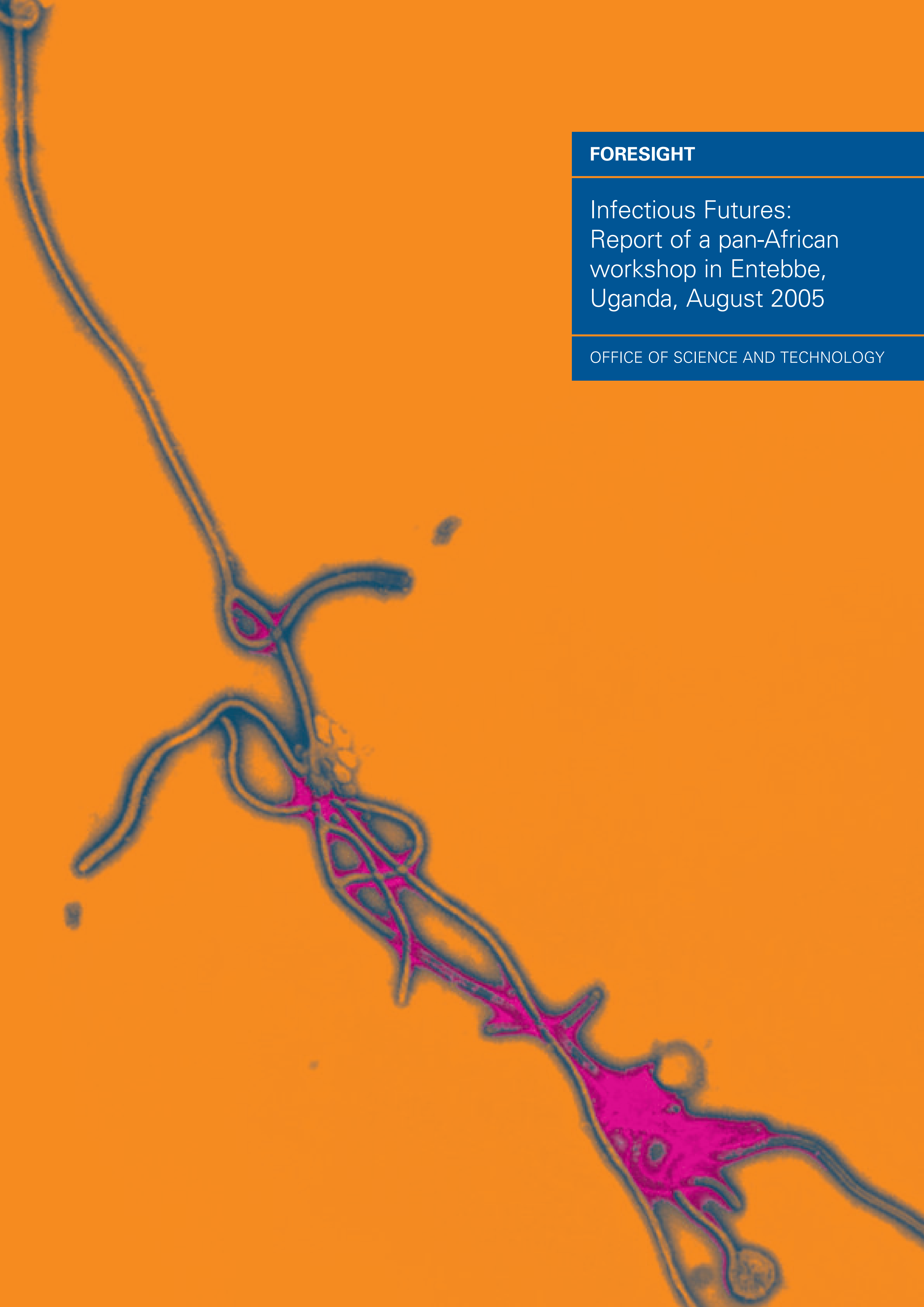


FORESIGHT

Infectious Futures: Report of a pan-African workshop in Entebbe, Uganda, August 2005

OFFICE OF SCIENCE AND TECHNOLOGY

Infectious Diseases in Africa: Using science to fight the evolving threat

Report of a pan-African workshop in Entebbe, Uganda, August 2005

Joe Brownlie, UK – Professor, Royal Veterinary College

Dilys Morgan, UK – Health Protection Agency

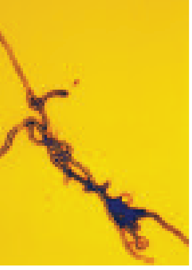
William Otim-Nape, Uganda – Former DG, NARO, Entebbe

Mark Rweyemamu, Tanzania – Former Head, Infectious Diseases-EMPRES, FAO

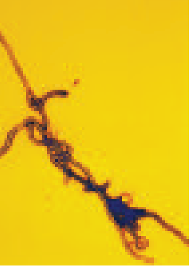
David Serwadda, Uganda – Professor and Director, Institute of Public Health, Makerere

Jeff Waage, UK – Professor, Imperial College London

The views detailed in this report are provided to stimulate further discussion and debate. They do not necessarily reflect the policies or views of any particular stakeholder organisations or governments represented at the workshop.



Lord Bach of Lutterworth, the project's sponsoring minister in the UK Department for Environment Food and Rural Affairs, offers his sincere thanks to the many leading experts and stakeholders who attended the workshop from across Africa and from around the world. He would also like to thank the Ugandan Government for its valuable support and encouragement.



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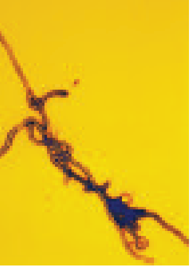


Executive summary

Introduction

In August 2005, a ground-breaking workshop was held in Entebbe, Uganda, concerning the future of infectious disease in Africa. This event was unprecedented in Africa and perhaps worldwide, since it brought together leading disease experts spanning plant, animal and human health. The aim was to take a fresh look at this crucial topic and to inject fresh thinking.

The event involved experts from 14 African countries, African institutions, and important international organisations such as the World Organisation for Animal Health (OIE), the Food and Agriculture Organisation of the United Nations (FAO), the World Health Organisation (WHO), the Bill and Melinda Gates Foundation, and the Gatsby Foundation. The workshop took place under the auspices of the UK Office of Science and Technology's Foresight Programme, in collaboration with leading African experts – Dr William Otim-Nape (Uganda), Dr Mark Rweyemamu (Tanzania) and Professor David Serwadda (Uganda).

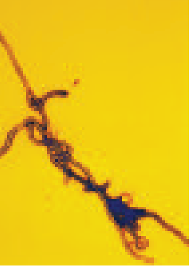
The event generated a wealth of expert advice about the future challenges facing Africa, and options for response. The views expressed are outlined in this executive summary, and set out in more detail in the full report. However, the intention is not to be prescriptive, but rather to stimulate further discussion and inform policy development within Africa and donor organisations.

The evolving threat of infectious disease in Africa and the role of science

The delegates started by underlining the fundamental and far-reaching impact of infectious diseases on human health: economic development; food security; poverty reduction and international trade in African plant and animal commodities and products. The effective management of infectious diseases therefore underpins the future development of the entire continent.

The workshop looked 10–15 years into the future to consider the evolving threat of diseases. Here, the picture was complex and uncertain, reflecting diverse socio-economic changes such as evolving patterns of land use and urbanisation, migration, trade, conflict and climate change. This uncertainty implies the need for policies for disease management that are flexible and can respond to the evolving situation.

The experts considered which classes of disease are likely to be important in the future. They argued that many existing major diseases are likely to remain so for many years to come. However, they also warned that we should expect new and unknown diseases to emerge – particularly zoonotic diseases from the domestic and wild animal reservoirs. HIV was cited as an example of the impact such new diseases could have.



The experts and stakeholders highlighted the key role that science could play in the struggle against disease. They noted that there are many excellent examples of disease management in individual countries and in international organisations. However, the following limitations were also identified:

- having to use syndrome-based treatments without recourse to specific diagnosis due to shortage of resources
- acutely low capacity for laboratory-based diagnosis at subnational level
- low activity in general surveillance
- at the national level, compartmentalisation of specialists according to sector (human, plant and animal) or administrative boundaries (government, academic and private institutions).

These all contribute to the present sub-optimal utilisation of the limited resource.

A pan-African vision for disease management

The magnitude of the evolving disease threat, coupled with the relatively low level of available resources in existing programmes, provide a strong argument for a major change in approach. The workshop delegates felt that this could best be achieved through an integrated and coherent vision for disease management across Africa. Only through such a pan-African vision would best use be made of limited resources, and only then would disease threats be managed most efficiently within and across national boundaries.

To be effective, such a vision would need to be a concerted effort, shared by African Union (AU) member governments, reflecting the needs of African society and supported by the international community. Importantly, its success would need to be underpinned by strong political will across Africa, and linked to national support for sustainable infrastructure. Its goal would be societies protected from the ravages of infectious diseases that compromise either human health or livelihoods or agriculture and economic development.

It was suggested that this vision could be implemented through the disease surveillance-driven objectives for:

- effective prevention of the spread of currently endemic, introduced, exotic, emerging or evolving diseases (and pests) in Africa or parts of Africa
- enhancement of African capacity and participation in the scientific and technological developments for early detection, specific diagnosis, early warning of evolving disease events, and national/regional capacities for early response to contain unusual disease episodes. This would help to break the cycle of each such episode turning into a serious epidemic

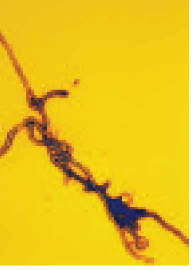
- science-based and socio-economically sound strategies either for disease containment or for the progressive control of those diseases that most threaten society, either as human disease problems or as an impediment to food security or the tradability of plant and animal commodities and products.

It was argued that the vision should encompass diseases in plants, animals and humans. Many areas of science and technology are common across these three fields and there is considerable scope for cross-fertilisation and efficiency savings by considering them together.

The development of the detailed vision would need to take careful account of national and continental development plans, in addition to current donor-supported initiatives such as the AIDS/malaria/TB, polio and rinderpest programmes or the AU–Inter-African Bureau for Animal Resources (IBAR) PACE programme, the cassava mosaic disease pandemic programme in the Great Lakes region; and the coffee wilt disease programme in east Africa. This implies the need for further close consultation with a wide range of stakeholders, both within Africa and internationally.

Conclusion

Clearly, a single workshop cannot hope to solve the immense challenge of infectious disease across Africa. However, it is hoped that the views of the experts and stakeholders presented in this report will act as a stimulus for discussion and a catalyst for further action. In particular, the idea of a pan-African vision for disease management offers a unique opportunity for Africa to take a global lead in its approach to the management of infectious diseases.



