Global Epidemics, Pandemics, Terrorism: Risk Assessment and European Responses

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Abstract

This paper analyses from a European point of view global risk dimensions, risk reservoirs, risk assessment, risk communication, risk responses and risk recommendations in the context of future epidemics and pandemics resulting from biohazards.

It focuses on infectious diseases associated with insects, rodents, birds, pigs, camels, bats, wildlife trade, food, humans (HIV/TB/Ebola), migrants, refugees, travelers, terrorists, bioterrorists, "dual use" of highly pathogenic agents, DIYbio-processing, DNA-programed assembly of cells, "gene drive"-technology, "internet", and the "new and unknown", the "unknown-unknown", the "unpredictable".

The pandemic of Ebola virus disease in Western African countries is used as a topical example and forms the subject of a specific assessment.

Terrorists themselves have much in common with pathogens. They can attack via air, soil, food or water or as living vectors, using all options available for killing other people, e.g. with aircraft, bombs, rifles, knives or biological or chemical weapons. They can act everywhere at all times and are mostly invisible, unmonitored and unknown.

At the end, several recommendations are made for preventing, assessing and responding to epidemics, pandemics and terrorism more effectively and efficiently in real time in order to save human lives.

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Analysis

Global Symbol for Biohazards

"Epidemics and pandemics – the invisible enemies?!" What recommendations would have been given by the General Field Marshal August von Gneisenau or General Carl von Clausewitz, the German military strategists and army reformers who both died of *cholera* in 1831 during their fight to construct a cordon along the national borders in order to keep the disease out of their country?

1831: *"…the cause of his death had to be kept secret. After all, Gneisenau had been sent out into the field by the army to set up cordons – that is to say, totally and rigorously controlled border fortifications – as a means of containing the cholera. If the news came out that he had died of the epidemic, the effect would have been devastating. Nonetheless, the real reason for his death leaked out, thus setting off exactly the reaction which the authorities had taken such care to prevent: "'If such a man cannot protect himself, is there any protection at all?' the crowd shouted." A catastrophe – the victorious general, the vanquisher of Napoleon, a Prussian icon, who had gone off to war again, this time against the cholera, had been defeated by it: "Gneisenau's death hit us like a lost battle". The epidemic had snatched him away without mercy – and a few weeks later his deputy Clausewitz, who had to announce his death in such vague and indirect terms, also fell victim in the struggle against it. Yet another disaster: Clausewitz himself, who had sent in such victorious reports from the "battle-field" where the cholera was to be defeated, had also succumbed to it. Another military star of the Wars of Liberation had been extinguished. Enormous efforts were required to come to terms not only with the death of the generals, but also with the heavy defeat itself. It was not until 13 September 1831, by which time the cholera had taken hold of the Prussian capital Berlin, that the king – who had barricaded himself in Charlotten-burg – made a long awaited announcement. Efforts to put a complete stop to the epidemic, he said, had not been successful, and since it was now autumn, the border fortifications and the inland blockades would be lifted with regard to the health of the troops. The important thing now was to undergo the ordeal with decency and dignity. For this reason it was up to each individual citizen "to follow faithfully the call of his duty and the voice of his conscience to enable them to meet the common danger with a calm spirit and undaunted confidence"* (Briese, 2003).

At this point I should like to recall a key phrase from Carl von Clausewitz's book "On War": ***"…to use the right amount of force at the right time and at the right place"***. Would that still be relevant in our own times? Let's answer this question at the end of the paper.

Worldwide, the spread of infectious diseases or plagues such as bacteria, viruses, fungi, parasites, prions, synthetic biology structures, nano-viruses, new/unknown organisms, bio-weapons, and terrorists presents growing epidemic and pandemic risks at different levels, such as soils, plants, crops, animals, humans, societies, economies, and the environment.

Most of the well-known diseases are endemic, i.e. they have existed for a long time in a particular region or population, such as rust fungi in cereals and soybeans, leaf blast and sheath blight in rice (Juroszek and von Tiedemann, 2015; Kim et al., 2015), foot-and-mouth disease and avian flu in animals (McKenna, 2015) or malaria, dengue fever, Zika-virus (ECDC, 11/2015) and HIV/TB in humans. An outbreak of diseases or plagues

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that attack many species at about the same time and may spread through one or several areas or communities is called an epidemic. When an epidemic spreads throughout the whole world, it is known as a pandemic.

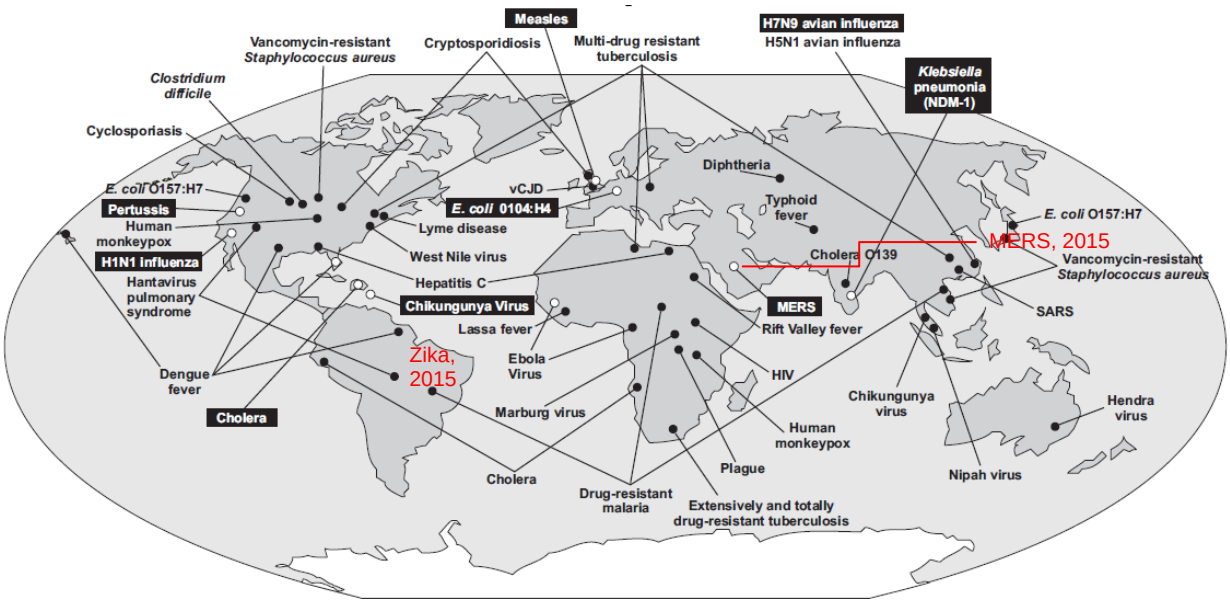
Risk is a daily reality where actual or imminent epidemics or pandemics are concerned. The key question here is very simple: What form will take the next epidemic or pandemic, where and when will it occur, and who will be involved? Based on this, the following questions will have to be answered in time: How can risks be assessed, how can outbreaks of infectious diseases and plagues be avoided, how can efficient and effective management tools be prepared, and how can outbreaks of epidemics or pandemics be tackled as quickly as possible (and by whom)? Also finally: Who will be in a position in future to make robust decisions despite deep uncertainties?

A. Risk Dimensions

At the beginning, a number of relevant parameters or findings should be recalled here:

1. Learning from the past implicates to be familiar with Paul de Kruif's '*Microbe Hunters*' (1926), Laurie Garrett's '*The Coming Plague*' (1994), and Michael Oldstone's '*Viruses, Plagues & History*' (2010), which are excellent reads for anyone with the slightest interest in how infectious diseases influence our lives.

2. Emerging and reemerging infectious diseases or agents during the period from 1990 to 2014 were documented by Koenig and Schultz (2015) in the figure below. The diseases or agents in the black boxes with the white dots show diseases or agents which occurred between 2010 and 2014 (in red 2015, Kern, 2016).



"Managing pandemic risk is important for all countries, but especially so for poor and fragile states, where a severe pandemic would result in significant harm to population health, economies, and communities. Pandemic prevention requires health systems with strong core public health functionality (veterinary and human) to detect contagion early, ensure correct diagnoses, and respond rapidly to stop the contagion from spreading."

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The World Bank has estimated the cost of this essential, permanent, global infrastructure at US$ 3.4 billion per year in all developing countries. The expected benefit of better preparedness is at least $37 billion per year, making such infrastructure a profitable use of public funds. The economic rates of return to investments in public health and strong health systems range from 50% to 123% per year, depending on disease risk.

The commission on a Global Health Risk Framework for the Future (GHRF) published a book at the beginning of 2016 under the title: "*The Neglected Dimension of Global Security – A Framework to Counter Infectious Diseases Crises*". A key statement sounds like that: *"Pandemics cause devastation to human lives and livelihoods much as do wars, financial crises, and climate change. Pandemic prevention and response, therefore, should be treated as an essential tenet of both national and global security – not just as a matter of health"* (Commission on GHRF, 2016).

4. The Cambridge Risk World Atlas 2015 as well as the **Lloyd's City Risk Index 2015-2025** give a comparison of the risks from different types of threats. According to this, "human pandemics" are in second place after "financial crises", with an estimated GDP risk of US$ 50 bn; "terrorism" is in place 9 with US$ 100 bn, and "plant epidemics" in place 14 with ~ US$ 50 bn. A breakdown of 20 global key threats also shows that between 2015 and 2025, 33 percent of the total GDP risks are from emerging threats such as cyber, social unrest, human pandemics, plant epidemics, and interstate wars. Surprisingly, the **WeltRisikoIndex 2015** within the **WeltRisikoBericht 2015** (Bündnis Entwicklung Hilft and United Nations University, UNU-EHS, 2015) addresses natural hazards covering earthquakes, violent storms, floods, droughts and sea level rise, but says nothing at all about hazards resulting from infectious diseases.

5. Infectious diseases in developing countries and pandemics have each of them the potential to kill more than 1 million people, and international terrorism would kill between 8,000 and 40,000 people. The likelihood of deaths for both risks is within the range of 5 to 10 percent (World Economic Forum – **Global Risk 2008, 2016**).

6. The open-source Global Terrorism Database 2015 (GTD) informs about terrorist events around the world from 1970 through 2014. Domestic as well as transnational and international terrorist incidents occurred during this time period includes more than 140,000 cases (GTD, 2015).

