

Main challenges in the control of zoonoses and related foodborne diseases in the South Mediterranean and Middle East region

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Summary

In the South Mediterranean and Middle East region, interactions between humans, animals, and the surrounding environment are frequently close. This fact is mainly manifested in traditional farming settings (by sedentary, semi-sedentary, and nomadic communities) as well as where livestock intensification has been introduced. A combination of complex factors in these settings (e.g. challenges in country infrastructures and cross-sectoral collaboration/coordination, traditional habits, poor social information, etc.) contribute to the emergence and, occasionally, to the endemic pattern of zoonoses. The phenomenal growth of international travel and trade, population displacement, and unhygienic settlements has increased the speed and ease with which pathogens and vectors can cross continents and cause outbreaks and epidemics. Programmes for the prevention and control of zoonoses have been implemented in several countries in this region; however, the expected results have not always been realised. The conflicts and civil unrest affecting certain countries in this region during the last decade, together with the mass displacement of people seeking refuge, have resulted in serious epidemiological and social impacts. Zoonoses and related food-borne diseases are, indeed, a worldwide challenge, whose prevention and control mainly depend on the actions of national authorities. Once peace has been established in this region, authorities need to address the burden of these diseases through resource mobilisation, the implementation of international agencies' technical guidance, and inter-country collaboration.

Principali sfide nel controllo delle zoonosi e delle malattie correlate di origine alimentare nelle regioni del Sud-Mediterraneo e del Medio Oriente

Parole chiave

Zoonosi,
Controllo,
Malattie trasmesse da
alimenti,
Medio Oriente,
Mediterraneo.

Riassunto

Nelle regioni del Sud-Mediterraneo e del Medio Oriente (SMMER) esiste una stretta interazione tra persone, animali e l'ambiente circostante. Questo avviene soprattutto dove il bestiame viene allevato tradizionalmente da parte di comunità stanziali, semistanziali o nomadi, ma anche dove è stato introdotto l'allevamento di tipo intensivo. Inoltre, un complesso di fattori critici (es. inefficienza delle infrastrutture del paese, di collaborazione/coordination intersettoriali, mentalità legata alle tradizioni, carenza nell'informazione della popolazione, ecc.) contribuisce all'emergenza e talvolta all'endemicità delle zoonosi. L'aumento straordinario dei viaggi e dei commerci internazionali, lo spostamento e la raccolta di popolazioni in luoghi igienicamente carenti hanno accresciuto la velocità e la facilità con la quale i patogeni e i loro vettori stanno attraversando i continenti, causando focolai di infezione, talvolta epidemici. Programmi di prevenzione e controllo delle zoonosi sono stati attivati in tutti i paesi dello SMMER, tuttavia senza i successi sperati. Conflitti e instabilità politico-sociali, che si sono manifestati in diversi paesi nell'ultimo decennio, con milioni di individui diventati migranti economici e rifugiati politici, stanno causando gravi conseguenze di carattere epidemiologico e sociale. Le zoonosi e le malattie correlate di origine alimentare rappresentano certamente una sfida a livello mondiale. La loro prevenzione e il loro controllo dipende dalla ferma decisione e dalla capacità delle autorità nazionali competenti di ristabilire, prima di tutto, condizioni di pace e, in seguito, dalla volontà di combattere queste malattie, reperire risorse e rendere operanti il supporto tecnico e direttivo delle agenzie internazionali e la collaborazione tra paesi.

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Introduction

People have always depended on animals as sources of food, transport, labour, and companionship. However countless species of animals are also sources of communicable diseases, which are transmitted through direct contact between humans and the domestic and wild animal reservoir, or indirectly through, for example, contaminated food, biological products, environment, and vectors. Such conditions are classically named zoonoses or zoonotic diseases.

For many years and in many countries zoonotic diseases have imposed a very heavy burden among people living and working in rural areas as well as in the crowded and unhygienic environments of most cities.

Zoonoses and related foodborne diseases (FBDs) are a progressive concern in the public health domain. The health and socio-economic impacts of these diseases have increasingly been documented in many countries: most notably, although not exclusively, in developing countries. Apart from causing human suffering, morbidity, and mortality, the diseases hamper agricultural production, decrease the availability of food, and create barriers to international trade, thus impairing national wealth and development (PAHO-WHO 2003, Maudlin *et al.* 2009, Bueno-Mari *et al.* 2015).

Reasons for zoonoses emergence, re-emergence, and spread

A number of factors have contributed to the expansion of the geographical distribution of zoonoses. These include: Increasing and largely unplanned urbanization, major population movements, new areas in food production, growing international trade in meat, milk, and other products of animal origin, the emergence of relatively easy and frequent travel, and tourism. This has occurred to the point that zoonoses are no longer confined to rural areas, but have gradually reached peri-urban and urban areas at a global scale (Mavroidi 2008, Maudlin *et al.* 2009, Tabbaa and Seimenis 2013, Bueno-Mari *et al.* 2015, Paweska 2015).

Interaction between humans and animals, the consumption of raw milk and fresh milk products, the intensification of animal production, illegal slaughtering, and inappropriate waste disposal, environmental degradation, and uncontrolled human population settlements – particularly in and around cities, often without adequate sanitary conditions – usually result in an increasing number of stray dogs and cats, rats, and arthropods, which may in turn transmit zoonotic diseases (e.g. rabies, leishmaniasis, echinococcosis, leptospirosis, etc.).

During the last decades, the alteration of ecological conditions has also played an important role in the emergence, re-emergence, and spread of zoonoses (Mavroidi 2008, Hassaimain *et al.*, 2013, Seimenis 2008, Seimenis and Tabbaa 2014, Paweska 2015, Klaus *et al.* 2016). Conflicts, population displacements etc. represent additional further burdening factors (WHO-EMRO 2015, 2016).

The South Mediterranean and Middle East Region (SMMER)

The SMMER includes the following countries, all of which are members of the WHO-Eastern Mediterranean Regional Office: Afghanistan, Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates, Yemen.

