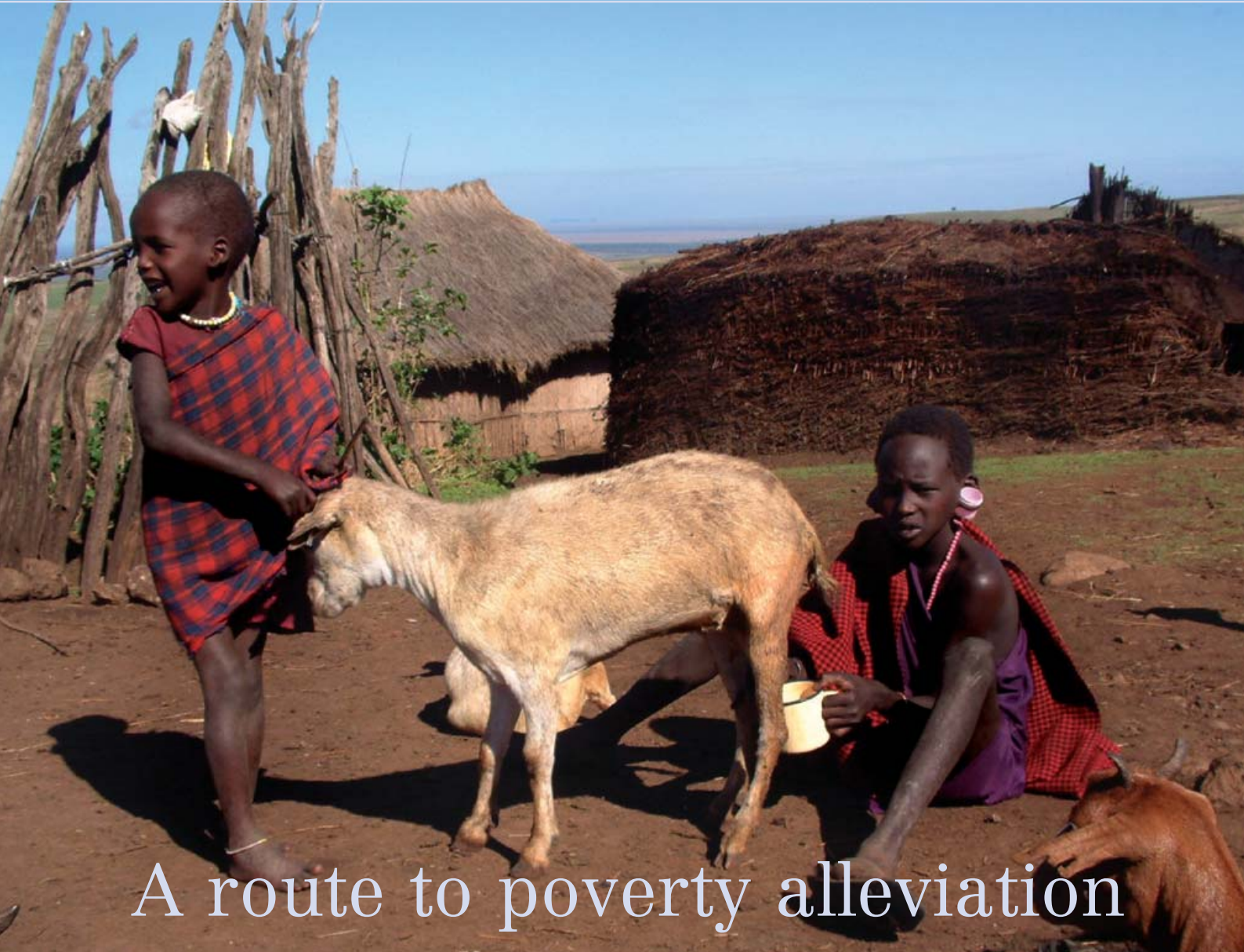


The Control of Neglected Zoonotic Diseases



A route to poverty alleviation

Report of a Joint WHO/DFID-AHP Meeting
with the participation of FAO and OIE

Geneva, 20 and 21 September 2005

AHP
Animal Health Programme

DFID



**World Health
Organization**

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Preface

As we enter the second phase of our attempt to meet the Millennium Development Goals, it is important to identify special areas where targeted interventions can have a real impact in reducing poverty in households and communities.

Because they affect both people and animals, especially where they involve livestock, interventions to control zoonoses require concerted action between the veterinary and the human health sectors, while also offering substantial benefits to both sectors. WHO has long taken the lead in bringing together international and national organizations to deal with the problems posed by both emerging and endemic zoonoses. Although much publicity has been accorded to the emerging zoonotic diseases, it is the endemic, and occasionally epidemic zoonoses, which year in, year out affect poor livestock keepers in marginalized communities. These diseases were the focus of this meeting.

Meanwhile, the DFID Animal Health Programme (DFID-AHP) has been engaged in research on zoonotic disease for two-and-a-half decades. It has become increasingly obvious that the results obtained in the field of animal health need to be very firmly linked with the work being done on disease in humans and this challenge has been enthusiastically taken up by the research community.

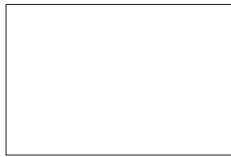
However, in order for the work being done on research and control to have a real impact, it needs to achieve a higher profile and attract more substantial and long-term funding. This meeting, organized jointly by WHO and DFID-AHP, brought together donors, researchers and those working on the control of endemic zoonoses in three continents, to discuss the current situation, recent achievements and map out a way forward.

It is our view that the control of endemic zoonotic diseases offers a very real and highly cost-effective opportunity for alleviating poverty in remote rural and marginalized peri-urban communities of poor livestock keepers. This report outlines some of the reasons why, as seen by those involved in research on and control of these diseases.

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Acknowledgements

We would like to thank all those who participated in this meeting and who provided the background material and presentations from which this report was compiled. Details of individual presentations can be found in the attached meeting agenda and these correspond to the relevant sections in this report. Other sections are based on the working group reports and the recommendations were formulated at plenary sessions of the meeting.

Particular thanks go to Winyi Kaboyo for chairing the meeting, Maria Vang Johansen for acting as rapporteur, and Marion Reverdin for the day-to-day organization of the meeting and for assembling an impressive dossier of background material and abstracts. For those readers who are interested, the full dossier can be obtained by e-mailing her at reverdinm@who.int.

Special thanks are also due to Alexandra Shaw for her tireless efforts in finalizing this comprehensive report.





Summary

Measures to safeguard human health and to control disease in livestock and other animals for the prevention of the transmission of animal-borne or zoonotic diseases are too often undertaken in isolation of one another. The meeting, organized jointly by the World Health Organization (WHO) and the Animal Health Programme of the UK Department for International Development (DFID-AHP), showed the dual benefits to be gained by both the animal and human health sectors by investing in the integrated and coordinated control of these diseases.

The meeting saw how, with more effective measures, we have the chance to simultaneously save lives and secure livelihoods. Effective control of zoonotic diseases would mean a decreased disease burden, poverty reduction and increased food supply for large numbers of the rural poor worldwide, thereby contributing towards the achievement of the Millennium Development Goals (MDGs) - <http://www.un.org/millenniumgoals/index.html>.

Cost-effective control measures already exist for several neglected zoonotic diseases such as rabies and brucellosis. More integrated interventions can be packaged through these existing structures. In certain cases, with the right programmes and adequate funding, this could lead to regional or even global control, or complete elimination of individual diseases such as dog rabies and echinococcosis in North Africa or brucellosis and echinococcosis in northern China.

The meeting recommended that the possible next steps to achieve an integrated animal-human health approach should include:

- promoting the concept of 'one health' by dealing with health problems in both people, their livestock and other domestic and wild animals they depend on through the development of integrated 'control packages' that address several disease/health problems;
- undertaking a number of measures to raise the profile of the neglected zoonotic diseases both internationally and within affected countries;
- systematically collecting data on the incidence of these diseases supported by studies to estimate their dual burden on people and on livestock, quantify under-reporting and identify communities and groups at risk;
- investing in the development of new tools needed to effectively control these diseases, particularly in the field of diagnostics.



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1

Why focus on endemic zoonoses?

The need to fight neglected diseases is incontestable – from a moral perspective, a human rights perspective and an economic perspective, as well as a global goods perspective.

WHO/CDS/CPE/CEE/2004.45

Although one or more of these diseases can be found in almost every livestock-keeping community in the developing world, they are often simply forgotten.

The endemic zoonoses occupy a unique position at the interface between zoonotic disease, neglected diseases and poverty perpetuated by poor health and threats to livelihoods.

Over recent years, public awareness of the risks posed to human health by various diseases of animal origin has been greatly increased by the emergence of new diseases which pose a worldwide threat to both human and animal health. There have been a number of high-level meetings to address the problems posed by the emerging zoonoses – zoonoses being those diseases which can be transmitted to people from animals. In particular, the WHO/OIE/FAO joint consultation held in May 2004 brought together the leading international organizations in the fields of both human and animal health.

At the same time, while much of health funding has been directed at the ‘big three’ major disease complexes of HIV/AIDS, tuberculosis and malaria, there has also been a growing realisation that in the shadow of these huge problems a number of other diseases have tended to be increasingly overlooked. These have come to be characterised as ‘neglected diseases’. In December 2003, an important workshop on the control of these diseases was held in Berlin. There is now widespread recognition that a cluster of ‘neglected’ diseases exists, which above all affect poor marginalised populations and which neither attract the health resources nor the research needed to control them effectively. These diseases play a key role in perpetuating poverty.

Turning to the animal side, recent research has highlighted the extent to which livestock play an important role both as a cash reserve and a source of income for poor people and offer great potential as a route out of poverty. However, in the field of development, livestock have tended to be treated as the ‘poor cousins’ of crop agriculture, receiving far less financial support from donors and national governments.

It is against this background that WHO and the DFID Animal Health Programme decided to set up a joint meeting focusing not on emerging zoonoses, but on zoonoses which are ‘endemic’ in the sense that, although they are subject to occasional epidemics, they are found throughout the developing world where the conditions for their maintenance and spread exist. These are, for the most part, diseases which have been present for centuries and which are usually associated with populations living in close proximity to their animals. Unlike the emerging zoonoses, which rightly attract considerable international attention, the endemic zoonoses fall very much into the category of neglected diseases and as a result some are now reemerging health problems. They affect the poorest communities. Because they also affect livestock, causing lowered productivity or death, they not only attack people’s health, but also their livelihoods.

2

Why we met

The meeting brought together people from three continents, from the veterinary and medical fields, from research and development, dealing with diverse problems ranging from worms, tsetse flies to rabid dogs – to address a problem of common interest and to benefit from the approaches each had developed.

The overall objective of the meeting was to bring together groups that would not ordinarily meet to address a problem of common interest. In the field of zoonotic disease this is particularly important, since effective control relies on active involvement of both veterinary and human health services. This dual involvement needs to take place at every stage, from research, organizing funding, planning, surveillance, creating public awareness, to implementing the actual control activities. Thus the meeting brought together researchers working on the selected diseases from both the livestock and human viewpoint, individuals involved in the control of these diseases in government and non government organizations as well as donors and representatives of UN agencies. People actively involved in zoonoses control in Africa, Asia and South America attended.

In order to provide a clear focus for the meeting, seven diseases of particular interest were selected: anthrax, bovine tuberculosis, brucellosis, cysticercosis, cystic echinococcosis, rabies and zoonotic trypanosomiasis. This was not intended as an exclusive list and the discussions ranged over a number of other zoonotic diseases. The list cuts across sub-disciplines, again with the objective of bringing together individuals who would not necessarily be working together otherwise.

The meeting was structured so as to provide a mix of presentations and posters on research and ongoing control activities while allocating over half its time to working-group discussions. The following pages report on the key themes dealt with – the need to understand why zoonotic diseases matter, their association with poverty, the problem of under-diagnosis, the difficulties of dealing with diseases that involve both medical and veterinary communities and the possibilities of benefiting both people and livestock in taking action to control these diseases. The report outlines a series of success stories for the selected diseases and reports on the working-group discussions on advocacy and prioritization for these diseases, how to promote cooperation between medical and veterinary institutions in their control, how to ensure that control efforts are sustained and what tools are missing for effective control of individual diseases.

A great deal of enthusiasm was generated at this first meeting of the group – people felt they learnt a lot and were able to share views, information and discuss difficulties with others working in similar situations. It represented an initial attempt at setting out the issues and problems involved. It is hoped that there will be further occasions when the synergy and dynamism generated can be exploited and used to set out a more detailed agenda and monitor our progress in dealing with endemic zoonoses in developing countries.

