth Plus strategic document on "Coordination of Epidemiological Surveillance between Points of Entry and the National Health System in the framework of the International Health Regulations 2005 in the Episouth Region". This document, based on the results produced by national situation analysis studies, was prepared in collaboration with the World Health Organization that afterwards developed a global guidance that cites the strategic document of EpiSouth Network and recommends using national situation analysis for national assessments as utilized in the EpiSouth studies.

The eighth strategic document, presented and discussed here, collects the results of four years of studies and activities in the field of the prevention and control of arbovirus infections in the Mediterranean Basin, Middle East and Black Sea Regions.

The main objective of this document is to contribute to the strategies for the prevention and control of arbovirus infections with a One Health approach, by focusing on integrated surveillance and multisectoral risk assessment.

We are confident that, as in previous occasions, this document will be useful to enhance and enrich this operational field of activity.

1. THE MEDILABSCURE PROJECT

The Mediterranean Region, defined here as the area including the Mediterranean Sea and the surrounding territories (including Back Sea coastal countries), is populated by over 500 million people, distributed in about 30 countries of Africa, Asia, and Europe, which share similar ecosystems and relevant vulnerability to climate change with similar disease epidemiology as well as common priorities for disease prevention and control (2).

The MLS project (http://www.medilabsecure.com), started in 2014, aims at consolidating a regional network of public health institutions and laboratories, belonging to 19 non-EU countries (Albania, Algeria, Armenia, Bosnia and Herzegovina, Egypt, Georgia, Jordan, Kosovo, Lebanon, Libya, Moldova, Montenegro, Morocco, Palestine, Former Yugoslav Republic of Macedonia, Serbia, Tunisia, Turkey, Ukraine), for the control of zoonotic emerging viruses. It represents a cluster for awareness, risk assessment, surveillance, monitoring and control of relevant emerging diseases, with special focus on arbovirus infections.

The network of countries presently involved in MLS project started to work together in 2007 with the Episouth project (3) as a framework for collaboration for communicable diseases surveillance and training in the Mediterranean Region. It subsequently consolidated with the Episouth-Plus project (1) with the inclusion of a regional reference laboratory network.

The overall objective of the MLS project is to increase, through capacity building and multi-sectoral collaboration, the health security in the Mediterranean Region by enhancing and strengthening the preparedness to common health threats and bio-safety risks at national and regional levels following a One Health approach.

World Bank Operational Framework-definition of One Health is:

> "collaborative approach for strengthening systems to prevent, prepare, detect, respond to and recover from primarily infectious diseases and related issues such as antimicrobial resistance that threaten human health, animal health and environmental health collectively, using tools such as surveillance and reporting with an endpoint of improving global health security and achieving gains in development. While using infectious disease/AMR as a starting point, we recognize this definition and approach is expandable for wider scope (e.g., water and soil pollution which have animal and environment connections)" (4).

Considering that "the desired impact of the One Health approach expected through intersectoral integration can only be achieved if also the capacities of each involved sector[1] are sufficiently strong and developed"(5), MLS is working with a comprehensive strategy addressing both the capacity of the single sectors and the intersectoral integration.

Four Working Groups (animal virology, human virology, entomology and public health) are performing selected capacity building activities (specialized trainings, quality assessments, knowledge and technology transfer, etc.) to strengthen the capacities for pathogen detection and disease control, fostering the intersectoral collaboration for integrated surveillance, risk assessment and early warning.

The reinforcement of relations of trust in the region is an objective and an instrument to facilitate the impact of the initiative and support its sustainability.

[1] In this document « sectors » refer to the different domains (human, animal, entomological, environmental) which can be involved in the vector borne disease surveillance.

2. AIM AND SCOPE OF THIS STRATEGIC DOCUMENT

As reported, this network of Mediterranean countries started to collaborate more than 10 years ago. Since then, the results of the studies carried out and the lessons learned from the activities implemented are reported and discussed in "strategic documents" (available from http://www.episouth.org/project_outputs.html), including recommendations for future actions.

These documents are prepared by the network members, who took part in the studies and activities, and are finalized with the help of subject matter experts.

We mention here, as an example, the Episouth Plus strategic document on "Coordination of Epidemiological Surveillance between Points of Entry and the National Health System in the framework of the International Health Regulations 2005 in the Episouth Region" (6). This document, based on the results produced by national situation analysis studies, was prepared in collaboration with the World Health Organization (WHO) that afterwards developed a global guidance (7) that cites the strategic document of EpiSouth Network and recommends using national situation analysis for national assessments as utilized in the EpiSouth studies.

In line with this approach, in four years of the MLS Project (2014-2017), the studies and activities implemented have provided relevant results and lessons learned that we report and discuss in this strategic document.

The main objective is to contribute to the strategies for the prevention and control of arbovirus infections with a One Health approach, by focusing on integrated surveillance and multisectoral risk assessment. In this Strategic Document, as well as in the Project's studies, we refer to integrated surveillance as synonymous of One Health Surveillance as per the definition provided by Stärk *et al.*:

> "One Health Surveillance consists of the systematic collection, validation, analysis, interpretation of data and dissemination of information collected on humans, animals and the environment to inform multisectoral decisions for more effective, evidence- and system-based health interventions" (8).

Firstly, a conceptual framework will be proposed to facilitate the description, comparison and assessment of integrated surveillance systems.

Secondly, recommendations for enhancing operationalization of One Health strategies in country health systems and regional contexts will be provided.

Last, but not least, the document aims at reporting and disseminating outside the network the achievements of the MLS Project, at acknowledging the constant collaboration and contribution of all the involved partners, at promoting sense of ownership and enhancing motivation and at fostering concrete collaboration and synergies with other networks and projects working in the Region.

3. ANALYSIS OF THE CURRENT SITUATION

The emergence and re-emergence of infectious diseases is linked to concurring determinants affecting the interfaces between the pathogens, the vertebrate and invertebrate hosts and the environment (9).

Among those determinants, globalization, environmental and climate changes, movements of peoples and animals, urbanization, land use, changes in host and vector distribution and livestock intensification, are recognized risk factors for the spatial expansion of diseases to new areas. In particular, globalization has been described as a determinant in redrawing pathogen distribution patterns in haphazard and unpredictable ways (10).