1. Introduction

In August 2005, a ground-breaking workshop was held in Entebbe concerning the future of infectious disease in Africa. This event was unprecedented in Africa and perhaps worldwide, since it brought together leading disease experts spanning plant, animal and human health. The aim was to take a fresh look at this crucial topic and to inject fresh thinking.

The event involved experts from 14 African countries, African institutions, and important international organisations such as the World Organisation for Animal Health (OIE), the Food and Agriculture Organisation of the United Nations (FAO), the World Health Organisation (WHO), the Bill and Melinda Gates Foundation, and the Gatsby Foundation (Appendix B provides a full list of attendees). The workshop took place under the auspices of the UK Office of Science and Technology's Foresight Programme, in collaboration with leading African experts – Dr William Otim-Nape (Uganda), Dr Mark Rweyemamu (Tanzania) and Professor David Serwadda (Uganda).

The event looked 10–15 years into the future and generated a wealth of expert advice about the challenge of infectious diseases facing Africa, and options for response. The views expressed are set out in this report. However, the intention is not to be prescriptive – but rather to stimulate further discussion and inform policy development within Africa and donor organisations.

The event proceeded in five successive stages, each considering issues relevant to diseases in plants, animals and humans. These five stages are reported in sections 2–6 and covered:

- the most important categories of future infectious diseases in Africa, and their drivers
- the factors that will make the future control of diseases in Africa less or more difficult
- future systems for the detection, identification and monitoring (DIM) of disease which would be of most benefit in Africa
- factors affecting the implementation of future DIM systems
- a strategic look at the future threats of infectious disease in Africa and what needs to happen to enable a step-change in capacity to manage those threats.

2. The most important future categories of infectious disease and their drivers

The attendees' first task at the workshop was to look ahead 10–15 years and identify the most important categories of infectious disease that could affect Africa in the future. They were also asked to consider the most important factors ('drivers') that were driving changes in risk levels.

Sections 2.1–2.3 set out the results of this task for plant, animal and human diseases in turn. Section 2.4 then provides a synthesis across the three sectors.

2.1 Future plant diseases and their drivers

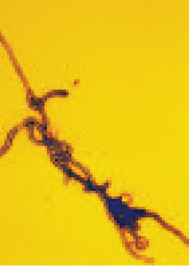
Future plant diseases

Participants first agreed certain definitions. 'Risks' were defined as 'the product of the probability of a disease outcome and the magnitude of its impact'. Also, for the purposes of this workshop, plant diseases were taken to be fungal, viral, bacterial or phytoplasmic in nature.

It is not considered likely that any one of these taxonomic classes will cause substantially greater risks than the others in the next 10–15 years. To assess risks, it was therefore felt more useful to look at the different ways in which new diseases arise, how they act and how they spread.

Three broad ways by which new diseases arise in Africa were identified as:

- *new-encounter diseases*, whereby a pathogen that previously existed on another (e.g. native) plant switches to and causes disease in a plant introduced to the area, and which had no previous contact with the pathogen. Examples include cocoa swollen shoot disease and the African cassava mosaic disease. New-encounter disease can also occur when an introduced agent becomes a pathogen and causes disease in an existing plant species.
- *re-encounter diseases*, which occur when a host plant, geographically separated from its native pathogen, re-establishes contact after a long time, e.g. when an introduced crop is established in Africa and a disease from the same crop in its area of origin is later introduced. The disease may be particularly severe if the plant has lost resistance over time.
- *co-evolution diseases*, which occur when a native or long-established disease on an African plant or crop evolves into a new and more virulent form, possibly as a result of recombination of different disease strains. Examples are UgV, the virulent strain of east African cassava mosaic begomovirus.



With the increasing emphasis on the commercialisation of agriculture as a means to eradicate poverty, Africa has been and will continue to be very dependent on introduced crops, in contrast to other continents. Consequently, re-encounter and encounter diseases are likely to cause the greater risks in Africa in future. Introducing new crops or new strains of crops into Africa in order to increase or diversify agricultural production would favour these types of infection.

On the basis of the properties of diseases, three important classes were identified:

- *airborne*. These are mostly fungal diseases, and are likely to be some of the most important in Africa in future, causing the greatest risks. This is because the spores of such diseases can be carried over long distances by wind or jet currents. Their spread can be so rapid as to overwhelm limited capacity to contain them using fungicides or deploying resistant varieties. Rust diseases, such as those on maize or soybean, are transmitted in this way. Coffee rust, *Hemelia vastatrix*, which was carried from the west coast of Africa to eastern Brazil, is one example
- *vector-borne*. These are mostly viral diseases and may be of growing importance. They could cause greater risks as vector populations may grow or change as crop intensification increases and other agronomic or climatic changes occur
- *seed-borne*. These are mainly fungal, bacterial and viral in nature, and will become more problematic and could cause greater risks in future. This will be the result of the current drive towards the intensification and commercialisation of agriculture, along with increasing trade in agricultural commodities and products. Such activities will result in the introduction of new and better-performing crop species and varieties and increasing trade in crop commodities and products within and across Africa. Vegetatively propagated crops are included in this category. For instance, it is now clear that a lack of local understanding that coffee wilt was a seed-borne disease contributed greatly to its spread through new plantings in the Great Lakes region of Africa.

Other categories of diseases discussed were soil-borne and water-borne, but it was felt these would be less important and could pose fewer risks compared to those described above.

Drivers of plant disease risk

Again, the attendees started by agreeing certain definitions.

A driver of a disease was defined as ‘a social, economic or physical factor that affects disease outcomes, either by changing the behaviour of disease sources or disease pathways, or by acting directly on disease receptors (i.e. the plant populations at risk)’.

Such sources may be phenomena or biological events that either give rise to potential new diseases, enable existing diseases to become more harmful and to infect new hosts, or enable diseases to spread to new areas via a disease pathway – a mechanism or route by which a disease organism can transfer from one host to another, within or between species.

The following important drivers of change in disease risks were identified and discussed:

1. *The current global and regional policy focus on reducing poverty (e.g. by the Commission for Africa)*. This places emphasis on wealth generation. The New Partnership for African Development (NEPAD) has put agriculture at the forefront of poverty eradication and has gone on to develop the Comprehensive African Agricultural Development Programme. The goal of this is agriculture-led development which eliminates hunger and reduces poverty and food insecurity, leading to the expansion of exports and higher economic growth.

   Achieving this goal will mean greater investment in agriculture, agricultural research and technology; the intensification and commercialisation of farming; and greater trade in agricultural commodities and products. This will demand a shift to high-value crops, the introduction and deployment of new crops including high-performing varieties such as horticultural crops, fruits and vegetables, internationally tradable cereals and legumes such as rice, maize, beans and groundnuts; and trade in ornamentals and spices. The intensification of farming will result in specialisation, loss of crop genetic diversity and uniformity of crop species and varieties, which may make them more vulnerable to disease epidemics. Greater trade in agricultural commodities and products will result in greater risks of disease introduction and spread. These factors will be crucial in driving future disease scenarios in Africa.

2. *Regional integration*. This will facilitate and increase movement of crops and crop products within Africa. Regionalisation, such as the creation of a common seed policy across the East African Community (EAC), will mean no barriers to seed movement between these countries. This may increase disease risk. Further, due to economic incentives, investors will be encouraged to open new areas of production where it is most cost-effective, bringing with it the risk of disease introduction.

3. *Changing agronomic practices*. This will alter the host–pathogen equilibrium and, depending on the direction to which the equilibrium is tipped, disease incidence may be increased or decreased.

4. *Environmental degradation*. This includes loss of biodiversity and loss of soil fertility due to intensive cultivation. Diminished biodiversity will bring about uniformity of plant species, making them vulnerable to pathogens and disease spread. It may favour weak pathogens or enable minor diseases to

emerge in importance. Similarly, loss of fertility will result in less vigorous plants that are highly susceptible to weaker pathogens. A notable example is the emergence of root rot of *Phaseolus* beans caused by otherwise weak parasitic fungi, namely *Pythium spp* and *Fusarium spp* which thrive on beans in areas of low soil fertility.

5. *Agricultural intensification*. As pointed out earlier, this is a major driver of disease change. Arising from an effort to increase production, particularly in high-value crops, intensification will result in loss of crop genetic diversity and alteration of farming practices. These will favour the rapid spread of adapted diseases through genetically uniform crops.
6. *Global warming*. This is another driver which will operate through new or better adapted vector or pathogen species, biotypes or strains. The new vector types may become more efficient in transmitting disease, including diseases they had not transmitted before. New strains of pathogens could become more virulent or may be easily transmissible by vector. All these trends result in increased disease risks.
7. *Civil strife*. Conflict will drive outbreaks of disease in areas where capacity and infrastructure to prevent and control diseases has broken down. Further, refugees fleeing strife areas will always carry plant material, capable of introducing disease, into new areas. Therefore the movement of people due to strife (or for economic reasons) will further contribute to the movement of crops and disease. The consequential movement of food aid may also continue to bring in new pathogens, as will accidental introduction by researchers bringing in new germplasms.
8. *Lack of institutional capacity for prevention and control of disease*. This will increase risk.
9. *Poor policy and regulatory frameworks for disease detection, identification, monitoring and control.*
10. *Intentional introduction*. In future, Africa cannot be immune to the risk of plant diseases introduced maliciously to undermine food security and stability. Clearly every effort must be made to prevent this.

2.2 Future animal diseases and their drivers

Future animal diseases

Firstly, animal diseases perceived to pose a high risk today and in the future were identified and are shown in Table 1.

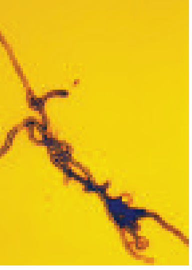
Table 1 Current and future animal diseases

Disease class	Current threats	Emerging threats
Transboundary animal diseases/ major epidemic diseases	• Rinderpest • Contagious bovine pleuropneumonia • Foot-and-mouth disease • New Castle disease • Peste des petits ruminants • Rift Valley fever • African swine fever • Contagious caprine pleuropneumonia • Poxvirus diseases	• Classical swine fever • Avian influenza • Transmissible spongiform encephalopathies • Aquatic transboundary animal diseases
Vector-borne diseases	• Rift Valley fever • Bluetongue • West Nile virus • Congo Crimean haemorrhagic fever • African swine fever • Dermatophillosis • Haemoparasitic diseases	• West Nile virus • Congo Crimean haemorrhagic fever
Zoonoses	• Brucellosis • Bovine tuberculosis • Anthrax • Rift Valley fever • Cysticercosis	• Hantaviruses • Flaviviruses • Transmissible spongiform encephalopathies • Avian influenza • Food-borne infections • Wildlife-derived haemorrhagic fevers

Drivers of animal disease risk

The key drivers of change in risks for animal diseases for the next 10–15 years were then debated. The three which emerged as most important are:

1. Movement of animals and animal products, and globalisation of trade.
2. Socio-economic factors, particularly poverty-related issues.