3

Why zoonoses matter

A large proportion of human pathogens – about 60% - are zoonotic and over 800 pathogens have been defined as zoonoses.

*Taylor et al., 2001
Woolhouse and Goutage, 2005*

Zoonoses are defined as those diseases and infections naturally transmitted between people and vertebrate animals. In most cases, animals play an essential role in maintaining the infection in nature and contribute in varying degrees to the distribution and actual transmission of infection in human and animal populations. These diseases have a variety of transmission mechanisms that may be direct such as in rabies and anthrax, or indirect, via vectors, food, water and the environment, as in the case of bovine tuberculosis and cysticercosis. Many, such as brucellosis, also have multiple routes of infection. With the constant and inevitable interaction of man and animals, zoonotic diseases remain a genuine threat to health and survival for people, their livestock, companion animals and wildlife.

A number of zoonoses are among the oldest known diseases and many are entrenched, particularly in rural agricultural communities. Increasingly they are also found in urban areas where people keep livestock and live in close contact with their animals. With the exception of zoonotic trypanosomiasis, or sleeping sickness, which is restricted to parts of Africa, the zoonoses focused on at the meeting are found worldwide, although for the most part, they have now been effectively controlled in richer countries so that their burden falls mostly on the developing countries. According to Coleman (2002), of the 27 infectious diseases listed in the WHO Global Burden of Disease DALY (disability adjusted life-year) table, 20 can be classified as zoonoses on the basis of documented natural transmission between animals and humans and in the case of seven of these (trypanosomiasis, schistosomiasis, leishmaniasis, Chagas disease, Japanese B encephalitis, hookworm and hepatitis caused by hepatitis E virus) there is evidence to show that the animal transmission cycle is important, so that veterinary intervention could affect the global burden of the disease. However, the extent to which the endemic zoonoses on which this meeting focused are neglected is evidenced by the fact that global estimates exist for only three of them, echinococcosis, trypanosomiasis and rabies. Foodborne diseases mildly or severely afflict almost half of the world's population at any given time. Their public health importance is often ignored because their true incidence is difficult to evaluate and the severity of their health and socioeconomic impacts is often unclear. Moreover, there is very limited information in most countries on the spread of foodborne zoonotic infections among the human population. Brucellosis, bovine tuberculosis, some parasitic diseases and salmonellosis are among the foodborne diseases of greatest importance.

It has been suggested that 75% of emerging pathogens fall within the category of zoonotic diseases. These include SARS, avian influenza, HIV, Ebola, West Nile virus and Nipah virus.

Ultimately, however, zoonoses matter not just because they are so common, but because they cause mortality and morbidity in people, while also causing significant economic losses in livestock. Their burden tends to fall most heavily on poor societies.

Elizabeth Miranda

The significance of zoonotic diseases is expanding and their health and socioeconomic impacts are increasingly being experienced by many countries, particularly the developing ones. In these countries, the establishment and implementation of adequate measures for livestock and consumer health protection against zoonoses, especially those that are new and emerging, has proven to be very difficult. Thus zoonotic diseases continue to further burden public health systems as well as to undermine efforts to boost livestock production and exports.

4

Zoonoses and poverty

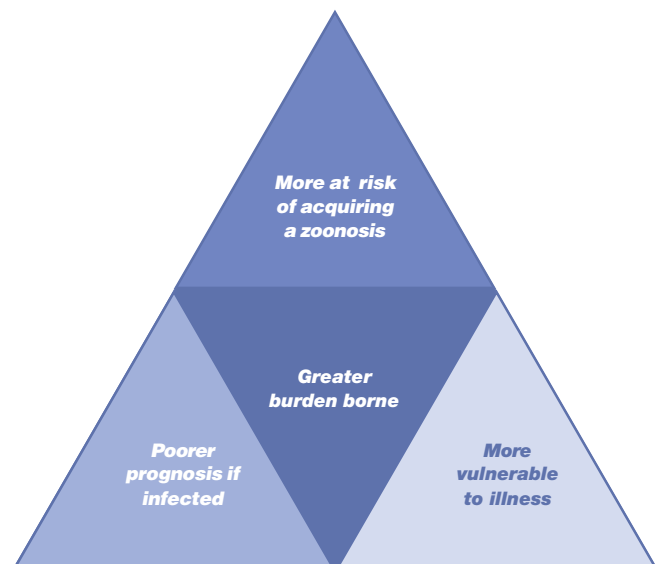
The impact of zoonotic diseases and foodborne infections and intoxications on health and wellbeing is greatest among the 800 million food-insecure livestock keepers, consumers, traders and labourers.

FAO

Zoonoses typically affect isolated rural livestock keeping communities and those living in urban slums. Thus, like other neglected diseases, neglected zoonoses can be characterized as diseases of 'neglected populations'.

The poor in every society, and particularly in developing countries, bear a disproportionately high share of the burden of disease. However, in the case of zoonoses, there are a number of reasons why their burden falls especially heavily on poor people which go beyond the usual reasons of access, affordability and vulnerability.

Firstly, poor people are more at risk of contracting many zoonoses. There is a strong association between poverty and living in close contact with animals, the reservoirs of disease. For some diseases the risk factors are very clear – bovine tuberculosis, anthrax and brucellosis are primarily occupational diseases, affecting livestock keepers and, in the case of anthrax, those who process animal products, such as tanners. For those diseases which affect consumers of livestock products, again the risks are skewed towards the poor. Pork which cannot be marketed because it contains cysts can be sold off cheaply, unpasteurized milk sold in non-sterile conditions, meat from dying animals slaughtered near the farm or in backyards are all bought or eaten by the poorest consumers. And with these livestock products come brucellosis, bovine TB, cysticercosis... Dogs living in areas where people are too poor to vaccinate them or deworm them are more likely to be rabid or carry tapeworms. Pigs living in areas with



poor sanitation are those which get cysticercosis. Recent research into the risk factors for TB in United Republic of Tanzania has clearly shown that for all forms of human extrapulmonary TB, the risk of disease was greatest among remote, marginalized and impoverished households.

Secondly, once infected, it is the poor who are least likely to get proper treatment. Again, there are a number of reasons why this is particularly so for zoonotic diseases. Most have to do with the sheer difficulty of obtaining a correct diagnosis – reflecting not just the lack of diagnostic facilities or cheap and effective tests but also the fact that zoonoses are mostly contracted by remote rural populations for whom the cost of repeated trips to health centres in search of treatment or diagnosis eventually becomes prohibitive. For example, those who were successfully diagnosed as suffering from zoonotic trypanosomiasis in Uganda had, on average, made three prior trips to a health facility – and these already represented the more affluent sub-group, those most likely to be able to insist on getting a correct diagnosis. In the case of rabies, where the key to survival from an infected dog bite is rapid administration of a good quality post exposure treatment, their

The lower down the income scale, the more likely is the high risk of multiple zoonotic infections...

Perry et al., 2002

Livestock contribute to the livelihoods of at least 70% of the world's rural poor.
Livestock in Development, 1999

Because zoonoses also affect their livestock, which poor households rely on as source of funds in emergencies, they not only make members of the family ill, but at the same time take away the funds that would be used to cope with that sickness.

availability is almost entirely a function of national and individual income – poor countries are unable to stock sufficient supplies, they are seldom available in rural locations and often, where they are available, quality human cell-culture vaccine which costs about US\$75 is only available to paying customers, others have to make do with cheaper alternatives which are less effective and can cause unpleasant and/or serious side effects.

Thirdly, the impact of disease is worst in poor households where a dual burden is borne since it affects both people and animals. In humans, some zoonotic diseases are clustered in certain age groups – for example sleeping sickness tends to be diagnosed in active adults as do diseases like anthrax, tuberculosis and brucellosis which are linked to livestock-keeping occupations. Illness or death of a breadwinner has a devastating impact on rural households. Other zoonoses primarily affect children, who are those most likely to suffer a fatal bite from a rabid dog. Dealing with these diseases places a big strain on the other adults in the household, either as carers or accompanying the patient while seeking or receiving treatment. In poor households, spare labour and spare funds do not exist so that the burden of looking after a seriously ill family member will push the household further into poverty or extreme poverty.

Furthermore, in communities where people are suffering from zoonoses, the livestock are sure to be affected as well. Animal trypanosomiasis, caused by trypanosomes which are not pathogenic to humans, coexists in the same herds and flocks which harbour the trypanosome causing sleeping sickness, and is a major cause of low productivity and mortality in African livestock. Cysticercosis causes major losses to pig producers through carcass condemnations and cystic echinococcosis through liver condemnations. Anthrax outbreaks are accompanied by high mortality in livestock. Tuberculosis and brucellosis depress livestock productivity and rabies, while mainly affecting carnivores, does cause deaths in livestock – usually cattle.

The number of poor livestock-keepers worldwide is estimated at somewhere between 500 and 900 million by various sources. For these people livestock are a vital component of their survival strategy and, if healthy and well managed, can offer a route out of poverty. Livestock, especially smaller animals, are sold to meet emergency expenditures – such as treatment and hospitalization of family members or food in times of shortage – and thus form a vital component of poor households' coping strategies. Small-stock tend to be kept by women and provide a modest regular income in the form of egg or milk sales which goes directly to women and children, the latter sometimes benefiting from the extra protein available in the household. Because poor people keep fewer animals, they are far more vulnerable to an animal's illness or death. And for animals too, the prognosis is worse if they are kept by a poor household - when an animal does fall ill, the livestock keepers are unlikely to be able to afford to treat it or to have good access to veterinary services and healthcare information.

Distribution of the world's 556 million poor livestock keepers



Source: Thornton et al., 2002

5

A problem of under-diagnosis: why we see only the tip of the iceberg

Zoonoses are amongst the most seriously under-diagnosed of all human diseases.

Schwabe, 1984

The first step in dealing with a disease is understanding the magnitude of the problem. For a variety of reasons, in the case of many zoonoses, their incidence is completely unknown, and usually greatly underestimated – far more so than is the case for other disease categories. This under-estimation in turn leads to neglect due to a lack of evidence for government and donor decision-makers on the importance of these diseases. This problem operates at the local, national (e.g. ministries of health) and international (e.g. Global Burden of Disease Study, donor priorities) levels.

The reasons for under-diagnosis fall into two broad categories. Firstly, many zoonotic diseases are inherently difficult to diagnose.

- They are often very **unevenly spread geographically**, being known in one locality and unknown in another.
- Their **symptoms are shared** with a number of other common diseases. For example, in any country where malaria is present, the recurrent fevers which are a characteristic of brucellosis will tend to be overlooked. The symptoms caused by the various tape worms and cysts transmitted via cattle, pigs, dogs and sheep are not easily differentiated from the many other intestinal problems and tumours found in various human populations.
- Definitive **diagnosis is complex** and/or reliable, cheap diagnostic tests are not available. Both are true for zoonotic trypanosomiasis, since the parasite is not always evident in the blood and for which the low-cost screening test used for the chronic, non-zoonotic form of the disease does not work. Bovine tuberculosis and the more common form of human tuberculosis often present very similar clinical pictures, but can require different treatment; however, few hospitals have the diagnostic capacity to distinguish between them.

Recent research has shown, for example, that there are up to 10 times more rabies deaths in African countries than officially reported and that there are 12 undetected deaths in the community for every sleeping sickness death officially reported in hospital settings in Uganda.

*Eric Fèvre
(see Cleaveland et al., 2002
Knobel et al., 2005
Odiit et al., 2005
Fèvre et al., 2005a, 2005b)*

Secondly, the channels through which diseases would normally be reported do not function effectively for a number of reasons.

- **The patients** may have poor knowledge of disease symptoms or general hygiene measures to prevent disease transmission. In Uganda, only about 33% of respondents to a questionnaire survey knew where to seek treatment for sleeping sickness and only 20% knew how to prevent the disease. Similarly, in Senegal, 0%, 10% and 18% of respondents knew of preventative measures for anthrax, bovine tuberculosis and brucellosis respectively (personal communication, Fred Unger). There may also be major financial barriers to patients reporting to health units, owing to the cost of treatment or simply the cost of transport.
- **The medical practitioners** in rural areas may not be qualified physicians (e.g. medical assistants), such that less common diseases are less-well diagnosed. Knowledge of different zoonoses was found to be poor amongst hospital staff in northern Tanzania, for

example. In centralized systems, there is little feedback to peripheral levels, so medical staff may be unaware of the “larger picture” for a particular disease problem.

- **The veterinarians** are often at the front line of dealing with zoonotic diseases, but receive little support from medical colleagues – there is a lack of awareness and responsibility for human health-related problems. There is a real need for integration of veterinary and medical sectors for disease prevention. Veterinary staff also lack the facilities for efficient diagnosis.
- **The health system**, as an institution, often fails to provide sufficient resources for diagnosis (e.g. microscopes, ultra-sound scanners, slides). There are also issues with the system of referrals and staff training and the transference of key data within the system.
- **The financial situation** is often a major obstacle across all of the above.