Emerging and re-emerging infectious disease agents are for the most part (70%) vector-borne or zoonotic (11). These pathogens have been able to adapt to human and animal populations and to environmental changes. These pathogens are sometimes also characterized by complex life cycles involving human and animal hosts and, in some cases, vectors (insects and ticks). For this reason, they require mutual animal and public health vigilance for rapid detection and intervention (12). An example of the impact of inadequate surveillance and preparedness for zoonotic disease threats is the initially unrecognized emergence and establishment of West Nile Virus (WNV) in the US that led to 37,000 human illnesses and 1500 deaths in the period 1999-2012 (13).

Mosquitoes are probably the most important vectors of human diseases. The incidence of mosquito borne diseases like dengue, zika, or WNV fever has been increasing in recent years in tropical and temperate countries. Climate and environmental changes engender both short- and long-term impacts on vector-borne pathogen transmission. It is estimated that average global temperatures will rise by 1.0-3.58°C by 2100, increasing the likelihood of many vector-borne diseases (14).

At the same time, deforestation causes drier conditions that will have an impact on the dynamics of infectious diseases, especially those associated with forest vectors and reservoirs.

The fact that some pathogens, such as Rift Valley Fever virus (RVFV) (15), can be transmitted by different competent vectors and transmission routes, further complicates this picture and can explain the observed rapid spread and establishment of some vector-borne diseases in new geographical areas.

Dengue virus (DENV) and WNV, two distantly related flaviviruses, are good examples of the rapid spread of arboviruses (16). The widespread establishment of WNV in the US and in the Mediterranean basin also demonstrates the vulnerability of non-endemic countries to the introduction of arboviruses (14, 17). Furthermore, the presence of several potential vectors in Southern Europe and North African countries represents a risk for RVFV epizootics in case of virus introduction in countries of the Mediterranean basin (18).

The Mediterranean Region may be considered a “hot spot” for the emergence and re-emergence of zoonoses (19-22). For this reason, in 1978, the WHO started an interregional Mediterranean Zoonoses Control Programme based in Athens with the participation of 17 countries. The Programme aimed at promoting prevention, surveillance and control of zoonoses and related foodborne diseases; strengthening collaboration between animals and public health services; implementing training activities; promoting veterinary public health activities and public health education and fostering collaboration among Member Countries (23).

This initiative fathered what, in 2004, would become known as the concept of One Health, underscoring the interdependency of human and animal health and their link with the ecosystems in which they co-exist. In the following years, much progress has been made at the international level to identify ways of collaboration between animal and human health agencies to reach the

joint goal of One Health. However, the translation of this international success into national programs has been slow (24).

The presence in the Mediterranean region of two important institutional networks is of particular interest:

- REMESA (*REseau MEditerranéen de Santé Animale*)
  This Mediterranean Animal Health Network is a common platform of CVOs (Chief Veterinary Officers) of 15 Mediterranean countries aimed at improving epidemiological surveillance (including vector-borne diseases) and information sharing in the Mediterranean region and at coordinating the development and implementation of animal health regional projects and programmes;
- REEV-Med (*Réseau des Etablissements d'Enseignement Vétérinaire des pays de la Méditerranée*)
  This is a Mediterranean Network of establishments for veterinary education aimed at improving the standard of veterinary education at the regional level. This network is represented by the Deans of the faculties and one of its objectives is to encourage the exchanges of information, educational and research projects between faculties.

Globally, the One Health conceptual approach has seen unprecedented revival in the last decade with fostered awareness, scientific debate and research programmes in the fields of disease surveillance, epidemiological studies and health care provision (11, 25).

Coordinating the many players involved in human, animal and environmental health is vital to meet the health challenges of tomorrow. In this context, three major international organisations – the WHO, the World Organisation for Animal Health (OIE) and the Food and the Agriculture Organization of the United Nations (FAO) – are working together to prevent and control health risks at the human–animal–ecosystems interface. They are developing global strategies and tools to ensure a consistent, harmonised approach throughout the world, and to better coordinate human, veterinary and environmental health policies at the national and international levels.

In 2010, the three organisations published a Tripartite Concept Note, describing their collaboration and objectives in the prevention and control of health risks at the human–animal–ecosystems interface (26). By working together in this way, they create synergy in their expertise and communications activities on issues of common interest, in order to mobilise their public and private partners, member country governments and public opinion.

In October 2017, the OIE, the FAO and the WHO released their third Tripartite strategic document reaffirming their commitment to provide multi-sectoral, collaborative leadership in addressing health challenges (27). The scope of their collaboration will be enlarged to more broadly embrace the One Health approach recognising that human health, animal health and the environment are interconnected. In May 2018 a memorandum of understanding was also signed (28).

The Global Health Security Agenda (GHSA), launched in February 2014 by the US Government and endorsed by over 40 countries, seeks to forge interdisciplinary global health collaboration. It focuses on all aspects of health care for humans, animals and the environment to better prevent, detect and control human diseases with an aim to strengthen country compliance with the International Health Regulations. This programme can also potentially generate collaborations, surveillance, interventions, research and improved policies through a One Health approach (29).

Joint External Evaluation (JEE) conducted by the WHO to assess IHR capacities is in place and more than 70 countries have been evaluated with this tool on 1st technical areas (One Health approach).

Also, the European Commission, with the publication of the Decision on serious cross-border threats to health in 2013, has stressed the need of interoperability between public health and veterinary sectors for preparedness and response planning (30).

On 11-12 December 2017 the European Centre for Disease Prevention and Control (ECDC), held an expert consultation "Towards One Health preparedness" which has released several recommendations for strengthening One Health Preparedness in Europe (31).

Finally, at the beginning of 2018 the World Bank released the Report "Operational Framework for strengthening Human, Animal and Environmental Public Health Systems at their interface" (4).

The development of a business case for One Health has also been proposed to describe the origin and expansion of this concept, with five potential areas where One Health could add value and reduce costs:

1. sharing health resources between the medical and veterinary sectors;
2. controlling zoonoses in animal reservoirs;
3. early detection and response to emerging diseases;
4. prevention of pandemics;
5. generating insights and adding value to health research and development (32).

4. EVIDENCE OF THE GAPS AND NEEDS TO BE ADDRESSED

Despite all efforts of cooperation between human and animal health, isolated silo thinking persists, particularly in the public health sector that struggles to perceive advantages of using a One Health approach (33).

One Health Surveillance (34) is the latest conceptual tool being proposed to prove the added value of the One Health concept, as per the business case described above (32), and to ultimately reduce the risks of infectious diseases at the animal-human-ecosystem interfaces.