3. Urbanisation and intensification of animal agriculture, especially aquaculture and increased monogastric and poultry production.

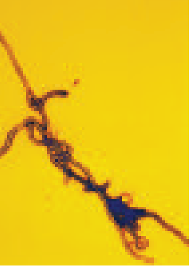
NB: Antimicrobial resistance was identified as an important factor but was recognised as a ‘source’ rather than a ‘driver’.

Specific diseases and drivers

The three disease classes and key exemplars (Table 2) were selected from the original list (Table 1) as the most likely risks/disease problems in sub-Saharan Africa in the next 10–15 years. The table provides information on their justification for selection, and their principal drivers.

Table 2 Examples of priority diseases and their drivers

Category	Exemplars	Justification	Driver
Major epidemic diseases that limit market access and/or trade	Foot-and-mouth disease	Easily transmissible and greatest animal disease impediment to market access. Africa has most complex sero-type and topo-type distribution in the world.	Animal movement and globalisation of trade
	Peste des petits ruminants	Slow spread over 40 years from west Africa to eastern Africa. Now present also in the Middle East and parts of Asia. Potential risk for further geographical spread to east and southern Africa; potential risk of infection of vast wildlife populations of east and southern Africa and change in host range to include cattle within the next 10–15 years. Currently, there is no specific information on these risks.	Animal movement and regional trade Poverty and socio-economic factors
	Contagious bovine pleuropneumonia	Serious potential for spread to free areas of southern Africa; inadequacy of current DIM and control tools.	Animal movement and regional trade
Vector-borne/ associated diseases	Haemorrhagic fevers • African swine fever	No vaccine developed so far; little ongoing research for either DIM or control tools. Disease likely to be a major threat to expanding peri-urban pig farming.	Urbanisation and intensification of animal agriculture
	• Wildlife-derived haemorrhagic fevers	Greater human/wildlife interface foreseen in the next 10–15 years.	Poverty and socio-economic factors
	• Aquatic haemorrhagic diseases	Increased aquaculture and movement of breeding stocks will enhance potential for spread of diseases.	Urbanisation and intensification of animal agriculture
Zoonoses	HIV-related infections	Immuno-compromised individuals in livestock-dependent communities will have increased susceptibility to bovine TB, brucellosis, and cysticercosis. So far this risk has not been adequately assessed.	Poverty and socio-economic factors Urbanisation and intensification of animal agriculture
	Avian influenza	Threat of a global pandemic. Lack of knowledge of circulating influenza viruses in wild birds including those migrating in and out of Africa. Poor primary animal and human healthcare is likely to lead to misdiagnosis in the early stages.	Animal movement and globalisation of trade Urbanisation and intensification of animal agriculture



2.3 Future human diseases and their drivers

Future human diseases

The most important diseases in the next 10–15 years were considered to be:

- HIV
- malaria
- respiratory illness (tuberculosis, acute respiratory illness, influenza).

Although these were considered 'old' or current disease problems, the incidence and impact of these infections are increasing. It was therefore thought that they would still be the major human infectious diseases in the next 10–15 years.

Other important infectious diseases and sources of disease discussed included:

- *zoonoses*. Most of the new and emerging infections are zoonoses.
- *vector-borne diseases*. This category includes malaria and zoonoses, but also other significant increasing infections not included elsewhere, such as dengue virus.
- *'neglected diseases'* e.g. filariasis, leishmanisis, trypanosomiasis. These are increasing in morbidity and mortality, but control and available treatments are decreasing. They are often poorly monitored and investment in preventing and treating these infections is low.
- *non-human primates* were the source of HIV, recently identified Simian immunodeficiency viruses and some outbreaks of viral haemorrhagic fevers. Since contact with these animals is increasing, there could be potential for an HIV-like agent emerging in the future. Although these diseases fall within the zoonoses category listed above, the subgroup of infections from non-human primates is considered so significant, it warrants a special category.
- *viral haemorrhagic fevers (VHFs)*. This group of infections is producing larger and more frequent outbreaks in some of the more inaccessible parts of Africa. Treatment is not available for many types of VHFs, and there is a high secondary spread to close contacts, especially healthcare workers.
- *sexually transmitted diseases*.
- *bioterrorism*. Although this was discussed, it was thought that, given their current problems, this was a relatively low priority for most African nations.

Drug resistance was felt to be a major problem in future, relevant to many of the infectious diseases outlined above.

Finally, there was also the feeling that *completely new infections* might arise, given that the pressures and drivers which facilitated many of the newer infections such as HIV would still be operating. The key implication of this is that policies for the management of infectious diseases in the future need to be flexible and adaptable to entirely new threats – as well as continuing to deal with major existing diseases, which are expected to retain importance.

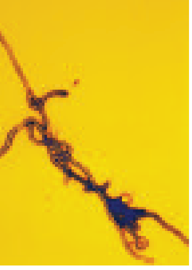
Drivers of human disease risk

The most important factors driving future levels of risk from infectious diseases ('drivers') were considered to be:

- heath system incapacity
- inappropriate drug use (prescribing practices, drug use, compliance)
- human behaviour, including sexual behaviour, migration, urbanisation.

The following diverse drivers, though potentially important, were deemed of less importance than the above priorities:

- vector populations, which are increasing mainly due to factors such as poor investment in control, insecticide resistance and changes in land use
- zoonotic contact, which is greatly increased in many African situations
- poor governance, which often means that resources do not reach the groups for which they were intended or are diverted away from the public good
- poverty, which underlies the capacity of most African countries to diagnose, manage, respond to and control infectious diseases
- scarce resources, which favour treatment over prevention. This is linked to poverty in that there is generally a shortage of money for preventative services
- nutrition/food use. Poor nutrition makes large populations more susceptible to infectious and other diseases
- poor diagnostic facilities/specificity, which means that infections are not diagnosed correctly. If tests are available, they often produce unreliable results, which makes the management and control of infections difficult
- political leadership, which could usefully be strengthened in many countries where health is often the poor relation on many political agendas
- ecology, where factors such as desertification and land use favour the emergence and increase of infectious diseases
- population pressure, where, as the population increases, so does the pressure on land, food and other resources, amplifying many of the other drivers discussed
- conflict, which brings together many of the drivers included here e.g. mass movement of populations, with overcrowding, poor sanitation, increased animal contact, poor nutrition etc.
- climate change, which was not felt to be a major driver, although it is likely to have some effects in disease emergence and control
- Pollution.



Other points raised in discussion

- It was constantly mentioned that the capacity to detect, identify and control existing infections is not present – let alone the capacity to deal with new infections.
- The identification of an agent does not necessarily indicate that it is the cause of disease. In the case of malaria, for example, many people have malaria parasites, but these may not be the cause of their illness. This misunderstanding can have adverse effects by leading to inappropriate diagnosis and incorrect treatment and management of cases.
- Geographical priorities are a consideration. Even within one country, the most important diseases vary greatly. Cameroon was cited as an example of a country which is small by African standards, but where the disease priorities vary greatly in the different geographical areas. The variation would be even greater across sub-Saharan Africa.
- Endemic versus epidemic diseases. Many of the diseases having the most impact are endemic.
- It was felt that we need to understand the selection pressures and genetic adaptation of infections, which enables them to move from animals to human hosts, in order to deal with them better.

2.4 Summary of the most important disease categories and their drivers – across plants, animals and humans

Looking across future risks from human, animal and plant diseases in Africa, some striking similarities and differences emerge.

Future threats from existing diseases

For human and animal diseases, there is a set of known diseases that will remain a priority for the next 10–15 years. For humans, HIV, malaria and respiratory diseases (tuberculosis, acute respiratory infections and influenza) are the primary concerns today. It is anticipated that their incidence and impact will increase in the next 10–15 years, and they will therefore remain the focus of DIM opportunities. For animal diseases, there is also a range of current, widespread diseases which will remain a priority, including foot-and-mouth disease, peste des petits ruminants, Rift Valley fever, African swine fever. Some of these, such as peste des petits ruminants and contagious bovine pleuropneumonia, are spreading and are providing particular DIM opportunities.

In contrast, for plant diseases, with their enormous diversity, future risks are likely to be less associated with specific existing diseases or even classes of diseases (e.g. viruses, bacteria) than with the properties that would give a new disease a particularly high impact e.g. wind-, seed- and vector-borne diseases, whereby the rapid spread of new diseases arising in one area will greatly increase their impact, and hence risk.

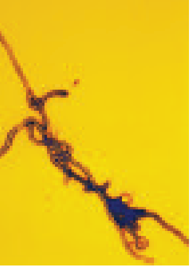
Specific classes of diseases which are likely to continue to be of importance include:

- vector-borne diseases of humans, animals and plants. These are considered to be of increasing importance as control of existing vectors is generally decreasing throughout Africa, while the range and intensity of these vectors are increasing.
- zoonotic infections. These will continue to be of primary importance in both animal and human health. Both commercial animals and humans acquiring new infections from wild animal species are considered to be a particularly high risk. The infections could then spread within the new host species or result in further inter-species spread. Viral haemorrhagic and immunodeficiency diseases, which may transfer from asymptomatic or symptomatic hosts, feature prominently among new risks for both humans and animals (including aquatic species).
- Emphasis on a set of current priority human and animal diseases may further marginalise the 'neglected diseases', the incidence and impact of which are increasing. Many of these are zoonoses. They are poorly monitored, and investment in the treatment and control of these infections is low e.g. trypanosomiasis.

The development of drug resistance is currently a major problem and it was agreed that in future this would get worse across almost all disease categories.

The threat of entirely new infections

The strong risk of the emergence of new infections is a common theme across the plant, animal and human kingdoms. There is a powerful impression that these may arise within Africa, possibly through new contacts between domestic and wild species and/or through the emergence of new diseases, including the evolution of resistant strains and the creation of new diseases through recombination of existing pathogens.