For these reasons, estimates of the incidence and burden imposed by zoonotic diseases, especially the neglected endemic zoonoses, seldom reflect their real importance in the communities in which they occur. Consequently much of the neglect of these diseases stems from a lack of evidence for government and donor decision-makers on their importance. Decision-makers at local, national and international levels rely on data on morbidity and mortality to make decisions about budgetary allocation. When data are lacking diseases are simply not prioritized.



© Photo: Eric Fèvre

Villagers queuing for sleeping sickness screening in eastern Uganda.

6

Divided constituencies: medical needs and veterinary responsibilities

Zoonoses often fall, overlooked, into the gap between veterinary responsibilities and medical needs.

Winyi Kaboyo

The medical and veterinary professionals and sectors have traditionally focused respectively on the improvement of human health and on livestock production as their primary objective. It is this compartmentalization of the medical and veterinary sectors which underlies the “*divided constituencies*” which predominate, but which is less desirable in poor countries where the zoonotic disease burden is greatest. Zoonoses have direct impact on public health and livestock production and therefore should be a point of convergence for the two sectors providing an opportunity for “*unified constituencies*”.

Successful zoonoses control requires four elements – a legal framework, a policy framework, institutional structures and a programme implementation plan – but currently there are gaps in each element.

Firstly, a strong legal and regulatory framework is essential to help enforce disease prevention and control laws and regulations; for example, in Nepal, a VPH programme was introduced but was subsequently abolished partly because the necessary legislation and regulatory guidelines were lacking. Gaps exist in disease control laws and regulations, e.g. in Uganda the *Rabies Control Act* empowers the veterinarian to deal with rabies in the animals while the same law is silent on the disease in humans; this is a major concern for the medical sector.

The crux of the problem is that for many zoonoses, it is the risk to human health that is most important, while the most effective control route is via the animal.

Secondly, policy frameworks and institutional mandates do not favour effective zoonoses control, because differences exist in the policy, vision and mission of the medical and veterinary sectors, with each emphasizing their traditional “*divided constituencies*” of public health and livestock production respectively. In Uganda, “the overall objective of the health sector is to reduce morbidity and mortality from the major causes of ill-health and the disparities therein”. This objective lacks emphasis on the minor causes of ill-health to which zoonotic diseases belong. Likewise in the veterinary sector the “National vision for the livestock sub-sector is to increase the production and productivity of the livestock resources on a sustainable basis...”. Although there is a policy on zoonoses, it mainly focuses on livestock production by: improving public health standards for animal products, reducing economic losses associated with condemnation of animal products and promoting the export of livestock and livestock products. The control of dog rabies does not directly benefit the livestock economy and is therefore not a priority of the livestock production policy.

Unsurprisingly, over-stretched and under-funded veterinary and medical services both hope the other will deal with a problem that each sees as the other's remit. For example, rabies control programmes anchored on mass animal vaccination and population control, cannot effectively compete for limited government agricultural resources mostly used for productive animals such as cattle and poultry.

Thirdly, institutional structures to bridge the gap between veterinary responsibilities and medical needs are lacking at technical and political levels. Some do exist – for example, The Pan American Institute for Food Protection and Zoonoses in Latin America, the WHO's Mediterranean Zoonoses Control Programme in Athens and a Veterinary Public Health office in Uganda. There is a lack of established structures to facilitate technical, inter-ministerial collaboration and training of medical professionals to address the zoonotic diseases burden which is usually regarded as the responsibility of the veterinarian.

Fourthly, when it comes to implementation of control strategies the same difficulties are again encountered.

In most poor countries, there is no mechanism by which human cases of zoonotic diseases are automatically reported to veterinarians nor animal cases to health services. Thus, the full burden of these diseases is not recognized, and more importantly, the risk posed is not appreciated and the opportunity to prevent transmission between animals and people is missed.

- In many countries zoonoses are neither a priority of the health nor the veterinary sector. In Uganda, according to the 1995 Burden of Disease Study, 75% of life years lost to premature death were due to 10 preventable diseases none of which was zoonotic. However, when the burden of zoonoses is studied in the communities where they actually occur, it becomes rapidly evident that this burden can be very high. For example, in Uganda, in an area where zoonotic HAT was prevalent, there were 178 times as many cases of malaria, but the burden of disease imposed by malaria was only three times as high (personal communication, Martin Odiit). The veterinary sector and the Pan-African Programme for the Control of Epizootics (PACE) have invested in control of livestock diseases that impact on the livestock economy such as rinderpest, foot-and-mouth disease, contagious bovine pleuro-pneumonia and other emerging diseases.
- Due to the scarcity of funds in poor countries and lack of external financial resources, zoonoses are usually ignored by either sector. For example, if zoonotic bovine tuberculosis was found to contribute significantly to the human TB burden, rather than compensate farmers in a cattle test and slaughter campaign, the medical sector would continue with the management of human TB cases while the veterinary sector would concentrate on meat inspection and condemnation of infected carcasses.
- There is also a significant human resource gap, with a dwindling number of committed professionals engaged in zoonoses control activities in poor countries. In sub-Saharan Africa, reporting of rabies drastically dropped from about 30 countries in 1993 to only four in 2003. This could be attributed to lack of human resources and poor intersectoral collaboration because of the “divided constituencies” where the medical and veterinary sector each takes reporting to be a responsibility of the other.



© Photo: Sarah Cleaveland

Taking blood to screen for livestock diseases – United Republic of Tanzania.

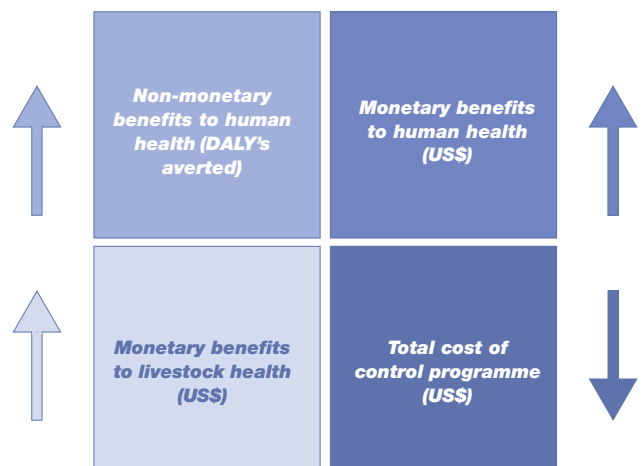
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Zoonoses control: a cost-effective opportunity for poverty alleviation

Much decision-making on resource allocation and the priority given to different disease control activities is influenced by economic arguments and evidence. However, neither the discipline of health economics nor veterinary economics has yet come up with a totally satisfactory way for dealing with those diseases which affect both people and livestock and therefore span both disciplines and, historically, studies have tended to look at problems either from the human or the animal side, but not both. The main stumbling block has been the difficulty of combining monetary and non-monetary elements. Recently however, some pioneering studies have looked at both aspects of the problem and combined the estimates of benefits and costs (e.g Budke et al., 2006, Carabin et al., 2005, Roth et al., 2003).

The components of benefits from controlling a zoonosis are illustrated in the figure opposite. They consist of the DALYS averted (the non-monetary component), monetary benefits to livestock in terms of improved productivity and animal treatment costs saved and monetary benefits to the human health sector in terms of savings in human treatment costs as well as patients' private costs both for treatment and through loss of income averted in patients and those caring for them.

The overall cost-effectiveness of any intervention to control these diseases should be considered in terms of its societal impact; that is in terms of how all three components of benefits compare to the costs of control. There are a number of reasons why this relationship is very favourable.



- For these diseases the DALYs incurred tend to be high in relation to the number of reported cases. This is due firstly to under-reporting, which leads to an underestimation of the true number of DALYs which can be averted by effective control. Secondly, a number of these diseases are severely disabling (neuro-cysticercosis, echinococcosis); others are inevitably fatal if untreated (rabies and sleeping sickness). Thus the DALYs which can be averted per affected individual are also high. Most are more prevalent in children (rabies, echinococcosis) or among economically active adults (sleeping sickness, cysticercosis) thus carrying a high disability burden.
- The monetary benefits from improved human health through disease prevention also tend to be high. This reflects the high cost of treatment for some of these diseases, ranging from US\$75 for good quality rabies post-exposure prophylaxis, US\$800 for treating a sleeping sickness patient in late stage of the disease to several thousand dollars for operations to remove hydatid cysts. For many

of these diseases, diagnosis is also expensive or difficult and, for this reason, patients themselves spend a lot on seeking treatment.

- Turning to the benefits from preventing disease in animals, this varies greatly from zoonosis to zoonosis. Some, such as anthrax, are associated with very high mortality or, like cysticercosis, cause substantial losses to livestock producers, especially poor producers. Others affect animals whose economic value is seldom quantified, particularly dogs in the case of echinococcus or rabies. In the case of trypanosomiasis, the particular trypanosome that affects people, while carried by livestock, does not harm animals – however, treating livestock to clear the trypanosome that affects people also clears those which make the animals ill, with substantial benefits to livestock production.
- Lastly, considering the cost of controlling these diseases, there are a number of reasons why these can be relatively low. Firstly, these diseases have been recognized for a long time and cost-effective preventive measures for controlling the animal reservoir exist – vaccines for rabies, brucellosis and anthrax, deworming for dogs and pigs. A further reason why the costs can be quite low is because these diseases tend to be clustered in certain locations and among certain high risk groups. This means that both public awareness campaigns and preventive measures can be very focused, targeting specific areas and communities. Furthermore, where several zoonoses are present in one area, further economies of scale can be realized. Thus the costs of preventing these diseases can be far lower than for more widespread global health problems.

During the course of the meeting, participants cited a number of studies and results, some of which are given in the table below. The ‘separable cost’ approach is further explained in Section 9. What these calculations confirm, and what became increasingly clear during the course of the meeting, is that we now have substantial evidence to confirm that intervening to control zoonoses is highly cost-effective when considered from a societal point of view, taking into account both the medical and veterinary aspects. This is an area where targeted interventions have an enormous potential for poverty alleviation.

Some calculations for the cost to the health sector per DALY averted if costs were shared between it and the livestock sector in proportion to monetary benefit: a selection of results cited during the meeting

Disease	Intervention	Cost per DALY averted	Source
Rabies	Dog vaccination in two districts of Tanzania, includes a research component	US\$10 (US\$26 including research)	Unpublished data: Alexandra Shaw and Sarah Cleaveland
Brucellosis	Mass vaccination of cattle, sheep and goats in Mongolia	US\$19	Jakob Zinsstag, from Roth et al., 2003
Echinococcosis	Deworming domestic and stray dogs	US\$10-12	Budke et al., 2006
Zoonotic HAT	Treatment of the cattle reservoir plus limited vector control	US\$9-18	Unpublished data: Alexandra Shaw and Paul Coleman

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Seven neglected endemic zoonoses: some basic facts

Anthrax

Anthrax is primarily a disease of herbivores, although all warm-blooded species are susceptible to an extent. The causative agent is the spore-forming bacterium *Bacillus anthracis*. The ‘reservoir’ of the disease is soil contaminated by spores in the recent past or even several decades ago. Humans normally acquire anthrax either by direct or indirect contact with infected animals, or through occupational exposure to contaminated animal products. Of 60 countries reporting anthrax in 2004, nearly 60% were developing countries. In animals, the disease is almost always rapidly fatal. In people the disease takes three forms. Inhalation anthrax is an occupational disease reported only in industrialized countries and acquired by breathing in spores; gastro-intestinal anthrax is acquired from eating infected meat from an animal that died of the disease and the cutaneous form, which accounts for more than 95% of reported cases in developing countries, is acquired through skin lesions. In strong contrast to the fear of this disease in the West caused by its bio-terrorist potential, its role, year in, year out, in causing illness in poor livestock-keeping communities and sudden deaths in their herds and flocks, is largely ignored.

Bovine tuberculosis

In humans, the vast majority of cases of tuberculosis are caused by *Mycobacterium tuberculosis*. However, TB can be caused by a number of other bacteria, of which *Mycobacterium bovis*, causing so-called ‘bovine tuberculosis’ is one of the more prevalent and has the widest host range of all TB bacteria. TB due to *M. bovis* often occupies sites other than the lungs (it is extra-pulmonary), but in many cases is clinically indistinguishable from *M. tuberculosis* infection. However, patients with *M. bovis* often do not respond to the drugs commonly used to treat TB, sometimes resulting in a fatal outcome. Other, far more expensive, drugs are often needed – placing an added burden on health services. Very little is known about the share of bovine TB in the global TB epidemic, but sporadic reports of cases are received from many African and Asian countries and recent work undertaken in the United Republic of Tanzania indicates that this may be a substantial fraction. Bovine TB appears to be increasing at a similar rate to the total number of cases of TB, and HIV is the greatest factor for progression of TB infection to active TB disease. In livestock, particularly cattle, the disease causes lowered productivity, but seldom death. Like brucellosis, bovine TB has been largely eradicated from herds in the developed world by a test-and-slaughter programme.