At this stage, sporadic national success stories exist in implementing One Health Surveillance that could serve as examples for further implementation (36) and integrated surveillance systems have worked in specific situations and contexts (35). International initiatives have been launched and supported by FAO, WHO and OIE and methodologies for the aggregation of existing databases at the human-animal interface have been tested (e.g., the FAO/OIE/WHO GLEWS+ initiative and the establishment of the "4-way linking" platforms) (37, 38).

Notwithstanding, barriers impeding the development of One Health Surveillance (such as legal issues, limited resources, hurdles to data sharing, unclear responsibilities, structural barriers between Ministries), still need to be addressed (13). Moreover, the difference in priorities between Ministries of Health and Agriculture are often underlined.

Integrated systems for data collection and analysis are considered to play a crucial and central role for prevention, forecasting and control, although these systems are still rarely implemented (39-41). In particular, Vrbova in 2010 (39) reports that, of 194 surveillance systems analysed, only 36 (19%) concomitantly collected data on human and animal surveillance.

Also, the identification of criteria and methods to describe and assess existing levels of integration of surveillance for specific exposures is recommended (42) to facilitate the evaluation of the impact and the added value of One Health Surveillance in the contexts where this integrated approach is being implemented.

It is extremely needed therefore to assess One Health surveillance systems within harmonised frameworks to be able to operationalise One Health approach on the basis of national situations (in terms of risks, available resources, legal issues, etc.).

One Health should be perceived beneficial by the involved entities, its added value should be evincible and with a spectrum of applications which may vary in accordance with the priorities and the available resources.

To achieve this, national and regional priorities should be clearly identified, capacity of all involved sectors should be enhanced and should be increased the awareness of the strategic relevance of multisectoral collaboration (including exchange of data and information and related analyses) in the prevention, surveillance and control of arbovirus infections.

5. THE PROJECT STUDIES

MLS decided to contribute to One Health implementation and operationalization in the Mediterranean Region mainly by identifying criteria to define integrated surveillance systems and then studying the level of integration of surveillances of different sectors involved in the control of arbovirus infections (human, animal, entomologic, environmental, etc.).

The first step was to propose a "conceptual framework" (Table 1) developed on the basis of existing operational protocols and procedures (43). The framework was designed to assess three levels of surveillance systems integration: policy/institutional, data-collection/data-analysis and dissemination, assuming that without actual integration at these levels the surveillance cannot be considered integrated and operationalised.

It is worthwhile mentioning that the "trans-sectorial" design of MLS Project (i.e., several representatives of different national sectors are involved in the Network) has greatly facilitated the exchanging between the levels involved in the integration of surveillance.

Table 1. Criteria to describe existing levels of integration between human/animal/entomological surveillance for a specific exposure (conceptual framework)

Level of integration	Sublevels of integration	Criteria
Policy and institutional level	Policy level	1. Existence of a national policy addressing integrated surveillance for this specific exposure
		2. Existence of a policy addressing integrated surveillance for this specific exposure at subnational level
	Institutional level	3. Existence of agreements among the institutions involved in human/animal/entomological surveillance for the specific exposure
		4. Existence of a coordination mechanisms among the institutions involved
		5. Existence of identified focal points for each of human/animal/entomological surveillance for the specific exposure
Data collection and analysis level	Interoperability mechanisms at data collection level	6. Existence of integrated data collection tools
		7. Existence of activation mechanisms of human surveillance based on signals from animal/entomological surveillance
		8. Other interoperability mechanisms at data collection level
	Interoperability mechanisms at data analysis level	9. Presence of DB exchange/merging/other mechanisms to facilitate joint analysis among sectors.
		10. Performance of joint/integrated data analysis among the different surveillance sectors
		11. Other interoperability mechanisms at data analysis level
Dissemination level		12. Existence of joint result dissemination mechanisms (e.g., bulletins, reports, papers, media reports, websites, etc.)

Source: Dente *et al*. 2015

This framework was utilised for the survey on integrated surveillance, for the literature review and for the situation analysis study implemented with MLS partners (Figure 1). These studies have addressed several aspects of integration of surveillance of arbovirus infections, as synthetized in the following paragraphs. For the detailed descriptions of the studies, refer to the reported references.

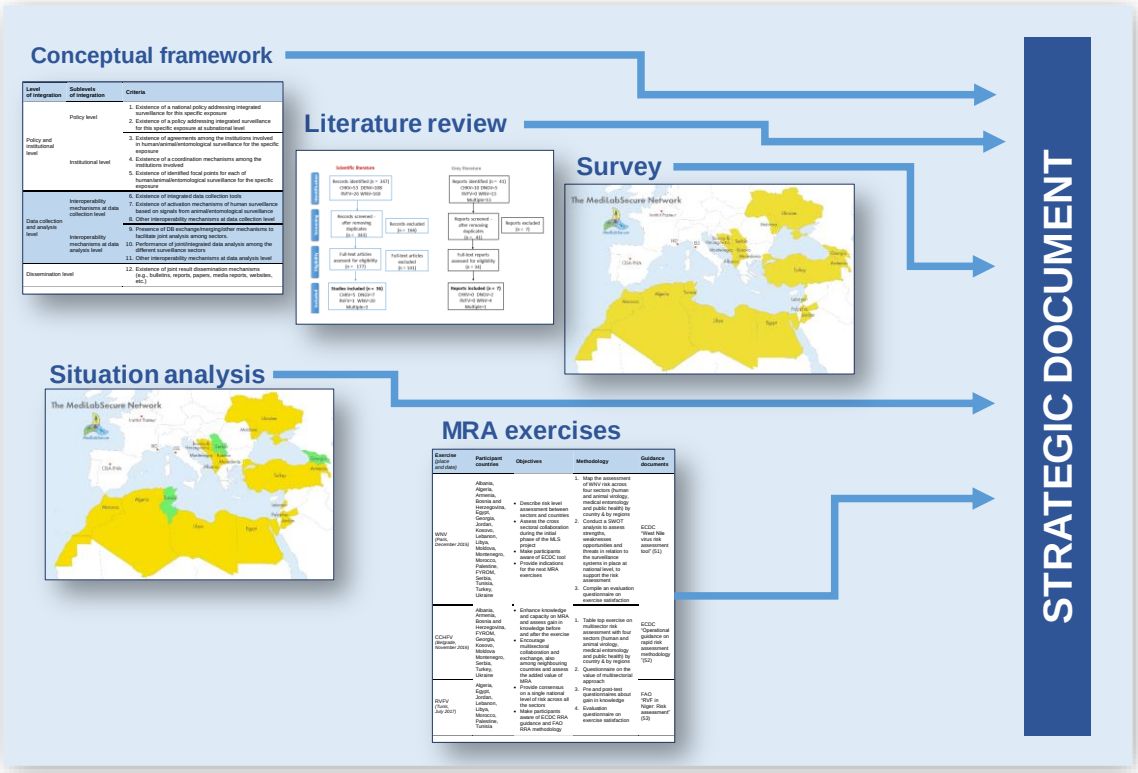

Figure 1. MLS studies and activities feeding the strategic document

5.1. Survey on integrated surveillance

We conducted a survey (December 2014-September 2015) with the 19 countries of the MLS network to assess and document the level of integration in surveillance of arboviruses between four sectors: animal virology, human virology, medical entomology and public health across three different levels: policy and institutional, data collection and analysis and dissemination of results (44).