Animal farming, human population, and zoonoses

The livestock in the SMMER is mainly composed of cattle, sheep, goats, camels, and, in certain areas, buffaloes. Traditional herds and flocks are small and dispersed. The nomadic and semi-nomadic breeding of small ruminants is commonly found in this region. Flocks and herds of different species and health status may share the same environment, thus increasing the chances of transmission of zoonoses. Moreover, the animal population links the human population and its surrounding environment. This is particularly true in traditional farming settings practiced by sedentary, semi-sedentary, and nomadic communities, as well as where livestock intensification has been introduced (Greger 2007, OIE 2009, Sherman 2011, Paweska 2015, Roess 2015, Klaus *et al.* 2016).

Most of the human population in these areas share almost similar geoclimatic and epidemiological conditions with regard to zoonoses and related FBDs, as well as common traditional habits and behaviours. The above factors contribute to the perpetuation of conditions such as brucellosis, cystic echinococcosis, non-typhoidal salmonellosis, leishmaniasis, rabies, and zoonotic bovine tuberculosis (Battelli *et al.* 2002, Garguri *et al.* 2004, WHO (HQ-MZCP)/OIE 2008, FAO 2009, Ruiz Bostigo 2010, Dakkak 2010, Dean *et al.* 2014, FAO 2014a, Wernery 2014, Horton *et al.* 2015, Musallam *et al.* 2016).

A combination of additional factors contribute to sustaining the transmission of zoonoses at endemic level (sometimes even triggering epidemics), and prevent existing disease control programmes from achieving their objectives. Such factors include: poor infrastructure, lack of trained professionals, weak or absent inter-sectoral collaborations,

limited diagnostic/laboratory capacity, weak public health education programmes and community participation, lack of funding, and weak commitment by decision-makers (WHO 2007, Tabbaa 2008, Maudlin *et al.* 2009, Molyneux 2011, Kock 2014, FAO 2014b, Paweska 2015, Mokdad Ali 2016, Zinsstag *et al.* 2007).

Foodborne zoonoses

In general, FBDs constitute a permanent problem in the whole SMMER. The WHO-Eastern Mediterranean Region has the third highest estimated burden of FBDs per population (the African and South-East Asia Regions being the first and the second, respectively). According to this evaluation, in SMMER, annual cases of foodborne zoonoses (FBZ) could represent 55-60% of the total cases of foodborne hazards (diarrheal and invasive infectious disease agents, helminths, chemical, and toxins). *Campylobacter*, *Escherichia coli*, and non-typhoidal *Salmonella enterica* infections have a high occurrence, while Cryptosporidiosis, giardiasis, listeriosis, toxoplasmosis, and trematode infections are present in most countries. The prevention and control of these conditions through safe food and water and appropriate management of urban waste water, represents a major challenge (Collins and Wall 2004, FAO/WHO 2004, FAO/WHO 2005, WHO 2008, Hassaimain *et al.* 2013, Tajkarimi 2013, Idriss and El-Habbab 2014, WHO 2015a, WHO-EMRO 2016).

Non-typhoidal salmonellosis remains among the main causes of foodborne illness. It is known to be an important cause of severe diarrhea, mainly among children, but also in other population groups. It also creates serious economic problems in poultry production, which is considered the main source of human infection.

The importance of FBZ as a public health problem is often overlooked because their true incidents are difficult to quantify and the severity of their social and economic impacts are not always fully understood. In the SMMER, there is a scarcity of reliable information both on their burden among the human population and on sources of food contamination. For example, a survey on foodborne pathogens in Jordan indicates significant under-reporting and under-diagnosis of *Salmonella* and *Shigella* infections. Notably, it was estimated that for each person with a laboratory-confirmed diagnosis, there are 270 additional infected people in the community (FAO/WHO 2005, FAO/WHO 2006, WHO 2008, Gargouri *et al.* 2009, Krause and Hendrick 2011, Musaiger 2011, Hassaimain 2013, WHO 2015a).

Many factors contribute to the incidence and endemicity of FBZ in the SMMER region. Good manufacturing practices and quality assurance

systems (Hazard Analysis Critical Control Points) have only recently been introduced into the food production and catering sectors. Nevertheless, street food vending is present in most countries in the region, and often vendors have little or no formal education in food handling practices. An additional factor is the lack of knowledge for issues relating to the importance of the hygienic living conditions, food handling, and food safety, which results in large consumption of raw milk, fresh milk products, and uncooked salads, for example (FAO/WHO 2004, FAO/WHO 2005, WHO 2008, Krause and Hendrick 2011, Musaiger 2011, Hassaimain *et al.* 2013, Takjarimi *et al.* 2013, WHO 2015a).

Emerging and re-emerging zoonoses

In spite of the many considerable achievements made in the control of communicable diseases in recent decades, emerging and re-emerging zoonotic diseases have remained one of the leading causes of morbidity and mortality in human populations. These diseases continue to retain the attention of the scientific community and public health officials around the world.

The phenomenal growth of international travel and trade has vastly increased the speed and ease with which pathogens, including drug-resistant strains and vectors, can cross continents and cause outbreaks and epidemics. The SMMER is not an exception. In addition to the contributing factors detailed above and the endemicity of certain zoonoses to the region, the close interaction of animals (both domestic and wildlife), animal products, and humans creates an environment that favours the emergence, re-emergence, and perpetuation of these types of infections (Greger 2007, WHO 2007, Chomel 2008, Seimenis 2008, FAO 2009, Sherman 2011, Molyneux *et al.* 2011, FAO 2011, Hotez *et al.* 2012, Wang and Craumen 2014, Wernery 2014, Wiethoelter *et al.* 2015, Bueno-Mari *et al.* 2015, Paweska 2015, Roess *et al.* 2015, Klaus *et al.* 2016, WHO-EMRO 2016). Some examples of emerging zoonoses are the following:

Rift Valley fever: two explosive epidemics occurred in Egypt in 1977-78 and in 1986-1987, with hundreds of human deaths and heavy losses among livestock. Other outbreaks occurred in Saudi Arabia and Yemen in 2000, for the first time outside of the African continent, causing 124 and 166 deaths respectively, and approximately 40% of abortions among sheep (Hotez *et al.* 2012, EFSA-AHAW 2013, McDowell and Rafati 2014, Wernery 2014, Klaus *et al.* 2016, Mokdad Ali *et al.* 2016).