Brucellosis

Brucellosis is one of the world’s most widespread zoonoses. Caused by various bacteria in the genus *brucella* which affect cattle, sheep, goats, pigs and some other animals, it leads to abortion, later permanently reduced fertility and chronically lowered milk yields in affected animals. It can be passed to people via direct contact with livestock or through drinking unpasteurized milk from an infected animal. In people, the main symptom is recurrent bouts of high temperature, hence its other name ‘undulant fever’ – and its tendency to be misdiagnosed as drug-resistant malaria in tropical countries. A chronic debilitating disease, it can cause a variety of other symptoms, including joint pain, fatigue and depression. It causes substantial losses to livestock producers in herds or regions where it is endemic. In most developed countries, test-and-slaughter programmes, together with compensation for farmers and accreditation and financial incentives for disease-free herds have more or less eliminated brucellosis in livestock and few human cases occur.

Cysticercosis and neurocysticercosis (NCC)

Cysticercosis is emerging as a serious public health and agricultural problem in many poorer countries of Africa, Asia and Latin America. Humans acquire *Taenia solium* tapeworms when eating raw or undercooked pork meat contaminated with cysticerci, the larval form of the tapeworm which develop in the intestine of humans where they establish and become adult tapeworms which can grow to more than three metres long. These adult worms shed eggs in human faeces that can infect in turn, the same or other humans as well as pigs – by direct contact with tapeworm carriers or by indirect contamination of water or food. The disease is thus strongly associated with pig keeping in conditions of poor hygiene. Ingested eggs result in larval worms that migrate to different parts of the human and pig body and form cysts (cysticercosis). Pigs can harbour thousands of these cysts, making the pork from these animals unsafe to eat and often resulting in the total condemnation of the pig's carcass. A principle site of migration in humans is the central nervous system. Human neurocysticercosis (NCC) occurs when the cysts develop in the brain. It is considered to be the most common parasitic infection of the human nervous system and the most frequent preventable cause of epilepsy in the developing world. WHO estimates that cysticercosis affects some 50 million people worldwide and, in endemic areas, causes some 50 000 deaths.

Cystic echinococcosis or hydatid disease

Cystic echinococcosis (CE) or hydatid disease is caused by the larval stage of the tapeworm *Echinococcus granulosus*. Its natural cycle is as a cyst in sheep and as a tapeworm in dogs. Dogs feed on infected sheep meat and in turn shed eggs in their faeces which are ingested by sheep. Humans become infected by ingesting food or water contaminated with faecal material containing tapeworm eggs passed from infected carnivores, or when they handle or pet infected dogs. Cysts, often sited in the abdomen, grow slowly over time and can become very large. The cure is usually surgery. Hydatid disease is found throughout the world in communities where sheep are reared together with dogs. It is highly prevalent in many developing countries, especially in poor communities. In humans, the incidence of surgical cases ranges from 0.1 to 45 cases per 100 000 and the real prevalence ranges between 0.22% to 24% in endemic areas. Control is through deworming of dogs and preventing dogs from eating undercooked sheep meat, especially offal, as well as abattoir control and health education. It causes serious human suffering and considerable losses in agricultural and human productivity. Transmission is facilitated by the general lack of awareness of transmission factors and prevention measures among the population at risk, abundance of stray dogs, poor meat inspection in abattoirs, improper disposal of offal and home slaughtering practices. The economic consequences are often not known, resulting in subsequent neglect during priority setting.

Rabies

Rabies is probably the best known zoonotic illness. It is caused by a virus, which usually enters the body through a bite or skin lesion and makes its way to the brain. Its dramatic symptoms in animals and people and inevitably fatal outcome in untreated patients after a cruelly unpleasant illness have made it by far the most feared of the zoonoses. From the public health point of view, the single most effective measure for preventing it remains dog vaccination, despite the occasional risk to dogs and people from infected wild animals. People who have been bitten by a suspect animal should first of all wash the wound and then seek post-exposure treatment. Various types of post-exposure treatment exist, but are often unavailable in isolated rural areas or too expensive for governments or individuals to afford. From age-stratified incidence rates, on average between 30% and 50% of human cases of rabies (and therefore rabies deaths) occur in children under 15 years of age. In some areas significant losses to livestock, especially

cattle, have been recorded. More than 99% of all human deaths from rabies occur in the developing world, with domestic dogs the source of the vast majority of human cases. Despite being one of the oldest diseases known to man and the existence of highly effective dog vaccine and post-exposure treatments for people, it is estimated that some 55 000 people a year suffer a dreadful death from this disease.

Zoonotic sleeping sickness or human African trypanosomiasis (HAT)

Unlike the other six diseases described, whose distribution is worldwide, sleeping sickness or human African trypanosomiasis (HAT) is limited to the continent of Africa where its insect vector, the tsetse fly, is found. There are two forms of sleeping sickness. The chronic gambiense form is found in Central and West Africa and although an animal can be found infected, the disease is maintained by transmission between the insect vector and humans. However, the animal reservoir is important in the acute rhodesiense form found in Eastern and Southern Africa. The causal agent, *Trypanosoma brucei rhodesiense*, infects humans, wild animals and domestic livestock, which maintain infection between epidemics, and co-



© Photo: Sue Welburn

Testing for sleeping sickness, south-eastern Uganda.

exists in animals with a complex of pathogenic trypanosomes (*T. congolense*, *T. vivax* and *T. b. brucei*) that present a major problem for livestock keepers in Africa. Untreated, the disease is always fatal in humans and devastating epidemics have occurred over the last century. Treatment is expensive, normally ranging from US\$150 to US\$800 per person, and in the later stages of the disease treatment itself involves some 5% mortality. Control is via the vector or the disease's human and livestock reservoirs. For rhodesiense, the key to preventing the disease in people is now thought to be by treating the cattle reservoir, using drugs which are effective not only against the trypanosomes pathogenic to humans but also those which cause substantial losses to livestock production – backed up by appropriate vector control measures.

For further information on any of these diseases, please visit the WHO zoonoses website www.who.int/zoonoses and individual health topics on www.who.int/topics/en.

A selection of articles outlining recent developments is cited in the references to this report alongside more general texts.

Relative public health burden of selected zoonoses associated with livestock and poor people in different sections of the community

Disease	Livestock keepers	Agricultural wage labourers	Consumers of livestock products	General population
Anthrax	3	3	1	1
Brucellosis	3	3	3	3
Cysticercosis and taeniasis	3	3	3	3
Rabies	1	1	1	1
Trypanosomiasis	2	2	1	1
Mycobacterium infections	3	2	3	1

Ranked as 1 = low, 2 = medium, 3 = high. Adapted from Coleman (2002).

9

Transforming a dual burden into a dual benefit: brucellosis in Mongolia

The control of brucellosis in humans and livestock (cattle, sheep, goat) provides a very good example of how zoonotic disease control can benefit both the human and the agricultural sector.

In Mongolia, where half the population is employed in the livestock sector, it has long been recognized that brucellosis is a major health problem for both livestock and people. A recent survey amongst herdsman and others working with animals showed 16% to be infected. It is widely accepted that human brucellosis can ultimately only be eliminated if the disease is controlled in the animal reservoir. The programmes of testing and slaughtering infected stock which were implemented in most industrialized countries are neither acceptable nor affordable in most developing countries. A cheaper alternative is mass vaccination of livestock. However, this is rarely taken up by the health sector, which views it as too expensive in relation to the benefit to human health, nor by the veterinary sector, which also sees it as an expensive measure to control a chronic disease that seldom involves high mortality.

In order to investigate whether, from a societal point of view, the dual benefits of such measures cost-effectively improve both human health and livestock productivity, an epidemiological and an economic model was used. The intervention modelled consisted of a planned 10-year livestock mass vaccination campaign using Rev-1 livestock vaccine for small ruminants and S19 livestock vaccine for cattle (Roth et al., 2003). Cost-effectiveness, expressed as cost per DALY averted, was the primary outcome. In a scenario of 52% reduction of brucellosis transmission between animals achieved by mass vaccination, a total of 49 027 DALYs could be averted. Estimated intervention costs were US\$ 8.3 million and the overall benefit was US\$ 26.6 million. This results in a net present value of US\$ 18.3 million and an average cost-benefit ratio for society of 3.2. Clearly such a programme would benefit society as a whole – but who should pay?

If the costs of the intervention were shared between the sectors in proportion to the monetary benefit to each, the public health sector would contribute 11%, which gives a cost-effectiveness of US\$19.1 per DALY averted, falling into the WHO band of highly cost-effective intervention, costing US\$25 or less per DALY averted. If private economic gain because of improved human health were included, the health sector should contribute 42% to the intervention costs and the cost-effectiveness would decrease to US\$71.4 per DALY averted, falling into the second most attractive band of interventions costing less than US\$150 per DALY averted.

Thus, if benefits to the livestock sector are added and the costs of the intervention are shared between the public health and agricultural sectors proportionally to their benefits, the control of brucellosis is profitable for both sectors. The cost-effectiveness of human brucellosis control may then be included among the highest priorities for major disease control programmes of WHO. Such trans-sectoral assessments, considering both human and animal health economics from a societal economic perspective, require innovative approaches to health economics and to zoonoses control in order to achieve improvements of public health in low-income countries that would otherwise never be cost-effective from a health sector point of view alone.

Using the 'separable costs' approach, if the monetary costs of brucellosis control were shared between the health and livestock sectors proportionately to the monetary benefits, controlling brucellosis would be profitable for both sectors. Furthermore, calculated in this way, the cost per DALY averted in the human health sector would be only US\$19.

Jakob Zinsstag

10

Going global: estimating rabies under-reporting in Africa and Asia

Extrapolating from an approach developed in Tanzania, where it showed the number of human deaths to be 100 times greater than those reported, gave an estimate of 55 000 deaths occurring annually in Africa and Asia, costing some 1.8 million DALYs.

**Cleaveland et al., 2002
Knobel et al., 2005**

The tragedy of rabies is that each human death is entirely preventable and the economic and psychological burden of the disease minimized. We currently have all the tools that are needed to eliminate human rabies, using mass dog vaccination to prevent disease in the major reservoir (the domestic dog) and appropriate human post-exposure prophylaxis (PEP) to prevent development of clinical disease in exposed people.

Sarah Cleaveland

A major factor in the low level of political commitment to rabies control has been a lack of accurate data on the true public health impact of the disease and a lack of information on the costs and benefits of disease control. Despite the often distinctive and distressing clinical signs of disease in people, it is well recognized that the number of human deaths officially reported vastly under-estimates the true incidence of disease. Several explanations for under-reporting have been proposed, such as a lack of laboratory confirmation of cases, absence of reporting from local to central authorities and the fact that many victims do not present to medical facilities. This may occur because people prefer to seek treatment from local healers, they may be too ill to travel or the clinical signs may be interpreted as “bewitchment” rather than disease.

A predictive approach to estimating human deaths in the United Republic of Tanzania has been developed, using a probability decision-tree method to determine the likelihood of clinical rabies developing in a person bitten by a dog suspected to be rabid. The advantages of using dog-bite injury data are considerable: (a) the incidence of dog bites is relatively high in comparison with cases, (b) dog bite injuries, when they occur, are often reported to medical authorities as people recognize the need for post-exposure prophylaxis (PEP) following rabid dog bites, and (c) the data are generally notified to central authorities. Dog bite injuries thus constitute a valuable and accessible source of rabies epidemiological data in many countries of Africa and Asia.

Using this probability-tree approach and detailed data on dog-bite injuries from the northern part of the United Republic of Tanzania, the incidence of human rabies cases in that country was estimated to be 100 times higher than officially recorded, with 1499 (95% confidence interval 891-2238) human deaths annually in comparison with the 10-20 human cases typically reported each year by central authorities. Adopting this approach in a re-evaluation of the rabies burden in Africa and Asia, a total of 55 000 (24 000-93 000) human deaths were estimated to occur annually in these regions and deaths due to rabies responsible for 1.74 million disability-adjusted life years (DALYs) lost each year. Model outputs have been validated through data subsequently collected in China, India and the Philippines.