The surveillances of the following arboviruses representing an actual threat or a potential risk in the Mediterranean Region were considered: WNV, Crimean-Congo haemorrhagic fever virus (CCHFV), DENV, Chikungunya virus (CHKV), Yellow Fever Virus (YFV) and RVFV.

Seventy-five contact points (CP) belonging to the four sectors from the 19 countries were invited to participate in the survey.

Responses were obtained from 61 CP (81%) of whom: 14 from the Black Sea region, 25 from North Africa and the Middle East and 22 from the Balkans.

Only some integration mechanisms have reportedly been set up in a number of countries, more frequently directed to the joint dissemination of results. Conversely, fewer countries have reported the existence of mechanisms/procedures for integrated data collection.

It has to be noted that the sectors of the countries involved have not always replied consistently. Where one sector reported integration in surveillance at one or more levels, in the same country this integration was described differently by the other sectors.

The results of the survey suggest that implementation of fully integrated One Health surveillance across the policy and institutional level to the data collection and dissemination level is yet to be fully developed in the Mediterranean Region across the four considered sectors.

The questionnaire addressed purposely only some of the proposed criteria for levels of integration with the aim of acquiring a preliminary description of the situation in the 19 countries involved in the network. Detailed assessment of existing links and procedures has been carried out in selected countries that have disclosed a certain level of integration in this survey (*see* The MediLabSecure situation analysis study).

5.2. Literature review

We conducted a scoping review (2015) to identify and examine surveillance systems for WNV, CHKV, DENV and RVFV, which involve human, animal, entomological, and environmental sectors (45). We analysed the findings using the conceptual framework previously developed.

In total 36, out the 166 full-text articles assessed for eligibility, met the inclusion criteria.

All articles, except one, specified the type of sectors involved in integration. Fifteen articles (56%) reported integration at all levels: policy and institutional, data collection and analysis, and dissemination.

Out of the 35 articles mentioning the added value of integrated surveillance, early warning and response was reported in 16 articles (46%); and the added value of early warning, impact assessment, and response was reported in 8 (23%). Five articles (14%) mentioned only the added value of early warning.

We retrieved 41 grey literature reports: the most frequent source was the ECDC (24/41, 59%) with 11/24 reports on WNV (46%) and 7/24 on CHKV (29%). While searching in WHO HQ, WHO Regional Office for Europe (WHO/EURO), and WHO Regional Office for the Eastern Mediterranean (WHO/EMRO) websites, documents published by other regional offices were retrieved. We selected 12 reports (12/41, 29%) addressing multiple arboviral diseases (8/12, 67%), DENV (3/12, 25%), and CHKV (1/12, 8%). We finally considered 34 reports to assess in full text.

Seven documents out of 34 (21%) met the inclusion criteria reporting about the integration between surveillance systems of different sectors: WNV (4/7, 57%), DENV (2/7, 29%), and multiple arboviruses (1/7).

In general, the articles and the documents did not report on lessons learned nor provide indications for integration strategies in the surveillance of VBD based on their experiences/studies.

Notwithstanding this, few stressed the needs of integration for a public health impact.

A joint publication of WHO and the Special Programme for Research and Training in Tropical Diseases (TDR) reported a table with examples of good and bad practices in DENV surveillance, where criteria of integration were identified among the good practices (46).

Hadler *et al.* (47) reported on an assessment of WNV and other arboviral surveillance capacities that was carried out in 2012 in the US. The selected indicators included inter-sectoral aspects. The assessment highlighted the changes that had occurred since 2004 (previous assessment) and identified the implications for public health practice.

The following articles recommended an integrated approach in the surveillance of arboviral diseases on the basis of the results of the studies/assessments described. Cito *et al.* (48), on the basis of the results of a survey conducted among six EU countries of the Mediterranean basin, recommended that:

> "[…] the surveillance of WNV and RVFV must include a high level of collaboration between different professionals such as veterinarians, public health officers, entomologists and climatologists for properly dealing with vector-borne zoonotic diseases. The multi-disciplinary approach requires the establishment of integrated information systems, covering human and veterinary fields as well as providing useful data on vectors distribution and abundance".

Krisztalovics *et al.* (49) reported on the surveillance of WNV neuro-invasive infections in humans in Hungary:

> "[…] the results of serological analysis used for confirmation of WNV cases are in most cases too late to apply control measures. For this purpose, it is very important to develop good collaboration with the veterinary sector to exchange information and undertake joint actions. At present, the Ministry of Health and the National Centre for Epidemiology are preparing to sign an agreement with the Ministry of Agriculture, regarding collaboration with the veterinary authorities, in particular, exchange of information and vector control measures".

Finally, Hernández-Ávila *et al.* (50) described a conceptual framework developed in Mexico for DENV surveillance, where epidemiological and entomological data are analyzed to produce risk maps that are used to target vector control activities. New epidemiological and entomological data are collected during control activities to assess their impact.

This continuous data collection process generates a knowledge database that can be used to evaluate the cost-effectiveness of control measures, accountability, and operational research.

From a methodological perspective, the review highlights that the criteria proposed in the conceptual framework for describing the integrated surveillance are consistently reported in the context of studies and programs related to integrated surveillance of the selected arboviral diseases.

5.3. The MediLabSecure situation analysis study

We designed a MediLabSecure Situation Analysis (MeSA) study to document how integration of laboratory/clinical human, animal and entomological surveillance of arboviruses was being implemented in the region (available from http://www.medilabsecure.com/events_mesa.html). To assess the three levels of integration (policy/institutional, data-collection/data-analysis and dissemination) we applied the mentioned conceptual framework, validated with the MLS survey and the literature review. We tested the use of Business Process Modelling Notation (BPMN) to graphically present evidence of inter-sectoral integration.