Highly pathogenic avian Influenza (HPAI-H5N1) appeared in Egypt in December 2003, and became endemic. Between then and September 2016, a total

of 356 laboratory confirmed cases of human infection were reported to the World Health Organization (WHO), and in 2016 two fatal cases occurred in children exposed to domestic poultry. Infections in poultry were recently detected in Lebanon and Iraq. Iran, Jordan, and Syria are considered at high risk for the introduction of HPAI-H5N1 from these countries as a result of the movement of live poultry, poultry-related products, and the migration of wild birds (Hotez *et al.* 2012, McDowell and Rafati 2014, Wang and Craumen 2014, FAO 2016, WHO 2017).

Middle East respiratory syndrome coronavirus (MERS-CoV) was first identified in Saudi Arabia in 2012 and since then many countries within SMMER have reported human cases. It is believed that humans can be infected with MERS-CoV through direct or indirect contact with infected dromedary camels. Strains of the virus were identified in camels in several countries, including Egypt, Oman, Qatar, and Saudi Arabia (Wernery 2014, Poletto *et al.* 2014, Roess *et al.* 2015, Alraddadi 2016, Mohd *et al.* 2016, WHO 2016, Zumla *et al.* 2016, Han *et al.* 2016).

Crimean-Congo haemorrhagic fever (CCHF) is one of the rapidly emerging viral haemorrhagic fevers. Sporadic human cases and outbreaks were reported from several countries in the WHO-Eastern Mediterranean Region. In 2014, Oman reported 18 cases of CCHF, including one death nearly 15 years after the first case was detected in the country. Nosocomial outbreaks were reported in Afghanistan, Iran, Iraq, and Saudi Arabia, which resulted in high mortality among hospital staff (Hotez *et al.* 2012, McDowell and Rafati 2014, Wang and Craumen 2014, WHO 2015b).

Other emerging zoonoses affecting SMMER include West Nile fever, reported in the early 1950s in Egypt; Alkhurma haemorrhagic fever, first reported in 1995 in Saudi Arabia; and, among emerging FBDs, Shiga toxin-producing *Escherichia coli* infection, first described in 1982 (Mohammadi *et al.* 2013, Sabatino *et al.* 2014, CDC 2014, Garbaj *et al.* 2016).

Regional activities on the prevention and control of zoonoses and related FBDs

SMMER countries have made several efforts to reduce the prevalence of some major zoonoses. Programmes to control such diseases have been implemented in most countries and/or zones by the responsible governmental agencies or by non-governmental organizations. Additional technical support is often provided by international organizations (IOs) such as the Food and Agriculture Organization of the United Nations (FAO), the World Organization for Animal Health (OIE), and WHO, although mainly on an ad-hoc basis, and usually in response to an emergency situation.

Prevention and control are indeed possible in the SMMER because of such programmes. However lack of resources and other factors mean that these programmes are not always sustainable. As a result, zoonoses continue to affect humans and livestock, and represent a heavy social and economic burden in the region [FAO/WHO 2006, WHO 2007, WHO/FAO/OIE 2008, WHO (HQ-MZCP)/OIE 2008, Tabbaa 2008, Kock *et al.* 2012, Stringer 2014, Musallam *et al.* 2016, WHO-EMRO 2016, Zinsstag *et al.* 2016].

In this context it should be noted that besides structural weaknesses, difficulties challenges with programme implementation also exist. For example, identifying, vaccinating, and monitoring most infected sheep and goats in brucellosis' infected flocks as well as controlling their movements, is difficult considering the types of nomadic or semi-nomadic farming that are prevalent in the region. Such situations create additional impediments to meeting programme targets for preventing and controlling zoonoses. It should furthermore be noted that successful prevention and control strategies rely on a thorough understanding of local and regional differences in animal husbandry practices, social customs, infrastructures, and epidemiological patterns. Additional impediments towards progress are represented by the conflicts, civil unrests, and population displacements in certain countries of the region (Barcelona Process 2000, FAO/WHO 2005, FAO/WHO 2006, WHO 2007, Tabbaa 2008, OIE 2009, FAO 2011, Molyneux *et al.* 2011, Roess *et al.* 2015, Klaus *et al.* 2016, Zinsstag *et al.* 2016, Mokdad Ali *et al.* 2016, WHO-EMRO 2016).

Social and economic impacts of zoonoses and related FBDs

The existing structural, social, breeding, geoclimatic, educational, and financial handicaps are conducting to an almost stationary epidemiological situation of zoonoses and related FBDs in certain countries or zones of the SMMER. Such conditions create progressive social and economic impacts that could be summarized as follows (FAO/WHO 2005, Seimenis *et al.* 2006, FAO 2009, Sherman 2011, Dean *et al.* 2012, Horton *et al.* 2015, WHO 2015a, Klaus *et al.* 2016, Mokdad Ali *et al.* 2016):

Social and economic impacts in humans:

- medical fees: costs of diagnosis, hospitalisation, nursing, medication;
- absence from work, therefore reduced income and productivity;
- deterioration of quality of life;
- social consequences of disability;

- abandonment of farming or agricultural activities by affected or at-risk persons.

Economic impacts in livestock:

- reduced yield and quality of animal production (meat, milk, wool, eggs, labour, etc.);
- reduced birth rate and infertility;
- reduced adult livestock replacement and availability of sufficient meat for human consumption;
- condemnation of organs and costs for destruction of viscera and/or carcasses in some cases;
- lowered price of animals, milk, and dairy products;
- ban on exportation and national movement.