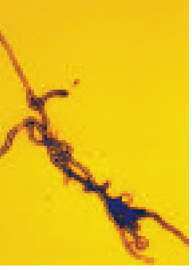


Common drivers of change in risk

There are a number of powerful drivers of current and emerging disease risks which act across diseases in plants, animals and humans:

1. Poverty affects many African countries and influences the capacity to detect, identify and respond effectively to emerging infections. Such capabilities are considered to be minimal in many cases.
2. Movement of people, animals and crops is a critical driver of risk for emerging diseases. The movement of people is a component of human behaviour, which is a major risk category for human disease. The movement of animals will be associated with migration and movement of people, but it may also be for trade. In both sectors, movement is inextricably linked to its climatic and conflict drivers and includes the problems associated with urbanisation. For crops, however, this driver will be particularly associated with the introduction of new crops into areas where production may be most profitable and therefore with the movement of diseases or the risk of picking up new, local diseases from other species.
3. Conflict is an important driver for the emergence of disease since it stimulates the relatively quick mass movement of people and animals – resulting in overcrowding, underlying malnutrition and the breakdown in any capacity and infrastructure to prevent and control infection.
4. A growing, internal African economy will drive increased risks from trade in food products. Urbanisation will contribute to this.
5. Changes in practices, whether these are agronomic, or in relation to animals or humans, are major drivers.
6. Inappropriate drug use cuts across all three sectors and promotes the emergence of drug- or pesticide-resistant infections. The effects of this driver are compounded by the inability to understand the mechanisms for microbial genetic adaptation in response to drugs.
7. Poor governance is a major risk underlying all other risks and activities across the three sectors.
8. For animals and plants, the intensification of production and trade are identified as major drivers of increased risk. Underlying both are African poverty-reduction objectives that are placing emphasis on wealth generation. Intensification means higher local densities of plants and animals, more genetic uniformity and greater inputs, including pesticides, drugs and vaccines, which will in turn affect vectors and the emergence of resistance, not necessarily in predictable ways. International trade opportunities will drive a demand for disease-free livestock and crops, intensifying the economic risks from new disease.

The importation of diseases from outside Africa was discussed. A current example, which exists for both humans and animals, is avian influenza. However, there was some debate about whether the risk (to animals and humans) from imported diseases may be lower in relative terms than that created by continuing and emerging diseases. In contrast, the balance between introduced and locally derived new diseases of crops may lean more towards introductions, due to the importance of the introduction of new crops.



3. The most important factors that will make the future control of diseases in Africa less or more difficult

The workshop attendees carried out a brainstorming session and listed important factors that will affect the future control of diseases in sub-Saharan Africa. Related factors were then grouped together and prioritised. In order to maximise the cross-fertilisation of views, this exercise was performed by mixed teams drawn from plant, animal and human disease experts.

The factors are of two kinds. Firstly, there are those relating to the nature of diseases, such as aspects of their biology or epidemiology. Some of these include new and old diseases for which there simply may be no effective controls (e.g. mycoplasma-like diseases) and those for which existing controls may no longer be acceptable e.g. use of DDT for disease vectors. Secondly, the group identified factors relating to disease control systems. Among these are government policy, regulatory frameworks, and governance issues. It was concluded that the factors in this group are the more important, as they present constraints and opportunities for dealing with the problems.

All the identified factors were further grouped and prioritised in terms of capacity, policy, governance and culture, with those of critical importance singled out.

Capacity

Capacity is an ability to formulate and achieve relevant objectives, accomplish goals, and satisfy stakeholders. It operates at individual, community, national and regional levels and involves human, physical, financial and management sectors. Importantly, capacity is significantly constrained in Africa by poverty.

The capacity constraints for infectious diseases were analysed at several levels. At the individual level, sub-Saharan Africa is constrained by a lack of skilled manpower to effectively deal with the problem. In particular, there is a shortage of skilled scientists, arising from insufficient training and a failure to retain trained personnel. Lack of support for African scientists has always led to most resources for African disease research going to scientists in developed countries. This has left African researchers frustrated and demoralised.

At the community level, education, raising sensitivity and creating awareness among local communities, the general public and other stakeholders are absolutely necessary to build their capacity to participate and contribute effectively to disease surveillance and control programmes. Furthermore, the power of religious and civil society organisations could be harnessed to improve capacity and participation at the community level.

The current infrastructure, including laboratories, equipment and communication systems to support infectious disease control, is already inadequate. This situation will worsen if no steps are taken to improve it. Efforts should therefore be made to address this gap.

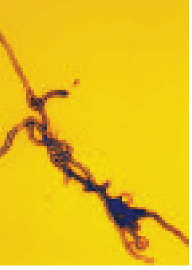
A continuing lack of surveillance systems means that the capacity to detect and eliminate new threats when they arrive will simply not exist. New infections may spread to cause the greatest losses and incur the greatest control costs. The current threats of HIV/AIDS in humans, cassava mosaic disease on cassava and foot-and-mouth disease in cattle are good examples. A system for disease surveillance in Africa is urgently needed.

Access to new technologies is important. Many are being developed for infectious diseases and coming onto the market, but most of these have proprietary rights and patents. The continent could miss out on these if it does not develop the capacity to access and apply them. Africa needs the capacity to negotiate, acquire, deploy and manage these important technological innovations. A failure to encourage and facilitate public/private partnerships to make new technology available will certainly affect the infectious disease situation. This will be particularly important in relation to poor intellectual property rights policy, where African scientists either do not have access to technology in the first place or, if they do, they cannot then undertake the necessary research.

Policy

A forward-looking policy for the control of diseases was seen as imperative for fighting infections in the future. Political goodwill and supportive government policies from African nations are very much needed if effective programmes to address infectious diseases across the continent are to be put in place. Such support and goodwill should result in increased resources for infectious diseases, subsequently leading to more effective programmes for control. Funding, both at the national and international levels, is crucial in any effort to address infectious diseases in Africa. Overall, the attendees felt that there was a mismatch between the scale of the impact of infectious diseases across Africa (in terms of economic development as well as human health) and the level of resources deployed by governments, development organisations and donors to manage the situation. This argues strongly for a reassessment of priorities by governments, development organisations and funding bodies.

Development assistance is important in improving and developing future disease control. However, while increasing assistance may help disease control, strong conditions are always placed on this by the donor community. As an example, structural reform that has privatised agricultural services and undermined animal and plant health capacity may have negative, counterproductive effects. Donors should be urged to revisit their position on this and similar issues.



Furthermore, a growing, global capacity in disease research and control, especially from the developed world, should be harnessed to benefit Africa through 'smart' partnerships.

Governance

Today, many African governments accord prevention and control of infectious diseases little or no priority in their national development programmes. This affects resource allocation in this very important area. To obtain effective results, vision and commitment to promoting infectious disease surveillance and control are required from all governments in sub-Saharan Africa.

In addition to the above, poor government policies, coupled with unsupportive legislation and regulatory frameworks, adversely affect the infectious disease situation in Africa. At the moment, Africa often operates through a 'rule of crisis', characterised by reactive management of immediate problems. There is a lack of proactive strategy and planning for possible future problems. HIV/AIDS demonstrates this point very clearly, as do infectious plant and animal disease epidemics such as cassava mosaic, coffee wilt and banana wilt diseases in the Great Lakes region. Continuation of poor disease control policies and a failure to develop improved ones will worsen the situation.

Poor regulation of drug and pesticide use will facilitate the development of resistance and the loss of technology, thereby proliferating disease, as is the case with malaria in humans.

There is a need for Africans to assume leadership in infectious disease surveillance and control, while working through smart partnerships that attract needed co-operation. Currently, Africans seem passive, even on issues that greatly affect them, and are too often driven by donors. It is usual for African studies to be commissioned by donors and executed by western researchers and, in many cases, African researchers play minor, supplementary roles. This has made it difficult to ensure continuity and easy availability of data to others who need to use such information.

The effective implementation of existing and new disease control policy and legislation is critical for infectious disease management in Africa. There have been many cases where government policies and programmes are not effectively implemented, which has affected the degree of success in managing diseases. This can arise as a result of civil strife and wars, lack of institutional capacity, and inadequate resources.

Civil strife and wars are particularly important in Africa as they disrupt all programmes, destroy infrastructure and skilled human resources, and trigger massive human displacement through movements of refugees across borders. This migration of refugees could introduce diseases into new areas. Current widespread decentralisation of responsibility for disease control without the resources necessary to achieve this is another way in which policy makers' efforts fall short. Corruption in government also undermines disease control programmes as it deprives them of much-needed resources.

The co-ordination of infectious disease programmes is crucial. At the moment, many programmes are isolated and poorly co-ordinated, causing duplication in some cases. At the national level, more inter-sectoral and inter-ministerial co-operation and co-ordination is required to improve disease control. On the other hand, regional co-operation, and particularly networking of disease control operations, could greatly improve control by allowing concerted action and making optimal use of very limited human and other resources. A more strategic and co-ordinated approach to infectious disease management is crucial if future risks are to be minimised.

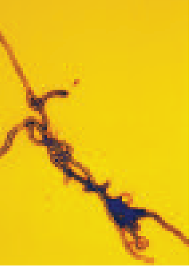
Regional integration and globalisation are other major factors. New initiatives for regionalisation in Africa, aimed at improving economic growth, may have positive or negative effects on disease control. Removing regional trade restrictions (e.g. on moving seed within the EAC could make control more difficult. A failure to develop or implement the effective control of cross-border movements could greatly increase disease problems and detract from the benefits of trade. Globalisation will definitely increase the trade in agricultural products and enhance the mobility of people across the world. The result could be a greater risk of introducing diseases to new areas.

Culture

In developing and implementing disease control policies, governments have placed far too little emphasis on the importance of culture. Yet culture has a substantial influence on the policies' success. Poor understanding and lack of acceptance of new methods, e.g. bed nets and new vaccinations, will lead to the failure of major programmes. In addition, many African farmers believe that diseases and their effect on crops in their fields are brought about by witchcraft or by soil problems. This makes timely intervention immensely difficult. Participation by communities in the development of disease control programmes will reduce this risk. There is, therefore, a need for greater public education and raising sensitivity, along with greater involvement of and ownership by beneficiaries in infectious disease programmes right from the outset.

Geographical considerations

Looking at capacity, policy and governance across the continent, central Africa and the Horn of Africa have the greatest difficulty in addressing these needs, while South Africa has the highest capacity, along with other Southern African Development Community (SADC) countries. East and west Africa are in an intermediate position.



4. DIM systems that could contribute most in managing future risks

Having identified the most important future risks of diseases in Africa, and the issues surrounding their management, the workshop delegates next considered how future DIM systems could contribute. This section provides their views on plant, animal and human systems in turn and then outlines issues that cut across all three.

4.1 Future DIM systems for plant diseases

The development of useful DIM technology for plant disease can only be effective under certain conditions that might be considered as prerequisites. These are:

- a critical mass of experts who can use these techniques. For instance, in surveys, expertise will be needed to interpret DIM systems and give very rapid decisions
- an effective surveillance and reporting system which could make use of an improvement in detection and monitoring (involving staff, field stations, information technology).

In the DIM of plant diseases, two types of diseases need to be recognised:

- those which are known but need to be more quickly detected and identified e.g. in the field. These are often endemic diseases.
- those which are not known and need to be detected and identified.

Both types of diseases will increasingly rely on immunological and gene-based technology for identification.