Additional components of rabies disease burden include (a) the side-effects of nerve-tissue vaccines which are still used widely in parts of Asia and contribute 0.04 million DALYs to the disease burden, (b) economic losses, which amount to US\$ 583 million annually, largely due to the direct and indirect costs of human post-exposure vaccination, (c) the fear and anxiety associated with receiving a bite from a suspected rabid dog, which could account for as many as 165 000 DALYs not included in the total above, (d) an animal welfare burden as a consequence of public attitude and treatment of animals in areas where dog rabies is endemic and (e) the extinction threat posed by dog rabies to several endangered wildlife populations.

11

From PCR to policy: new ways of controlling zoonotic sleeping sickness

In eastern Uganda, modern PCR tests have made it possible to prove conclusively that one-fifth of cattle harbour trypanosomes which are pathogenic to humans, alongside various trypanosomes which chronically lower cattle productivity and cause occasional deaths in livestock.

Sue Welburn

Untreated, trypanosomiasis in people is always fatal and in the later stages of the disease the treatment itself carries a 5% risk of mortality. The PCR work has convinced the Government of Uganda to adopt block treating of cattle around outbreaks of sleeping sickness. This both stops transmission to people and greatly benefits livestock production, since the drugs used also clear the animals of the trypanosomes which make them ill.

Control interventions for human African trypanosomiasis (HAT) are often implemented as a crisis response when the level of disease in people is considered unmanageable. Resources are then deployed with the aim of removing infective parasites from people (by chemotherapy) and attempting to control tsetse flies. During the intervening periods farmers and communities are left to fend for themselves despite the ongoing low level disease risk. To effectively control a zoonotic disease we need to be able to identify the animals maintaining the infectious agent and estimate the size of the reservoir harbouring the disease agent. Traditional methods using microscopy to visibly identify parasites have underestimated the extent of the animal reservoir – routinely by as much as 60%. Consequently few resources have been directed at dealing with the disease in the principal reservoir, livestock. Sleeping sickness is difficult and expensive to treat in people and treatment itself has a high risk of mortality (up to 5%). In contrast, elimination of the parasite from animal hosts is affordable and effective; a single treatment with a cheap injectable drug is sufficient to clear the animal of all circulating trypanosomes.

Modern PCR techniques are now able to detect species of trypanosome circulating in animal hosts and determine what proportion of these parasites are human infective. In areas endemic for HAT, for every three *Trypanosoma brucei brucei* (non-human infective) infected animals observed of any species, one of these animals will be infected with *T. b. rhodesiense* (human infective). Using the most sensitive PCR methods available, we have shown that in areas of East Uganda endemic for HAT, up to 85% of village cattle screened monthly over an 18-month period were positive by PCR for *T. brucei* and 18% of cattle harboured *T. b. rhodesiense*, far higher than the 1% found using traditional microscopy. Once infected, cattle, which can live for ten or more years in these production systems, maintain *T. brucei* infections for life, outliving tsetse control programme cycles. Since parasitaemias are relatively low in local zebu cattle and as animals rarely show visible clinical signs of trypanosomiasis, they are infrequently treated. Parasitaemias in cattle are, however, high enough for uptake by tsetse flies which only require a single trypanosome to become infected if susceptible (one parasite in 30 micro-litres of blood is sufficient). Cattle, which are critical village investments, thus present a long term health risk to rural people.

As a result of this research, the Government of Uganda is tabling legislation for the block treatment of cattle around outbreaks of HAT, as well as of animals moving into new areas from HAT endemic regions, a measure which will stop transmission and thus save human lives – just under half of the people infected die without getting treatment. This will also help improve livestock productivity. Nevertheless, this type of block treatment will need to be very carefully targeted, as it is neither possible nor appropriate to repeatedly treat every animal without the risk of resistance to the drugs developing and thus compromising the efficacy of the very limited armoury of human treatments. Modern technologies need translating into affordable pen-side diagnostics so that interventions can be targeted to high-risk disease carriers and sustainable low-cost tsetse control options need to be further explored.

12

Bringing vets and medics together to deal with bovine TB in the United Republic of Tanzania

Bovine tuberculosis in people was considered a rare exception in Tanzania. Now research has shown that it forms a significant fraction of the overall TB epidemic and the need for differential diagnosis and treatment is recognized.

Rudovik Kazwala

Collaboration between veterinary and medical researchers studying bovine tuberculosis has had wide repercussions: bringing vets and medics together to research other diseases, the setting up of an emerging diseases and zoonoses group in the livestock ministry and the initiation of a series of joint meetings between them and representatives from the ministries responsible for human health and livestock production.

For all forms of human extrapulmonary TB, the risk of disease was greatest among remote, marginalized and impoverished households.

Rudovik Kazwala and Sarah Cleaveland

Bovine tuberculosis in Tanzanian cattle was first confirmed in the early 1950s. Tuberculosis lesions are found from meat inspections – for example surveys undertaken in the districts at the centre of the southern highlands indicate the presence of tuberculosis lesions in 20% of cattle slaughtered. However, the lack of facilities to culture mycobacteria means that it has been difficult for the Veterinary Investigation Centres which are responsible for livestock disease surveillance to identify and report the disease.

Tuberculosis in humans due to *M. bovis* generally occurs as the extra-pulmonary form. In Tanzania, the proportion of extra-pulmonary TB amongst all forms of tuberculosis stands at nearly 16%. The majority of these cases have been recorded in the Arusha region in the northern part of the country, where regional data indicate up to 30% of total TB cases are those of the extra-pulmonary form. Cases of extra-pulmonary tuberculosis are on a simultaneous increase with the total cases of tuberculosis reported each year (which increased from 7000 to 63 000 between 1992 and 2004). In the regions with a high number of cattle kept per head of the human population an exceptionally high proportion of extra-pulmonary TB was found during surveys: Arusha, 30%, Mbeya, 28.1%, Iringa, 27.3%, Shinyanga, 19.8%, Mara, 19.7%, Dodoma, 19.4%, and Mwanza, 10.8%.

A phase of intensive research on bovine tuberculosis, its incidence and risk factors in people and livestock began in the early 1990s. The signing of the first Memorandum of Understanding between Sokoine University of Agriculture (SUA) and the National Medical Research Institute (NIMR) in 1996 formalized and facilitated the growing collaboration between veterinary and medical researchers which has now extended to work on other zoonoses, notably brucellosis and rabies. For the first time in tropical Africa, it was possible to demonstrate unequivocally that *M. bovis* does contribute to the human epidemic, with about 10% of extra-pulmonary human TB cases and 4% of pulmonary cases caused by *M. bovis* in the United Republic of Tanzania. A further key finding has been the identification of atypical mycobacteria species as a cause of 50% of cases of extrapulmonary TB. The standard medical treatment for human TB has been directed towards *M. tuberculosis*, but these research findings suggest that consideration needs to be given to non-*M. tuberculosis* forms of the disease and the zoonotic component of the tuberculosis epidemic.

This collaboration and the research results have been instrumental in a number of policy changes. The perception regarding *M. bovis* infection in cases of extra-pulmonary human TB cases was changed. In the third edition of the Manual for National Tuberculosis and Leprosy Programme, a statement regarding the rarity of *M. bovis* infection in cases of extra-pulmonary TB was deleted. A change has also been made by the national veterinary authorities as TB is now among the diseases being reported to the OIE. A section dealing with non-epizootic diseases and in particular zoonotic diseases, has been set up in the ministry responsible for livestock. Changes have also occurred at NIMR where the Muhimbili Research Station, which was the focal contact unit within NIMR, has been elevated to Centre status. It has been proposed that a department responsible for studies on zoonotic diseases is established within this Centre.

13

Engaging stakeholders: creating networks to combat cysticercosis

The Cysticercosis Working Group in Eastern and Southern Africa (CWGESA) was set up in 2001 to increase awareness of this growing problem and promote a coordinated regional programme dealing with the disease.

*Samson Mukaratirwa
and Arve Lee Willingham*

Engaging stakeholders at all levels is essential for the success of any control programme. Because effective zoonoses control cuts across the conventional discipline boundaries and government service structures, bringing together all stakeholders to discuss how to tackle a disease problem is even more important, as dialogue between different groups is unlikely to happen otherwise. The engagement process involves formal and informal contacts with a variety of groups which include individuals, organizations, communities, industry, agencies, etc. This enhances cooperation, increases communication, improves decision-making, maximises the effectiveness of each participant's resources and eliminates redundancy.

By 2001, a group of scientists carrying out research on livestock helminths in Eastern and Southern Africa had firm evidence that there was a marked increase in the prevalence of *Taenia solium* cysticercosis and in its impact on the nutritional and economic well-being of smallholder farmers and rural communities. Recognizing this problem, the scientists formed the Cysticercosis Working Group in Eastern and Southern Africa (CWGESA) in order to facilitate increased awareness of the problem and help promote a coordinated regional approach for research and control of *T. solium*, while making more effective and efficient use of resources (Boa et al., 2003). The working group now includes representatives from 11 endemic countries; its general assembly has met three times and its technical advisory group twice. At the last general assembly meeting, in November 2004, some 50 scientists and individuals actively involved in cysticercosis control attended.

The success story of the CWGESA is anchored in the involvement of stakeholders at local, regional and international levels in forming its structures and formulating a regional action plan for combating *T. solium* cysticercosis/taeniosis in the Eastern and Southern African region. This approach can be used as a model for the creation of similar networks/working groups in other regions. The implementation process of the regional action programme is structured to involve close collaboration among all stakeholders. The formation of regional networks/working groups could form the basis for establishing a global programme for combating cysticercosis through the International Cysticercosis Coordination Centre.



© Photo: CWGESA

Third Meeting of CWGESA general assembly, Maputo, Mozambique, November 2004.

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Adopting effective surveillance and control templates for anthrax

Although Europe and North America have been successful in preventing imports of livestock products contaminated with anthrax in the enzootic countries, sporadic outbreaks of the disease continue to be recorded.

Reporting is at best very patchy, as evidenced by the fact that reports tend to be confined to one animal species, when outbreaks almost always involve several and can include wildlife. Humans can be the sentinels of animal cases and where only human cases are recorded, it is clear that cases in animals have been missed.

Peter Turnbull

Anthrax is a very good model for assessing control programmes in many parts of the world because (a) it is fairly common or common in many countries, and (b) it is relatively easy to diagnose. So if it is being missed when present, it is likely that other diseases circulating in the same area, which are harder to diagnose, are also being missed.

In Europe and North America, which acquire anthrax through contaminated imports from enzootic countries, there has been a reduction to near nil of contaminated imports. This, at least in part, reflects the reduction of the disease in the exporting countries through vaccination and other improved control programmes. However, it is clear that we do not know a lot about the incidence of the disease in enzootic areas. A glance at the figures given on the OIE website shows the relatively small numbers being reported and the very sporadic nature of reports from the enzootic countries. Interviews with district level veterinary staff in various countries of sub-Saharan Africa confirm that anthrax is an ongoing problem, but this is not apparent from available figures. Comparing the latest available (2004) data with those of five years earlier, little change is apparent in figures of countries other than Ethiopia, Guinea and Zimbabwe. Of those countries reporting at all, half are reporting just bovine cases. This matters because humans can contract anthrax equally well from sheep, goats and other domestic species.

What evidence is there that there is under-reporting as inferred above? Two contrasting situations can be cited, in this instance. In Turkey, human cases are shown as exceeding animal cases in 2001 to 2003. The explanation given is that often more than one person contracted the disease from a single animal. This becomes believable if both public health and veterinary services are reporting efficiently. In contrast, in a survey under taken by Peter Turnbull in a district of Tanzania in 1999, a substantial number of human cases were found to have been recorded in the health clinics but not a single case in the corresponding veterinary clinics. In this case humans are the sentinels of animal cases and the evidence of under-reporting is clear.



© Photo: Jakob Zihnsstag

Women and children with their families' cattle in Gredaya, Chad. Anthrax poses a perennial problem for pastoral peoples.

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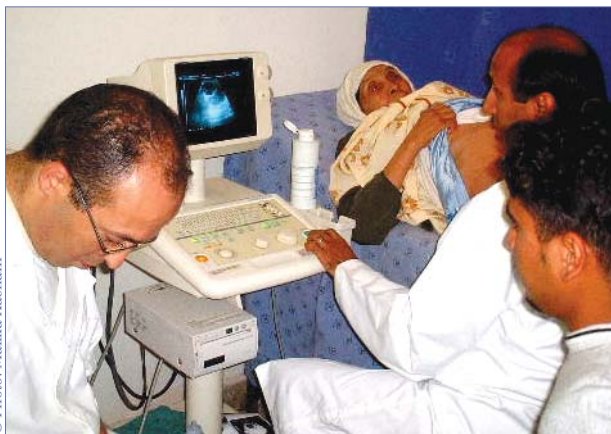
Combating a hidden threat:
cystic echinococcosis in Morocco

Key components of a successful pilot project to combat cystic echinococcosis (CE) in Morocco were an innovative approach to health education alongside ultrasound surveys and the use of non-invasive treatments as an alternative to surgery.