Administrative costs:

- costs from delayed economic growth at the animal breeding level;
- government compensations for positive animal slaughtering and replacement;
- costs for increased laboratory surveys and diagnosis;
- costs for medical and veterinary personnel training associated with prevention and control activities;
- costs for intensified professional training and public health education programmes, including those associated with using mass media.

The way forward

Zoonoses and related FBDs represent a very important public health problem. However, many aspects and factors involved in their prevention and control cannot be addressed by the health sector alone. Success in reducing the public health burden of zoonotic diseases depends on collaborations between medical and veterinary sectors, especially inasmuch as those collaborations result in information exchange, laboratory diagnosis, surveillance, staff training, and community awareness. There is also need for national programmes to mobilize and commit the necessary resources. Inter-sectoral collaboration and coordination are fundamental to controlling zoonoses and FBDs. However, the processes involved in planning and implementing inter-sectoral actions are complex. Each country in the SMMER should therefore develop its own strategy and approaches (Shimshony and Economides 2006, Zinsstag 2006, Zinsstag *et al.* 2007, Mantovani 2008, WHO 2008, Tabbaa 2008, Molyneux *et al.* 2011, WHO 2011,

Idriss *et al.* 2014, WHO/OIE/WB 2014, Stringer 2014, Mwangi *et al.* 2016).

A primary challenge to the effective implementation of zoonoses prevention and control programmes is the establishment of effective public health and animal health epidemiological surveillance systems with well-trained staff. Sectors such as health, consumer protection, animal health, agriculture, and the environment must be aware of – and involved in – cooperative efforts in this domain. It is well-known that the main function of epidemiological surveillance systems for zoonoses and related FBDs is to provide the information required to select appropriate interventions. Analysis of surveillance data makes it possible to identify operational options, their cost, and their benefits. Active and integrated surveillance systems should therefore be adopted by all countries in order to ensure that a high quality of data is collected (Shimshony and Economides 2006, WHO 2007, Tabbaa 2008, Chomel 2008, Seimenis 2010, FAO 2011, WHO 2011, FAO 2014b, Holloway *et al.* 2015, Zinsstag *et al.* 2016).

Outbreaks often occur in areas far from health care centres and services; therefore, reliable relevant data on distribution, incidence, prevalence, and mortality are scarce. This is partly due to a lack of appropriate diagnostic tools suitable to such conditions. Diagnosing and detecting pathogens are basic requirements for the prevention and control of any communicable disease; therefore, national programmes need to strengthen capacities within laboratories, so that they can assume this responsibility (Barcelona Process 2000, FAO 2005, WHO 2007, FAO 2011, WHO 2011, Kock *et al.* 2012, WHO/OIE/WB 2014).

Considering the complexity of factors involved in the emergence, re-emergence, and/or endemicity of zoonoses and related FBDs, national control programmes should be developed with long-term objectives that include active collaborations with IOs such as the FAO, OIE, and WHO, whose mandates include providing technical advice and assistance and, where appropriate, resource mobilisation. Close collaboration and information exchange is required particularly among countries that share borders. Collaborations should be based on legal agreements, and should involve public health and animal health sectors, as well as other relevant professionals. Raising awareness among decision-makers and policy-makers on the social and economic burden of zoonoses in humans and animals will enhance commitment and financial support towards the achievement of the targets set by national control programmes (Zinsstag 2006, WHO/FAO/OIE 2008, WHO 2010, Hotez and Savioli 2012, WHO/OIE/WB 2014).

Discussion

In the SMMER, several zoonoses and related FBDs are endemic and others are emerging or re-emerging. They represent a permanent threat to human and animal populations, but also lead to significant economic loss by reducing the availability of animal products and by creating barriers to the international trade of live animals and their products (FAO/WHO 2006, Shimshony and Economides 2006, Seimenis 2008, FAO 2009, Sherman 2011, Wang and Craumen 2014, Paweska 2015).

Lowering the burden of FBDs and making food safer and suitable for national and international trade depends on establishing effective surveillance mechanisms and on improving production, processing, and food control systems compliant with international standards. Strengthening public health education systems and improving the hygiene of feeding conditions is another relevant set of priorities for social and economic development (Collins and Wall 2004, Krause and Hendrick 2011, Musaiger 2011, Molyneux *et al.* 2011, Hassaimain *et al.* 2013, Tajjkarimi 2013, Idriss and El-Habab 2014, WHO 2015, WHO-EMRO 2016).

The availability of safe food improves public health and is also a basic human right. Poor and marginalised populations are moreover more susceptible to ill health because of unsafe food and water. Safe food therefore constitutes an important platform for development and poverty alleviation (Collins and Wall 2004, FAO/WHO 2004, FAO/WHO 2005, WHO 2008, Molyneux *et al.* 2011, Musaiger 2011, Tajjkarimi *et al.* 2013, Idriss *et al.* 2014).

Among all the activities relevant to the prevention, surveillance, and control of zoonoses and related FBDs, the major roles and responsibilities reside in the human and animal health sectors. Without coordination, horizontal inter-communication, and collaboration, any programme – no matter how appropriately planned – has little possibility of success. Such handicaps reduce programmes to expensive activities that achieve only partial and short-term results (Zinsstag 2006, Zinsstag *et al.* 2016, Kahn *et al.* 2007, WHO/FAO 2008, FAO 2014b, Klaus *et al.* 2016, Mwangi *et al.* 2016).