The current **Global Terrorism Index 2015** shows that the number of deaths caused by terrorist attacks hit an all-time high of 32,658, which was a record rise of 80 per cent compared with 2013 and a nine-fold increase since the beginning of the century. More than half of them were done or claimed by the so-called 'Islamic State' (IS) and Boko Haram. More than 90 percent of terror deaths today (200 per day) are Muslims, killed principally by other Muslims.

Furthermore, the current **2015 Terrorism & Political Violence Risk Map** from Aon Risk Solutions (2015) shows that Western countries saw the greatest number of country risk rating increases, mainly due to terrorism threats. The threat is centered on direct attacks on people and disruptions of business activities rather than on damage to property.

The **real economic impact of terrorism across the globe** reached US$ 52.9 bn in 2014, increasing tenfold since the start of the century, as the latest Global Terrorism Index 2015 shows. The figure is the highest since at least 2001, when it was calculated at US$ 51.5 bn following the 9/11 attack on the World Trade Center in New York". However, costs from terrorism are lower than from other forms of violence. The losses from violent crime and homicide globally were 32 times greater than losses from terrorism and the number of lives lost 13 times higher, according to the **Global Terrorism Index 2015** (Institute for Economics and Peace, 2015).

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7. Agroterrorism, a subset of bioterrorism, is the deliberate introduction of animal and crop pests and diseases with the specific aim of generating fear, causing economic damage and destabilizing social structures. It is included for the purpose of assessing the potential risk in agriculture and food production.

B. Risk Reservoirs

Over 70 percent of human diseases originate in animals (FAO, 2013). Furthermore, the expanding human population is not only encroaching more and more on wildlife regions, but is becoming increasingly dependent on animals for food. Around 70 percent of the rural poor and 10 percent of the urban poor are dependent on livestock. And, it is well documented, that there is a strong association between zoonoses, poverty, hunger and livestock keeping (Grace et al., 2012). A broad documentation of the emergence and resurgence of diseases and the connections between livestock, wildlife and humans was given by Friend in 2006. We will now list some of the reservoirs of zoonotic diseases, plagues or vectors to be expected in the future:

1. Insects

Malaria, the *Anopheles* mosquito-borne infectious disease caused by *Plasmodium* parasites, is the greatest danger for most people of the world. About 3.2 billion people – nearly half of the world's population – are threatened by malaria. In 2015, there were roughly 214 million malaria cases and an estimated 438 000 malaria deaths (WHO, 11/2015).

Dengue is a mosquito-borne viral infection, which causes flu-like disease, and occasionally develops into a potentially lethal complication called severe dengue. The global incidence of dengue has grown dramatically in recent decades. About half of the world's population is now at risk and there is no specific treatment for dengue or severe dengue. Dengue prevention and control depends entirely on effective vector control measures (WHO, 2012; 5/2015).

Zika virus indigenous circulation has been detected in the Americas since 2014. Zika fever is a mosquito-borne viral disease, which many health authorities believe can cause microcephalogy, a condition in which human fetuses develop undersized brains and skulls when a virus is transmitted through the placenta of an infected mother. Increasing cases of Zika virus have been detected in Chile and 18 states in the North-East of Brazil as well as in Colombia for the first time. Case monitoring and vector control activities have been started (WHO, 10/2015). Beginning 2016, Zika virus epidemic is a matter of fact in Brazil. Nearby 4000 new born are suffering from microcephalogy, especially in the Northeast of Brazil. Brazilian government has started a nation-wide program (hotels, bars, restaurants, cities, rural areas) in order to tackle the Zika virus epidemic and to enable safe Olympic Games in August 2016. More than 220.000 members of Brazil's armed forces will go door-to-door to help in mosquito vector control in order to eradicate the problem and to safe lives (The Guardian, 1/2016). The WHO declared the Zika virus and its suspected link to birth defects an international public health emergency on February 1, 2016. Some global health experts contended the decision had more to do with politics triggered by media hypes than with medical relevance. Nevertheless, the intensive vector control spray actions will significantly reduce other mosquito-borne diseases and improve people's lives, although collateral damage cannot be excluded, particularly in the field of health and environment.

Leishmaniasis, another vector-mediated infectious skin disease, which is caused or transmitted by infected sand flies, is increasing in Syria and neighboring countries. The war, the ongoing terror, the severe erosion of

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the healthcare systems, and the bad housing conditions for refugees are significantly increasing the risk of exposure to these infection (Sharara and Kanj, 2014).

2. Rodents

Rodents are significant reservoirs of future zoonotic diseases (Han et al., 2015). Of 2,277 extant rodent species, 217 species are reservoirs harboring 66 zoonoses caused by viruses, bacteria, fungi, helminths, and protozoa. Infectious diseases transmitted by rodents not only include bubonic plague, but also lesser-known illnesses like tularemia, hantavirus, hemorrhagic fever and others. Predicted hotspots of novel rodent reservoir diversity occur in a broad range, spanning arctic, temperate, tropical, and desert biomes. The areas accommodate a broad spectrum of mammalian species and are characterized by middle- to high-income economies. Key hot spot regions are located in the Middle East and Central Asia. However, London and Paris are among the top 10 most rat-plagued cities in the world.

3. Birds

More than 48 million birds have been affected by the outbreak of a highly pathogenic avian influenza, mostly in Iowa, according to the U.S. Department of Agriculture. The disease has been found in wild birds, as well as in a few backyard and commercial poultry flocks. The U.S. Center for Disease Control and Prevention considers the risk to people from the infections to be low, according to the Agriculture Department. No cases of human infection with the A(H5N2) viruses have been detected in the U.S., Canada or internationally (Leberfinger, 2015).

At the present time, the fourth wave of A(H7N9) avian influenza is threatening livelihoods and public health in China and neighboring countries. Out of the 678 human cases reported to date, 271 have died. Infected poultry has to be destroyed (FAO, 10/2015). Remembering that the A(H1N1) strain of 2009 – known as "Schweine-grippe" – created a pandemic that caused over 100,000 to 200,000 respiratory deaths globally.

4. Pigs

Enhanced biosecurity will play a vital role, and for this reason safeguarding of swine health and human health has top priority (Kern, 2012).

A mysterious virus named PEDv (Porcine Epidemic Diarrhea virus) wiped out more than 10% of America's pig population in less than a year during 2013 (Davis and Waters, 2014). No vaccine was available, but vaccine development was started. Fortunately, PEDv does not pose a risk to human health and is not a food safety issue.

For the last 200-300 years, a new or variant plague has occurred in veterinary species every 2-3 years (Scott, 2007). This can be expected to remain the case during the coming decades.

5. Camels

Middle East respiratory syndrome (MERS) is a viral respiratory disease caused by a novel coronavirus (MERS-CoV) that was first identified in Saudi Arabia in 2012. At the moment, there is an ongoing outbreak in the Republic of Korea. A single infected traveler was amplified by infection in hospitals and movement of cases within and among hospitals ("*doctor shopping*") (WHO, 6/2015). No vaccine or specific treatment is currently available.

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Coronaviruses are a large family of viruses that can cause diseases ranging from the common cold to Severe Acute Respiratory Syndrome (SARS). Approximately 36% of reported patients with MERS have died. Although the majority of human cases of MERS have been attributed to human-to-human infections, camels are likely to be a major reservoir host for MERS-CoV and an animal source of MERS infection in humans. However, the exact role of camels in transmission of the virus and the exact route(s) of transmission are unknown. The origins of the virus are not fully understood but, according to the analysis of different virus genomes, it is believed that it originated in bats and was transmitted to camels sometime in the distant past (WHO, 2015). Concerning Europe, the risk of widespread transmission of MERS-CoV in the community after sporadic importation into the EU/EEA remains low.

6. Bats

Bats are also reservoirs for infectious diseases. Three different frugivorous and insectivorous bat species are considered to be possible Ebola virus reservoirs. Ebola virus transmission to wildlife species is thought to occur from ingestion of fruit that has been contaminated with infected fruit bat saliva or feces (Alexander et al., 2015). These bats feed on guavas and mangoes, as well as city gardens and cultivated crops.

Every year, there are confirmed cases of bats carrying rabies. Indeed, this is a disease to be feared. The WHO estimates the rabies virus kills more than 55,000 people worldwide each year. Rabies is the most lethal human infectious disease known, with a fatality rate of nearly 100 percent. SARS-CoV and MERS-CoV are also associated with bats.

7. Biosecurity and Wildlife Trade

With the wildlife trade being one of the possible sources of the current Ebola pandemic it is worth noting that there is currently no international body comprehensively regulating the health risks of the international wildlife trade.

There are already many documented cases of diseases transmitted from wild animals to humans, from one wild animal to another and from wild animals to agricultural crops. In addition to these, potentially zoonotic pathogens – including Highly Pathogenic Avian Influenza H5N1 and the retrovirus simian foamy virus – have been discovered in recent studies of confiscated wildlife or wildlife products which had been imported or were destined for international trade.

Bushmeat has become an important commercial commodity which is illegally traded nationally and internationally. This type of illegal trade is a pathway for the spread of pathogens. It has been estimated that ca. 5 tonnes of bushmeat are imported illegally into Europe every week without any veterinary health inspection. Uncontrolled transport of bushmeat is taking place continuously from one African country to another (Chaber, 2010).

8. Foodborne

There are many reasons why foodborne disease remains a global public health challenge. Some diseases are well under control, others emerge as new threats. Globalization of the food supply chain has led to the rapid and widespread international distribution of foods. Pathogens can be inadvertently introduced into new geographical areas at any time. In developed countries many resources are available for investigating and controlling outbreaks of foodborne diseases, but only some are directed at developing countries (WHO, 2008).

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9. Humans (HIV / TB / Ebola)

Nearly 37 million people throughout the world are living with the **HI-virus**. The eastern part of the WHO European Region has the most rapidly growing HIV epidemic in the world. The number of people newly infected with HIV is decreasing globally, but the number of people living with HIV in Eastern Europe and Central Asia has tripled since 2000 and the number of people newly infected with HIV continues to rise (WHO Europe, 2011).

Tuberculosis (TB) is a contagious airborne disease caused by *Mycobacterium tuberculosis*, which infects one third of the world population.