Serbia and Tunisia participated in the study with WNV and Georgia with CCHFV surveillance. In the three countries, we observed integration across sectors and levels except in data collection and data analysis. Data collection was interoperable only in Georgia, data analysis was never

interoperable. In all countries, surveillance was mainly oriented towards outbreak response, triggered by an index human case.

The study has highlighted that some features are common across the three countries. In particular:

- Animal and entomological surveillance are integral part of the system, but the central role of the human surveillance is underlined by several factors:
  i. it is always the detection/notification of suspected human case/s that triggers the response of the systems and starts the flow of communication between sectors;
  ii. a strategic plan and a multisector committee have been established in the three countries and are always under the coordination of the Directorates in charge for human surveillance;
  iii. the human sector can be delegated by the other sectors in the dissemination of data and information and in the communication to the public, but the opposite is rare.
- In the three countries, the surveillance strategy includes identification of areas by level of endemicity: distribution of sampling points and monitoring are determined by risk assessment of exposure (areas at risk of epidemics).
- Medical entomology activities are under the responsibility of more than one Institution (Ministry of Health, Ministry of Agriculture, Research Institutes), with relevant tasks in terms of planning and coordination.

The three integrated surveillance systems showed a spectrum of integration, with peculiar processes born from specific situation drivers as well as recurrent features and common challenges, and prove that integrated surveillance can be operationalised with a diverse spectrum of options. However, in all countries the integrated use of data for early warning and inter-sectoral priority setting is pioneeristic. We also noted that early warning before human case occurrence is recurrently not operationally prioritized.

The proposed framework enabled a standardized analysis of one-health surveillance integration and BPMN was easily understandable and conducive to detailed discussions among different actors/institutions.

6. MULTISECTOR RISK ASSESSMENT EXERCISES

As reported previously, very few countries worldwide and in the Mediterranean Region have managed to collect and analyse surveillance data across sectors, and even fewer have interoperable databases. Ultimately, this limits early warning and risk assessment capacities with impact on the prevention and control of arbovirus infections.

The awareness of the strategic relevance of multisectoral collaboration in the control of arbovirus infections can be enhanced by implementing specific Multisectoral Risk Assessment (MRA)[2] exercises at national or regional level, with the participation of representatives from all countries belonging to the same geographic region.

Risk assessment exercises performed with this approach can:

- foster data and information sharing across involved sectors, thus reducing informative gaps;
- exploit the experiences and contributions from the different sectors;
- support the identification of a national/regional "cross-sectoral" risk assessment outcome;
- guide the prioritisation of actions and the allocation of resources, also taking into account the cross-border dimension.

In fact, when the risks are assessed at regional level, they often show similar priorities, and lead to the possibility of sharing lessons learned and opportunities of joint actions, especially at borders (see the cases of CCHFV cluster in 2008 at the borders between Greece and Bulgaria and in 2009 between Georgia and Turkey).

Towards this aim, in the framework of the MLS Project (available from http://www.medilabsecure.com/events_RA.html), we organized three MRA exercises (Table 2) on:

- WNV;
- CCHFV;
- RVFV.

The aim of these exercises was not only to formulate more reliable risk assessments, but also to promote a process leading to a homogenous understanding of risk across sectors in a given country using a structured strategy of assessment.

We relied on the following existing RA methodology and guidance documents: the ECDC "West Nile virus risk assessment tool" (51) for the WNV exercise; the ECDC "Operational guidance on rapid risk assessment methodology" (52) for the CCHFV exercise and the FAO rapid risk assessment methodology as utilised in "The RVFV in Niger: Risk assessment" (53) for the RVFV exercise.

All mentioned tools and guidance documents were developed by subject-matter experts, had been piloted in other contexts and were in line with the pathogens and methodological priorities identified by the MLS countries.

Moreover, in the CCHFV and RVFV exercises, the added value of the multisectoral approach was assessed.

[2] Multisectoral Risk Assessment (MRA): assessment with the concomitant participation of all the relevant sectors involved in the surveillance of a given arbovirus infection

Table 2. Overview of the three multisectoral risk assessment exercises of the MLS network

Exercise *(place and date)*	**Participant countries**	**Objectives**	**Methodology**	**Guidance documents**
WNV *(Paris, December 2015)*	Albania, Algeria, Armenia, Bosnia and Herzegovina, Egypt, Georgia, Jordan, Kosovo, Lebanon, Libya, Moldova, Montenegro, Morocco, Palestine, FYROM, Serbia, Tunisia, Turkey, Ukraine	• Describe risk level assessment between sectors and countries • Assess the cross sectoral collaboration during the initial phase of the MLS project • Make participants aware of ECDC tool • Provide indications for the next MRA exercises	1. Map the assessment of WNV risk across four sectors (human and animal virology, medical entomology and public health) by country & by regions 2. Conduct a SWOT analysis to assess strengths, weaknesses opportunities and threats in relation to the surveillance systems in place at national level, to support the risk assessment 3. Compile an evaluation questionnaire on exercise satisfaction	ECDC "West Nile virus risk assessment tool" (51)
CCHFV *(Belgrade, November 2016)*	Albania, Armenia, Bosnia and Herzegovina, FYROM, Georgia, Kosovo, Moldova Montenegro, Serbia, Turkey, Ukraine	• Enhance knowledge and capacity on MRA and assess gain in knowledge before and after the exercise • Encourage multisectoral collaboration and exchange, also among neighbouring countries and assess the added value of MRA • Provide consensus on a single national level of risk across all the sectors • Make participants aware of ECDC RRA guidance and FAO RRA methodology	1. Table top exercise on multisector risk assessment with four sectors (human and animal virology, medical entomology and public health) by country & by regions 2. Questionnaire on the value of multisectorial approach 3. Pre and post-test questionnaires about gain in knowledge 4. Evaluation questionnaire on exercise satisfaction	ECDC "Operational guidance on rapid risk assessment methodology "(52)
RVFV *(Tunis, July 2017)*	Algeria, Egypt, Jordan, Lebanon, Libya, Morocco, Palestine, Tunisia			FAO "RVF in Niger: Risk assessment" (53)

FYROM: Former Yugoslav Republic of Macedonia

In order to assess the multisectoral added value the following risk questions were asked to the participants:

– *for CCHFV* (11 countries)
  1. Are there contextual factors that may affect the risk assessment?
  2. Are effective treatments and control measures available?

