Risks of Emerging Infectious Diseases: Evolving Threats in a Changing Area, the Mediterranean Basin

M. Vittecoq¹,², F. Thomas², E. Jourdain³, F. Moutou⁴, F. Renaud² and M. Gauthier-Clerc¹,⁵

¹ Centre de Recherche de la Tour du Valat, Arles, France
² Maladies Infectieuses et Vecteurs: Ecologie, Génétique, Evolution et Contrôle, UMR (IRD/CNRS/UM) 5290, Montpellier, France
³ INRA, UR346, Saint Genès Champanelle, France
⁴ Laboratoire Santé Animale de Maisons-Alfort, Anses, Maisons-Alfort Cedex, France
⁵ Département Chrono-Environnement, UMR UFC/CNRS 6249 USC INRA, Université de Franche-Comté, Besançon, France

Keywords:
emerging infectious diseases; Mediterranean region; global changes; risk factors

Correspondence:
M. Vittecoq. Centre de Recherche de la Tour du Valat, Arles 13200, France.
Tel.: +33 (0) 4 90 97 20 13;
Fax: +33 (0) 4 90 97 20 19;
E-mail: vittecoq@tourduvalat.org

Received for publication June 26, 2012
doi:10.1111/tbed.12012

Summary

The Mediterranean basin is a biodiversity hotspot; it has historically had a large human presence that has shaped ecosystems for millennia. As the cradle of many civilizations, the area was one of the main theatres for transitions that punctuated both human and pathogen histories, which are intimately linked. Today we are living through another great historical transition summarized in the expression 'global changes'. In this context, we are witnessing a rise in the emergence of pathogens widely associated with aforementioned global changes. The Mediterranean basin might be especially vulnerable to this phenomenon due to the acute consequences global changes will have in this key intercontinental interface region. In addition, Arab revolutions and European economic crisis are creating both sanitary issues and presenting new opportunities to improve infectious disease control and prevention in the region. The aim of this review is to identify the impacts that ongoing changes might have on the risk of infectious disease emergence in the Mediterranean basin. We focussed on three key domains undergoing transformations: (i) resources, namely safe drinking water and animal products, (ii) socio-economic factors including health inequalities within countries and poor sanitary conditions linked to ongoing conflicts and (iii) movements of people and goods that are reshaped by current changes and are intimately linked to the risk of disease proliferation. Building on recent examples, we try to identify upcoming challenges and discuss ways to meet them in the light of existing international human and veterinary health guidelines and their possible improvements.

Introduction

The twenty-two riparian countries and territories of the Mediterranean Sea share a unique climate coupled with an extremely rich natural and cultural heritage. The economy of the region remains mostly dependent – especially on the southern rim – on natural resources (Plan Bleu, 2009). Zone of exchanges and of conflicts at the same time, the region is still in search of stability. This stability must be built from common approaches on shared issues that include disease risk management.

The Mediterranean basin is unique in its combination of a major biodiversity hotspot and a historically large human presence, which has shaped ecosystems for millennia (Blondel and Aronson, 1999). As an example, during the Middle and Upper Pleistocene, invasions of Mediterranean islands by Homo sp. led to the near-complete extinction of the endemic fauna (Schule, 1993; Alcover et al., 1998). As the cradle of many civilizations, the area was also one of...
the main theatres for transitions that punctuated both human and pathogen histories, which are intimately linked (McMichael, 2004). Contemporary with the beginning of agriculture, the emergence of animal domestication among early human settlements in the eastern Mediterranean enabled enzootic pathogens to enter *Homo sapiens* (Weiss, 2001). New infections spread in human populations: tuberculosis has been identified in Egyptian mummies from as early as 2000 BC (Zink et al., 2003) and bone lesions typical of brucellosis were detected on the skeletons of the fugitives from Herculaneum (a Roman city near Pompeii) as early as 79 AD (Capasso and Capasso, 1999).