Rapid DIM of known plant diseases

Two systems for identifying known diseases were discussed: field-based kits for DIM in crops; and a system for DIM at points of entry e.g. to be used by quarantine services.

For both systems, however, it was agreed that any rapid DIM systems may have to be backed up by systems that confirm the presence and identity of the pathogen. It is also important that the development of new DIM systems does not undermine useful existing diagnostic methods, their application and improvement.

Kits for disease identification in the field

For identification of known diseases in the field, a dipstick-type kit that is reasonably accurate, quick (e.g. less than 10 minutes) and robust for field use is desirable. ELISA-based tests may be useful here.

This DIM technology would be particularly applicable for diseases that lack visible symptoms during spread and therefore where pre-symptomatic detection improves control. Potato wilt is an example. This technology would be useful for detecting latent infections and also seed-borne infections.

The precise specifications of such a system would depend on the level of training of users. However, it would need to be robust (including thermostable), sensitive, reliable, accessible (and affordable), adaptable (usable with limited training) and, ideally, able to cover a range of diseases.

Kits for identification at points of entry

These would need to have the following key characteristics:

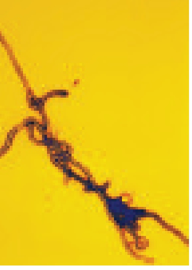
- rapid identification and confirmation, within 12–24 hours, in order to clear shipments
- high throughput
- the capacity to identify multiple, known diseases (e.g. on a quarantine list)
- reliability
- affordability.

Quick tests may require back-up confirmation. However, identification at points of entry, e.g. ports, will need to be highly accurate and legally defendable.

Identification of new plant diseases

DIM systems for identifying the cause of new disease outbreaks will probably require a laboratory base. They will need to be available in Africa both at the national and regional levels and should allow high-speed access to resources, which include the infrastructure, equipment, databases and other information resources needed to support identification. A source of experts to interpret data will also be required.

A regional centre of excellence in infectious diseases is recommended. This would have nodes at national and subnational levels. High-speed communications systems between a centre and nodes, with databases on stream internationally, may also be required.



A gene-based system, such as PCR, may underpin such a laboratory, although, for some diseases, other systems would be useful – e.g. fatty-acid-based technology for bacteria.

Experience with recent disease outbreaks suggests that such a system would accelerate control programmes, perhaps with the chance of eradicating new diseases before they were too firmly established. With cassava mosaic virus, traditional serological methods did not detect the new pathogen, nor did some genomic methods. Sequence analysis finally gave the answers and took about six months to develop. Banana wilt is an example of a new and spreading disease that could also have benefited from rapid detection and identification.

Other DIM systems for plant diseases

Several other desirable DIM systems were identified and summarised briefly:

- spore traps to provide routine sampling of airborne pathogens, backed up by systematic surveillance across countries
- remote (e.g. satellite) sensing of diseased crops, using radiation-based technology (e.g. crop colour, reflectance or volatile compounds) linked to a GIS system would be useful. This might be of use for diseases affecting perennial crops, such as coffee wilt and banana bacterial wilt
- trap nurseries to pick up specific pathogens before they become widespread. There is a precedent for this in Africa. This could also be linked to remote sensing technologies
- epidemiological modelling to predict outbreaks of new disease, using various sampling systems
- biological sensors for disease detection
- DIM methods to identify new biological control agents of plant diseases.

Other issues to consider

There is a need to develop partnerships to guide technology and promote access. Here, the key issues would be: who wants the technology? who will pay? and who will oppose it? The last of these implies a need for an effective communications strategy.

The technology of new DIM systems should not be considered in isolation. It should embrace what would follow on for the patient/animal/plant after diagnosis or disease identification. It is also important to consider whether a technology is economical with respect to the diseases addressed.

4.2 Future DIM systems for animal diseases

Using a brainstorming technique, 19 areas were identified as critical to the future DIM of animal diseases in Africa. Each area was then classified into three categories:

- specification
- technology
- system.

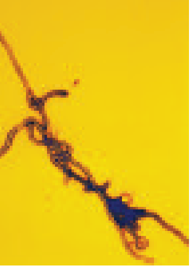
The outcome of the exercise is summarised in Table 3.

Table 3 Priority areas for DIM systems in the future

DIM priority area	Classification
1. Rapid identification	Specification
2. Transferable technology	Specification
3. Simple to use	Specification
4. Robust	Specification
5. Pen-side (hand-held devices to allow field testing)	Specification Technology
6. Affordable and cost-effective	Specification
7. Animal identification and traceback	System
8. Differentiation between vaccinated and field infected	Specification
9. Detection of subclinical infected and carriers	Specification
10. Measuring immune response (vaccination and infection)	Specification
11. Measuring immune signatures	Specification
12. Sensitivity and specificity	Specification
13. Strain differentiation	Technology
14. Genomic technology available at national laboratories for DIM e.g. contagious bovine pleuropneumonia, African/classic swine fever	Technology
15. Diagnosis of chronic bacterial diseases e.g. TB, brucellosis, contagious bovine pleuropneumonia	Technology
16. Test for efficacy of intervention e.g. antibiotic treatment	System
17. Technology applicable to primary healthcare diagnostic capability	System
18. Ability to measure stress and stressors to monitor welfare	Technology
19. System for multiple aetiological diagnosis	Technology

From the list in Table 3, the following priorities were identified as offering the greatest potential for improving the future DIM of infectious diseases in Africa:

- pen-side diagnostic tests
- availability of affordable genomic technology in national laboratories for DIM



- technology available to primary healthcare diagnostic capability (i.e. subnational and field level)
- differentiation of naturally infected from vaccinated animals.

4.3 Future DIM systems for human diseases

The delegates started by assessing the general requirements for future DIM systems. They then considered the specific needs for managing HIV, malaria and respiratory diseases respectively (these were the three most important categories of future disease identified earlier in the workshop).

General requirements

- There is a need to distinguish infection from disease (the presence of malaria parasites in adults in many parts of Africa does not mean that malaria is the cause of their symptoms).
- Markers of susceptibility e.g. TB, malaria. This would include correlates of immunity.
- Systems for public/population-level health and tools and for individual care would have different requirements.
- Rapid detection of bacterial infections with antibiotic resistance, and ability to detect unusual infections for sepsis, pneumonia, meningitis, respiratory pathogens etc. This would be especially useful for HIV-infected adults where a more unusual range of infections could be the aetiological agent (e.g. PCP, crypto etc.).
- Development of dried-blood-spot technologies.

These requirements suggest the desirability of a point-of-care (POC) device/ system for individual diagnosis/surveillance:

- As results are produced, the device automatically collects and communicates them back to a surveillance centre.
- Cost per test needs to be <$0.5 for patient care, although surveillance costs would be more cost-tolerant.
- It could use blood, saliva or other body fluids.
- There would be intelligent analysis of data, which then goes back to the point of care.

Specific needs for HIV

- The ability to easily monitor drug resistance.
- A priority would be a readily available easier, cheaper, simpler diagnostic tool with the facility for monitoring the stage of infection and response to treatment e.g. CD4 or other staging system. This would allow healthcare workers to manage patients according to protocols, and would identify patients on failing drug regimes that could then be referred for more expert management.
- A simple test to diagnose infection in the newborn. This could be applied to POC kits. At present, such infections are only diagnosed by using sophisticated techniques in certain centres, which hampers the management and treatment of very young children infected with HIV.
- The ability to monitor incidence, for example, with a 'detuned assay dipstick' that detects infection within a certain period such as three to six months after the time of becoming infected.

Specific needs for malaria

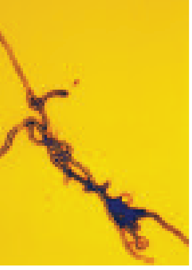
There is a need for a reliable diagnostic system for malaria, which must:

- differentiate whether malaria parasites detected in an individual are actually causing disease (as mentioned above)
- measure the specific immunological responses to malaria to identify infection
- detect drug resistance, which is increasing.

Specific needs for respiratory diseases

The need for a quick and reliable diagnosis of pandemic influenza was discussed, but the group concluded that what is really needed is a breath test to diagnose all common (and possibly uncommon) causes of respiratory symptoms.

The above suggests the desirability of *a handheld POC device as above, or a breath test system for respiratory diseases (sampling volatiles)*.



Priorities for DIM systems for human diseases

The attendees were asked to vote on what they thought were the greatest future priorities for DIM systems for human diseases in Africa. The results, in order, (highest first) were:

1. POC individual diagnostic/surveillance devices, which automatically collect and communicate results back to the surveillance centre
2. monitoring the drug resistance of HIV and other viruses, bacteria and parasites (quantitative and qualitative)
3. a breath test for respiratory diseases
4. a readily available, easier, cheaper, simpler diagnosis and monitoring test for HIV, including staging/CD4
5. the ability to monitor HIV incidence with a 'detuned dipstick'.

Discussion points

- Target diseases would vary between Europe and Africa, but participants envisaged region-specific chips using the same platform on a POC device. These could be produced for use on animals, plants and humans.
- There is a need to overcome commercial communication issues – including ensuring that equipment and software from different manufacturers are mutually compatible.
- All the devices discussed need to be based on effective information, communication and analysis of data, with systems in place to manage outputs. Unless there is the capacity to monitor and to respond to reported incidents and analyse the reports in a timely, meaningful way, this is not effective surveillance.
- There is a big gap in contact tracing/reporting. Even if diseases were diagnosed, would there be the resources to control the infections e.g. following up and tracing contacts?
- There are existing technologies that could help the diagnosis and management of infections in Africa, but they are not available due to cost or logistical support.
- Would there be the need for reference centres to confirm test results, especially if indeterminate, or is there the assumption that the specificity and sensitivity of the testing will be high?
- The need for sentinel centres to monitor disease and trends was discussed, but the group thought this minimalist approach would probably not be representative. They would be likely to over-represent urban areas where there are usually better infrastructures.

- African leadership, engagement, and smart partnerships are necessary in order to develop technology appropriate to Africa's needs.
- More population-based surveillance is needed, as is the capability to respond to surveillance data.

Important factors for assessing priorities were:

- applicability
- priority
- impact on the management and control of disease.

Finally, the attendees underlined a key difference between developed countries, such as the UK, and Africa – developed countries can respond to new health problems, whereas Africa is overwhelmed with coping with current problems.

4.4 Summary of future DIM systems – for plants, animals and humans

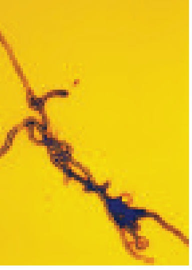
Not surprisingly, the most appropriate DIM systems for human, plant and animal disease differ in detail. However, for all targets, it was agreed that DIM technologies have to be inexpensive, rapid, robust, simple to use and simple to train people to use.