Several determinants can lead to development-hampering conditions. They include: socio-political and socio-cultural behaviours such as lack of cross-sectoral coordination, vector ecology, occupational activities, natural disasters, uncontrolled urbanisation, indiscriminate use of insecticides, weak national infrastructures, lack of public health education and community awareness. Such conditions entrap the most vulnerable populations. These factors are among the most critical determinants affecting the health

of individuals and societies; they also increase vulnerability to diseases by limiting access to quality health care, safe and nutritious food, and adequate housing. National animal health services should not restrict their activities to safeguarding livestock. Rather, their aim should be to protect public health. Equally, public health services should not limit their activities to diagnosing and treating patients, but rather should aim to identify the sources of human zoonotic infection and inform veterinary services, thus enabling them to take necessary further actions. It should be clearly understood that animal health and human health are inextricably linked and that both sectors share common goals of protecting, promoting, and improving the health, wellbeing, and economic development of the community (Kahn *et al.* 2007, Zinsstag *et al.* 2007, WHO/FAO/OIE 2008, Mantovani 2008, FAO 2009, Molyneux *et al.* 2011, Stringer 2014, WHO/OIE 2014, Zinsstag *et al.* 2016, Mwangi *et al.* 2016).

Entrenched behaviours fostered by ignorance are additional important obstacles to zoonoses prevention and control. Sustained public health education activities should therefore be undertaken by both human and animal health sectors in order to increase the success of intervention outcomes (Collins and Wall 2004, Zinsstag 2006, WHO 2007, WHO/FAO/OIE 2008, Tabbaa 2008, Seimenis 2010, WHO 2010, Stringer 2014, Holloway *et al.* 2015).

Another important factor contributing to long-term surveillance, prevention, and control programmes, is capacity building, a basic strategy needed to build the technical capacity of staff in all SMMER countries. The training of staff from multiple sectors provides an environment to share and consolidate knowledge and, moreover, can help establish necessary intersectoral relationships. The adoption of a coherent staff training strategy leads to key outputs in the medium and long term (WHO 2007, Seimenis 2010, FAO 2011, Idriss *et al.* 2014, Holloway *et al.* 2015).

The following key achievements can be attained through capacity building:

- i. more and better qualified professionals and community-based workers in public health, animal health, and related sectors;
- ii. better understanding of the importance of efficient early-warning systems and of the exchange of information through intersectoral collaboration and coordination;
- iii. expertise in country- and regional-level contingency and preparedness plans, including horizontal inter-communication systems;
- iv. promotion of appropriate legislative and financial support to zoonotic and FBDs programmes and their management;

- v. enhanced support from major IOs to encourage and support countries in the capacity development of their public health, animal health and related sectors;

In conclusion, the implementation of a coherent and comprehensive capacity-building strategy is expected to have a beneficial and long-lasting impact on country development as well as specific control and prevention programmes.

There is no doubt that the prevention and control of major zoonoses and related FBDs depend on the commitment of national authorities to address the burden of these diseases, mobilise resources in different sectors, and establish and coordinate intersectoral collaborations, especially between public health and animal health services, in association with education and community-awareness programmes. Close and legally ratified collaboration between neighbouring countries is an additional important parameter. These comprehensive approaches can, with the support of international technical collaborations, contribute to the alleviation of human suffering as well as mitigate the social and economic burden associated with this group of diseases (WHO 2006, Zinsstag 2006, WHO 2007, WHO/FAO/OIE 2008, WHO 2010, Seimenis 2010, FAO 2011, Idriss *et al.*

2014, Stringer 2014, WHO/OIE/WB 2014, Holloway *et al.* 2015, Mwangi *et al.* 2016).

In recent years, conflicts and civil unrests in certain countries of the SMMER have displaced millions of people. Health services and facilities have been disrupted, medical supplies are becoming rare, and access to health care is dwindling. As a result, prevention and control programmes for communicable diseases have been affected. Detecting and responding to outbreaks has deteriorated, while projecting future needs has become a challenge (WHO-EMRO 2015, Mokdad Ali *et al.* 2016, WHO-EMRO 2016).

In conclusion, the control of zoonoses, related FBDs, and communicable diseases is a world-wide challenge for governments, regional and local administrations, public and animal health sectors, scientific institutions, IOs, and affected communities. The first step to addressing this challenge in the SMMER is to reestablish stability throughout the region. This is, for the time being, the absolute priority and the most necessary condition for gradual social and financial development and the reduction of population displacements and its effects. Following this, only the coordinated and consistent involvement of relevant parties would open the way for effectively addressing the burden of zoonotic diseases in this region.

References

- Alraddadi B.M. 2016. Risk factors for primary Middle East respiratory syndrome corona virus illness in humans: Saudi Arabia 2014. *Emerg Inf Dis*, **22** (1), 49-55.
- Barcelona Process: inventory of the means for controlling communicable diseases in the countries of the Mediterranean. 2000. In Proc. International Conference "Barcelona Process. First Ministerial Euro-Mediterranean Conference on Health", Montpellier, 3 December 1999, pp. 239. Final Report, September 2000. Institut de Vieille Sanitaire, France.
- Battelli G., Mantovani A. & Seimenis A. 2002. Cystic echinococcosis in the Mediterranean region: a long lasting association. *Parassitologia*, **44**, 43-57.
- Bueno-Mari R., Gouveia-Almeida A.P. & Navarro H.C. 2015. Emerging zoonoses: eco-epidemiology, involved mechanisms and public health implications. *Front Public Health*, **3**, 157.
- Center for Disease Control and Prevention (CDC). 2014. Alkhurma hemorrhagic fever. Atlanta, U.S.A. <https://www.cdc.gov/vhf/alkhurma/index.html> accessed on 30 March 2017.
- Chomel B.B. 2008. Control and prevention of emerging parasitic zoonoses. *Int J Parasitology*, **38**, 1211-1217.
- Collins J.D. & Wall P.C. 2004. Food safety and animal production systems: controlling zoonoses at farm level. *Rev Sci Tech Off Int Epiz*, **23**, 685-700.
- Dakkak A. 2010. Echinococcosis/Hydatidosis: a severe threat in Mediterranean countries? *J Vet Parasitol*, **174**, 2-11.
- Dean A.S., Crump L., Greater H., Schelling E. & Zinsstag J. 2012. Global burden of human brucellosis: a systematic review of disease frequency. *PLoS Negl Trop Dis*, **6** (10), e1865.
- Dean A., Schelling E. & Zinsstag J. 2014. Brucellosis. In *Neglected tropical diseases in Middle East and Nord Africa* (McDowell M.A. & Rafati S., eds). Springer, 217-233.
- European Food Safety Authority Panel on Animal Health and Welfare (EFSA-AHAW). 2013. Scientific opinion on Rift Valley Fever. *EFSA Journal*, **11** (4), 3180.
- Food and Agriculture Organization of the United Nations (FAO). 2009. Livestock and human and animal health – Threats related to livestock diseases. FAO, Rome, 75-93.
- Food and Agriculture Organization of the United Nations (FAO). 2011. Good emergency management practices: the essentials – A guide to preparing for animal health emergencies (Honhold N., Douglas I., Greening W., Shimshow A. & Lubroth J., eds). FAO Animal Production and Health Manual No. 11. FAO, Rome.