Today, the Mediterranean region is inhabited by 460 million people and plays a key interface role between Asia, Africa and Europe as one of the main hubs of the global transport network. The area is thus potentially at high risk for disease emergence and spread (Seimenis et al., 2006; Jourdain et al., 2007). Experts have warned that upheavals, which are currently shaking the region, will modify these risks and may enhance them if not properly dealt with (e.g. Rechel et al., 2011; Jabbour, 2012). The European part of the basin is confronting an important economic crisis, which is already threatening health systems in some countries like Greece (Kentikelenis et al., 2011). The southern part of the region has been experiencing revolutions that bring both sanitary crises (e.g. WHO, 2011) and create new opportunities to improve infectious disease control and prevention in the young democracies (Jabbour, 2012). These phenomena act in synergy with global changes defined as the interactions between natural changes in the Earth’s physical and biological structure and the broader effects of human activities (Ecosystems Panel, 2000). The Mediterranean area appears particularly vulnerable to global changes that notably include pollution, climate change, land use change and the exponential increase of people and goods transport. Indeed, the prediction of reduced precipitation in North Africa is of major concern because 22% of the world’s water-poor population lives in the Mediterranean basin (Giorgi and Lionello, 2008; Plan Bleu, 2009). Moreover, increasing urbanization and human population density in coastal areas are critical in the Mediterranean area, where land use changes have led to the disappearance of more than 50% of wetlands over a century (MWO, 2012).

In this context, our aim is to identify the impacts that ongoing changes might have on infectious disease (re)emergence risk in the Mediterranean basin. We focussed on three key domains undergoing change: (i) resources, namely safe drinking water, to which a large part of Mediterranean inhabitants have no access and animal products that account for an increasingly large part of the Mediterranean diet, which bring new risks of zoonosis transmission; (ii) socio-economic factors including health inequalities within countries and poor sanitary conditions linked to ongoing conflicts; and (iii) movements of people and goods that are reshaped by current changes and intimately linked to disease spread risks. We discuss ways to mitigate the expected impacts of ongoing changes in the light of existing international human and veterinary health guidelines and their possible improvements (Table 1; WHO, 2005; UNDP, 2010; OIE, 2011; UNODA, 2012).

**Resources**

**Water crisis**

Water availability is already a major issue in the southern and eastern parts of the Mediterranean basin, where 180 million people are ‘water-poor’ (<1000 m³ per capita per year) and 60 million suffer conditions of water scarcity (<500 m³ per capita per year; Plan Bleu, 2009). This situation will likely worsen with ongoing changes. The regional effects of climate change on the water cycle may deplete water resources, increase their variability and weaken their exploitability (Giorgi and Lionello, 2008). The most water-poor areas are likely to be the most affected (Giorgi and Lionello, 2008). This trend may be amplified by soil sealing caused by the rapid urbanization of the Mediterranean coast, which prevents infiltration and thus recharge of groundwater (Plan Bleu, 2009). Increasing tourism activities in the region are associated with water use conflicts, especially during summer, when the water needs of both agriculture and tourism facilities are high (Eurostat, 2009; Plan Bleu, 2009). Furthermore, urbanization and conflicts favour the development of slums with poor access to safe drinking water (UNDP, 2010). In 2010, 13% of urban inhabitants of southern Mediterranean countries were living in slums (UNDP, 2010).

These changes may enhance the impact of waterborne diseases such as enteric fevers, which are already problematic in the Mediterranean area. As an example, although very few cholera cases were reported in the Mediterranean basin during the last decade (WHO, 2012a), *Vibrio cholerae* has recently been isolated from freshwater (Eddabra et al., 2011), water of coastal areas (Vezzulli et al., 2010) and fish living in both marine and freshwater habitats (Halpern et al., 2008; Senderovich et al., 2010) in European and North African countries. The increasing numbers of refugees resulting from ongoing conflicts in North Africa and the Middle East might create ideal conditions for new cholera outbreaks, which often occur in overcrowded settlements (Bompague et al., 2009; Mahamud et al., 2011). Because *V. cholerae* proliferation is dependent on climatic conditions (Lipp et al., 2002; Koelle, 2009), global warming might also increase the risk of cholera re-emergence even in southern European countries (Guégan, 2002).
The emergence of antimicrobial drug resistance complicates the treatment of common waterborne diseases such as *Escherichia coli* infections worldwide (WHO, 2012b). In the Mediterranean basin, a wide variety of antimicrobial drugs are commonly found in groundwater (Rabiet et al., 2006; Mompelat et al., 2009), and their concentration might increase in the near future by water scarcity (Petrovic et al., 2011). These drug residuals favour the evolution of resistant pathogens that are also commonly isolated in groundwater as well as in aquatic birds in Mediterranean countries (e.g. Bonnedahl et al., 2009; Economides et al., 2012).