WHO (10/2015) has reported 28,581 confirmed, probable and suspected cases of **Ebola virus** disease, including 11,299 deaths related to West African countries (Liberia, Guinea, Sierra Leone). Seven countries announced imported cases, with or without local transmission: Italy, Mali, Nigeria, Senegal, Spain, U.K. and the U.S (ECDC, 10/2015). The Ebola epidemic seems to be at a halt, because reports are showing low-level transmissions. Liberia was declared Ebola-free by the WHO in September, Sierra Leone in November and Guinea end of December 2015.

10. Migrants, Refugees, Travelers

In 2013, the number of international migrants worldwide reached 232 million, up from 175 million in 2000 and 154 million in 1990; the number of internal migrants was 740 million. Every day an estimated 120,000 people are migrating to cities in the Asia-Pacific region (International Organization for Migration (IOM), 2015).

More than 4,000 airports throughout the world are connected with one another by 25,000 flight routes. Furthermore, over the next 20 years, as forecasted by Boeing (2015), there is a doubling of airplanes worldwide. The number of people traveling every year is about three billion. For different reasons, nearby 2.5 million people travel across borders each day, including more than one million each week between developing and developed countries.

As far as undocumented (illegal) migration is concerned, an estimated 500,000 people cross EU borders each year without the necessary travel and health documents.

During 2015, 1 million refugees/migrants will have reached Germany. The EU forecasts that another 3 million refugees/migrants will have come to Europe by 2017. At the present time, an infectious disease can spread as much as 100 to 400 kilometers per day.

11. Terrorists

Terrorists operate without any ethical scruples, bringing death and horror to innocent men, women and children throughout the world in order to satisfy their own degenerated ego. They can attack via air, soil, food, water, or as living vectors (“brain washed, mutated, degenerated suicide human bombs”) using all options available for killing other people, e.g. with aircraft, bombs, rifles, knives or CBRN-weapons. They can act everywhere at all times without any mercy. They are mostly invisible, unmonitored and unknown. Most of them live under miserable conditions or are social outcasts (N.N. statements in TV talk shows and radio reports, 2015).

An informative behavioral analysis of lone-actor terrorists is given by Gill (2015).

Terrorists are endemic in all societies, epidemic in countries such as Syria, Iraq, Libya, Nigeria, Mali, Chad, Sudan, Yemen, Somalia, and Afghanistan, and at present pandemic, i.e. they are spreading their terror over the

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world to their neighboring states, to the U.S., and more and more to Europe. For reference, an actual global terrorism and political violence risk map is given by Aon Risk Solutions (2015). Terrorists have a severe impact on the quality of free life, societies, migrations, economies, the environment and last but not least on global peace, where people can live in **Liberty**, **Equality**, and **Fraternity**.

12. "Dual Use" of Highly Pathogenic Agents

The security threat posed by synthetic biology can be summarized as follows: it is apparently easier for non-professionals to manipulate dangerous pathogens, which makes it easier for terrorists to use bio-weapons. DNA synthesis has become cheaper and can be outsourced. It seems to be easier for terrorists to obtain the basic materials to create biological threat agents or to design absolutely new pathogens (Jeffersen et al., 2014).

13. DNA-Programmed Assembly of Cells / Organoids

DIY/DIT Synthetic-Biology 3DP? Maker Citizen-BioScientists Build Community Labs for Bio-Hacking. "DIYbio is a new sibling in the DigiFab/3DP Family. Healthcare/3D printing hybrid products and systems comprises the fastest growing segment of 3DP today. BioPrinting of functioning tissues and organs—using patient-specific DNA and living cells—is the climax objective of the sector. And, not *yet* realized—but already conceived, planned and advancing: rapidly". This was the key story of Grant in October 2014.

In 2014, the CEO of Cambrian Genomics announced an investment of US$ 10 million to "print more DNA", for example to print a special virus that kills off microbes in the vagina that cause yeast infections and other sexually transmitted diseases. Cooperations with the pharmaceutical industry haven been started. How scared are people about infectious diseases?

14. Internet

In a paper under the title "*The Next Pandemic Could Be Downloaded from the Internet*" (2014), Snyder-Beattie wrote: "Scientists in California sequenced the DNA for the "type H" botulinum toxin. One gram of this toxin would be sufficient to kill half a billion people, making it the deadliest substance yet discovered – with no antidote. The DNA sequence was not placed on public databases, marking the first time a genetic code has been withheld from the public for security reasons.

As biological discoveries accelerate, we may need to censor even more genetic data. The line between digital data and our physical world is not as clear-cut as it once was, with the advent of 3D printing technologies and DNA synthesizers.

Many people are familiar with the first printed gun, cited heavily by the media as a dangerous development. But many would probably be surprised to learn that analogous technology is used to print pathogens."

Under the sub-headline: "*Pandora's box 2.0"* he continued: "The machines that make this resurrection possible serve many legitimate research purposes. Instead of painstakingly manipulating DNA in a local lab, scientists can get made-to-order sequences from a variety of DNA synthesis companies from around the world.

Alternatively, if they have some extra cash and desk space, they could get one of the machines right here on Ebay. Access to such a machine gives scientists a critical edge in many areas of genomics research." Can amateur biologists be a risk by creating new infectious diseases? or: Is there a new man-made threat in front of us?

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15: The "New and Unknown", the "Unknown-Unknown", the "Unpredictable"

An excellent documentation of emerging infectious diseases is given in the journal "Emerging Infectious Diseases" published by Centers for Diseases Control and Prevention, USA. However, the possible "new and unknown" or the "unknown-unknown" threats are not, or cannot be, covered there.

How scared people and societies should be? What can be done at which costs?

C. Risk Assessment - Europe

1. Insects

Europe has very high standards of infection control procedures in Europe. Risk assessments are carried out systematically. The healthcare structure is robust and prepared to tackle infectious diseases transmitted by insects in reasonable time and at justifiable costs. Nevertheless, due to climate factors, countries in southern part of Europe need to improve and implement risk assessment tools, monitoring programs and vector control systems.

In 2014, VBORNET – European Network for Arthropod Vector Surveillance for Human Public Health was started. The objective of VBORNET is to establish a European Network of entomological and public health specialists in order to assist ECDC in its preparedness activities on vector-borne diseases. One of its main tasks is to set the basis for Pan-European administrative unit distribution maps of the major arthropod vectors of diseases. Furthermore, the molecular identification of insect-borne diseases via DNA barcoding or molecular markers based on handy tools should be used to improve valid risk assessments as early as possible.

Concerning the running Zika virus disease epidemic in Brazil, the actual ECDC Rapid Risk Assessment (1/2016) provides valuable information about the Zika virus epidemiology and information to travelers (pregnant women should consider to postpone travel to the currently affected areas) and EU residents living in affected areas.

The significant impact of climate change on insect-borne infectious diseases is not addressed here; it is evaluated in a separate paper. For further reading, an actual global overview concerning El Niño and health is given by WHO (1/2016). Furthermore, in May 2016 the UN Environmental Assembly will focus on the nexus of climate change and public health.

2. Rodents

The excellent documentation of the two large collaborative research projects funded by the European Commission, Framework 6 and 7, named EDEN (2004-2010) and EDENext (2011-2015), where 58 partners from 23 countries in Europe, the Middle East, and Africa were involved, underlines that Europe is well prepared to cope with vector-borne diseases transmitted by insects or rodents (EDEN, EDENext, 2015). EDENext enables overall pictures of emerging risks and supports early warning systems. The work of EDENext is not only protecting and improving public health of Europeans, but is also part of a coordinated international effort.

All in all, it can be concluded that Europe has put in place not only a robust health care and hygiene system but also a well-functioning risk assessment system. Nevertheless, control of rodents has to be improved to minimize infection risks, especially in cities.

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3. Birds

The highly pathogenic avian influenza (HPAI) of the subtypes A(H5N1) and A(H5N2), which have recently been detected in the Dordogne region of France appear to have evolved from low pathogenic avian influenza virus circulating in Europe. No human case has been reported related to A(H5N1) virus in France or A(H5N2) world-wide. Nevertheless, the national crisis plan was activated. Although the risk is considered low, other European countries should be prepared for a possible introduction of the virus, as stated by ECDC (12/2015).

Between 2003 and 11/2015, 844 laboratory-confirmed cases of avian influenza A(N5N1) virus infection, including 449 deaths, were reported to WHO from 16 countries. Small clusters of human cases were identified, but all cases had been exposed to birds prior to disease onset – mostly in backyard facilities. No sustained human-to-human transmission has been documented so far and no human cases have been reported in Europe. Transmissibility of these H5 type viruses to the general public in Europe can be considered to be extremely low. The surveillance and control of pathogenic viruses in poultry and wild birds is covered by EU legislation and is continuously monitored and permanently reported. Furthermore, ECDC regularly reassesses the risk posed by H5-type viruses to humans (ECDC, 12/2015).

A(H7N7) avian influenza outbreaks in poultry farms in Denmark, the Netherlands, Germany, and UK between 2011 and 2015 were tackled by culling the animals. The risk of zoonotic transmission to the general public in Europe is considered to be extremely low.

A(H7N9) avian influenza, the fourth wave has already begun and caused mortality in roughly 40 percent of reported human infections. A(H7N9) is more related to humans than A(H5N1) and therefore seems to have a higher risk potential.

At present there is a promising weapon against A(N7H9) in the form of a live attenuated influenza vaccine (LAIV). Researchers from Russia and the WHO reported (Rudenko et al., 12/2015) that application of the LAIV has produced a good immune response against A(H7N9) and was shown safe in a phase 1 human trial.

Another, more critical and controversially debated approach is the creation of mutant forms of A(N7H9) to assess the absolute risk potential by increasing the virulence of A(N7N9) or to induce drug resistance. Scientists identified genetic changes in the H7N9 virus that could make it adapt more readily to mammals. Bioterrorism fears are running high.

4. Pigs

Enhanced biosecurity will play a vital role in pig (meat) production in Europe. The veterinary system is very robust and effective for tackling infectious diseases as quickly as possible. Nevertheless, improved monitoring systems or biomarker systems have to be developed in order to prevent outbreaks and to provide the right solutions in time (Kern, 2012). According to Haas from the Robert Koch Institute (2015), the international plans for coping with pandemics are being constantly revised and adapted in the light of most recent scientific knowledge. This is done primarily by involving all relevant stakeholders in pandemic prevention.

An increasing risk is the use of antimicrobials in pig production and the increasing problem of drug-resistance. Drug-resistance and drug-resistant infection do not respect borders or barriers between animals, humans and the environment (O'Neill, 2015; Van Boeckel et al., 2015). A reduction of unnecessary use and waste of antim-icrobials is a key challenge in order to reduce the risk for future infectious diseases.