- Food and Agriculture Organization of the United Nations (FAO). 2014a. FAO works to curb the burden of brucellosis in endemic countries – Case studies from Euroasia and the Near East. Focus On, 8, Rome. <http://www.fao.org/3/a-i3916e.pdf>.
- Food and Agriculture Organization of the United Nations (FAO). 2014b. Risk based disease surveillance. FAO Animal Production and Health Manual No. 17. FAO, Rome.
- Food and Agriculture Organization of the United Nations (FAO). 2016. Highly pathogenic avian influenza (H5N1 HPAI) spread in the Middle East: risk assessment. EMPRESS watch 36, FAO, Rome. www.fao.org/3/a-i6155e.pdf.
- Food and Agriculture Organization of the United Nations (FAO) – World Health Organization (WHO). 2005. The impact of current food safety systems in the Near East/ Eastern Mediterranean Regions on human health. Report of a FAO/WHO Regional Meeting on Food Safety for the Near East, Amman, Jordan, 5-6 March, Rome. [www://http.fao.org/es/ESN/food/meetings/NE_report_en.pdf](http://www.fao.org/es/ESN/food/meetings/NE_report_en.pdf).
- Food and Agriculture Organization of the United Nations (FAO) – World Health Organization (WHO). 2006. Joint technical consultation on food safety regulations and international trade in the near East Region. Report of the 27th Regional Conf. for the Near East, Doha, Qatar, 13-17 March 2004. FAO, Rome. www.fao.org/Unfao/Bodies/RegConferences/nerc27/27Nerc_en.htm.
- Garbaj A.M., Awad E.M., Azwai S.M., Abolghait S.K., Naas H.T., Moawad A.A., Gammoudi F.T., Barbieri I. & Eldaghayes I.M. 2016. Enterohaemorrhagic *Escherichia coli* O157 in milk and dairy products from Libya: isolation and molecular identification by partial sequencing of 16SrDNA. *Vet World*, **9**, 1184-1189.
- Gargouri N., Walke N., Balbeisi A., Hadadin A., Salah S., Ellis A., Braam H.P. & Angulo F.J. 2009. Estimated burden of human *Salmonella*, *Shigella* and *Brucella* infections in Jordan 2003-2004. *Foodborne Pathog Dis*, **6**, 481-486.
- Greger M. 2007. The human-animal interface: emergence and resurgence of zoonotic infectious diseases. *Crit Rev in Microb*, **33**, 243-299.
- Han H-J., Yu H. & Yu X-J. 2016. Evidence for zoonotic origin of Middle East respiratory syndrome corona virus. *J Gen Virology*, **97**, 274-280.
- Hassaimain N.A., Hassaimain M.A., Ahmed N.A., Shaapan R.M., Bakarar A.M. & El Fadaly H.A. 2013. Public health importance of foodborne pathogens. *World J Med Sci*, **9** (4), 208-222.
- Holloway I., Mussallam M., Whiting M., Good L., Van Winden S., Silva-Fletcher A., Ababneh M., Abu-Basha E. & Guitian J. 2015. Building capacity to reduce biological threats in the Middle East. *Vet Rec*, **177**, 337-338.
- Horton D.L., McElhinney L.M., Freuling C.M., Marston D.A., Benyard A.C., Gohartz H., Wise E., Breed A.C., Saturday G., Kolodziejek J., Zilahi E., Al-Kobaisi M.F., Nowotny N., Mueller T. & Fooks A.R. 2015. Complex epidemiology of a zoonotic disease in a culturally diverse region. Phylogeography of rabies virus in the Middle East. *PLoS Negl Trop Dis*, **9** (3), e003569.
- Hotez P., Savioli L. & Fenwick A. 2012. Neglected tropical diseases in the Middle East and Nord Africa: review of their prevalence, distribution and opportunities for their control. *PLoS Negl Trop Dis*, **6** (2), e1475.
- Idriss A.W. & El-Habbab M.S. 2014. Middle East food safety perspectives. *J Sci Food Agr*, **94**, 1922-1927.
- Kahn H.L., Kaplan B. & Steel J. 2007. Confronting zoonoses through closer collaboration between medicine and veterinary medicine. *Vet Ital*, **45**, 5-19.
- Klaus G., Huss A., Heederssik D.J.J. & Coutinho R.A. 2016. Human-livestock contacts and their relationship to transmission of zoonotic pathogens, a systematic review of literature. *One Health*, **2**, 65-76.
- Kock R., Croft S., Dixon M., Fletcher C., Good L., Guzman J., Heymann D., Lyianage R., Mckeever D., McNerney R., Peeling R., Moran M., Pfeiffer D., Waage J. & Wu L. 2012. Prioritizing the need for new diagnostic, medicines, vaccines and management practices of zoonoses which have significant impact in the developing world. DFID Zoonoses Report 6, Royal Veterinary College, Hattfield, UK.
- Krause D.O. & Hendrick S. 2011. Zoonotic pathogens in the food chain. CAB International, Wallingford, UK.
- Mantovani A. 2006. Mediterranean and zoonoses: a long lasting association. *Giornale Ital Med Trop*, **11** (3-4), 57-64.
- Mantovani A. 2008. Human and veterinary medicine: the priority for public health synergies. *Vet Ital*, **44**, 577-582.
- McDowell M.A. & Rafati S. 2014. Neglected tropical diseases in Middle East and Nord Africa. Springer, Verlag.
- Musaiger A.O. 2011. Food consumption patterns in the Middle East region. Arab Center for Nutrition, Manama, Bahrain.
- Musallam I.I., Abo-Shehada M.N., Hegazy Y.M., Holt H.R. & Guitian F.J. 2016. Systematic review of brucellosis in the Middle East: disease frequency in ruminants and humans and risk factors for human infection. *Epidemiol Infect*, **144**, 671-685.
- Maudlin I.A., Eisler M. & Welburn C. 2009. Neglected and endemic zoonoses. *Phil Trans R Soc*, **364**, 2777-2787.
- Mavroidi N. 2008. Transmission of zoonoses through immigration and tourism. *Vet Ital*, **44**, 651-656.
- Mohammadi P., Abiri R., Rezaeei M. & Salmanzadeh-Ahrabi S. 2013. Isolation of Shiga toxin producing *Escherichia coli* from raw milk in Kermanshah, Iran. *Iran J Microbiol*, **5**, 233-238.
- Mohd H.A., Al-Tawfiq J.A. & Memish Z.A. 2016. Middle East respiratory syndrome coronavirus (Mers-CoV) origin and animal reservoir. *Virology Journal*, **13**, 87.
- Mokdad Ali H., Farounzafar H., ElBcheraoui C., Moradi-Lakeh M., Khalil I., Afshin A., Tuffaha M., Charara R., Barber R.M. & Wagner J. 2016. Health in times of uncertainty in the eastern Mediterranean region, 1990-2013: a systematic analysis for the global burden of disease study. *Lancet Glob Health*, **4**, e704-13.
- Molyneux D., Hallaj Z., Keusch G.T., McManus D.P., Ngowi E., Cleaveland S., Ramos-Jimenez P., Gotuzzo E., Kar K., Sanchez A., Garba A., Carabin H., Bassili A., Chaignat C.L., Meslin F-X., Aboushama H.M., Willingham A.L. &