Implementing appropriate water treatment and surveillance is crucial to the prevention of disease emergence in the Mediterranean basin. Indeed, even in European countries, most of the existing treatment systems do not eliminate either antimicrobial drugs or all pathogenic bacteria (e.g. Wéry et al., 2008; Mompelat et al., 2009). Water safety is not specifically addressed by international health guidelines, which focus on the risk of diseases spread from one country to another rather than within countries (WHO, 2005). One of the Millennium Development Goals championed by the United Nations (UN) is to 'halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation' (UNDP, 2010). This international effort has already significantly improved water access in the Mediterranean region (IME, 2007; UNDP, 2010). Nevertheless, ongoing changes may impair this progress because the countries involved may not be able to sustain their current efforts.

**Livestock revolution**

On a global scale, economic development tends to be accompanied by an increased demand for animal protein. In the Mediterranean basin, this increase is especially pronounced because the diet traditionally contained little meat. Mediterranean inhabitants still eat less animal products than the European average, but the proportion of animal protein in their diet has increased steadily since the 1960s with strong variability between countries (Gil et al., 1999; García-Closas et al., 2006). This increasing demand for animal products leads to the development of industrial rearing practices that favour the emergence of new pathogens because the animals have genetically poor immune capacities and are raised in stressful and crowded conditions that facilitate rapid disease transmission and evolution (Steinfeld, 2004; Lebarbenchon et al., 2010). In addition, domestic animals, notably poultry, remain a key subsistence source for many poor Mediterranean inhabitants (FAO, 2009). Epizootics are very costly for these inhabitants, whose economic well-being depends on their animals, and they are at high risk for zoonotic disease transmission because animals and humans live in close contact (FAO, 2009). Emerging zoonotic diseases have to
be controlled simultaneously in different kinds of rearing facilities in the Mediterranean region, which entails the implementation of a very complex epidemiological network.

These challenges have been highlighted by the difficulties encountered in the control of the highly pathogenic H5N1 avian influenza viruses (HPAIV). The coexistence of industrial poultry, where conditions are favourable for the evolution of HPAIV, and family poultry, where surveillance and vaccination campaigns are difficult to implement due to the multiplicity of poultry owners, complicates the control of HPAIV. This is notably the case in Egypt, where HPAIV infections have regularly been reported since 2006 in both poultry and humans (Fasina et al., 2010; OIE, 2012a). Epidemiological studies have highlighted the importance of taking into account socio-economic factors to adjust compensation schemes and implement effective collaborations with poultry owners (Meleigy, 2007; Leibler et al., 2009). The current turmoil in the Mediterranean basin raises concerns about the durability of these recently forged collaborations, which represent keystones for the surveillance of zoonotic diseases (Guan et al., 2012).

HPAIV epizootics also underscored the importance of wildlife surveillance in the understanding of zoonotic disease epidemiology (e.g. Olsen et al., 2006). Wildlife surveys revealed that wild waterfowl represent a source of new influenza viruses that can evolve into highly pathogenic forms in the context of industrial farming (Lebarbenchon et al., 2010).

For other zoonotic diseases, wild species may be important pathogen reservoirs, adding another compartment to include in the surveillance network. As an example, bovine tuberculosis (caused by *Mycobacterium bovis*) is a zoonotic disease that can affect the health of both cattle and humans (Humblet et al., 2009). Recent studies in France and Italy showed that wild boars (*Sus scrofa*) are spillover hosts of bovine tuberculosis, while in Spain this species is considered a reservoir host that needs to be targeted by vaccination campaigns to prevent outbreaks in cattle (Serraino et al., 1999; Humblet et al., 2009; Gortazar et al., 2011). Interestingly, studies in Spain reveal that the intensification of game management may increase the prevalence of bovine tuberculosis. Indeed, wild boars and red deer living in high densities in fenced hunting estates were shown to be at higher risk of tuberculosis infection than those living in unfenced areas (Vicente Baños et al., 2007; Castillo et al., 2011). In southern and eastern Mediterranean countries, the few available data suggest a high prevalence of *M. bovis* in cattle, representing substantial risks of infection in the population (Ozmen et al., 2005; Hassanain et al., 2009; Bouzid et al., 2010; Ben Kahla et al., 2011). Wild host species are also likely existing in these countries, but their identity and role in tuberculosis transmission dynamics remain to be investigated. In these countries, the priority for now is to implement efficient disease surveillance in domestic animals.