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Nevertheless, new vaccines with user-friendly systems will be made available in aerosols, water and feed inclusions. Improvements in prevention, control and eradication of infectious disease will be developed. Healthful and safe products controlling microbes, toxins and parasites will be available in time.

Furthermore, as addressed by the FAO (2013), there is a tremendous change in disease landscapes in livestock production. This must be taken carefully into account in order to avoid transmissions of infectious diseases.

5. Camels

The majority of the MERS cases continue to be reported from the Middle East, specifically from Saudi Arabia. Due to the substantial number of people traveling between the Middle East and EU countries, and the continued circulation of the virus in camel populations in the Middle East, the sporadic importation of cases to Europe must continue to be expected. The risk of widespread transmission of MERS-CoV in the community after sporadic importation into the EU/EEA remains low (ECDC, 8/2015).

6. Bats

'Bats were the forgotten species. No-one thinks of them as posing a threat to human life' [Dr Richard Suu-Ire, Ghana Wildlife Veterinary Specialist, 2012] was a quote made by Waldman et al., 2015. This changed significantly after the Ebola pandemic in Africa 2014/2015. On the one hand, bats are of significant value for the pest-control services in agriculture, e.g. in the U.S. by US$ 3 billion per year. On the other hand bats are vectors for lethal diseases infecting humans and animals.

Europe is inhabited by 52 bat species, some of which are threatened with extinction, and bats are protected. Although viruses with zoonotic potential have been detected in European bats, no clear assumption can be made up to now. However, bat-borne zoonotic risk of emergence in Europe is relatively low (Kohl and Kurth, 2014), but routes of bats migrating from endemic territories to European countries are not well investigated. Therefore, the analysis of the ecology, the behavior and pathogen transfer of the different bat species is important in order to understand infections and how to combat emerging diseases.

7. Biosecurity and Wildlife Trade

In Europe, imports via wildlife trade are possible pathways of infectious diseases, but the risk of an extensive distribution of pathogens is low. Nevertheless, the international wildlife trade will have to be suitably regulated in order close this gap and to minimize the potential risk of infectious diseases. Imports of bushmeat to Europe should be blocked and efficient control systems must be put into practice.

8. Foodborne

In Europe foodborne diseases occur year after year. But the food inspection service as well as the installed traceability system along the food chain enables quick reactions to stop infections by pathogens. The risk is moderate, but can be effectively managed.

Nevertheless, in a more and more fully integrated global food value chain it is necessary to take into account the estimates published by van Boeckel et al. (2015). Between 2010 and 2030, global consumption of antimicrobials for cattle, chicken, and pigs will increase from 63.1 to 105.6 tonnes - nearly double in Brazil, Russia, India, China and South Africa. A report from seven European countries (Norway, Sweden, Denmark, Austria,

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Switzerland, the Netherlands, and Belgium) showed a strict correlation for eight classes of antimicrobials of antimicrobial-resistant commensal *Escherichia coli* in pigs, poultry, and cattle (Chantziaras et al., 2014).

In China, a new gene that makes bacteria highly resistant to a last-resort class of antibiotics has recently been found in humans and pigs - also in samples of bacteria with epidemic potential, because the gene can be easily copied and transferred between different bacteria (Liu et al., 2015). This is an "alarming" signal.

The increase of antimicrobial consumption as well as the resistance pattern will have to be systematically assessed for their potential impact on animal and human health. An appropriate global management of antimicrobial-resistance must be installed as quickly as possible.

9. Humans (HIV / TB / Ebola)

The World Health Organization in Europe is running programs to halt and gradually reverse **HIV** in Europe, especially in Eastern Europe. The strategic goal is universal access to comprehensive HIV prevention, diagnosis, treatment, care and support.

TB prevention and care is incomplete: 360,000 people fall ill with TB annually (1,000 daily); of these. 75,000 are infected with MDR-TB. Annual mortality is 38,000. The 15 high burden countries in Europe are: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan (WHO, 2015). The ambitious objective of the new WHO program 2016-2020 is to end tuberculosis in Europe by 2030. Key problems are the increasing problem of drug-resistance, the unsatisfactory political cooperation and the poor ability of the health care systems to reach the infected people.

Relevant publications from the ECDC (2014, 2015) have shown that: "Europe is not exempt from the public health risk posed by **Ebola**. However, the risk of Ebola spreading widely in the EU population is still considered low. Although the Ebola virus is highly contagious, its spread is limited to very specific conditions involving close contact with the bodily fluids of an infected person or corpse." Furthermore, Europe has very high standards of infection control procedures, well-integrated and responsive disease surveillance networks as well as a robust healthcare system. Nevertheless, despite the low risk, the EU needs to be prepared for the possibility that a traveler infected with the Ebola virus returns to the EU and that further secondary cases may occur in Europe. "It is important that prevention measures are implemented, including informing and sensitizing returning travelers and healthcare providers and ensuring that European health systems are prepared for the diagnosis and treatment of Ebola should the need arise."

In the U.S. more than 30,000 travelers were screened for Ebola on arrival at airports from West African countries over the past year, but no case of Ebola disease was ever detected. At least one person, a New York City doctor, who had treated Ebola patients and returned to the U.S. in October 2014, passed through screening without protection. The airport screenings "do not pick up Ebola" (Jansen, 2015).

Alternatively, quick and cost-effective biosensors, smartphone-connected diagnostic tests or bio-chips (Organ-On-A-Chip World Congress 2016 & 3D-Culture, 7/2016) should be developed and put in place.

10. Migrants, Refugees, Travelers

An analysis and assessment of the potential risk for transmission of infectious diseases to Europe caused by migrants or refugees from Afghanistan, Middle East or African countries indicate that the risk of an uncontrolled epidemic/pandemic is low.

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In general, refugees/migrants are healthy, but it is important to check the status concerning HIV/TB, malaria/ dengue or other diseases, and also vaccination, as early as possible, best at the point of entry to Europe. It is essential that refugees/migrants are given information and access to health care systems of European countries. The strong water, sanitation and health infrastructure, the excellent health care systems in Europe in combination with functioning disease surveillance networks will be robust and effective enough to tackle the upcoming health problems.

11. Terrorists

So called 'Islamic State' and al-Qaeda affiliated groups have the internet capabilities and resources to carry out terrorist attacks against the EU and the West.

Up to now, unfortunately, the civilized world is not well prepared to stop or eradicate this type of new "inhuman" pathogens called "l*one wolves"*. Europeans may live in a comfort zone (Western countries accounted for 4.4 percent of terrorist incidents and 2.6 percent of deaths over the last 15 years), but they are increasingly under attack. Attacks carried out by "lone wolves or actors" and the encouragement of small-scale attacks is on the increase (Europol, 2015; Roell, 2015).

Violence, violent conflicts and terrorism do not happen only in far-distant countries, it's now happening next door, on the underground, in railway trains, in aircraft, on the road, in hotels, in restaurants, in markets, in supermarkets, in schools, in tourist centers, during sport, musical or religious events, etc. Biological weapons or infectious pathogens have not been used by terrorists here in Europe, up to now.

A paper from Keremidis et al. (2013) about the historical perspective on agroterrorism cases from 1945 until 2012 shows that agroterrorism was not considered to be a serious problem in that period. Nevertheless, the authors admitted that this might be due to a lack of empiric data, or to the fact that atypical biological weapons or "non-high-risk" agents only were used in the four attacks which actually occurred.

Suffert et al. (2009) assessed the threat to European agriculture and forestry from plant pathogens as agroterrorist weapons and points out that it would be potentially more important to disrupt regional or global trade than to cause direct damage to European crops. Up to now, no anticrop agroterrorist act using appropriate pathogens has ever been demonstrated, but it cannot be excluded forever. In Europe the risk is low, early detection and control systems would be available very quickly to bring down an anticrop bioterror attack. In the field of anti-animal bioterror attacks, the issue is more complicated (Perrings, 2015), but manageable. Nevertheless, in view of technological developments in the field, the improvement or establishment of early detection systems will pay off.

12. "Dual Use" of Highly Pathogenic Agents

In 2011, a joint action initiative was established in Europe by the European Network on Highly Pathogenic Bacteria (ENHPB) and of P4-laboratories (ENP4-Lab). Both networks have the aim to improve the efficiency, effectiveness, and response capabilities of laboratories directed at protecting the health of European citizens against high consequence bacteria and viruses of significant public health concern. By doing this, they tackle several sensitive issues regarding Biosafety, Biosecurity and "dual use" concerns. 37 highly specialized diagnostic laboratories from 22 countries participate in quality assurance exercises to assess their diagnostic approaches and to define measures for improvement and maintenance of their diagnostic capacities and capabilities. A bacterial network emerged from the EU funded project EQADeBa (EAHC n°2007 204), coordinated by the Robert Koch-Institute (RKI), Germany, and served as a basis for the European Network on Highly Pathogenic

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Bacteria (ENHPB). Another network is the European Network of P4-laboratories (ENP4-Lab) project (EAHC n°2006 208), coordinated by L. Spallanzani, National Institute for Infectious Diseases (INMI), Italy. Both partner networks have taken all measures to minimize the misuse of exchanged biological material. They make these measures transparent for the legislative agencies and authorities and create a network of trusted and reliable laboratories which professionally handle biological material and information to prevent any misuse of it (Grunow et al., 2014).

13. DNA-Programmed Assembly of Cells / Organoids

At the present time there are still no global regulations specifically covering synthetic biology or designed to mitigate any misuse of it, particularly by non-institutional experimenters (Carter et al., 2014). There is only, a self-regulation in connection with "culture of individuals and corporate responsibility". The essential issue in this century of bioeconomy is to regulate and monitor "synthetic biology" in such a way that society is not deprived of the positive potential of this technology.

In particular, it must remembered that attempts to design and/or produce a pathogen run up against considerable difficulties because they focus mainly on material features and thus fail to take account of important socio-technical factors, such as tacit knowledge. It is not enough merely to be in possession of a pathogen - it will be necessary to have weapons as well before a pathogen can present a serious threat. Assumptions about synthetic biology and bioterrorism are misleading and are often used only for the purpose of arousing fears (Jeffersen et al., 2014). In Europe, the risk that this type of technology can simply be used by non-experts for the effective development and distribution of dangerous new pathogens is relatively slight. Nevertheless, the rapid rate of new developments in this dynamic sector suggests that careful monitoring and control is called for.