There was a general concern that DIM technologies may be unaffordable or unserviceable in an African context. Further, the value of DIM technologies depends on the ability to use the information that they provide. National programmes might lack the ability to follow up a diagnosis with treatment or efforts to monitor or eradicate the disease, for want of resources and trained personnel.

There was considerable interest in systems that involve a hand-held device for POC diagnosis and/or surveillance of, for example, important bacterial diseases. They could be sophisticated or, in the case of plants, simple dipstick tests. For human disease detection, they could test saliva, blood or breath, depending on the infection. For animal disease systems, hand-held devices would permit field or 'pen-side' testing. For plant systems, they would provide rapid diagnosis of diseases that may lack obvious symptoms in early stages of spread.

As well as identifying known diseases, individual, portable devices could be used for:

- distinguishing among a range of unusual infections, e.g. in HIV/AIDS patients. For plants, a system for accurately diagnosing a range of diseases could be valuable in ports, where it could identify new introductions or clear exports without holding up the movement of plants, animals and goods



- measuring immune response and signatures, indicating susceptibility
- measuring stress and stressors to assess animal and human welfare
- measuring the efficacy of treatment
- distinguishing infection from disease.

These systems would need to be available for effective use by technical staff under field conditions. For human systems, it is particularly valuable that information taken by a hand-held device can be transmitted to a central facility for prevalence and distribution analyses.

A second desirable technology identified for all systems is a more lab-based system using nucleic acid methods to identify new diseases, or to confirm diagnoses (e.g. from hand-held devices). This technology could be made available to national laboratories or designated regional centres of technology.

A range of other DIM technologies was identified for plant diseases, including earth observation, traps to sample vectors, airborne spores and epidemiological modelling systems.

5. Issues surrounding the implementation of the most desirable future DIM systems

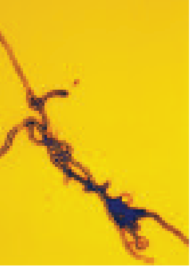
Looking across plants, animals and humans, the most desirable DIM systems identified were:

- a POC system which would diagnose an infection and transmit the test result back to a surveillance or monitoring centre
- a dipstick for diagnosis ('quick and dirty')
- a laboratory-based genomics system.

The discussion addressed both generic issues that would affect the implementation of all of these systems, as well as issues specific to each.

5.1 Generic issues

- *Acceptability and reliability of testing.* These factors affect a range of issues including privacy and differing attitudes towards infectious diseases. They are particularly relevant for DIM systems for human diseases – believing and having confidence in the result is crucial and is closely related to test performance. This implies the need for tests to have high sensitivity and specificity. Corresponding issues for animal and plant diseases centre around commercial interests, especially trade. Here, quality assurance would be an important component of any system.
- *Sustainability.* This was highlighted as a major concern. There is a long history in Africa of the provision of equipment without the corresponding back-up for parts, consumables, maintenance etc. Too often, even minor malfunctions render equipment unusable and permanently unused. Concerns include:
  - laboratory equipment and its maintenance
  - provision of consumables
  - human resources
  - procurement
  - availability.
- *Storage and shelf-life characteristics.* These are crucial in an African environment. There is often poor stock rotation and control, and a lack of wide-scale refrigeration or cool rooms. High temperature and often humidity cause the rapid deterioration of many products.



- *Cost of test.* This might vary for human, animal and plant use and whether it was used commercially for quality control or for individual animals/plants. The cost would have to be balanced against the resources of a community and its willingness to pay.
- *Lack of infrastructure.* There is little capacity to respond to potential problems/incidents if identified. There needs to be an investment in infrastructure to redress this problem.
- *Access to diagnostics.* This is a major issue in many parts of Africa. All too often, the large urban areas are provided with services that are not available in rural districts.
- *Adaptability.* Many systems are often originally developed for the developed world. This implies the need for the effective adaptation of such systems for African needs. However, such adaptations should not be seen as a substitute for developing systems, at the outset, for use in African situations.

5.2 Issues specific to individual systems

POC used for diagnosis and transmission of data to surveillance/ monitoring site

This could be used at different levels:

- individual (lay)
- primary care/community
- professional.

However, after discussion, it was agreed that the issues affecting use of the systems are probably similar for all users (though issues associated with specific user-groups are highlighted below).

There were concerns over confidentiality if information is being transmitted. The level of data collected would need to balance the requirement to collect sufficient information of epidemiological value, without jeopardising the identity of the subject. This would be important for human, animal and plant diseases.

There would need to be advanced data collection, management and analysis at the surveillance/monitoring centre. And there would need to be timely analysis and response.

Training and interpretation issues for each of the three classes of users were considered in turn:

- *Individual.* Training/interpretation would be more crucial if the device was for individual use, and there might be problems with follow-up and compliance. If a positive result was obtained regarding a potentially culturally sensitive infection, there could be denial of the result. There could also be incomplete treatment of the infection, depending on the resources of the individual doing the test – this would further fuel drug resistance.
- *Community.* Groups would be required to pass on information about the need for a test and the implications of a positive result. Follow-up of the test result might be difficult, particularly if there is limited availability of treatment.
- *Professional.* Training is less of an issue here, but individuals might be less trusting if information about themselves, their family, crops or animals is being shared with and transmitted to others.

Dipstick

If used by the individual, there would be no sharing of data, and positive test results that might have an impact on identification, monitoring and control could be hidden. This could happen in human disease if the infection was associated with stigma and in animal and plant disease to prevent quarantine or destruction of stock or to allow the sale of infected goods.

The problem of partial or inadequate treatment would also be an issue. Sensitivity/specificity issues are crucial with dipstick technology. There has been adverse experience with dipstick technology in human health in the past, and this could result in a lack of credibility in the results.

Laboratory-based genomics

Transport and communications to and from the laboratory would be important as the lack of infrastructure currently makes this difficult in many countries.

Cost/sustainability issues would be particularly important for this system – including ensuring the availability of adequately trained staff to operate such systems, and ensuring adequate provision to retain those staff.

The potential unavailability of databases on genomic sequences of African infections was raised. It was felt that Africa might be given low priority compared with more developed countries in the development of such databases (attendees citied analogies with drugs for neglected African disease). Also, even if data were available, would there be equitable access?

Other important issues include: the timeliness of sharing of information/results including feedback, with source of samples; intellectual property rights; using information for research/publications versus using the results in a timely manner for public good.

There is also the potential for the misuse of samples without consent and feedback. The system would need to be embedded in a strict ethical framework.

Concern was expressed that a lack of regulatory services may affect the integrity of this system.

General comments

Today's technology was yesterday's future technology, but, either way, technology is very lacking in Africa today. There is a need for mechanisms to enable new systems to be introduced and used in areas such as Africa where the need is greatest.

There needs also to be political will and engagement to ensure sustainability.

POC systems have potential, but may undermine current efforts to improve what is there now, or what is currently being developed.

A key difference between the management of animal and human diseases is that the former is dominated by prevention (through vaccination) rather than diagnosis and treatment. A concern was voiced that some vaccines use attenuated organisms, and there is a worry that the diagnostic tests considered might not distinguish between infection and vaccination.

6. A vision and strategy for the management of infectious diseases of plants, animals and humans in sub-Saharan Africa

On the last day of the workshop, the attendees were asked to stand back, and to take a broad and strategic look at the future of infectious disease in Africa. They were challenged to look at the big picture and advise what really needs to happen to obtain a step-change in capability in disease management.

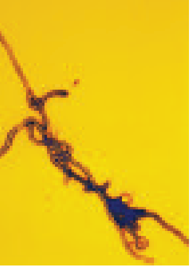
This was a unique opportunity to hear the collective views of so many diverse experts – not just from across the continent, but also from leading international organisations. The following records the outcome of the discussions and is intended to be both challenging and thought-provoking.

6.1 Setting the scene

Infectious disease is now widely regarded as the major constraint on agricultural and animal development and on human health and well-being in sub-Saharan Africa. In spite of notable successes in controlling pandemics of infectious diseases, such as polio in humans and rinderpest in cattle, the continent still has life-threatening epidemics of infections that presently cripple plant and livestock production and the very survival of many human communities across the continent. At the global level, it is acknowledged that Africa has the heaviest burden of infectious diseases, whether of humans, animals or plants.

In future, the infectious disease burden in Africa is likely to get still worse. This is because of a number of factors such as increasing urbanisation, the intensification of agriculture (including plant and animal agriculture and aquaculture), the increased mobility and movement of people, animals and agricultural commodities, increasing wildlife–livestock–human contact, and the impact of climate change on disease vectors. As the world becomes increasingly concerned about the spread of infectious diseases, there is a serious risk that Africa could become even more marginalised in the future than at present. It is difficult to foresee a successful and global future for sub-Saharan Africa without addressing the challenge posed by the infectious disease burden.

As the nature of some of these diseases has proven intractable to easy identification and present-day control tools/methods, there is an urgent need for both vision and commitment to provide the strategy for the future. In the final session of this workshop, the participants considered the options for developing such a vision and strategy.



There was considerable support for the view that African diseases are primarily an African responsibility, even though they have global impacts. It was also felt that investigations into African problems need to be conducted, in a major part, within Africa. Furthermore, it was a strongly held view that such initiatives have to be generational and long-term, not merely the typical three- to five-year research projects. There was, however, support for 'smart partnerships' between African and developed countries, which might offer both expertise and training in relevant scientific technology.

There was a consensus that addressing the infectious disease challenge in Africa requires a quantum leap in the application of detection, identification, surveillance and monitoring systems. This implies the need to influence science-based disease control strategies. While responsibility for this is primarily African, it was recognised that this would also serve the international public good – and as such should draw on international support. In the increasingly global world, it is in the interest of the industrialised countries not to be indifferent to the persistence of dangerous infectious diseases in Africa.

6.2 Underlying problems for the DIM of infectious diseases in Africa

The following key issues were identified either in earlier sessions or in the break-out groups for this session:

- having to use syndrome-based treatments without recourse to specific diagnosis due to shortage of resources
- acutely low capacity for laboratory-based diagnosis at subnational level
- low activity in general surveillance. For human and animal infectious diseases, surveillance is generally limited to activities of specific projects or targeted disease control programmes e.g. polio or rinderpest. For plants, there is little or no regionally co-ordinated surveillance for pests and diseases and the quarantine system operates poorly in many sub-Saharan Africa countries. So the capacity for early detection, early warning and early response to changing patterns of new or old diseases in Africa is weakening, and increasingly, infectious disease control strategies (whether of plants, humans or animals) are becoming late-reactive emergency containment programmes.
- There are some excellent international agricultural research centres located in Africa with an animal or plant health mandate. These are essentially centres of technology for defined research objectives but none of them is involved in infectious disease surveillance. Their existence would be an excellent technological asset in any future surveillance programme for infectious diseases. There are no such international centres for human diseases located in Africa.