3. Is it likely to cause severe disease in the population?
4. What is the potential for transmission within your country?
5. Is this threat unusual or unexpected?

– *for RVFV* (8 countries)

1. Risk of persistence in your country question
2. Risk of introduction in your country
3. Prevention and control options
4. Preparedness measures
5. Risk factors for new areas
6. Risk factors in Africa and other areas with a history of RVF infection or outbreak

The added value resulted as particularly valuable in "setting the scene" (i.e., the main factors characterising the context) and in analysing comprehensively the situation having access to information and knowledge provided by each of the sectors involved in the exercise (see the added value for risk questions 1 and 5 in Figure 2 and for risk questions 3, 4 and 6 in Figure 3).

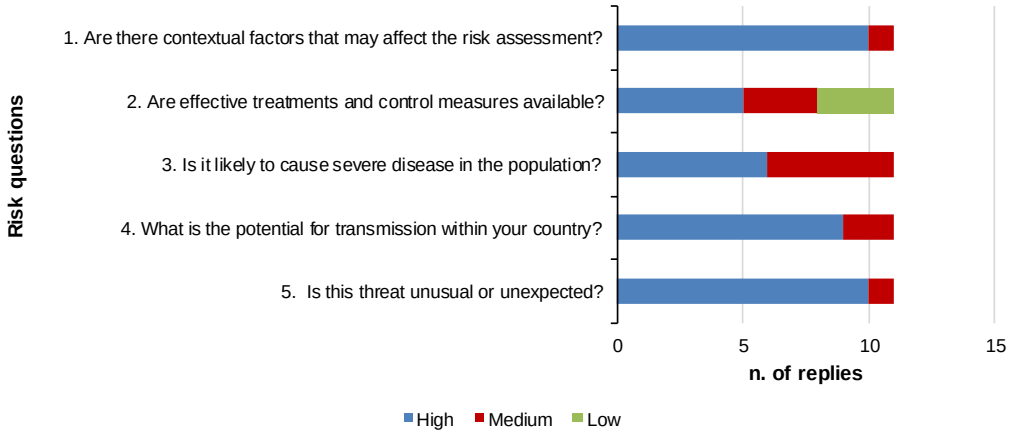

Figure 2. Multisector added value for CCHF exercise (11 countries)

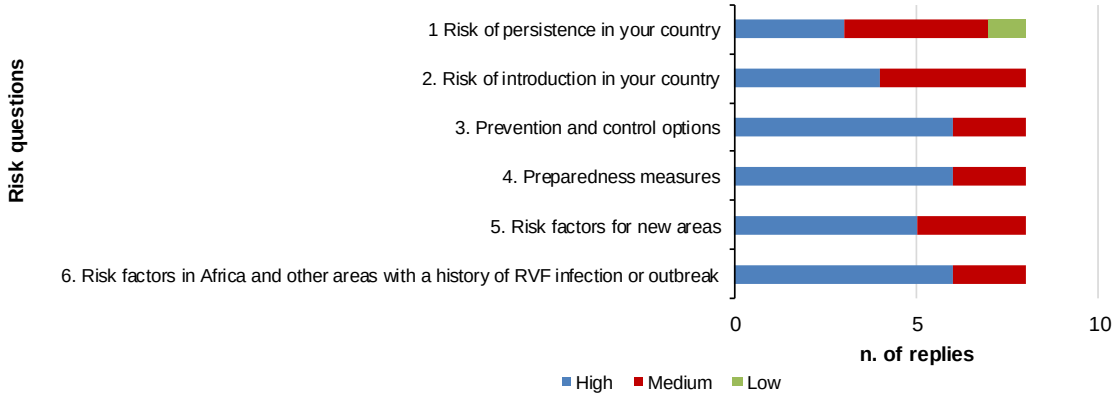

Figure 3. Multisector added value for RVF exercise (8 countries)

Using available tools and guidance documents avoided duplications and allowed to rely on existing recognized guidance. The use of a defined assessment framework ensured that the exercises were aligned to current international standards and practices and allowed to compare and discuss the pros and cons of different methodologies.

Independently from the methodologies used, the participants expressed their appreciation for standardized methods for RA able to produce comparable results across countries that could facilitate the exchange of experiences.

Considering that different sectors may rightfully assess the risk differently, this approach has the advantage of enabling actors in each sector to recognize this variability and the reasons behind it. This awareness is a first step towards the identification of national inter-sectoral priorities in terms of surveillance and response that, in turn, can guide a one-health approach for resource allocation.

7. DISCUSSION

The analysis of the three systems in the countries involved in the MeSA study suggests that integration in surveillance, although conceived in accordance with specific components and criteria, is operationalised with a *spectrum of options*, where not all components need to be always in place. The health system organization, the resources available and the local epidemiology of the disease under surveillance influence the final architecture of this integration.

The type and number of institutions and stakeholders in charge for implementing the surveillance activities in the countries, and therefore involved in the MeSA study, give the idea of the complexity of relations and interactions. As we already pointed out, step-up of inter-sectoral regional capacities for emerging viral threats is a methodological, rather than disease driven approach, which may lead to much greater efficiencies in the long term, though it may dilute efforts, increase costs and complicate capacity building in the short term (42).

Therefore, it is understandable that countries retain and consolidate those integration components that proved to improve their surveillance systems and enhance long lasting cost-effectiveness in the light of their national health organisation, local situations and available resources.

The inter-sectoral collaborations have a key role in several aspects connected to the implementation of One Health: early warning, integrated surveillance; risk assessments; data provision and information sharing (to cope with the lack of common inter-sectoral data systems at national level). These collaborations can be enhanced by facilitating the understanding of reciprocal roles, responsibilities and needs and by setting common priorities with balanced resources allocation.

Although integrated systems for data collection and analysis are still rarely in place, they are fundamental for planning and implementing prevention, prediction and control actions. The articles and documents retrieved in the framework of the literature review refer to integrated data collection and analysis, but often do not describe the systems in detail. In most cases, each sector seems to collect and analyse its own data of competence, and only the results of these data analyses are then shared with the other sectors. This might explain why only 56% of the articles (14/25) reporting integration at the data collection and analysis level mentions the criteria of integration (e.g., the existence of a common database or data system) as proposed by our framework.