14. Internet

A paper from Grushkin et al. (2013) summarizes the risk as follows: "The DIYbio community is not an anonymous threat to public biosafety and security. Rather, the movement provides a new channel for public science engagement and education and a broad opportunity for economic and scientific innovation. The negative portraits drawn by policymakers and media mismatch the survey data. DIYbio shows a well-networked community that is aware of the risks and ethics related to biotechnology. The data also shows that DIYers are almost exclusively working with BSL 1 organisms, rather than the pathogens imagined in the press." Nevertheless, "as the DIYbio movement grows and becomes more technically adept, greater governance may be required. However, contrary to news reports, the community is already actively engaged in developing codes of conduct, developing safety protocols, and discussing the various regulations that may affect it."

Since DIYbio-processes via internet are not well covered in Europe, relevant capacities will have to be installed in order to assess and minimize any risk caused by error or terror.

15. The "New and Unknown", the "Unknown-Unknown", the "Unpredictable"

Thoughts, options, possibilities, risk potentials, scenarios of future "unknown" epidemic or pandemic threats are not outlined here. This should be done by responsible 'think-tanks' familiar with the different fields.

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D. Risk Communication - Europe

"Communication decides everything." This was a core message of Christoph Unger, President of the German Federal Office of Civil Protection and Disaster Assistance (BBK), at the 11th European Congress on Disaster Management in Berlin. He said that citizens must be involved, and that the population should be drawn into various risk management decisions - there must be effective communication in both directions in order to dispel fears and ensure that the crisis topic does not develop an uncontrollable momentum of its own in the internet. He also said that use should be made of the social media, and especially of the BBK's new smartphone app NINA (Emergency Information and News App). NINA is the first app offering site-specific warnings of hazards and large-scale emergencies in all parts of Germany and providing information and tips for cases of emergency in the area of civil protection (Unger, 9/2015). This app should be extended to cover epidemics and pandemics and to provide assistance for the prevention of pandemics.

At EU level, there is the ECDC (European Centre for Disease Prevention and Control) in Stockholm, an excellent information and communication centre which runs a highly professional and regularly updated website "Rapid Risk Assessments" for infectious diseases.

In 2013, the center clearly described the challenges of the European context for communicable disease risk communication:

1. Today, it is widely recognized that effective risk communication is crucial for limiting morbidity and mortality from communicable diseases, in addition to minimizing the potential damage that communicable diseases can wreak on national economies and public health infrastructure.
2. Building trust with the public is essential for risk communication to be effective but difficult to achieve in practice.
3. Risk communication is an integral component of a larger framework for risk management.
4. Effective risk communication ensures clear objectives, consistent messages, and transparent and credible decision-making.
5. Communicating risks effectively requires not only the provision of information, but also explanations of the complexities and uncertainties associated with the nature, magnitude, significance and control of a risk."

Fortunately, ECDC (1/2013) operationalized these basics by publishing valuable guidelines on the "rules" and essential elements of an effective risk communication, summed up as follows:

1. Do more good than harm (beneficence, non-maleficence).
2. Ensure an equitable distribution of risk (equity).
3. Fair process of decision making (fairness, natural justice).
4. Seek optimal use of limited risk management resources (utility).
5. Promise no more risk management than can be delivered (honesty).
6. Impose no more risk than you would tolerate yourself (the Golden Rule).
7. Be cautious in the face of uncertainty ("better safe than sorry").
8. Foster informed risk decision making for all stakeholders (autonomy).

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9. Risk management processes must be flexible and evolutionary to be open to new knowledge and understanding (evolution, evaluation, iterative process).
10. The complete elimination of risk is not possible (life is not risk-free).

Or in other words, risk communication should follow the "**10 C's**": **C**ertain, **C**lear, **C**oherent, **C**omplete, **C**oncise, **C**oncrete, **C**onscience, **C**orrect, **C**ourteous, and **C**redible **C**ommunication (Kern, 2013).

Furthermore, the Centers for Disease Control and Prevention (12/2015) runs daily podcast shows highlighting key articles in current issues of emerging infectious diseases in a very professional and attractive way – an excellent communication approach to involve, to inform and to educate the public at large. By doing this, ECDC puts risks in perspective, which is essential for enabling the public at large to compare the risk issue with other similar, more familiar risks in order to avoid contra-productive panic reactions.

This important and critical range of topics has been extended by the WHO in the framework of its Risk Communication Programs (1/2015) in order to improve the management of a pandemic at all stages. This will involve training people in risk communication, improving risk communication capacities in countries with little or no such capacities, and developing and running a global emergency communication network to support countries before, during and after public health emergencies.

E. Risk Responses: Ebola - Europe

There is a difference between an earthquake and an epidemic. An earthquake comes suddenly and has an immediate effect. An epidemic is the exact opposite. It often comes insidiously, stealthily and slowly. Long before the actual breakout, many epidemics have already cost the lives of the weakest and most vulnerable.

Let's quote a blog of the Global Health Portal at Northwestern University written by Drewry, May 2015: "In the case of the most recent Ebola outbreak in 2014, the 21st known outbreak of the disease, the world 'ignored prior outbreaks, warnings of the environment, and the increased probability of outbreaks,' says Garrett. The world had no diagnostic tools, no surveillance, no vaccine, and no known treatment, leaving medical workers and communities horribly underprepared for the outbreak. In fact, from the very beginnings of the most recent strain, a lack of communication between the governments of Sierra Leone and Liberia, as well as delayed action by the WHO, created a precarious delay in response. This lapse in preparedness struck Garrett as a "breakdown in solidarity and collaboration in global health."

Lessons from Ebola – Preparation for Future Epidemic / Pandemic

"For months, the Ebola epidemic spread faster than the international community, including Center for Disease Control and Prevention (CDC) responded. Critical barriers in the affected countries include limited electronic connectivity; insufficient numbers of trained staff; inability to surge rapidly enough to provide needed case detection, education, contact tracing, and isolation services; and poorly functioning national health and public health systems with staff who often were unpaid, untrained, and poorly supervised. Surveillance and data management systems were overwhelmed." That was a summary given by CDC directors Frieden and Damon in November 2015 (2015).

Ebola Virus Disease (EVD) caused 28,581 confirmed, probable and suspected cases including 11,299 deaths in West African countries (Liberia, Guinea, Sierra Leone) reported by WHO (10/2015). 881 confirmed cases and

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513 deaths occurred among healthcare workers. Furthermore, there was a calculated economic loss of US$ 1.6 billion for the three countries compared with the economic growth in the previous year 2014.

The outbreak of EVD in West Africa is unprecedented in its scale, severity, and complexity and the largest emergency operation the WHO has ever undertaken (WHO, 2015). The role of the WHO is brought out in a comprehensive, unsparing and constructive analysis drawn up by Kekulé (5/2015). Numerous inadequacies and errors led to a fatal misjudgment of the epidemic in West Africa, and it was not until 8 August 2014 that the WHO declared the Ebola epidemic as a Public Health Emergency of International Concern (PHEIC), in other words as a pandemic.

1. Risk Early Warnings were made by Médecins Sans Frontières (MSF) March 13, 2014. March 21, 2014 in Lyon, it was confirmed that the case from Guinea was the deadly Ebola Zaire. The WHO decided to keep an eye this development and to await the results of monitoring.

2. Risk Monitoring was carried out only by the US company *Metabio*, which was unable to find any Ebola viruses in the tested samples. WHO included the information without further question in their reports, which – according to Kekulé (5/2015) – proved to be the most serious mistake made during the initial phase of the epidemic. During June and October 2014, 4,600 people died of EVD.

3. Risk Assessment by WHO in August 2014 was brutally clear, but too late: the Ebola epidemic / pandemic was running in the three West-African countries and there was great concern that it might be transmitted throughout. National health care systems in the countries were unprepared and did not have adequate capacities to tackle the EVD-epidemic on their own.

4. Risk Interconnection was now the matter of fact with all 194 countries which in 2005 signed the international health regulations to tackle epidemic (technical, medical, economic support). The international support started very slowly and was not coordinated effectively or efficiently.

5. Risk Management significantly overcharged the capacities of the WHO. Risk Management was taken over in mid-September 2014 by the United Nations installing the UN Mission for Ebola Emergency Response (UNMEER) until July 31, 2015 having achieved its core objective of scaling up the response on the ground. This was the first health mission outside the WHO.

6. Risk Responses were very heterogeneous from different countries around the world, often done in a hurry and often hampered my bureaucratic hurdles. Here are just a few selected examples.

Germany: Since March 2014, the Bundeswehr Institute for Microbiology had taken part in the campaign to control the Ebola outbreak in West Africa. A new mobile laboratory system was put into service at four different places (Sanitätsdienst der Bundeswehr, 6/2015), and the evacuation aircraft “Robert Koch” was also made available. This converted Airbus is the only one of its kind throughout the world and serves as a special isolation unit in which infected patients can be cared for and transported at any stage of the disease.

An interdepartmental working group under the direction of the Federal Chancellery commissioned the German Red Cross (DRK) to set up and operate an Ebola treatment center with technical and logistic support from the German army. The center was ready by the end of December, and voluntary staff were given a crash course in Würzburg – but not one patient was ever treated at the Health Care Centre. The costs amounted to roughly 39 million euros.

UK: The UK sent 750 troops and a hospital ship to Sierra Leone to help combat the spread of Ebola. In a hangar not far from the UK city of York, medical staff from the 22 Field Hospital in Aldershot carried out a training

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exercise to prepare them for treating other medics infected by the disease (NATO Watch, Davis, 10/2014). More than 4,000 people assisted the Ebola response in Africa. In Sierra Leone about 40,000 lives were saved by providing Ebola treatment beds, but 12,500 more cases could have been prevented if the beds had been available just one month earlier.

Europe: The European Union, together with its Member States, has made available over €1.9 billion in financial aid to contain the outbreak of Ebola virus disease (EVD) in West Africa and help with recovery. In addition, the European Commission allocated very nearly €870 million for emergency measures and long-term support.

In autumn 2014, the EU launched an Ebola research program with a total budget of nearly €240 million (€138.4 m from the Horizon 2020 program and €101 m from the pharmaceutical industry). The focus is on vaccine development, diagnostic test systems and treatments. Furthermore, the EU is helping to fight infectious diseases in Sub-Saharan Africa, including Ebola with a budget of 2 billion over the next 10 years.