The scarcity of surveillance data in domestic animals in the southern and eastern parts of the Mediterranean basin as well as in other developing countries raises questions about the adequacy of the disease information system implemented by the World Organisation for Animal Health (OIE). This system defines compartments (countries or smaller geographical zones) infected or free of disease for each notifiable disease. As an example, most countries that did not report bovine tuberculosis in 2011 are in fact lacking a bovine tuberculosis surveillance system, which illustrates the ambiguity of national sanitary statuses (OIE, 2012b). This lack of surveillance highlights the need to modify OIE international guidelines so that the world is not represented as closed compartments that contain a disease or not, but as an interconnected network in which different pathogens circulate regardless of national borders.

**Socio-economic factors**

Growing socio-economic inequalities

Health inequalities, although variable among countries, remain high within most Mediterranean countries and tend to grow due to ongoing changes (e.g. Patel and Burke, 2009; Boutayeb and Helmert, 2011). Urbanization increases the gap between rural and urban areas — as well as between conventional habitats and slums in cities — in terms of sanitary conditions and access to healthcare (Patel and Burke, 2009). Moreover, the economic crisis and the political instability currently experienced in the Mediterranean basin enhance these disparities through the increase in underprivileged populations, including homeless people and undocumented migrants, and the concomitant decrease of health actions aiming at helping them (Busch-Geertsema et al., 2010; Boutayeb and Helmert, 2011; Rechel et al., 2011).

In rural areas, access to health services remains generally more difficult than in urban areas, leading to lower use of medical care and under-reporting of diseases. In rural populations living in close contact with domestic and wild animals, which carry a large diversity of pathogens, this lack of surveillance may favour disease (re)emergence. As an example, the number of West Nile cases reported in humans and horses since 2010 has dramatically increased all over the Mediterranean basin (Papa et al., 2010; Sirbu et al., 2011; OIE, 2012c). Mosquitoes generally transmit this virus from bird to bird, but they occasionally infect mammals, sometimes causing serious clinical signs (Dauphin et al., 2010). The lack of surveillance in both animals and humans in the rural areas where the virus re-emerged did not allow an accurate map to be made of West Nile
virus circulation foci. This would have allowed the prediction of future outbreaks and an assessment of the risk of disease transmission through blood transfusion, although recent studies showed that blood donors living in risk areas should be systematically tested for West Nile virus infection (Pezzotti et al., 2011; Papa et al., 2012). In addition, the screening of sentinel wild bird species proved to be effective for identifying circulation areas (Jourdain et al., 2008).

The importance of effective surveillance in rural areas was also alarmingly illustrated by local outbreaks of bubonic plague in Algerian villages in 2003 and 2008 (Bertherat et al., 2007; Bitam et al., 2010). These outbreaks presumably originated from endemic rodent foci that were formerly unknown because of a lack of surveillance. The concomitant detection of a rodent plague focus in Libya (Tarantola et al., 2009) raises the fear of plague re-emergence from rural foci to neighbouring cities in the current context of socio-political revolutions and population displacements.

In urban areas, undocumented migrants, homeless people and slum inhabitants, who live in poor sanitary conditions with low access to medical services, have a higher risk of contracting zoonotic, water-borne and vector-borne infections than better-off urban populations (Brouqui, 2011). Indeed, this growing population is often in contact with a wide range of vectors favoured by poor hygiene (e.g. body lice and bed bugs) or the presence of rats or other anthropophilic urban species (e.g. fleas). These vectors can transmit various diseases, some of them lethal. As an illustration, epidemic typhus cases have been increasingly reported from the homeless population of Marseille, France (Brouqui et al., 1996; Badiaga et al., 2011).