The three surveillance systems we analysed with the MeSA study showed that the integrated use of data for early warning and inter-sectoral priority setting is still pioneeristic.

We also noticed that an integrated early warning system leading to reduce human case occurrence is currently not operationally prioritized.

This finding is in line with the results of the survey on integrated surveillance we conducted with 19 countries of the Mediterranean Region, which showed how the integration efforts were more frequently focussed on the joint dissemination of results than on the development of mechanisms/procedures for integrated data collection and analysis.
This suggests that each sector collects surveillance data separately and afterwards results are collated for a common dissemination.

Although more than 80% of the articles recognized *early warning* as the main added value of integrated surveillance, integration between sectors was mainly described in the context of response activities (e.g., setting up control measures). Consequently, the prevention and mitigation of impacts through the development of early warning systems based on an integrated inter-sectoral approach still need attention and consolidation.

Conceptual frameworks, like the one proposed, help in consistently conducting studies and researches aimed at operationalising One Health at national and regional level.

Six out of the 10 main threats to global health listed by the WHO (54) are occurring at the human, animal and environmental interface: comprehensive regional assessments with a One Health approach made by national authorities using a similar framework can be a relevant global added value for the global health security agenda.

FINAL RECOMMENDATIONS

Here below we present the main recommendations to enhance the surveillance of arbovirus infections under a One Health approach. These recommendations are the outcome of a long process including studies, activities and discussions with the partners and other experts. The presented recommendations are not exhaustive and may vary in relevance with the time and the countries.

1. *Assessing the National/Local Situations (with studies, sharing of lessons learned, collaborations, etc.) and identifying priority areas for multi-sectoral efforts*

   It is important to identify priority areas to direct multi-sectoral efforts for the control of arbovirus infections. Areas of multi-sectoral collaboration can include, among others, surveillance, early warning (risk assessment, modelling, etc.) and vector control. National situation analysis can help to describe local situations and resource availability, to guide prioritization, and ultimately to support operationalization of the One Health approach.

2. *Enhancing competences and awareness of intersectoral collaboration and facilitating data and information sharing*

   To increase competences and awareness on inter-sectoral collaboration towards inter-sectoral priorities, including cross-border ones. MRA can enhance inter-sectoral collaboration towards early warning. This approach allows at identifying the fundamental integrated dataset and it is also relevant to reduce gaps due to unavailability of shared data and information. It can also promote the use of multiple sources of information across sectors and facilitate consensus on operational arrangements for the Risk Assessment as also recommended by the WHO in the Western Pacific Regional Action Plan for Dengue Prevention and Control (55). This could finally support the identification of common national preparedness and surveillance priorities across sectors and, ultimately, guide resource allocation and common policies across sectors for preparedness and response activities against a common threat in a more coordinated and harmonized way.
   MRA can also focus on cross-border priority threats and facilitate identification of reliable reference laboratory/s to rely on in case of cross-border threats.
   Reinforcing Risk Communication capacity is another relevant strategy to facilitate coordination and collaboration between all the stakeholders involved and to appropriately inform and sensitise civil society as well as policy makers.

3. *Facilitating operationalisation of One Health strategies*

   Describe and assess integrated surveillance systems

   Additional studies should describe procedures and mechanisms adopted by those countries with a certain level of integration. The good practices identified in these countries should be shared to increase awareness and to provide practical guidelines for the implementation of integrated strategies in other countries with similar or comparable conditions.

Evaluate added value of integrated systems

The benefit for the countries of having an integrated surveillance (in terms of disease detection, more efficient disease control and tangible financial savings) should be assessed and compared with the performances of those surveillance systems scarcely or not integrated at all (see recent studies conducted in Italy on One Health added value for WNV surveillance) (56, 57).

Provide an evidence based "business case"

Assessments and evaluations should provide data and information to feed in an evidence based "business case" on One Health surveillance which can legitimately guide the development of national and international One Health policy.

The MLS studies showed that legislation on One Health collaboration might be available, but often the Standard Operating Procedures needed to facilitate implementation are lacking.

What is more, a robust "business case" facilitate interaction between technical staff and policy makers making possible actual upgrading/adaptation of the concerned systems.

Promote intersectoral databases

The development of national inter-sectoral databases, enriched by joint data analysis and dissemination systems should be promoted. At least, as reported in the proposed Conceptual Framework, interoperability mechanism for data collection and analysis should be considered and developed.

Promote harmonization of surveillance systems and their interaction

Although it would be rather impossible to develop a unique surveillance system that would respond to all geographical and epidemiological situations, systems harmonisation should be promoted. The purpose of harmonization is to propose evidence-based standards to identify the most relevant surveillance activities, to improve data sharing process, and to optimize the use of financial and human resources. In addition, criteria for harmonisation that consider integration, which ultimately facilitate also interaction between sectors including different perspectives. Indications for harmonisation of the entomological surveillance have been identified and discussed by MLS in the Roadmap toward the harmonization of entomological surveillance systems in the Mediterranean area regarding the risks of mosquito borne virus transmission, June 2018 (Appendix B). Similar guiding document can be developed for the other surveillance systems.

4. *Networking and regional strategies in synergy with international strategies*

Collaboration and coordination between projects, networks and institutions working towards the same aims should be made feasible and sustainable since the planning phase of any initiative under coordinated institutional umbrella/s (e.g., FAO/WHO/OIE Commitment Providing multi-sectoral, collaborative leadership in addressing health challenges) (26-28).

Cross-border priorities should be identified to motivate trustful collaboration among countries and institutions and enhance effective use of available resources.

Taking advantage of networks for facilitating the exchange of information, activities, projects and related results.

In many instances, the Mediterranean countries (2), share similar disease epidemiology as well as common priorities for disease prevention and control.

Surveillance and control of vector borne diseases is a well-known priority for the region and more specifically, arbovirus infections are a recognized endemic or emerging priority in several countries characterized by favourable environmental drivers and climatic features (58-60). The future of the countries of this region is highly interconnected and interdependent.
For this, it is really relevant to contextualise the regional strategies for the prevention and control of arbovirus infections in the One Health paradigm supported by international strategies (like the United Nation 2030 Agenda for Sustainable Development).