Within Europe, a medical evacuation system was established. The Medevac system ensures evacuation to an equipped hospital in Europe for international health workers and other EU nationals diagnosed with the virus or considered at risk (European Commission, 12/2015).

"The risk of Ebola to the general public in the EU is very low and the EU has very high standards of healthcare infrastructures and preventive care" reported by the European Commission Section Humanitarian Aid and Civil Protection, December 2015.

USA: In Liberia, the American army set up eleven centers with hundreds of beds, which were completed by the end of December 2014, when the spread of EVD was already declining. Only 28 patients have been assisted in two of these centers, whilst the others remained completely empty (Satolli, 5/2015). Giving Ebola patients single beds reduces the spread of infection as they separate patients from one another and from hospital staff. The installation of such capacities a couple of months earlier would have saved the lives of thousands of people.

U.S. Forces Europe / EUCOM: General Breedlove, Commander of the U.S. Forces Europe concluded in February 2015 within chapter C titled: "Operation UNITED ASSISTANCE: Fighting Ebola in Africa" the following: "EUCOM (United States European Command) has worked in support of AFRICOM's efforts to stop the spread of Ebola from epidemic plagued countries in Africa, providing intra-theater lift, equipment, and personnel through and from the EUCOM AOR through established basing and access. EUCOM has proactively and aggressively engaged a number of European nations to secure permissions for U.S. Forces to use facilities and infrastructure for DoD-directed 21-day controlled monitoring in Europe and to relay the protocols necessary to prevent the inadvertent transmission of the Ebola disease onto the European continent. Furthermore, EUCOM has worked closely with various U.S. Embassies and other Combatant Command personnel to help shape the development of host nation permission requirements, while identifying and allaying European fears via robust information and intelligence sharing efforts."

NATO: "Does NATO Have a Role in the Response to Ebola?" was the question raised by Davis, director of NATO Watch in October 2014. The answer is: Yes, indeed, the NATO has played - and is still playing - a significant role in tackling the Ebola problem. Key NATO countries contributed by providing capacities relevant for stopping Ebola, but they were not always early enough.

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Most NATO member states also have medical professionals in their military forces who could potentially treat Ebola. Pre-deployment training, personal protective equipment, strict medical and hygiene protocols, and constant monitoring would mitigate the risks of soldiers becoming infected.

Furthermore, NATO also has a Centre of Excellence for Military Medicine (MILMED COE) located in Budapest, Hungary, which is tasked with facilitating interoperability between the military medical services in NATO. It has eight member nations (Czech Republic, France, Germany, Hungary, Italy, the Netherlands, Romania and the UK) and the Centre has four medical branches: Deployment Health Surveillance Capability (DHSC) - a satellite branch is located in Munich, Germany.

However, the specific challenges associated with naturally occurring epidemics have never been the focus of any sustained NATO activity. This will be changed.

WHO: The WHO acknowledges its own failings on Ebola in the West-African countries, which demonstrated how the organization was unable to respond quickly to fast-moving epidemics in developing countries (Hayden, 2016).

A harsh and critical, but constructive proposal to reform the WHO at all levels is given by Checchi et al. (2016). The authors criticize that the current split between teams working on epidemic and pandemic control and those focusing on armed conflicts and disasters is widely seen as unhelpful and that political dependencies are overcrowding professional expertise (*'protocol over substance'; 'caution over courage'; 'hierarchy over competence'; 'conservation in estimating problems'*).

The WHO will have to undergo a fundamental change if it is to protect human beings more effectively against epidemics/pandemics - as the WHO itself has recognized (Kupferschmied, 2015; WHO, 5/2015).

Constructive recommendations on financing pandemic preparedness and response for the WHO and other stakeholders were elaborated during a workshop organized by the Board on Global Health of the Institute of Medicine, Washington in August 2015. Participants illuminated the financing tools available to close the gap between an infectious disease outbreak and response, as well as ways to fund the systems that could prevent epidemics from occurring in the first place (Board of Global Health of the Institute of Medicine, 2016).

F. Risk Recommendations – General Europe

Risk Monitoring, Risk Evaluation, Risk Assessment, Assessing Solutions, Implementing Solutions

1. Foresight Infectious Diseases

It is not possible to know in advance when a pandemic will come or how severe it will be, nor can anything be said beforehand about the transmissibility of an infectious disease, or about its timing, nature, extent or seriousness. Unfortunately, information on past pandemics provides no guarantees for the future. Nevertheless, foresights or scenarios are necessary, because it is an option to have a look into the future and future challenges in the field. Common sense tells us that global networks must be redesigned not only in terms of technical issues, but more and more with a view to economic, political, social and military interdependencies (air and sea transport, climate change, environmental risks, social disparities, failure of national governance, interstate conflicts, large-scale migration, dual use of new emerging technologies, terrorism/bioterrorism). The global spread of epidemics can be assessed in a general way only, but the key to managing complex systems on the

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ground is a decentralized and rapidly acting organization. Predictions should be handled carefully by scientists, decision-makers, journalists and the public at large.

2. Early Detection of Diseases

Real time monitoring is the key to avoiding epidemics or pandemics, and the question is: What is the best way to close the information gap 'local vs global robustness'? It seems paradoxical, but the world is nowadays better prepared to detect and stop emerging health threats than at any time in history – at the same time, under the headings "globalization" and "hyper-connectivity", the risk that infectious diseases will spread is also greater than ever. Up to now, only 64 of the 194 members of the WHO have surveillance procedures, laboratories and data management capabilities. The U.S. is now helping 30 other countries to improve their health care systems (The Economist, 2015). The World Bank should implement as quickly as possible the "global pandemic emergency financing facility".

Just food for thought: "When there is uncertainty about what to expect and what will work in response, and when things don't go quite as planned, it seems the answer is to be nimble." (Anita Makri, 2015).

A significant improvement is expected from the new Food Chain Crisis – Emergency System (FCC-EMPRES) introduced by the FAO in 2015. The system helps countries to monitor transboundary threats, and to improve early detection of threats and early warning in order to respond better to food chain emergencies. EMPRES Animal Health focuses on transboundary animal diseases, including zoonoses such as African swine fever, avian influenza, Ebola, foot and mouth disease, Middle East respiratory syndrome coronavirus, peste des petits ruminants, Rift Valley fever, and others. EMPRES Plant Protection focuses on locusts, armyworms, fruit flies, rust diseases of wheat and coffee, wilt diseases of banana and cassava, and maize diseases. EMPRES Food Safety focuses on foodborne pathogens and chemical contaminants (FAO, 2015).

Furthermore, the FAO via 'FAO in emergencies app' has recently introduced a mobile app named "EMA-*i*" (Event Mobile Application) which enables collection of information on animal diseases in the field in real-time. The app generates a report that is sent to the global EMPRES-*i* – database system, where it is verified and validated in order to support quick decisions and right responses in time (FAO, 2015).

This innovative approach should be implemented worldwide as widely and rapidly as possible, because this will improve the possibilities to save lives and livelihoods in both developing and developed countries. European societies should significantly support this approach, because last but not least it is in their own interest. A yearly evaluation of the new option should be done by international experts in the field and communicated to the public at large.

3. Use of Collective Intelligence

One option for pinpointing epidemics or pandemics seems to be via Google researches.

If a sufficient number of people carry out an internet search for the word "fever", the Google database assumes that an influenza outbreak is imminent - and is often right. Health experts are keeping an interested eye on the company. However, the data from Google have to be updated on a daily basis. The company provides internet users with information on influenza epidemics. For this purpose it evaluates search queries - i.e. words which users enter into the input field of the online search engine- and presents the accumulated data in graphic form on a specially created page.

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This is a classic example of the use of collective intelligence and it may possibly enable us to recognize an epidemic up to one week in advance.

4. Biomarkers for Infectious Diseases

Risk assessment for infectious diseases will be significantly improved by using a broad spectrum of biomarkers which are currently being developed throughout the world. During the next couple of years it will be possible to identify more or less all infectious diseases reliably, quickly and in a cost-effective way everywhere in the world. This will be a key breakthrough, because early and timely detection of diseases by biomarkers can prevent the spread of infectious diseases, and drastically lower the human death rate. A number of laboratories are currently developing mobile health technologies for rapid testing and tracking of infectious diseases. Smartphone-connected diagnostic tests for infectious diseases that integrate advances in biomarker discovery, microfluids, nanosensors, microelectronics and nanoparticles are on the way. This will open up the possibility of using the web-accessible information system to track self-reported symptoms of infection across populations (London Center for Nanotechnology, 2014).

Microsoft has developed an "army of drones" to stop mosquito epidemics. This drone technology for catching mosquitoes and studying the diseases they carry could save many lives in remote regions where malaria and dengue fever run riot. Innovations of this kind should be supported by European Commission programs.

5. Antimicrobials – Drug-Resistance

As soon as a person dies, the body essentially gets its first break from a war that it has been fighting every moment of its life.

When bacteria start to win that war in a living person, it's called an infection, and the body naturally tries to flush the pathogen out of the body. Or, alternatively, antimicrobials are used. Meanwhile a broad spectrum of bacteria has figured out our defense system based on antimicrobials. They are becoming increasingly resistant, and we are confronted by the failure of some of our last lines of defense, resulting in illness and death. Misuse and overuse of antimicrobials are common and are weakening health care systems worldwide.

Resistance to antimalarial drugs is a recurring problem. Especially in South East Asia multi-drug resistance is reality.

A positive example is mentioned, which shows the suitability of new biotechnologies to produce new antimalarial drugs. World Health Organization has recommended artemisinin-based combination therapies (ACTs) for the treatment of malaria caused by the parasite *Plasmodium falciparum*. Artemisinin is a sesquiterpene endoperoxide with potent antimalarial properties, produced by the plant *Artemisia annua*. However, the supply of plant-derived artemisinin is unstable, resulting in shortages and price fluctuations and complicating the production planning of ACT manufacturers. A stable source of affordable artemisinin is required. By the use of "synthetic biology" it was possible to develop strains of *Saccharomyces cerevisiae* (baker's yeast) for high-yielding biological production of artemisinic acid, a precursor of artemisinin (Paddon et al., 2013).

Furthermore, actually, WHO has launched the Strategy for Malaria Elimination in the Greater Mekong Subregion (2015-2030). Robust surveillance systems have to be implemented in all countries as quickly as possible so that more efficient and effective conventional programs can be started to eliminate malaria transmission.