The objectives set by the UN through the Millennium Development Goals have led the FAO and WHO to implement action plans that brought considerable improvement in healthcare access in both rural areas and slums in the Mediterranean region (UNDP, 2010). In addition, since the beginning of the H5N1 crisis, OIE and FAO have coordinated international efforts to strengthen surveillance of avian influenza infections in both domestic and wild animals (Dauphin et al., 2010). Unfortunately, the current economical and socio-political crises in the Mediterranean basin have tended to decrease healthcare funding and disrupt the operation of institutions while an increasing number of vulnerable people are at risk of zoonotic infection. Learning from past examples (Suhrcke et al., 2011) and current evidence, medical experts warn Mediterranean governments of the growing epidemiological threat that impacts of the current crises and changes represent for their population because disease emergence could be favoured. Improving healthcare programmes for rural populations and underprivileged urban inhabitants appears crucial to prevent future disease emergence. For zoonotic diseases, efficient surveillance of wild and/or domestic animal reservoirs is also essential.

Ongoing and future conflicts

The Mediterranean basin is characterized by its extensive cultural diversity as well as by major economic contrasts between coexisting developed and developing countries. It has historically been an area of exchanges and conflicts (Bethemont, 2002). Military and commercial contacts between Mediterranean populations have allowed them to swap their germ pools for several millennia. Greek and Roman wars notably favoured the dispersal of bubonic plague throughout the Mediterranean basin, from the Athenian plague that started in 430 BC to the Justinian plague that raged from 541 to 542 AD (Soupios, 2004; Raoul and Drancourt, 2008). As another more recent example, Spanish soldiers imported typhus from America to Europe during the Spanish succession war in the early 18th century (Nguyen-Hieu et al., 2010).

Today, in addition to the long-lasting Israeli–Palestinian tensions, Arab revolutions have faced violent repression, inducing conflicts in the southern and eastern parts of the Mediterranean basin since December 2010. During the same period, Southern European countries have experienced social struggles associated with the implementation of austerity plans by several governments in response to the economic crisis. Alarmingly, these conflicts may worsen in the near future due to climate change, as it may lead to water shortage. Indeed, a recent study showed that climatic events may have had a role in 21% of the civil conflicts in the five last decades (Hsiang et al., 2011).

Conflict areas are particularly good breeding grounds for emerging diseases. They disrupt health institutions, making monitoring programmes ineffective and access to medical care difficult, while people’s immunity is critically decreased by stressful conditions (Gayer et al., 2007). For example, the incidence of typhoid fever in Palestinian refugees increased from 4.3 per 100 000 inhabitants in 2006 to 13.0 in 2007, whereas no outbreak has been recorded in Israeli people since 1985 (UNRWA, 2007). The displacement of people induced by conflicts leads refugees to abandon combat areas and gather in areas with poor sanitary conditions. Zoonotic disease outbreaks may be favoured when people return home because of rodent proliferation in places where water and food supplies have been left unprotected. In 2000, for example, Albanian refugees returning home after the Kosovo war faced an outbreak of tularemia characterized by the sudden emergence of 327 cases although the disease had formerly rarely been reported in the Balkans (Reintjes et al., 2002).

International organizations, such as WHO and different non-governmental organizations (NGOs), have a key role
to play in coordinating healthcare and disease surveillance during conflicts when national institutions are temporarily unable to assume these tasks. As an illustration, WHO warned of disease outbreak risks in Libya in 2011 and coordinated the implementation of medical care measures in collaboration with NGOs and local professionals (WHO, 2011). However, in a context of conflict, the efficient implementation of relevant health measures may be severely impaired by access limitations, as is currently the case in Syria (ICRC, 2012).