- Kioy D. 2011. Zoonoses and marginalized infectious diseases of poverty: where do we stand? *Parasites & Vectors*, **4**, 106.
- Mwangi W., Figueiredo P. & Criscitello M.F. 2016. One Health: addressing global challenges at the nexus of human, animal and environmental health. *PLoS Pathog*, **12** (9), e1005731.
- Pan American Health Organization – World Health Organization (PAHO-WHO). 2003. Zoonoses and communicable diseases common to man and animals. 3 ed. Scientific and Technical Publication No. 580, PAHO, Washington D.C.
- Paweska J.T. 2015. Factors affecting the emergence of zoonoses. 6th FIDSSA Congress, South Africa, 05-08 October.
- Poletto C., Pelat C., Levy-Bruhl D., Yazdanpanah Y., Boelle P.Y. & Colizza V. 2014. Assessment of the MERS-CoV epidemic in the Middle East region and risk of international spread using a novel maximum likelihood analysis approach. *Eurosurveillance*, **19** (23), 1-10.
- Refai M. 2002. Incidence and control of brucellosis in the Near East region. *Vet Microbiology*, **90**, 81-110.
- Ripani A., Boujdour R. & Zrelli M. 2015. Review of rabies situation and control in the Nord Africa region with a focus in Tunisia. *OIE Bulletin*, **1**, 72-77
- Roess A., Carruth I., Mann M., Kabbash I., Melaku S., Atia M., Mohamed M., Bansal S., Lahm S., Terefe Y. & Salman M. 2015. Livestock movements and emerging zoonotic diseases outbreaks: applying ecological, network and sociocultural theories to assess the risk of Middle East respiratory syndrome from camels trade in Ethiopia and Egypt. *The Lancet*, **3**, S26.
- Ruiz Bostigo J.A. 2010. Leishmaniasis in the World Health Organization – Eastern Mediterranean Region. *International J Antimic Ag*, **365**, 62-65.
- Sabatino D., Bruno R., Sauro F., Danzetta M.L., Cito F., Iannetti S., Narcisi V., De Massis F. & Calistri P. 2014. Epidemiology of West Nile Disease in Europe and in the Mediterranean Basin. *Biomed Res Int*, **20**, 1-10.
- Seimenis A. 2008. The spread of zoonoses and other infectious diseases through international trade of animals and animal products. *Vet Ital*, **44**, 591-599.
- Seimenis A. 2010. Capacity building for zoonotic and foodborne diseases in the Mediterranean and Middle East regions: an intersectoral proposed strategy. *International J Antimic Ag*, **365**, 75-79.
- Seimenis A., Morelli D. & Mantovani A. 2006. Zoonoses in the Mediterranean region. *Ann Ist Sup Sanità*, **42**, 437-445.
- Seimenis A. & Tabbaa D. 2014. Stray animal populations and public health in the South Mediterranean and the Middle East regions. *Vet Ital*, **50**, 131-136.
- Sherman D.M. 2011. The spread of pathogens through trade in small ruminants and their products. *Rev Sci Tech Off Int Epiz*, **30**, 207-217.
- Shimshony A. & Economides P. 2006. Disease prevention and preparedness for animal health emergencies in the Middle East. *Rev Sci Tech Off Int Epiz*, **25**, 253-269.
- Stringer A. 2014. Improving animal health for poverty alleviation and sustainable livelihoods. *Vet Rec*, **175**, 526-529.
- Tabbaa D. 2008. Control of zoonoses in emergency situations: lessons learned during recent outbreaks (gaps and weaknesses of current zoonoses control programmes). *Vet Ital*, **44**, 611-620.
- Tabbaa D. & Seimenis A. 2013. Population displacements as a risk factor for the emergence of epidemics. *Vet Ital*, **49**, 19-23.
- Tajkarimi M., Ibrahim S.A. & Fraser A.M. 2013. Food safety challenges associated with traditional food in Arabic speaking countries of the Middle East. *Trends Food Sci Techn*, **29**, 116-123.
- Wang L.F. & Craumen G. 2014. Emerging zoonotic viral diseases. *Rev Sci Tech Off Int Epiz*, **33**, 569-581.
- Wernery U. 2014. Zoonoses in the Arabian Peninsula. *Saudi Med J*, **35**, 1455-1462.
- Wiethoelter A.K., Beltran-Alcudo D., Kock R. & Mors M. 2015. Global trends in infectious diseases at the wildlife-livestock interface. *Proc Natl Acad Sci USA*, **112**, 9662-9667.
- World Health Organization (WHO). 2007. Risk reduction and emergency preparedness: WHO six years strategy for the health sector and community capacity development. WHO, Geneva, 20 pp.
- World Health Organization (WHO). 2008. Foodborne diseases outbreaks guidelines for investigation and control. WHO, Geneva.
- World Health Organization (WHO). 2011. The control neglected zoonotic diseases – Community based interventions for prevention and control. Report of the 3rd Conference organized with ICONZ, DFID-RIU, Gates Foundation, SOS, EU, TDR, FAO, with the participation of ILRI and OIE, WHO Headquarters, Geneva, 23-24 November 2010. WHO, Geneva.
- World Health Organization (WHO). 2015a. The Global Burden of Food Borne Diseases – Foodborne Disease Burden Epidemiology Group 2007-2015. WHO, Geneva.
- World Health Organization (WHO). 2015b. Summary Report on the Meeting on prevention and control of Crimean-Congo haemorrhagic fever in the Eastern Mediterranean Region, Muscat, Oman, 7-9 December. Doc.WHOEM/CSR/103/E.
- World Health Organization (WHO). 2016. Frequently asked questions on Middle East respiratory syndrome coronavirus (MERS-CoV) (http://www.who.int/csr/disease/coronavirus_infections/faq/en/ accessed on 30 March 2017).
- World Health Organization (WHO). 2017. Influenza at the human animal interface. Monthly Risk Assessment, Summary (www.who.int/influenza/human_animal_interface/HAI_Risk_Assessment/en/ accessed on 27 April 2017).
- World Health Organization – Eastern Mediterranean Regional Office (WHO-EMRO). 2015. Refugees and internally displaced persons in the Eastern Mediterranean Region: a health perspective. Position paper, November (<http://www.emro.who.int/images/>