- For animal and plant systems, there are AU and subregional institutions (e.g. IBAR, the AU-Inter-African Phytosanitary Council, the SADC-Livestock Technical Committee) which can act as co-ordinating organisations for DIM. They work closely with and are supported by the FAO and the OIE. But no such African-owned regional organisations exist for human infectious diseases and therefore the inter-country co-ordination of the surveillance for human infectious diseases is left to the WHO.
- At the national level, in many countries there is excessive compartmentalisation of specialists either according to sector (human, plant and animal) or according to administrative boundaries (government, academic and private institutions). Accordingly, there is sub-optimal utilisation of the meagre available resources that could drive a surveillance-based programme.

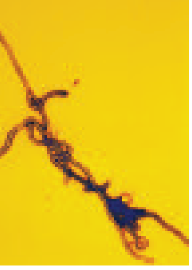
6.3 A new paradigm for the DIM and control of infectious diseases in Africa

The workshop concluded that in order for Africa to make the requisite quantum leap in the DIM of infectious diseases and, thereby, rational disease control strategies, new and innovative approaches need to be introduced. In particular, there is a need to create an articulated pan-African vision for managing infectious diseases as a crucial factor in human, animal and plant health and to human well-being, agriculture and economic development, food security, poverty reduction and to international trade in African plant and animal commodities and products.

However, to be effective, such a vision needs to be accorded a high priority at the national and continental level and integrated into the national and continental development plans in addition to the current donor-supported programmes, such as the AIDS/malaria/TB, polio, rinderpest or the AU-IBAR PACE programme and the cassava mosaic disease pandemic in the Great Lakes region, or the coffee wilt disease programme in east Africa.

The following ideas and approaches were suggested by the experts present for further consideration:

1. DIM and thereby surveillance of infectious diseases should be primarily rooted in scientifically strong, national systems. These should in turn have effective subnational or community-based foci for primary diagnosis close to the point of primary (animal, plant, or human) healthcare.
2. The most serious infectious diseases of humans, plants and animals are transboundary by nature (i.e. can easily spread to other countries and reach epidemic proportions). Since many African communities inhabit ecological systems that transcend national boundaries, it is important that disease surveillance systems in Africa be co-ordinated on the basis of regional co-operation among countries within a common ecosystem, i.e. an epidemiological cluster through a 'Pan-African Programme on Infectious Diseases in Africa'.



3. Within each epidemiological cluster of countries (or geopolitical subregional cluster, e.g. the EAC, or the Economic Community of West African States, there should be at least one laboratory that is able to undertake the identification and genetic characterisation of infectious disease agents from the national surveillance programmes. These could be regarded as subregional centres of excellence (CoE) in infectious diseases, capable of recognition by the WHO, the OIE, the FAO and the AU/ISTRC as regional reference laboratories or collaborating centres.
4. Current international agricultural research centres or NEPAD COEs in agriculture could act as outstanding centres of technology that could support the regional and national centres, especially on genetic identification of PCR products of infectious agents (insofar as the mandates of these centres permit such collaboration).
5. There was a strong endorsement that the new approach to the DIM of infectious diseases in Africa should strive to be cross-sectoral (i.e. integrated between plants, animals and humans) at the national and epidemiological cluster (or regional/subregional) level. This was considered by the workshop to be a novel mechanism for the optimal utilisation of resources, and would enable the quantum leap required to address the present and future infectious disease burden in Africa.
6. The Pan-African Programme on Infectious Diseases in Africa would be co-ordinated at national, cluster, subregional or pan-African level and would operate through a system of partnership and networking, via virtual (rather than physical) centres. This would ensure that any new funding would be primarily channelled into DIM activities rather than into constructing new infrastructures with high overhead costs that might prove to be unsustainable.

Taken together, the above suggest that the **Pan-African Vision for Infectious Disease Management** could be articulated as:

'A pan-African concerted effort, shared by AU member governments, reflecting the needs of African society and supported by the international community, with the goal of a society protected from the ravages of dangerous infectious diseases that compromise either human health or livelihoods and agriculture and economic development.'

This vision would be implemented through the disease-surveillance-driven objectives for:

- the effective prevention of the spread of currently endemic, introduced, exotic, emerging or evolving diseases (and pests) in Africa or parts of Africa
- the enhancement of African capacity and participation in the scientific and technological developments for the early detection, specific diagnosis, early warning of evolving disease events, and national/regional capacities for early

response to contain unusual disease episodes. These would help to break the cycle of each such episode turning into a serious epidemic

- science-based and socio-economically sound strategies either for disease containment or for the progressive control of those diseases that most threaten society, either as human disease problems or as an impediment to food security or the tradability of plant and animal commodities and products.

The next section (6.4) develops the concept of a Pan-African Vision for Infectious Disease Management in more detail.

6.4 Developing a Pan-African Vision for Infectious Disease Management

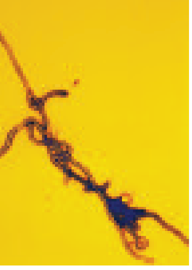
A sub-Saharan African global vision for the detection, identification and management of infectious diseases needs to identify current and future risks that affect human health/well-being, livestock and plant production. Furthermore, in the face of such risks, technologies will be needed to detect and identify microbial pathogens in approved national and regional centres and, thereafter, apply the control measures that might be undertaken. If the future vision extends beyond the next 10–15 years, it is highly probable that newly emerging or re-emerging diseases will occur and that a sub-Saharan African capability to rapidly contain such infections will also be needed. The advantage of trans-sectoral (plants, animals and humans) integration is obvious when considering that about 75% of newly emerging human diseases will be of animal origin.

Also, unless checked, the current level of spread of infectious diseases in Africa will preclude African agricultural commodities from international trade. In this context, future technologies for the detection of infectious disease will impact considerably on the movement of humans, livestock and plants for international travel and trade. To secure and exploit world trading, controlling infectious disease through novel detection and identification systems will safeguard national export and import programmes as well as international human mobility.

There was a strong feeling that the present OST Foresight project on the DIM of infectious diseases could act as a critical 'catalyst' to inform and influence the G8 and Commission for Africa to support a Sub-Saharan African Vision and Strategy on Infectious Disease Management.

Ownership of the Vision and Strategy

Ownership and responsibility for the Sub-Saharan African Vision and Strategy for Infectious Disease Management will need to be established – it should represent an integrated vision of how sub-Saharan African countries will identify and combat future infectious diseases. There is a persuasive argument that the AU should champion the realisation of the Vision and Strategy now and in the future. There is clearly a need for national governments to sign up to the Vision and Strategy and thereby strengthen the control of those epidemic diseases that do



not respect national boundaries, such as diseases of animals, e.g. foot-and-mouth; of humans, e.g. AIDS, and of plants, e.g. cassava mosaic virus, coffee and banana wilt disease epidemics. It is also important, therefore, that the WHO, the FAO and the OIE are associated with the Sub-Saharan African Vision and Strategy for Infectious Disease Management, as these organisations have global mandates for human, plant and animal health.

Leadership that provides the vision for future approaches to infectious diseases will need to be at the highest scientific and political level. Here, there is opportunity to engage with the relevant pan-African governments and agencies and international development and funding bodies. Individual governments and African society would need to share the goals of such a Pan-African Vision and Strategy for Infectious Disease Management.

Linkages with national strategies and infrastructure

The crucial issue for this Pan-African Vision and Strategy should be the acceptance of responsibility by member nations for their own disease detection and control. Without this buy-in, there will be inequalities in trade, tourism and national productivity between neighbouring countries, and possibly the failure to secure long-term funding for either regional or cluster centres of technology or excellence or international funding for partnerships between developed and developing countries. It is clear that funding agencies are not prepared to provide this continuing background support and so national governments should be able to shoulder this responsibility.

Therefore, the starting point for implementing the Pan-African Vision and Strategy for Infectious Disease Management should be at the national level. Here, there are financial and other resource constraints. The biggest stumbling block, however, may be institutional set-ups, as there is excessive compartmentalisation of scientific expertise according to administrative and sector divisions. So, a first step could be to set up in each pilot country, an inter-ministerial National Institute for Infectious Diseases, that is, a *virtual centre* (not a physical one) to function as a networking mechanism for DIM programmes that pool resources from both government and academic establishments across the three sectors (animal, human and plant). In line with the stated new paradigm, the virtual centre would seek to co-ordinate programmes within existing infrastructures, concentrating new funds on equipment, reagents and operational expenses far more than on new buildings. It is acknowledged, however, that in some cases it may be necessary to upgrade existing buildings in order to make them compatible with the safety requirements for handling infectious agents.

The national and pan-African vision for disease DIM and control should ensure that the strategy is rooted in strong community empowerment and networking for both the supply and delivery of samples for analysis and information. It is in the interests both of governments and communities that diseases are controlled and that new epidemics are detected rapidly and prevented from spreading widely. The responsibility for community networks should be at the national level; there is obviously a national advantage in such effective networks. The subnational primary diagnostic centres should remain client-based and linked to the separate primary healthcare systems for humans, animals and plants.

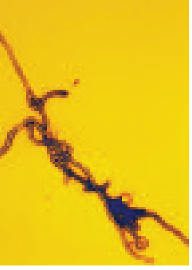
It was considered that there is a real need for strong scientific and economic arguments to be provided to national governments in order to substantiate the costs and benefits for disease control across all three sectors. The continued attrition of healthcare services across all these sectors in many sub-Saharan African countries will invalidate the delivery of many future technical advances in disease control. Thus, the identification of the importance of community networks should be seminal to any pan-African strategy for the overall diagnosis and control of infectious disease.

The role of regional and cluster centres of excellence for infectious diseases

Within designated regions or clusters, the establishment of technological CoEs would empower their hinterlands to access, assess and modify technologies relevant for national needs. Moreover, the networking of such centres across the regions/clusters would provide a powerful framework for integrated monitoring and surveillance. Such centres would need to be dedicated to the surveillance of infectious diseases (utilising the most modern technologies) and not be merely hubs of potential technologies.

Well-resourced CoEs would also help stimulate ‘smart partnerships’ between developed and developing countries, enabling them to make progress in the generation of long-lasting scientific links. However, such centres would not be entirely dependent on outside funding bodies. They would be essential hubs within the overall sub-Saharan African strategic framework, providing regional outreach to all national programmes for DIM.

The CoEs would act as regional/subregional reference and co-ordination centres (RRCCs). The regional centres would address aspects of epidemiology and disease surveillance, reference microbiology, and control. In line with statements made in the Commission for Africa Report, the suggestion is to have an RRCC co-ordination centre in each region/epidemiological cluster or subregion that is linked to new and existing centres via a virtual network. The network would also link with national and local disease surveillance/control services.