Malika Kachani

The programme involved collaboration between veterinarians and physicians, with the latter undertaking the ultrasound examinations and case management. This photo shows physicians in our team, re-examining patients who were identified as positive during ultrasound survey, a liver cyst in this case.

Khénifra, Morocco



© Photo: Malika Kachani

In Morocco, high prevalence rates of cystic echinococcosis (CE) have been reported both in the definitive and in the intermediate hosts, including humans. Comparable prevalence rates have been reported in other countries of North Africa and in the Middle East. To date, there has not been any programme to control this zoonotic disease in the region. However, there are considerable barriers to the designing and implementation of a control programme, not just the lack of human and financial resources but also a failure to prioritize and a lack of awareness of the magnitude of the losses associated with the disease. Conducting robust field trials is also difficult.

To deal with these problems, firstly, data from sporadic prevalence surveys was compiled, showing alarming prevalence figures: rates of 56% in stray dogs and 80% in cattle and 26% in sheep in convenience samples taken at abattoirs – while in the human population the overall prevalence was 1%, rising to 14% in children aged one to 15 years. A programme of sensitization of relevant government departments and holding workshops followed, with the creation of an inter-sectoral commission for zoonoses control and involvement of international organizations and pharmaceutical companies.

A pilot control programme was then implemented based on: health education; control and treatment of dog populations; abattoir upgrading, prevalence surveys, inspection and regulation; ultrasound surveys, treatment of infected people and public education. Surveys of knowledge, attitude and practices (KAP) and the cost of the disease were also conducted.

The programme included a number of unique and novel features. It targeted dogs for more than one disease by making use of the existing rabies control programme. It used novel health education methods, such as plays and meetings to target diverse audiences and ultrasound surveys as an opportunity for public education. Non-invasive treatments were promoted, to reduce the costs and trauma associated with surgery.

This pilot programme has had a considerable impact on the affected populations, the local authorities and the health and agricultural structures, both at the regional and central level. It has made it possible to establish the protocol for a control programme and thus paved the way for control on a larger scale.

It was successful in attracting and combining local and international sources of funding and fostering collaboration between veterinarians and physicians. There is a strong need to implement a control programme at the national level and this will make a more significant impact on the whole country. Meanwhile, the lessons learnt will be of great relevance to other countries in the region in dealing with their problem of CE.

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Working towards cysticercosis elimination in northern Peru

Neurocysticercosis (NCC) is the main cause of acquired epilepsy in developing countries and probably in the world, with a gross estimate of attributable fraction of around 30% of all seizures.

In a province of Peru, various interventions are being tested for their efficacy, cost and acceptability, with a view to finding an approach that can be used to eliminate cysticercosis.

Hector Garcia

Neurocysticercosis (NCC) is potentially eradicable and several attempts to control it in field conditions have been made. Mass human chemotherapy (against the intestinal tapeworm) has been tested numerous times, with promising, albeit somewhat inconclusive, results. A wide field-based programme to eliminate cysticercosis in a province of Peru is under way, funded by the Bill and Melinda Gates Foundation. In its initial phase, this programme compares six different interventions, covering a total of 37 villages (with approximately 20 000 inhabitants and 6000 pigs). Two combined interventions will be derived from this step and comparatively tested during one further year. The intervention ultimately selected will be applied throughout the study area (covering some 100 000 inhabitants) and followed up for the next four years. Major obstacles include the lack of basic sanitary facilities in endemic areas, the extent of domestic pig raising (based on free-ranging animals and thus with no investment in feeding them) the costs of the interventions and most importantly, their cultural acceptability. This is the first systematic effort towards controlling and potentially eliminating cysticercosis transmission. One of the obvious problems with control efforts in the past has been that these were launched with a total lack of data to support efficacy, acceptability and cost of the proposed interventions. By testing different interventions, this programme aims to overcome this problem. Once the Peruvian data has been collected and analysed, its findings should serve as the basis for the rational development of other regional programmes.



© Photo: The Cysticercosis Working Group in Peru

Foraging pigs, Cusco, Peru.

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Barriers and bridges: a problem analysis

In February 2005, as a preliminary to the present meeting, medical and veterinary researchers from seven African countries with recent field experience working on zoonoses gathered at a workshop in Nairobi to discuss the issues involved in controlling zoonotic diseases. They compiled a list of bridges and barriers which are given below.

Bridges	Barriers
Collaboration, integration, networking and partnership from inception to completion of both research and control activities and bringing together both medics and vets and basic and applied research	Rivalry (institutional and professional), competition, institutional separation, poor linkages (e.g. between ministry of health and veterinary authorities)
	Bureaucratic bottlenecks: who makes the decisions?
	Control of zoonotic diseases based on fire-fighting/crisis management
	Unregulated international trade in livestock and livestock products hampers control
Buy-in from professional associations	Lack of clarity about roles of the public and private sector partners
	Confusion: who pays, who gains?
Sufficient money in budget(s)	Lack of resources
	Budgetary separation: veterinary and medical costs not pooled
Capacity building: common training in zoonotic diseases for both veterinary and medical doctors and fieldworkers	Training: lack of emphasis on zoonotic diseases
	Weak veterinary public health infrastructure
Dual benefit: gains for animal and human health	Difference of emphasis: medics focus on individual patients, vets on populations
	Malaria: cattle can be important in its epidemiology, yet it is not a zoonosis so is not included in zoonotic initiatives
Demand-driven, problem-led research	Research being not demand-driven but donor-led
	Applied research is not recognized or rewarded as being as important as basic research
Advocacy for zoonotic disease control	Inadequate resources for dissemination of results and raising public awareness
	Lack of consensus on priority-setting

Factors identified by the workshop participants were clustered into bridges and barriers – it was perhaps telling that there were far more barriers than bridges... In drawing up these lists it is hoped that they can be used as checklists to guide planning, organization and management of future zoonosis research and also to allow veterinary and medical authorities to identify and tackle some of the over-arching problems such as the lack of emphasis on zoonotic diseases in the training of both medics and vets.

Keith Sones

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Working towards the Millennium Development Goals

The fight against endemic zoonotic disease and the dual burden it imposes on poor people's health and that of their livestock can make a significant contribution towards meeting the MDGs in poor and marginalized livestock-keeping communities.

Livestock have been under-utilized as a weapon for poverty alleviation.

Perry et al., 2002

MDG 1 Eradicate extreme poverty and hunger

On the human health side, the links between disease, poverty and hunger are well known. However, zoonoses also kill livestock and chronically lower their productivity. Livestock are an important component of poor households' coping strategy, to be sold when food is short or to meet family emergencies. They can be used to supplement the family's diet. Keeping livestock is now widely recognized as a route out of poverty – if healthy, they grow and multiply and they can be sold to supplement household income or increase the household's asset base.

MDG 2 Achieve universal primary education

Poor health is a major reason why children either do not attend school or perform poorly when they do. Tackling chronic causes of ill health such as tapeworm infections enables children to attend school more regularly and benefit from it. On the livestock side, studies have shown that one of the main reasons for selling livestock is to pay school fees or for school associated expenditures – healthier livestock thus support schooling.

MDG 3 Promote gender equality and empower women

In most of the developing world, small stock such as sheep, goats, chickens and guinea pigs are usually owned and managed by women. Numerous studies have shown that keeping these animals provides women with an independent source of income over which they have control and which they can use to channel resources directly to their children or reinvest in their money-making activities.

MDG 4 Reduce child mortality

Zoonoses control helps reduce child mortality at several levels.

- Children are particularly prone to some zoonoses: they account for the bulk of the 55 000 rabies deaths occurring annually and cystic echinococcosis is most prevalent in those aged one to 14 years.
- Improving livestock health helps provide extra income for poor families and enables them to diversify their income sources and spread risk.
- Livestock outputs, particularly milk, help maintain child health.

MDG 5 Improve maternal health

Maternal health is improved by dealing with zoonoses in the same way as child health.

- Some zoonoses, such as cysticercosis and sleeping sickness, target adults.
- For all illnesses, but particularly disabling wasting and mental conditions such as those associated with sleeping sickness and neurocysticercosis, women are called upon to devote a large share of their time to caring for sick members of the family both at home and when seeking or receiving treatment outside the home.

MDG 6 Combat HIV/Aids, malaria and other diseases

Controlling these diseases, which are clustered in and therefore impose a significant burden on poor communities of pastoralists, smallholder crop/livestock farmers and landless urban and peri-urban livestock keepers, is an important component of meeting this goal.

MDG 7 Ensure environmental sustainability

Measures to promote and support good animal husbandry will contribute to meeting this goal. Many of the situations which facilitate the spread and maintenance of zoonotic disease are also environmentally damaging. This is particularly true of the unsanitary conditions with free-ranging livestock which promote the spread of various tapeworms and the associated diseases of cysticercosis and cystic echinococcosis. Many zoonoses also affect wildlife. Rabies in particular has affected many species, in particularly threatening the survival of Africa's highly endangered wild dogs and Ethiopian wolves. Bovine TB impacts on some species such as the Cape Buffalo and anthrax also causes sporadic epidemics in wild herbivores. Wildlife not only transmit these diseases to domestic animals and people, but also suffer in turn when they contact livestock and become diseased. Controlling these diseases in their domestic reservoir can help protect the planet's wild species.

MDG 8 Develop a global partnership for development

Effective zoonoses control relies on intersectoral collaboration between veterinary and medical groups at district, national and regional level. Partnerships between these groups, and between them and international organizations and donors, are a vital part of this.



Woman taking her pigs around in her daily routine in the Central Peruvian Highlands.



Threatened by rabies: wild dogs in the United Republic of Tanzania.

© Photo: The Cysticercosis Working Group in Peru

© Photo: Anne Hillborn, Serengeti Cheetah Project

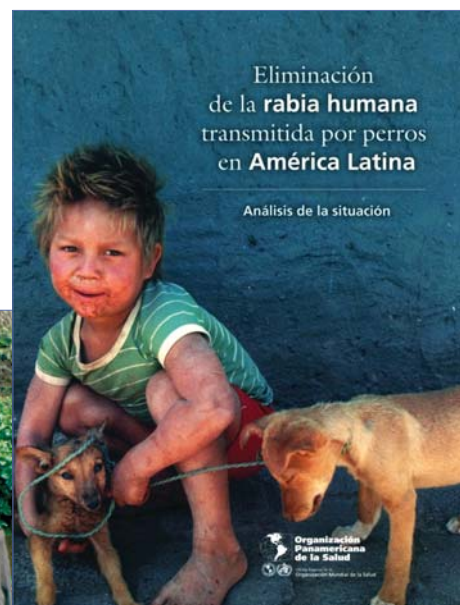
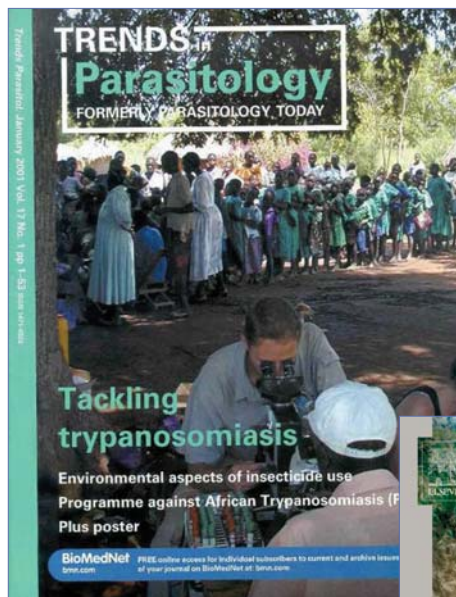
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Raising the profile of neglected endemic zoonoses

The emerging zoonoses attract much public attention because of their potential for rapid spread and the worldwide threat that they pose. The neglected endemic zoonoses, for the most part, do not pose a worldwide threat. In the affluent parts of the world they have mostly been eradicated or, due to their close links with poverty and poor living conditions in close proximity with host animals, are of little relevance. First World livestock production systems, for the most part, no longer involve such close human contact with stock. Thus the meeting **agreed** that work to raise the profile of these diseases at international, regional, national and district levels should be given high priority.

Community education is important to change perceptions of zoonotic disease – and to show people what burdens they are bearing due to these diseases.