A completely new option for the control of the malaria mosquito has been opened up by the Clustered Regularly Interspaced Short Palindromic Repeats (CRIPS)-technology, or what is known as "gene drive" technology.

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By means of the gene drive system, a part of the partner chromosome is cut out, after which the repair system copies the alteration of the first chromosome over to the second chromosome. In this way an entire population of mosquitos carrying the pathogen could be eliminated fairly rapidly. The debate on the pros and cons is fully underway. National and international bodies will have to establish appropriate guidelines as quickly as possible in order to capture value coming from this new type of technology, to avoid "collateral damage" in the environment, and to block any misuse.

6. Animal / Human Health Care Products – Drug-Resistance

First of all, all countries should agree on legal obligations to report animal diseases.

Second, countries should agree to document the use of antimicrobials for the treatment of infectious diseases and maintenance of terrestrial and aquatic animal health (Kern, 2014), because new classes of antimicrobials in the veterinary sector are unlikely in the near future.

Third, increase of antimicrobial consumption as well as the resistance pattern will have to be systematically assessed for their potential impact on animal and human health.

Fourth, together with the private sector, an efficient and effective global management of antimicrobial resistance must be installed as quickly as possible to tackle the essential problem.

Fifth, a further option, which sounds revolutionary, is coming from a new antimicrobial strategy based on Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)-Cas-technology (Yosef et al., 2015). Temperate and lytic bacteriophages are modified to deliver a functional (CRISP)-CRISPR-associated (Cas) system to destroy antimicrobial-resistant bacteria.

With regard to the new (CRIPS)-technology, a far-reaching interdisciplinary risk evaluation is essential for ensuring freedom to operate and avoiding a deleterious public debate. Nevertheless, the use of human germ line editing – either to remove inherited diseases and stop them being passed onto future generations or to enhance human capabilities – was deemed to be too risky and to involve too many issues (Megget, 2016). A binding global CRISPR-technology treaty will have to be put in place in order to avoid any misuse as a new weapon of mass destruction.

7. Pesticides – Resistance

Vector control via insecticide-treated mosquito nets and indoor residual spraying are the most important ways to prevent or reduce malaria transmission. Detection and monitoring of insecticide resistance levels are essential for tackling the malaria problem. The Global Plan for Insecticide Resistance Management (GPIRM) in malaria vectors started by WHO together with a broad spectrum of stakeholders in 2012 is a necessary approach. Melinda & Bill Gates Foundation and Bayer AG are highly committed to the development and improvement vector control programs.

Another problem which has to be addressed here is the fact that illegal (faked, falsified, counterfeited) plant protection products make up around 10% of the European crop protection market (European Commission, 2015). In most of the developing countries this figure has scarcely been assessed, but is at a much higher and more dangerous level. Fake pesticides account for up to 30 percent of the pesticide market, endanger crops and human health in India (Das, 2015). They are hardly compatible with correct and safe use or with an appropriate pesticide resistance management. Long-term cooperation with non-EU countries will have to be built up if this dangerous and criminal development is to be avoided.

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8. Vaccine Production

Currently there are no licensed vaccines available against malaria or any other human parasite. But fortunately, there is a research vaccine against P. *falciparum* (RTS, S/AS01) ready for introduction as a malaria control tool (WHO, 10/2015).

The U.S. Government effort to produce vaccines on demand raises questions about cost and strategy. A dozen gleaming-white trailers, each about the length of a bus, hold equipment for producing millions of doses of medical countermeasures against some of the world's deadliest threats. These mobile clean rooms can be configured to manufacture vaccines against pandemic influenza or antidotes for biological, chemical or radioactive agents. The US$ 286 million site at Texas A&M University in Bryan is one of three new biodefense centers created by the US Department of Health and Human Services (HHS). It will start making its first vaccine this summer.

Once completed in 2017, it will be able to make 50 million doses of flu vaccine in just four months - capacity that biosecurity experts say the United States needs to prepare for future pandemics. Europe should cooperate with the U.S. and implement essential complementary capacities.

The new WHO induced "Pandemic Influenza Preparedness (PIP) Framework" with its "Standard Material Transfer Agreements" (1/2015) must be operationalized as quickly as possible. Legally binding agreements between the WHO and certain companies and institutions that receive biological materials from PIP ensure that these companies and institutions commit themselves to share benefits based on the nature of their work and their capacities. These agreements guarantee access by the WHO to vaccines, antivirals and other supplies in the event of a pandemic. A fair, efficient and equitable access to critical life-saving supplies should be enabled for all countries. This action will significantly improve the preparedness for future pandemics. The actual WHO report of the (PIP) framework advisory group (12/2015) titled "Pandemic influenza preparedness: sharing of influenza viruses and access to vaccines and other benefits" is demonstrating the essential cooperation between the public and the private sector.

Furthermore, the actual recommendations made by the Commission on a Global Health Risk Framework for the Future (Commission on GHRF, 2016) should be carefully considered, especially the recommended commitment of $US 1 billion per year for global R&D to maintain a portfolio of relevant drugs, vaccines, diagnostics, personal protective equipment, and medical devices.

9. Europe – US Cooperation – Asia Cooperation

The U.S. is developing an interconnected global network of Emergency Operations Centers and multi-sector response to biological incidents. It promotes the establishment of Emergency Operations Centers; trained, functioning, multi-sector, rapid-response teams, with access to a real-time information system; and capacity to identify the source of an outbreak. Furthermore, the U.S. is improving global access to medical and non-medical countermeasures during health emergencies. It strengthens the capacity to produce or procure personal protective equipment, medications, vaccines, and technical expertise, as well as the capacity to plan for and deploy non-medical countermeasures (U.S. Department of Health and Human Services, 2014). Europe should support this approach and synergize this network.

The pandemic preparedness in Europe and in Asia is very different. In some poorer Asian countries they 'have plans to make plans' to tackle epidemic/pandemic. Most European countries have fairly well developed national action plans and implemented response systems, but are not being prepared for all challenges having

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a "multi-sector" approach (Asia-Europe Foundation, ASEF, 2011). For pandemic influenza threats, the member states and the European Commission have response plans.

The ECDC (European Center for Disease Prevention and Control) was established in 2005 and is a key center for combating infectious diseases. ECDC should assume a more stringent leadership function or undertake initiatives to save time when tackling epidemics and to prepare a structure which can respond more flexibly to different threats - or, in other words, "to become more fit-for-purpose" in real time.

Mindful of the fact that "90 percent of European external trade and 40 percent of its internal trade is transported by sea, safe and secure seas and oceans are of fundamental importance for free commerce and trade, the EU economy and living standards" (European Union, The EU Maritime Security Strategy and Action Plan 2015). This innovative cross-sectoral approach promotes better civil-military cooperation and coordination between internal and external security actors such as the police and the defense forces. It will make the EU's maritime security policy more coherent, effective, cost efficient, and enhance the crisis response in the maritime domain. However, in this EU Maritime Strategy and Action Plan 2015 the sector health, epidemic/pandemic is not addressed at all. This gap must be closed as soon as possible.

In a severe pandemic, maritime transport systems of critical supply chains such as food, energy and medical supplies are placed under stress and essential products can quickly run out. Disruptions can be much more damaging than the pandemic itself.

In response to the last Ebola epidemic, the brand new document "Pandemic Planning Guide 2016", published by the American Petroleum Institute, Washington in March 2016, offers an excellent plan to provide capabilities for tackling a pandemic and securing essential maritime transport and travel.

This **PPG** is a concrete blueprint of a holistic 'Infectious Disease/Pandemic Plan' with a road map and a pandemic preparedness checklist for maritime shipping, especially for oil and gas shipping. Not only Europe, the whole maritime shipping world (cruise ships, ferries, cargo ships, and warships) should implement this PPG as soon as possible in order to have a resilient and robust tool during a pandemic.

Nevertheless, "military planning has to be 'reality-based', not founded on wishful thinking, and look at realistic scenarios to forces choices between competing priorities" and "countries need to decide honestly what their fundamental national defence needs are, and (if they are in an alliance) what they can contribute to the collective" (Director of the Ditchley Foundation, 2014). At the present time in Europe, National Security Strategy and Strategic Defence Plans with global relevance for countering threats that do not recognize national borders have been declared only by the UK (HM Government, 2015), France (Revised National Military Strategy Following Paris Terror Attacks 2015) and Spain (Presidency of the Government, the National Security Strategy, 2013).

Furthermore, Europe cannot go on indefinitely depending on the US security blanket, but will have to implement capacity building activities and provide sufficient capabilities to tackle pandemics and terrorism in order to safeguard human life, living standards and sea lines of communication (SLOC). NATO is the key alliance platform.

10. NATO

NATO has essential capabilities and capacities to fight infectious diseases. However, experience obtained during the Ebola epidemic/pandemic in West Africa indicated that there is a strong need to synchronize and to synergize actions to enable an effective and efficient 'collective response'.

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DHSC, in cooperation with the German Medical Intelligence, published a risk assessment of the Ebola outbreak in West Africa on the 24 September 2015: “From an epidemiological point of view, self-limitation of this outbreak in the near future (to use this euphemism fully aware of its ethical implications and long-term consequences) is apparently not a likely scenario. Doubtlessly, robust and urgent actions are needed to prevent such a catastrophe. In this context, the answer how far the NATO should and can be involved is not to be answered in a technical risk assessment. Nevertheless, this report supports the position that it could be in the best (security) interest of NATO nations and in perfect accordance to their fundamental values to substantially and jointly assist UN and the affected countries in their efforts to contain the outbreak and to protect the world peace.”

Consequently, NATO needs "to be prepared to address existing or emerging biodefense threats up to Bio Safety Level (BSL) 4 which may pose a risk to NATO members, and overall global stability and security" and NATO forces should be well prepared to set up state of the art field medical facilities which are trained in the management of chemical and biological warfare and have the equipment ready to isolate and treat patients. Nevertheless, such a task force must be able to act rapidly and flexibly for the control of epidemics.

Bill Gates (2015), who has made contributions of US$ 28.3 billion in charity to fight infectious diseases, raised a global call to action against the next epidemic based on lessons from Ebola. In his “Global Call to Action: The Next Epidemic — Lessons from Ebola”, he says that NATO should be called in for all epidemics and should make epidemic response a high priority. The final arrangement should include a reserve corps of experts with the broad range of skills needed in an epidemic.” Education and Training is essential! In an emergency, the only thing that usually works very quickly is what has already worked in the past!