Knowing that active terrorist groups, either religious or separatists, are numerous in the Mediterranean basin (Europol, 2012), another aspect of the risk of infectious disease emergence is linked to the potential use of pathogens as biological weapons. No bioterrorism event has recently been reported, although this has happened in Mediterranean history (Berche, 2009). For example, the bubonic plague outbreak of 1346, which killed a third of the European population, originated from the Genoese fleeing from Sicily after the siege of Kaffa by the Tartars. The besieged had been intentionally contaminated by their attackers, who threw corpses of plague victims into the city (Derbes, 1966). Biological weapons may not be preferred by terrorists because they are difficult to control (Berche, 2009). Nevertheless, the inexpensive nature of biological weapons along with their significant capacity to create panic among affected populations, even from a small number of cases, suggests that the risk of their spread is not negligible. The pathogenic agents most likely to be used are those that are most easily spread, involve severe symptoms and for which treatments are long or nonexistent; these include the agents of smallpox, anthrax, plague, botulism, tularemia and viral haemorrhagic fevers (e.g. Ebola virus, Lassa virus; Rotz et al., 2002). An essential component on the preparation for bioterrorism is the implementation of surveillance systems that can rapidly detect and monitor the course of an outbreak and efficiently react, with the aim of minimizing the associated morbidity and mortality. However, few surveillance systems have been specifically designed for collecting and analysing data for the early detection of a bioterrorist event (Bravata et al., 2004). A recent debate was raised by research studies aimed at understanding how mutations could increase the capacity of direct mammal-to-mammal transmission of the deadly H5N1 HPAIV (Fidler, 2012). This debate emphasized that neither the international convention on biological weapons (Table 1; UNODA, 2012) nor WHO have the legitimacy to regulate research projects performed for peaceful purposes (Fidler, 2012). Key ethical questions are raised by such research projects because they generate both the knowledge needed to implement efficient health policies and a risk of emergence and spread in the population of dangerous pathogens (Brumfiel, 2012). This recent debate urges the creation of new international guidelines that could be inspired by the existing international framework for handling the smallpox virus (WHO, 2010).

**Movements of goods and people**

Each component of the current changes experienced in the Mediterranean basin described above generates new flows of goods and/or people. Water scarcity, which is predicted to worsen in the near future, forces most Mediterranean countries to import ‘virtual water’, that is, to increase their importations of various goods whose production requires large amounts of water (MWO, 2012). Industrial rearing practices resulting from the growing demand for animal protein lead to increasing movements of live animals and livestock products (Steinfeld, 2004). Economic inequalities encourage rural inhabitants to move to urban areas and people from the poorest countries to emigrate to wealthier countries, which partly explains why overall human movements linked to permanent immigration have never been so high (OECD, 2011). Conflicts inside and outside the Mediterranean basin increase the numbers of refugees fleeing combat zones and entering safer countries (UNHCR, 2012). In addition, growing tourism is associated with human mobility within the region. In 2007, 30% of worldwide international tourist arrivals (about 275 million people) occurred in Mediterranean countries (Plan Bleu, 2009). This number was expected to rise to 235–300 million people by 2012 (CEPF, 2010). This exponential increase in the movement of people and goods may have major consequences on pathogen dissemination, as illustrated by the extremely rapid and worldwide spread of SARS in 2002–2003 and of the new H1N1 variant in 2009–2010 (Colizza et al., 2007; Khan et al., 2009).

The effect of current changes associated with these new possibilities of spread can favour the emergence of new infectious diseases in the Mediterranean region. As an example, Rift Valley fever, a severe mosquito-borne disease affecting ruminants and occasionally humans, was originally present only in Sub-Saharan Africa. In 1977, it spread in Egypt from Sudan, probably through camel trade (Abd El-Rahim et al., 1999). Rift Valley fever outbreaks have been subsequently regularly observed in Egypt causing human and animal losses (Ahmed Kamal, 2011). The intensification of animal trade and the multiplication of extreme rainfall events linked to climate change will probably increase the risk of Rift Valley fever spread in the Mediterranean basin urging for reinforced surveillance of this disease in the region (Chevalier et al., 2010). In the same way, dengue and chikungunya might spread to regions where one of their mosquito vectors (*Aedes albopictus*) has become established after its introduction by the trade of used tires (Schaffner and Karch, 2000). Although
A. albopictus has been present in Italy and France since the 1990s (Schaffner and Karch, 2000; Romi et al., 2008), only a single local chikungunya outbreak has been reported in Italy and two autochthonous human cases have been detected in France (Rezza et al., 2007; INVS, 2012). Surveillance in both countries was based on vector surveys and syndromic surveillance of humans leading to reports of suspected cases (Gobbi et al., 2012; INVS, 2012). Encouragingly, this example shows that appropriate surveillance and management measures can efficiently deal with emerging health risks.