Much has already been achieved. The research community has made a substantial contribution towards furthering this goal through a number of recent scientific publications and reports. There have been several high profile articles in *The Lancet* and new ground has been covered, particularly in methodology, through a number of publications in the *Bulletin of the World Health Organization* (see references). During the meeting work in progress was reported on.





A number of programmes, alliances, networks and working groups have been set up which specifically focus on endemic zoonoses. These include WHO's Mediterranean Zoonoses Control Programme (MZCP), the Alliance for Rabies Control (ARC) and various working groups such as the Cysticercosis Working Group in Eastern and Southern Africa (CWGESA). The newly set up Global Alliance for Livestock Vaccines (GALV) is also aiming to facilitate the development of animal health products targeted at the currently unmet needs of poor livestock keepers in developing countries.

Securing commitment at the **national level** was regarded as the most essential. Endorsement by government is a pre-requisite before NGOs or other agencies can work in the **districts** and with **communities**. Often government departments are not prepared to commit their own funding, or divert resources from other pressing problems until they are assured that there is an ongoing (financial) commitment on the part of donors and central government. This problem particularly works against diseases like zoonoses which are inapparent and not currently the subject of large scale campaigns. A number of processes are involved; the key ones are advocacy combined with evidence of cost-effectiveness and stakeholder consultations. Policy papers directed at national bodies, such as ministries of finance, can play an important role.

The **district level** is of particular importance given the increased decentralization introduced in many countries. Here, promoting awareness is a key element which needs to reach right down to communities, where health education is particularly important.

A number of organizations are already dedicated to work on zoonoses.

Some useful websites are:

- www.rabiescontrol.org
- www.mzcp-zoonoses.gr
- www.who.int/zoonoses
- www.who.int/rabies
- www.who.int/rabnet

At the **international level** advocacy should not just point to the dual burden imposed on human and animal health by these diseases, but should also emphasize the importance for public health and well-being in the context of the human-animal relationships by presenting zoonoses as one of the many facets of this relationship. Advocacy through dissemination of basic information on risk/specific diseases, policy statements, lobbying and data harmonization all have a role to play.

The need to raise the profile of these zoonoses thus emerged from every working group's discussions. The groups went on to make recommendations on how this should be achieved, through providing better evidence on the burden of neglected zoonoses as a basis for advocacy, finding ways of bring veterinary and human health organizations together, looking for cost-effective methods of control and identifying the tools missing to achieve improvements in control.



© Photo: Elizabeth Miranda

Owner preparing dog to bring it to village vaccination post on a mass immunization day, taken in Laguna, Philippines, 2006.

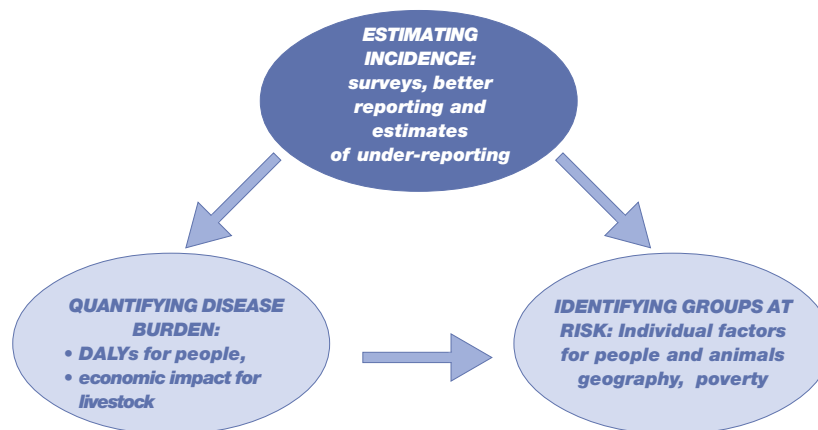
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Providing evidence for advocacy and prioritization

In order to support effective advocacy so as to ensure that the control of zoonotic diseases is appropriately prioritized in health and veterinary policy, work needs to be undertaken on:

- *improving estimates of the burden of disease,*
- *ways of estimating under-reporting,*
- *ways of improving reporting,*
- *risk factors for people and animals,*
- *the geographical spread of these diseases,*
- *investigating their association with poverty.*

In order to attract the human and financial resources needed to deal with zoonoses, the problem of under-reporting and the lack of a clear idea of their burden on individuals and communities need to be addressed. It is also important to identify groups at risk both so as to be able to plan interventions and to gain a deeper understanding of the burden of these diseases and where and on whom it falls. These issues were addressed by a working group at the meeting.



The most cost-effective way to obtain the information required is through strategic case studies on a small scale, looking at medical, veterinary, social and economic aspects of zoonoses and focusing on the problems of the poor. These will need to be firmly grounded in rigorous epidemiological methodology. They would involve gathering of basic evidence by in-country professionals with appropriate partnerships (researchers, donors, policy makers). This activity needs to be a funding priority amongst international donors. This small-scale research needs to be multi-institutional from the outset, involving key sectors (e.g. medical and veterinary). Over time, such small-scale projects could be scaled up to include a greater number of transmission systems, ecosystems, social settings etc.

These studies need to be undertaken in parallel with efforts to improve overall data collection on zoonotic disease. There are opportunities for specific collaboration with other high profile diseases, e.g. HIV/AIDS, particularly in terms of the data gathering exercise. In the longer term, capacity building is critical for improving reporting as is the development of better field-applicable diagnostic tests for some diseases.

Methods for estimating **under-reporting** will tend to be very specific to individual diseases and their epidemiology. These can be developed during the course of the small-scale studies in one location and tested in another as a proof of concept. Epidemiological modelling is likely to be an important component. Following the development of the methodology, a consortium of partners can **validate** the methodology in a range of different settings (multiple districts, country clusters, WHO/FAO regions, etc.). Where countries have surveillance systems in place, the above focused studies can also be used to validate the surveillance systems and improve the quality of the data collected through that system. Some of the diseases under discussion may not fit in the paradigm normally used for reporting and it may be necessary to revise the way in which we collect data on these diseases.

The group stressed the importance of locating a poverty focus. It is also important to avoid falling back into individual disease approaches and to retain a systems approach – a key component would be studying the impact of zoonoses as a whole on selected communities.

Improving on existing estimates of the **burden of these diseases in humans** firstly requires basic field data, which should be gathered by the strategic small-scale studies. Secondly, there is a need for commonly accepted and unified methodologies for determining burden and cost (e.g. a standardized way of determining the disability weights due to a particular infection). These unified methodologies need to be sanctioned by over-arching bodies such as WHO. In addition to estimating the burden in terms of DALYs, the other components of human health costs need to be investigated, from costs to the health service to patients' costs for seeking treatment, during treatment and for lost income.

Looking to the **burden of these diseases in animals**, again epidemiological studies are needed, looking at the species and age/sex groups affected and the nature of the impacts (e.g. mortality, carcass condemnations, lowered fertility, etc.) which then need to be translated into monetary terms and analysed against a background of the types of livestock keeper affected. There may also be a need to consider the wildlife–human/livestock interface, depending on the geographical setting and this may involve considering how to value threats to endangered species, a complex area of economics. Lastly, these costs need to be combined to look at the **total societal burden** (at the appropriate scale). This requires communication between research groups and networking.

The research reported on in some of the documents discussed during the meeting has already made substantial contributions towards developing approaches for and gathering this type of knowledge – for example Budke et al. (2006) and Carabin et al. (2005) in analysing the available information on the economic impact of echinococcosis and cysticercosis, Knobel et al. (2005) in obtaining a global estimate of the burden of rabies, Roth et al. (2003) in investigating the dual burden of brucellosis, and Odiit et al. (2005) on a methodology for quantifying the under-reporting of sleeping sickness.

Turning to risk factors, for both people and animals, to better identify risk groups (in order to target research and control efforts), we need to understand the distribution of poverty and at-risk populations through poverty mapping, socioeconomic surveys, livestock and human censuses and other proxy indicators such as ecological systems (e.g. landscape mapping). Geographical information systems (GIS) are particularly useful in this regard. For individual diseases, **risk factors** specific to them need to be identified and studied.

Finally, the working group highlighted two areas which need special attention.

- There is value in considering zoonoses as a group and studying their impact as a whole on a community. Consideration should be given to conducting a demonstration project looking at zoonoses as a group in a region where zoonoses are a problem. Multi-disease assessments are required from a control perspective – where dealing with several diseases at once offers economies of scale – or from the perspective of risk groups (pastoralists, urban poor). As discussed above, this approach needs to be validated in different settings.
- There is need for a specific analysis of the poor as the priority group – to capture the relative importance of these diseases given the poverty status of the populations affected. In particular, the combined effects of these diseases on humans and their animals needs to be studied as well as risk factors, both for acquiring a zoonotic infection and for the burden it imposes in relation to wealth status.

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Dealing with institutional issues: veterinary and medical cooperation

Bringing together veterinary and medical organizations, data and control activities at all levels is essential if zoonotic diseases are to be effectively dealt with. A working group considered these issues at international, national and district levels.

At the international level, the key organizations are WHO, FAO and OIE. In WHO, as well as the Department of Food Safety, Zoonoses and Foodborne Diseases, both the Departments of Control of Neglected Tropical Diseases and the Department of Epidemic and Pandemic Alert and Response – including the Global Outbreak Alert Response Network, which is not exclusively concerned with zoonoses – need to be involved. At OIE, as well as the ad hoc group on emerging zoonotic diseases, there are the working groups on TB, brucellosis, rabies, BSE and avian influenza. FAO and OIE's joint Global Framework for Trans-boundary Animal Diseases (GFTADs) provides a useful template, as does the FAO/OIE/WHO development of a global initiative for rapid detection of and response to disease outbreaks - GLEWS (Global early warning system for major animal diseases). The Pan American Health Organization (PAHO) and WHO's Mediterranean Zoonoses Control Programme (MZCP) are actively involved in the organization and implementation of zoonotic diseases control at regional level. Africa and Asia can draw lessons from these regional organizations. Africa and Asia could make use of their existing regional structures, e.g. the East African community, SADC, ASEAN, APHCA, which could be exploited for zoonoses initiatives, including training. In Africa, the end of the PACE programme will leave a big gap and points to the need for new regional initiatives.

The setting up of a joint FAO/WHO 'body' for the coordination of global control of zoonoses in collaboration with OIE and the IUCN veterinary specialist group – for both neglected and emerging zoonoses that could support regional initiatives – should be investigated. Another option would be to form an International Alliance for Zoonotic Diseases (along the lines of the Alliance for Rabies Control which is already in existence or the PAHO Rabies Committee).

However, at the national level the situation is often very difficult. In some regions, both formal links and informally developed good relations and working practices have become established over time. The MZCP, an alliance of 10 countries in the European and Eastern Mediterranean regions, has been very successful in involving both veterinary and medical authorities and individuals at every level, from attending training to joint data sharing and processing. Elsewhere, especially in Africa, under-resourced health and veterinary services have great difficulties in taking on board problems which each regards as rightly belonging to the other. For example, in Uganda, despite the initiative of establishing a Veterinary Public Health (VPH) unit within the Ministry of Health, success has been limited because the government lacks the mechanisms for institutional collaboration and there is no legal framework for implementing effective control. Nevertheless, there have been successes in data sharing and collection such as for rabies and trypanosomiasis. Encouraging the setting up of VPH units in the ministries of

health, within their own budgets, would be a very positive step. In many countries, and particularly in Africa, the need for the reinforcement of veterinary infrastructure remains an important issue. The role of international organizations is very important as these initiatives are very difficult to support from a national level.

At the district level, there is great potential for integrating zoonoses control into the existing veterinary and primary health care infrastructure. In the human health sector, this could be done alongside activities such as childhood vaccinations, maternal health and school health (deworming, nutritional education and vaccination) and sanitation/hygiene. In the veterinary sector, zoonoses control can be undertaken at the same time as routine work such as animal vaccination, deworming and dipping and be included in local courses and para-veterinary training.

The existing medical primary care services could be a useful conduit for disseminating information about prevention and control of zoonoses. These structures could also be a useful source of epidemiological data, e.g. animal-bite injuries. Steps should be taken to integrate zoonotic disease information in school curricula as part of children's general health education.

While much of zoonoses control work can thus be integrated into horizontal health structures, for enforcement of legislation/regulations it might be better and more effective to have vertical structures. Vertical structures are also recommended for specific task forces to solve specific problems in exceptional circumstances – e.g. BSE, anthrax outbreaks – which provide a good platform for incorporating representatives from different sectors.

The working group noted that there is need to look at legislation, to ensure that the necessary legal and regulatory framework is available to ensure coordination between veterinary and medical institutions and to enable access to data. There needs to be a strengthening of cross-sector linkages at all levels to facilitate easy reporting. The relationship between FAO and WHO (veterinary and medical) should be strengthened at the regional and national level in the exchange of information concerning zoonoses. National veterinary services ought to be professionally obliged to report zoonoses to OIE.