This does not mean that troops alone should be used to stop an epidemic/pandemic or terrorists, because soldiers do not fight pathogens or terrorists. Soldiers can perform useful tasks during emergencies and fight against external hazards, but a militarizing of the public health or police sector is not necessary. Effective and efficient public healthcare systems as well as police structures will be the cornerstones for avoiding and tackling vital threats. The implementation of the United Nations health-related Sustainable Development Goals (SDGs) will be the best way to tackle the global health challenges, especially epidemics/pandemics and terrorism.

11. “Dual Use” of Highly Pathogenic Agents

In Europe, a reliable and safe network of laboratories working with highly pathogenic agents has been established. Nevertheless, all accidents, mistakes or unexpected issues should be documented and reported to relevant control organs.

At the present time and in view of the current situation in Europe, there is very little risk that highly pathogenic agents will be used by individual persons or terrorists, for both technical and efficiency reasons.

12. Migrants, Refugees, Travelers

The statement of the European Academies, Science Advisory Council (EASAC) in 2007 and Fernandes et al. in 2009 can be reconfirmed beginning of 2016 that: “Most migrants are healthy, and detection of diseases at screening on arrival in the host country must also not be used as a reason to deny entry to the EU. Denying entry to the EU because of detected infections will not prevent, but rather propagate, the spread of disease because infected refugees/migrants might become inaccessible to the public health service but still remain in contact with susceptible populations within the EU.”

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Nevertheless, since there is at present an increasing number of HIV- and TB-infections, especially in Eastern European countries, it will be necessary to organize a clear information system and a culturally adapted education system in this field to familiarize refugees/migrants with the situation. Single events, e.g. TB in Leipzig should be treated, and reported via established health care information systems. Journalists and reporters should treat the issue responsibly and refrain from creating sensational headlines, or fears of epidemics sparked off by refugees. This would be false and highly immoral.

Europe, with its well-structured healthcare system, will be in a good position even in future to provide medical care for the further three million refugees/migrants who are likely to come to Europe by 2017. Moreover, if we take a look at the disproportionately greater numbers of tourists throughout the world, we will arrive at very similar conclusions. In 2014, "the world is in motion", and infectious diseases are spreading ever further. There were 1,133 billion international tourist arrivals worldwide (+4.3% over 2013); 84 million in France, 65 million in Spain, 56 million in Africa, 51 million in the Middle East, 33 million in Germany and UK, 14 million in South Korea. By 2030, it is forecasted that there will be 1.8 billion tourist arrivals globally (UNWTO, 2015). There will be significantly more frequent contacts with unknown remote areas, with other biocenoses, with other people and other organisms, or with known and unknown infectious diseases. After the experience gained from the Ebola epidemic/pandemic, Europe will have to make the necessary adjustments and build up suitable structures.

The important thing is to ensure the rapid diagnosis of health abnormalities which may be directly connected with infectious diseases and to treat them effectively. To this end, the necessary preconditions must be created to ensure that full records are kept of each individual person.

13. Terrorism

Terrorists themselves have a great deal in common with pathogens, as has been said earlier.

Although, for example, a planned action to spread smallpox or Ebola viruses over large areas would present an extreme challenge for Europe and its health system, Europe would very quickly install robust, efficient and effective defense mechanisms to combat this new type of pandemic threat.

For tackling terrorists, the last words of Louis Pasteur on his deathbed (1895) should be considered as a strategic lead idea: "*The pathogen is nothing; the terrain (the soil in which disease develops; the milieu) is everything."*

Experts in the control of epidemics and pandemics should be involved to find the right solutions against terrorists and bioterrorism.

Furthermore, as mentioned earlier, reliable and credible communication is a key. "Silly talk shows" or newspaper or journal articles repeating "fluffy stories" are not helpful at all, but merely trigger anxiety and nothing else. The fear of an epidemic/pandemic is contagious.

Now at the beginning of 2016, people in Western Europe are familiar with the relevant risks produced by terrorists. There is no hysteria at all. They are ready for valid information about progress made, but also for explanations of the complexities and uncertainties which are associated with the nature, magnitude, significance and control of terrorists.

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Nevertheless, terrorists will change or "mutate", they will change the area of attacks (see terror attacks in January/March 2016: Zliten, Libya; Istanbul, Turkey; Jakarta, Indonesia; Ouagadougou, Burkina Faso; Brussels, Belgium), as well as the methods used. This will have to be assessed as early as possible.

Last, but not least, only a quick and successful military action on the ground in Syria, Iraq and Libya followed by robust economic investment programs will dry out the so called 'IS' in Syria/Iraq/Libya and the disease of terrorism worldwide.

14. Risk / Crisis Communication

In Europe, ECDC (European Center for Disease Prevention and Control) provides useful information about the actual status of infectious diseases worldwide. However, most people are not familiar with the real risk of such biohazards. Most of the media deal with the topic only as long as events such as the Ebola virus are actually going on, thus simply creating hypes and often anxieties among the public at large. This must always be taken into account for the purposes of risk and crisis communication in Europe.

In general, in Europe the risk communication network for infectious diseases is available and works effectively, but modern information technologies and social networks have to be permanently implemented in order to avoid or to minimize the impact of epidemics or pandemics.

Furthermore, the public at large reacted without any panic to the recent terror acts in France, Turkey and Belgium the terror warning in Germany and UK. This would seem to show that the public is capable of a correct and robust response.

G. Risk Assessment / Prevention / Management – Final Remarks

To go back to the recommendation from General von Clausewitz, quoted at the beginning of this paper: "… to use the right amount of force at the right time and at the right place". Nowadays it might be more appropriate to say: … to deploy selected, properly qualified and well equipped personnel in sufficient numbers at the right time and at the right place, and to coordinate their activities – synergized by an effective i.e. clear, consistent and credible risk/crisis communication.

"Who will be in a position in future to make robust decisions despite deep uncertainties in future - and to do this in time?" was the question asked at the beginning. Well, it can be assumed that, confronted with these hyper-complex and hyper-linked challenges, no one has a clue about what happened during past epidemics or pandemics, or who has the keys for all future ones.

However, it is essential that the following courses of action should be taken:

1. WHO must restructure its own risk and management system as quickly as possible to avoid or tackle epidemics and pandemics effectively in future.
2. Essential risk assessment capabilities in Europe for epidemics or pandemics must be improved by implementing a more decentralized and flexible network of organizations, based on an agreed functional master plan.
3. The following key partners must be involved in the European steering platform: WHO, FAO and OIE (World Organization for Animal Health) via GLEWS+ Global Early Warning System for Major Diseases Including Zoonoses) completed by a CROPHealth team; GOARN (Global Outbreak Alert Response Network); IMO (International Maritime Organization); NATO, MILMED COE (Centre of Excellence for Military Medicine);

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EUCOM (U.S. Forces Europe); European Commission; ECDC (European Center Disease Control and Prevention); International Federation of Red Cross and Rd Crescent Societies; Médecins Sans Frontières (MSF); key NGOs; WEF (World Economic Forum); new cross-disciplinary CESI (Center of Excellence for Science Intelligence); EUROPOL; N.N.

4. Europe, and the whole maritime shipping world, must implement the "Pandemic Planning Guide 2016" published by the American Petroleum Institute, Washington in March 2016 in order to tackle a pandemic and to secure inevitable maritime transport and travel.
5. The newly established medical evacuation system (MEDEVAC), which ensures evacuation capacities in Europe, must be suitably improved.
6. A reserve corps of trained experts (RESCUE CORPS) with the broad range of skills must be set up to tackle epidemics or pandemics caused by various kinds of pathogens.

At the present time, 27 promising recommendations for action at the national, regional and international levels have been agreed on by the High-Level Panel of the United Nations (2016) to build up the global capacities required for the management of future health risks and crises. Actions which can be taken immediately are the following:

"*First, the WHO must build a new Centre for Emergency Preparedness and Response and ensure that the world has a standing capacity to immediately identify and respond to emerging communicable disease threats. The Centre must have real command and control capability, access to specialized human and operational resources to execute a health response, and the ability to visualize and share validated surveillance data in real-time.*

Second, all countries must meet the full obligations of the IHR. Where capacities are lacking, support should be provided to urgently implement a core set of measures.

Third, appropriate financing is required. Assistance should be provided to countries requiring additional support for IHR compliance, while WHO and the new Centre for Emergency Preparedness and Response must be resourced to meet global needs. In addition, a fund ($US 1 billion) should be established to support R&D for vaccines, therapeutics and diagnostics for neglected communicable diseases."

The Ebola crisis was a global wake-up call! Significant actions are on their way to strengthen the global health structure under the leadership of a reformed and improved WHO. A permanent monitoring of implementation of WHO reforms will be essential in order to manage future crises.

Considering all this, a global, regional, national and local risk prioritization multi-layer matrix of all organizations and resources must be established in order to identify gaps, weak spots and decision bottlenecks, and to develop a practicable, robust road map and global health security agenda. The WHO must be enabled to take leadership based on competence, capability, courage, cooperation, and credible communication. The reorganization should be realized by end 2017.

Dear colleagues, all scientific knowledge and extension work to avoid, to combat conclude by quoting what and to eradicate infectious diseases and plagues leading to epidemics or pandemics has grown out of the painstaking work of generations past and present.

There is no need to draw up a list of all eminent individuals personally, but I think this is the right time and place to thank all those scientists, companies, veterinary medics, medics, nurses, politicians, civilians, journalists, policemen, soldiers from whom we received our basic knowledge, values and support and who lost their life to honor them, and to give them a round of applause.

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May I ask you all to stand? - Thank you very much!

Let me conclude by quoting what **Saint-Exupéry** wrote in 1948: "*As for the future, your task is not to foresee, but to enable it*" (The Wisdom of the Sands, Saint-Exupéry, 1948), i.e. to improve our existing operative platforms, to assess and handle relevant risks effectively, in order to avoid and to manage emerging known and unknown infectious diseases, plagues and biohazards in time, in order to have a better life on earth.

***

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He has been awarded by various organisations for significant accomplishments in the field of agricultural innovation. In 2007, the secretariat of UNCCD (United Nations Convention to Combat Desertification) recognized Dr Kern by upholding his title as *"Eminent Person".*

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