Increasing migrant flows across the Mediterranean basin might promote the emergence of diseases in countries where their spread has been limited by effective control measures. Multidrug-resistant tuberculosis is notably of major concern in this context (WHO, 2012c). Countries with a low incidence of human tuberculosis, such as France and Spain, report that the incidence of latent Mycobacterium tuberculosis drug-resistant infections is higher in foreign-born residents than in the native population (e.g. Robert et al., 2003; Monge-Maillo et al., 2009). The detection of latent cases is crucial both to treat infected patients and to avoid extensive transmission of such serious diseases. The implementation of syndromic surveillance in migrants proved efficient in some European countries (e.g. Riccardo et al., 2011). However, this surveillance system does not allow the detection of asymptomatic cases, which have to be specifically searched for in migrants arriving from areas with high incidence levels. Such specific control programmes can rapidly decrease the health impact and transmission risk of resistant tuberculosis, as illustrated by the programme implemented in Israel over the last decade (Chemtob et al., 2003). This programme followed WHO guidelines on multidrug-resistant tuberculosis control therefore highlighting the major role of WHO for successfully implementing such programmes.

WHO guidelines provide recommendations for homogenous implementation of efficient control measures among countries that respect the human rights. Indeed, ethical issues must be considered. For example, the circulation rights of migrants can be denied due to serious infections. In the same way, importation bans linked to sanitary crises can have severe economic outcomes. This crucial point is extensively addressed in the International Health Regulation guidelines (WHO, 2005). Yet no enforceable actions exist to force WHO member states to apply WHO guidelines. This acute issue was recently discussed by the IHR Review Committee following the 2011 E. coli European outbreak that harmed the Spanish economy, notably due to a Russian import ban that violated WHO recommendations (Fidler, 2011). Moreover, IHR only deals with the control of international flows but not national disease control programmes. Similarly, the OIE terrestrial code focusses on the flows of animals and their products between countries but not the control of diseases within each member state, even if this issue has been addressed in the control of HPAIV. Each government has to implement its own disease control measures, yet international organizations might play a key role to guide and help set up these programmes.

Conclusion

Intensive current and future changes confronting the Mediterranean basin will have major impacts on the risk of infectious disease emergence. Managing these risks should be a priority for all Mediterranean governments because they may affect both the health of their inhabitants and the country’s economy. The ageing of the population is likely to make this challenge even more complex. Indeed, the proportion of older people (>65 years) in southern Mediterranean countries, which is today approximately 5%, will increase over the next decades and reach the level already attained in northern Mediterranean countries, which is over 15% (Christensen et al., 2009; CIA, 2012). Disease risk management has become an important component of good governance that can be a crucial condition to implement fruitful international relations (Fidler, 2004).

Mediterranean countries are intimately related to each other because of their common history, cultural and commercial links, and numerous human flows. These links should favour an increased collaboration in managing the risks of disease emergence. International organizations, notably WHO and OIE, play a key role in guiding such collaboration. Action plans targeting emerging diseases of international concern, such as H5N1 avian influenza or HIV, have led both WHO and OIE to move from actions focussing on human and animals flows, which traditionally benefit developed countries, to actions guiding local control programmes and integrated surveillance network, which benefit both developed and developing countries. Furthermore, as proposed by the One Health Initiative (http://www.onehealthinitiative.com/), collaborations between human, animal and environmental health professionals should be reinforced. The integration of these modifications to the WHO and OIE guidelines are necessary to adapt to an interconnected world, where the identification of separate epidemiological compartments is becoming harder and harder.

Acknowledgements

We sincerely acknowledge Stephen Larcombe for his valuable comments during the preparation of this manuscript. M. Vittecoq is supported by an AXA research fund Ph.D. fellowship. This work was funded by the Agence inter-éta-
blissemes de recherche pour le développement, the MAVA foundation and the Région Provence-Alpes-Côte d’Azur.

References


Eddabra, R., W. Moussaoui, G. Prévost, F. Delandale, A. Van Dorselseaer, O. Meunier, J. M. Scheftel, and R. Mimouni,

M. Vittecoq et al.


Mompelat, S., B. Le Bot, and O. Thomas, 2009: Occurrence and

Mahamud, A. S., J. A. Ahmed, R. Nyoka, E. Auko, V. Kahi, J.
Ndirangu, M. Nguthi, J. W. Burton, B. Z. Muhindo, R. F. Brei-
man, and R. B. Eidex, 2011: Epidemic cholera in Kakuma refu-


Ozmen, O., O. Kursun, and M. Ozcelik, 2005: Bovine tuberculo-


Riccardo, F., C. Napoli, L. Ruggeri, M. C. Rota, M. G. Dente, S. De Santis, and S. Declich, 2011: Syndromic surveil-