The RRCCs would work with the national hubs (National Institutes for Infectious Diseases) in:

- monitoring infectious diseases of plants, animals and humans in their region and progressively creating a pan-African surveillance network
- assisting countries within the region in controlling disease outbreaks (through advice and assistance to disease management professionals and African governments)
- researching disease control methods appropriate to local conditions and local needs
- promoting the spread of relevant technology and capability for disease control in their respective regions
- building scientific capacity by training all cadres of staff in the identification, diagnosis and control of infectious diseases.

Specific advantages for linking infectious disease surveillance and control strategies in plants, animals and humans

The Pan-African Vision and Strategy for Infectious Disease Management advocated by the workshop would be unprecedented anywhere in the world, so it would not be so much a case of Africa catching up, more a case of Africa taking a ground-breaking approach in this important area.

It is, above all, a vision for the optimal utilisation of the human expertise and relatively meagre resources available. Advances in genomics, electronics and information technology create new opportunities that apply equally to the diagnosis and epidemiology of plant, animal and human disease. An integrated strategy has scientific merit and deserves the serious attention and support of the G8 and the international donor community. The key advantages can be summarised as:

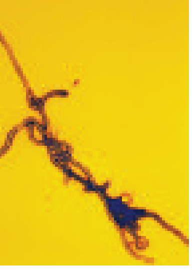
- greater ease in obtaining a critical mass in the scientists and experts involved
- promoting the most efficient use and development of the human scientific resource. This reflects the fact that new and emerging detection and identification technologies are increasingly common for the three sectors (e.g. genomics and informatics)
- better sharing of disease monitoring data, for example, between human and zoonotic diseases
- promoting the sharing and spread of best practice in disease surveillance and control
- economies sharing scientific and support facilities

- promoting the cross-fertilisation of science across the three areas
- the inclusion of human, plant and animal disease control, which would address both economic development and human health, thereby linking the output of the centres to a range of policy needs.

Such an approach would also encompass two wider benefits. Firstly, it would act as a focus for the development of technology relevant to African problems, rather than that derived from technology from developed countries. Furthermore, this novel approach would provide the kind of scientific challenge to the new generation of African scientists that should propel them to undertake work in Africa and will both address an issue central to African development and be conducted at the global cutting edge of science.

6.5 Conclusion

Clearly, a single meeting of experts cannot, by itself, hope to solve the challenge of infectious disease in Africa. However, this report has argued that a step-change in approach – a quantum leap – is needed. A key output of the workshop has therefore been the expression of a range of expert views on how such a leap could be achieved. Those views have been presented above, not to tell African governments and stakeholders what must happen, but rather to stimulate fresh debate and fresh thinking in this area. It is hoped that those governments, the AU and stakeholders will themselves take these ideas forward and develop them further.



Appendix A:

Areas of commonality of the proposed Pan-African Vision and Strategy with the Report of the Commission for Africa[1]

These include:

Science

- Promoting capacity in science and technology (Ch 4, para 26).
- Using centres of scientific excellence as springboards for developing scientific capacity (Ch 4, para 28).
- Up to 30 centres proposed in physical, medical and social sciences (Ch 4, para 30).
- The need to combine physical centres of excellence with virtual networks of research that are internationally competitive (Ch 4, para 29).

Agriculture

- The need to link the creation of centres of excellence with the need to expand agricultural research (Ch 4, para 32).
- The huge burden faced by farmers from pests and diseases affecting crops and livestock (Ch 7, para 83) – particularly important in view of the large dependence of some African economies on commodities (Ch 8, para 49).
- The need for major growth in research in agriculture in Africa over the next 10 years (Ch 7, para 92).

Health

- The need for urgent investment to repair and develop health systems (Ch X, para XX).
- Promoting capacity-building in the health worker crises (Ch 6, para 40).
- Building information and management systems for health, and using them to build capacity (Ch 6, para 41).
- Strengthening infrastructure – including access to affordable diagnostics etc (Ch 6, para 42).
- Development of effective diagnostics (Ch X, para 43).
- Adopting a regional approach to achieve critical mass between small markets and limited capacity (Ch X, para 45).
- Taking the initiative forward as a partnership between the WHO and the AU/NEPAD (Ch X, para 49).
- Investing in the training of health workers (Ch X, para 50).
- The need to integrate better the various existing initiatives which are tackling different diseases in Africa (Ch X, paras 33 and 58).

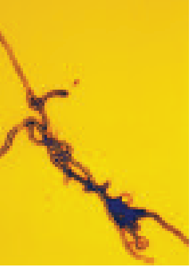
[1] *Our Common Interest: Report of the Commission for Africa*, March 2005 – ISBN 0-1410-2468-2

Appendix B:

Experts and stakeholders who attended the Foresight workshop on infectious diseases: Entebbe 1–3 August 2005

The following provides a list of attendees. Those marked in bold are the organising team.

Attendee	Position	Organisation
Dr Sidibe Amadou Samba	OIE Regional Representative	World Organisation for Animal Health, Bamako, Mali
Dr William Amanfu	FAO Animal Health Officer	Food and Agricultural Organisation, Rome, Italy
Ms Alice Baxter	Manager International Plant Health Matters	Department of Agriculture, Republic of South Africa
Dr Eshetu Bekele	Senior Researcher Plant Pathology	Ethiopian Agriculture Research Organisation, Ethiopia
Professor Joe Brownlie	**Professor of Veterinary Pathology and Director of ECTP**	**Royal Veterinary College, UK**
Mr Komayombi Bulegeya	Commissioner, Crop Protection	Ministry of Agriculture, Animal Industry and Fisheries, Uganda
Dr Deborah Burgess	Senior Programme Officer	Bill and Melinda Gates Foundation, USA
Dr Kevin DeCock	Director	CDC Kenya
Dr Mike English	Senior Research Fellow	KEMRI/Wellcome Trust Collaborative Programme, Kenya
Mr Derek Flynn	**Foresight Infectious Diseases Project Leader**	**Office of Science and Technology, UK**
Dr Berhe Gebreegziabher	Director	National Veterinary Institute of Ethiopia
Professor Dominic Kambarage	Professor of Veterinary Medicine and Public Health	Sokoine University of Agriculture, Tanzania
Professor Mark Laing	Director	African Centre for Crop Improvement, Pretoria, South Africa
Dr Berga Lemaga	Co-ordinator	Association for Strengthening Agricultural Research in Eastern and Central Africa, Entebbe, Uganda
Dr John Lynam	Managing Director	Kilimo Trust/Gatsby Charitable Foundation, Kampala, Uganda
Dr Keith McAdam	Director	Infectious Diseases Institute, Makerere University, Uganda
Professor Uswege Minga	Professor and Registrar	The Open University of Tanzania
Professor Malcolm Molyneux	Director	Malawi-Liverpool Wellcome Trust
Dr Dilys Morgan	**Head, Emerging Infections and Zoonoses**	**Health Protection Agency, UK**
Dr Monica Musenero Masanza	Epidemiologist	Ministry of Health, Uganda



Attendee	Position	Organisation
Dr Jotham Musiime	Consultant	Formerly Director African Union–Inter-African Bureau for Animal Resources, Nairobi, Kenya
Professor Anthony Musoke	Research and Technology Manager	Onderstepoort Veterinary Institute, South Africa
Dr Baleguel Nknot	Managing Director	Yaounde Initiative Foundation, Cameroon
Dr David Nowell	Agricultural Officer	Food and Agricultural Organisation, Rome
Dr Stephen Nutsugah	Senior Research Scientist/ Head, Plant Pathology Section	Savanna Agricultural Research Institute, Ghana
Professor Timothy Obi	Professor of Veterinary Medicine and Public Health	Ibadan University, Nigeria
Dr James Ogwang	Agricultural Director of Research	Coffee Research Institute, Kituza, Uganda
Dr William Olah-Mukani	Director of Animal Resources	Ministry of Agriculture, Uganda
Dr Ahono Olembo	Assistant Director	African Union–Inter-African Phytosanitary Council, Yaunde, Cameroon
Dr Alex Opio	Assistant Commissioner	Ministry of Health, Kampala, Uganda
Dr Fina Opio	Director of Research	Namulonge Agricultural and Animal Production Research Institute, Uganda
Dr William Otim-Nape	**Former Director General**	**National Agricultural Research Organisation, Uganda**
Dr Erasmus Otolok-Tanga	Consultant	Institute of Public Health, Uganda
Dr Rosanna Peeling	Diagnostics Research and Development	World Health Organisation, Geneva
Dr Alistair Robb	Health Adviser	Department for International Development, Kampala, Uganda
Dr Francis Runumi	Commissioner for Planning – Health Services	Ministry of Health, Uganda
Dr Mark Rweyemamu	**Consultant**	**Tanzania**
Dr Osman Sankoh	Communication and External Relations Manager	Indepth Network, Ghana
Dr Sidi Sanyang	Consultant in the Executive Secretary's Office	Forum for Agricultural Research in Africa, Accra, Ghana
Dr Scott Sellars	Scientific Officer	Department for Environment, Food and Rural Affairs, UK
Dr David Serwadda	**Consultant**	**Institute of Public Health, Makerere University, Uganda**
Dr Dewan Sibartie	Deputy Head, Scientific and Technical Department	World Organisation for Animal Health, Paris
Dr Peter Sinyangwe	Director	Veterinary Services, Ministry of Agriculture and Co-operatives, Zambia

Attendee	Position	Organisation
Dr Evans Taracha	Operating Project Leader	International Livestock Research Institute, Kenya
Dr Eugene Terry	Interim Network Co-ordinator	Biosciences Eastern and Southern Africa, Kenya
Dr Yaya Thiongane	Director	Laboratoire national de l'élevage et de recherches vétérinaires, Senegal
Professor David Thomas	Professor for	Institute of Public Health, Makerere University, Uganda
Dr Graham Thompson	Research and Technology Manager	Agricultural Research Council – Institute for Industrial Crops, South Africa
Dr Karim Tounkara	Head, Diagnostics technology Transfer	African Union–Inter-African Bureau for Animal Resources, Nairobi, Kenya
Dr Modibo Traore	Director	African Union–Inter-African Bureau for Animal Resources, Nairobi, Kenya
Dr Peter Tukei	Assistant Director	CDC/KEMRI, Kenya
Dr Emily Twinamasiko	Senior Research Officer – Adaptive Research	National Agricultural Research Organisation, Uganda
Professor Jeff Waage	**Head Agricultural Sciences**	**Imperial College London**
Dr Henry Wamwayi	Chief Technical Adviser	Somali Animal Health Services Project
Dr Fabio Zicker	Co-ordinator, Research Capability Strengthening	World Health Organisation, Geneva

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