- stories/eha/documents/migrants_refugees_position_paper.pdf?ua=1 accessed on 29 April 2017).
- World Health Organization – Eastern Mediterranean Regional Office (WHO-EMRO). 2016. Communicable diseases: shaping the future of health in the WHO Eastern Mediterranean region - reinforcing the role of WHO, 2012-2016. Progress report May 2016 in the 63rd Session of the Regional Committee for the Eastern Mediterranean, Cairo, Egypt, 3-6 October (<http://www.emro.who.int/entity/about-us/index.htm> accessed on 29 March 2017).
- World Health Organization (Head Quarters - Mediterranean Zoonoses Control Programme) (WHO-HQ-MZCP)/ World Organisation for Animal Health (OIE). 2009. Inter-country workshop on protecting humans from domestic and wildlife rabies in the Middle East, Amman, Jordan, 23-25 June 2008. Final Report. <http://www.oie.int/doc/ged/D6490.pdf>.
- World Health Organization (WHO)/Food and Agriculture Organization of the United Nations (FAO)/World Organization for Animal Health (OIE). 2008. Zoonotic diseases: a guide for establishing collaboration between animal health and health sectors at the country level. WHO, Geneva. www.wpro.who.int/publications/docs/Zoonoses02.pdf.
- World Health Organization (WHO)/World Organization for Animal Health (OIE)/World Bank-Group (WB). 2014. WHO-OIE operational framework for good governance at the human-animal interface. www.who.int/ihr/publications/WHO-OIE_Operational_Framework/en/.
- World Organization for Animal Health (OIE). 2009. Livestock population in the Middle East in 2009. In 10th Conf. of the OIE Regional Commission for the Middle East, Doha, Qatar, 26-29 October, Final Report. OIE, Paris. www.oie.int/doc/ged/D7031.pdf.
- Zinsstag J. 2006. Looking for economical sustainable solutions. In *The control of neglected zoonotic diseases: a route for poverty alleviation*. Report of a Joint WHO/DFID-AHP Meeting with the participation of FAO and OIE, 20-21 September 2005. WHO, Geneva, 32-33.
- Zinsstag J., Schelling E., Roth F., Bonhof B., Desavigny D. & Tanner M. 2007. Human benefits of animal interventions for zoonoses control. *Emerg Infect Dis*, **13**, 527-531.
- Zinsstag J., Abakar M.F., Ibrahim M., Tschopp R., Crump L., Bonfoh B. & Schelling E. 2016. Cost-effective control strategies for animal and zoonotic diseases in pastoralist populations. *Rev Sci Tech Off Int Epiz*, **35**, 673-681.
- Zumla A., Dar O., Kock R., Mutun M., Ntumi F., Kaleebu P., Eusbio M., Mfinanga S., Bates M., Mwaba P., Ansumana R., Khan M., Alagaili A.N., Cotten M., Azhar E.I., Maurer M., Ippolito G. & Petersen E. 2016. Taking forward a "One Health" approach for turning the tide against the Middle East respiratory syndrome coronavirus and other zoonotic pathogens with epidemic potential. *Int J Infect Dis*, **47**, 5-9.