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APPENDIX A
List of Country Institutions involved in the MediLabSecure Network

Countries participating to the MLS Network

Albania	Food Safety and Veterinary Institute
	Institute of Public Health
Algeria	Institut National de la Médecine Vétérinaire
	Institut National de Santé Publique
	Institut Pasteur d'Algérie
Armenia	National Center for Disease Control and Prevention, MoH
	Republican Veterinary-sanitary and phyto-sanitary center for laboratory services (SNCO)
Bosnia and Herzegovina	Institute for Microbiology and Molecular Diagnostics
	Ministry of Civil Affairs
	PI Veterinary Institute of the Republic of Srpska "Dr. Vaso Butozan" Banja Luka
	Public Health Institute of the Federation of Bosnia and Herzegovina
	University Clinical Center
	Veterinary Faculty Sarajevo
Egypt	Ain Shams University
	Animal Health Research Institute
	Ministry of Health and Population
	National Research Centre
Georgia	Laboratory of Ministry of Agriculture
	National Center for Disease Control and Public Health
Jordan	Laboratory Directorate of the MoH
	Ministry of Agriculture
	Ministry of Health
Kosovo	National Institute of Public Health of Kosovo
	University of Prishtina, Faculty of Agriculture and Veterinary Sc.
Lebanon	Lebanese Agricultural Research Institute- LARI
	Lebanese University
	Ministry of Public Health
	Rafik Hariri University Hospital
Libya	National Center of Disease Control
Moldova	Institute of Zoology
	National Center for Public Health
	Republican Veterinary Diagnostic Center
Montenegro	Biotechnical faculty
	Diagnostic Veterinary Laboratory
	Institute of Public Health

Morocco	Institut National d'Hygiène
	Institut Pasteur du Maroc
	Ministry of Health
	Office national de sécurité sanitaire des produits alimentaires (ONSSA)
Palestine	Ministry of Health
	Veterinary School - An-Najah National University
Republic of Macedonia	Institute of Public Health
	Ss. Cyril and Methodius University in Skopje, Faculty of Veterinary Medicine
Serbia	Faculty of Agriculture, University of Novi Sad
	Institute of Public Health of Serbia "Dr. Milan Jovanovic Batut"
	Institute of Veterinary Medicine of Serbia
	Institute of Virology, Vaccines and Sera, Torlak
Tunisia	Institut de la Recherche Vétérinaire de Tunisie
	Institut Pasteur de Tunis
	Ministère de la Santé Publique
Turkey	Ankara University, Faculty of Veterinary Medicine
	Hacettepe University
	Public Health Institute of Turkey
Ukraine	State Body "Ukrainian I.I. Mechnikov Research Anti-Plague Institute of Ministry of Health of Ukraine"
	State Institution "Kyiv Oblast Laboratory Center of the State Sanitary-Epidemiological Service"
	State Scientific and Research Institute of Laboratory Diagnostics and Veterinary and Sanitary Expertise

APPENDIX B
Extract from “Toward the harmonization of entomological surveillance systems in the Mediterranean area regarding the risks of mosquito borne virus transmission”

The executive summary is here reported from the "Roadmap toward the harmonization of entomological surveillance systems in the Mediterranean area regarding the risks of mosquito borne virus transmission", document of the MediLabSecure project published in June 2018.

Executive summary

Vector borne diseases (VBDs) are a major threat to human and animal health. The epidemiology of these diseases is changing on local, regional, and global scales due to several determinants (e.g., travel and trade globalization, changes in land use and cover, pathogen evolution, changing lifestyles, urbanization, climate change, etc.). Surveillance is a cornerstone for risk management of VBDs and should be considered as an integrated and a holistic approach from a One Health perspective. In this regard, entomological surveillance is a major component of every surveillance system dedicated to VBDs and is complementary to human, animal and environment surveillance.

The purpose of this roadmap is to facilitate the definition of entomological surveillance systems in order to improve preparedness and response activities to VBDs. It first recognizes the impossibility to develop a unique surveillance system that would respond to all geographical and epidemiological situations. As a consequence, the purpose of harmonization is rather to propose evidence-based standards to identify the most relevant surveillance activities, to improve data sharing process, and to optimize the use of financial and human resources. This roadmap is intended to policymakers for decision support in implementing entomological surveillance programs. It might also be useful to health professional involved in other area of surveillance to share a common background on the possibilities and limitations of the entomological surveillance. Medical entomologists and vector control professionals can also rely on it to advocate for adapted entomological surveillance systems.

Every surveillance system should be designed to answer to well-defined objectives. Considering entomological surveillance, different main objectives can be listed: (1) to identify the vector species involved in transmission of infectious agents, (2) to identify the circulating strain pathogens, (3) to perform risk assessment of VBD transmission and set public health priorities, (4) to provide an early warning system tool to detect public health threats and guide public health actions, (5) to optimize and guide implementation of vector control in time and space, (6) to detect the development of insecticide resistance, and (7) to evaluate the efficacy of implemented vector control measures. The design of entomological surveillance system must consider the entomological and epidemiological contexts in order to be adapted to ongoing situation.

Beyond these aspects, more concrete guidance is proposed for arboviruses transmitted by recently established populations of invasive mosquitoes (e.g., *Aedes aegypti*, *Ae. albopictus*) and main emerging mosquito borne pathogens. Some basic knowledge on mosquito fauna is always useful prior to disease emergence Regardless of the risk, some basic knowledge on the mosquito fauna is always needed. This basic background consists of the identification of the main vectors that are present in the area of interest as well as the most likely invasive species to be introduced and established in the region. Population density, seasonal dynamics and spatial distribution should also be considered as relevant data to anticipate possible invasion risks of both vectors and VBDs.

Then, a state of knowledge in the area of interest is proposed for the different arboviruses and their potential vectors, leading to risk-based surveillance proposals. The first group of mosquito-borne arboviruses is dengue, chikungunya, Zika, and yellow fever; the second one includes West Nile fever; and the third comprises Rift Valley fever. The main objectives which can be pursued in the Mediterranean area are highlighted depending on the entomological and epidemiological contexts.

Finally, major priorities are discussed to implement entomological surveillance in a comprehensive framework. The interest to adopt a "One Health" approach is undoubtedly relevant given the specific nature of vector borne diseases at the interface between humans, animals, and the environment. Particular emphasis is given to the implementation programs, policies, and operational research within an integrated and holistic framework. In this regard, two key essential dimensions for progress are detailed: (1) the integration of surveillance capacities by interdisciplinary expertise and cooperation, and (2) an integrated

approach at the different geographic scales: local, regional and global. The relevance of this approach is now widely acknowledged. However, advocacy and collaboration opportunities are needed for the implementation and support of sustainable surveillance systems aiming to prevent and control VBDs.

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