WHO's Mediterranean Zoonoses Control Programme (MZCP)

A successful regional example of intersectoral collaboration

1. Has 10 member countries each of whom contributes US\$20,000 per year, with a national coordinator in either health or agriculture and a focal point in the other sector.
2. Has fostered collaboration between public health and animal health sectors that previously did not exist.
3. Represents the first time the two sectors had gathered together to work towards a common purpose and decision-making was, at first, slow and difficult (in theory, everyone agreed, but in practice, the different sectors were territorial).
4. Each activity (for example, a training course) is compulsorily attended by both sectors. No activity is attended only by representatives from one sector.
5. A key element has been the installation of computer systems, with training provided: the importance of generating data was recognized, leading to a five-fold increase in reporting in the Syrian Arab Republic.
6. Nevertheless, problems still exist with reporting from the private sector, even with notifiable diseases.

www.mzcp-zoonoses.gr

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Looking for economically sustainable solutions

Animal health can be a gateway for public health in pastoral communities.

Jakob Zinsstag

The design and funding of cost-effective control strategies was discussed by a working group, taking as its starting point the planning of control programmes. A first step, for all diseases, is to ensure that we have an adequate understanding of their epidemiology. Although we know a lot about some diseases in some populations, for others we simply don't yet have sufficient knowledge – for example, it is quite probable that we have yet to properly understand the main routes of transmission for bovine tuberculosis in Africa. This work needs mixed teams of human and veterinary specialists, the latter dealing with both livestock and wildlife. Once the transmission routes are understood, a control strategy can be tested in a pilot control trial. When setting out action plans, it is important to differentiate between long- and short-term action plans. Short term action plans include building an evidence-based and developed consensus for centralized action. Long-term action plans involve pursuing centralized action at national and international levels. Zoonotic diseases should be scrutinized for highly-effective interventions which could be applied with highly-concerted efforts and maybe work towards elimination.

For greater intervention impact and cost-effectiveness, grouping the zoonoses should be considered. A possible division would be by animal category affected – e.g. into those affecting dogs, livestock and wildlife. This would emphasize the differences between those that impose substantial monetary losses and those that primarily affect human health and welfare. It also makes it possible to tackle a group of diseases – for example brucellosis and bovine tuberculosis, which can be transmitted via milk or by dogs as transmitters of both rabies and echinococcosis. Another route to more effective delivery and greater cost-effectiveness could be by targeting specific communities – poor pastoralists, urban landless livestock keepers and dealing either with a cluster of zoonoses or a cluster of health interventions tackling both zoonotic and non-zoonotic diseases in both people and livestock. This could be particularly beneficial in the case of remote communities, such as pastoralists.

Calculating the cost-effectiveness of different interventions is a key component of both advocacy and planning. Ways of estimating the burden of disease in people and animals were discussed by another working group. These estimates need to be combined with calculations of the costs of interventions, to the health sector, to patients and to livestock keepers, to animal owners and to those managing wildlife. It is important to carry out a full societal/economic assessment which should include human and non-human benefits, monetary and non-monetary benefits and the full benefits – including local and international trade and other disease impacts, such as on tourism via wildlife. Modelling has an important role to play in identifying cost-effective strategies. Both disease transmission models and economic models are needed which deal with diseases affecting people, livestock, companion animals and wildlife. A starting point can be calculating the implications of the 'do nothing' alternative. It was noted that modelling generally demonstrates that controlling zoonoses in the animal reservoir is more cost-effective than dealing with it in humans. Even where the animal

reservoir does not consist of economically productive livestock, the benefits to human health are usually such that control is cost-effective by international standards.

Lastly, the group considered sustainable ways of funding zoonotic disease control. Although control of these diseases has been demonstrated to be highly cost-effective from a societal point of view, this does not mean that the society or affected communities have the means to fund that control. The usual solution of differentiating between public and private goods and seeking payment from private individuals for the latter and from public funds for the former does not work well in the field of



Start of a brucellosis screening session in a pastoral area of the United Republic of Tanzania.

zoonotic disease. Although treating animals for zoonotic diseases does benefit livestock keepers, this benefit is often small in relation to the benefits accruing to human health in the wider community. In particular, poor livestock keepers are often unable to mobilise even small sums to improve animal health when faced with far more urgent household needs. However, it may be possible, where these diseases affect relatively better off communities, to ask them to pay for certain control measures while others are publicly funded. Thus, introducing any mechanisms for cost-recovery requires careful thought. A number of studies have shown that seemingly minimal payments for health services are totally unaffordable by the poor no matter how badly they need them. It may be more feasible in some situations to impose a tax/private contribution which could initially be used to fund control and later, when the disease has been controlled, is retained and earmarked for future campaigns aimed at eliminating the disease. One very promising possibility would be to adopt the 'separable costs' approach, whereby costs are allocated between the health and animal sector in proportion to the monetary benefits each is expected to reap from the control

A number of studies of health interventions in both the livestock and human health fields have shown that even very small payments for highly beneficial interventions cannot be afforded by the poor. Thus demonstrating cost-effectiveness is not enough to guarantee funds. The resource gap will continue to need bridging for these neglected zoonotic diseases.

programme. This would help overcome the problem of the veterinary sector having to pay for a programme which is seen as mainly benefiting human health. Although in itself it would not bridge the resources gap, it would clarify where the responsibility for obtaining extra funding and donor inputs would lie – and potential donors would have a clearer idea of where the benefits from their investments would accrue.



Sheep pen in Mongolia, where brucellosis is endemic

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Identifying missing tools

The neglected endemic zoonoses have been well known for a long time and many have been largely dealt with in Europe and North America, so that tools and effective control strategies do exist for most of them. However, as is the case with all diseases of poor and neglected populations, there is little commercial motivation for funding the development of new diagnostics, drugs or vaccines and therefore the impetus for developing them has been lacking. During the meeting, a working group looked at what tools were available and what was needed.

Anthrax

Control tools for anthrax exist if properly delivered and applied. If properly stored, no cold chain is required for the livestock vaccine. There are currently some quality control problems which need to be dealt with and delivery can be problematic in pastoralist systems. In humans, if cutaneous anthrax is easy to diagnose, this is not the case for gastric anthrax. Correct diagnosis is constrained by poor sensitivity of existing tests, the need for microscopic examination of samples, lack of awareness of the disease and of trained personnel. Drugs to treat humans are available.

Bovine tuberculosis

Better diagnostics for both people and animals are needed, in particular to enable differentiation between human and bovine tuberculosis (the culture requires six weeks for differentiation, serology is regarded as insensitive and there is also a difficulty in differentiating). In animals, excluding environmental mycobacteria is a problem. A better BCG vaccine is also needed. Associated risk factors such as HIV need to be recognized.

Brucellosis

Species-specific diagnosis poses difficulties – and is important since the severity of the disease in humans depends on the causal agent. Surveillance from the medical side is poor with a large incidence of under-reporting. A control vaccination in animals would work but a cold chain would be required for delivery in tropical environments therefore a recombinant vaccine would be the ideal.

Cysticercosis

Diagnosis in humans remains a problem; bed-side/field applicable tests for taeniasis are required. There is a strong need to measure cysticercosis in the population. Serology exists for pigs – pen-side tests would enable control activities and they are also needed for epidemiology. A new vaccine for pigs requires assessment (no cold chain is required). Cysticercosis is on the list of eradicable diseases.

Cystic echinococcosis

Better drugs for treating human hydatidosis are required. Diagnostic tools are available – ultrasound and serology. Conventional control can work, although control structures require identifying and sustaining. Delivery systems are still needed. The new vaccine for sheep requires assessment (no cold chain) but the new dog vaccine is a longer-term undertaking. The dog rectal-stick test is another possibility.

Rabies

There is need for a reliable early stage ante-mortem test in animals and humans. For disease control, efficient sterilization/dog contraception is required to be used in combination with rabies vaccination. Delivery and access problems remain as the dog vaccine requires a cold chain and achieving a 70–75% immunization coverage in any given dog population is difficult.

Zoonotic human African trypanosomiasis (HAT)

Pen-side and bed-side diagnostics are essential. Effective drugs which are not toxic are desirable. A full range of tools for tsetse control are available, but tend not to be sustainable outside of tsetse control programmes. Drugs to treat the animal reservoir are cheap and readily available, but not always correctly applied. A suite of DNA technologies could be applied; the question is whether a single test for trypanosomes or species-specific diagnosis is more desirable. If a quick technology was required, e.g. a simple brucei diagnostic or a diagnostic for all trypanosomes, it is likely it could be produced in less than three years.

Overall, the biggest gap seems to be in the field of diagnostics. Good pen-side and bed-side diagnostics are lacking for almost all of these endemic zoonoses. This in turn is reflected in the problem of under-reporting, differentiation from other more common illnesses and difficulty in correctly diagnosing and treating patients, which have been discussed in other sections of this report. For some diseases, simple decision support tools can be of great help in differentiating between similar conditions affecting humans or livestock.

Most needed are cheap and effective bed/pen-side diagnostics. A lack of these, combined with a low level of awareness of these diseases, is the main reason for their persistent under-diagnosis.

Among the possibilities discussed at the meeting was the prospect for combined diagnostics and multi-vaccines. It would be expensive to build such products but it would offer cost savings in delivery. It would be useful to look into interaction between the research science base and the private sector to deliver useable and desirable products; new initiatives such as the Global Alliance for Livestock Vaccines (GALV) have been set up to foster public-private partnerships to make such products available to poor communities.



© Photo: Eric Fèvre
Field laboratory work in Uganda.

Lastly, the importance of nurturing good research facilities was emphasized. This could take the form of identifying and supporting 'centres of excellence'. The design of effective interventions requires high-quality epidemiological data, and high research costs can reduce the cost-effectiveness of national and regional control programmes. Current field research projects provide an opportunity for donor agencies to identify successful programmes and to take advantage of pre-existing infrastructure (laboratory facilities, vehicles, etc.) and positive working relationships with host governments and local communities. By identifying such 'centres of excellence' it would be possible to expand current research activities in specific geographic areas to investigate additional zoonotic diseases at relatively little extra cost. Just as important, there is an inherent advantage to expanding the activities of highly effective research groups who are most likely to provide high-quality data on a particular problem. Successful research is the outcome of a team's ability to work together, to recruit good collaborators from different sectors (human health, veterinary, wildlife), and to provide the best possible training for graduate students and post-docs. A local research capacity building component would be an integral part of this. This provides a "bottom-up" model for developing integrated research programmes. By formally linking these research groups to district, national or regional disease surveillance programmes, there would be a fundamental connection between daily record-keeping in health clinics/hospitals, veterinary centres, etc, with data analysts who would return their findings to local communities.

Identifying and supporting "centres of excellence" for zoonotic disease research would make it possible to build on existing teams and relationships and to formally link their work to regional disease surveillance activities.

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Five reasons for action

The endemic zoonoses, although apparently not as prevalent as high profile diseases afflicting poor countries, merit special consideration and investment for the following reasons.

(1)

Zoonoses selectively affect **poor families in poor and marginalised communities**, particularly poor pastoralists, resource poor crop-livestock farmers in remote areas and landless livestock keepers in urban and peri-urban slums.

(2)

Their apparently low incidence is an illusion in many cases – where evidence-based studies on **under-reporting** have been undertaken, the true incidence is between two and 100 times greater than that reported.

(3)

Zoonoses tend to be **clustered** in certain communities and among identifiable groups at risk, where they impose an above average burden. This clustering also offers highly cost-effective control options, especially where it is possible to target more than one zoonotic disease or to integrate the work with other human and animal health programmes.

(4)

In these communities, zoonoses impose a **dual burden** on human and animal, (mainly livestock) health, often affecting the same household and pushing it further into poverty. Dealing with these diseases thus reaps a double harvest, saving people's lives and securing their livelihoods, thus further increasing cost-effectiveness.

(5)

Simple and relatively low-cost **tools and strategies exist** for the control of most of these diseases, although cheap and effective bed-side and pen-side diagnostics are usually lacking. Much can be achieved by health education and control of the animal reservoir.

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Resolution: to work towards
'One Health' systems

Neglected diseases of poor people equal diseases of neglected communities ... and we should look at their health problems holistically.

Successful examples of 'one health' systems include joint human and animal vaccination campaigns among Chadian nomads where mixed teams of veterinary and public health personnel undertook animal vaccinations (anthrax, contagious bovine pleuropneumonia), covering some 52 000 bovines and EPI vaccinations for some 4200 children and women as well as vitamin A distribution and sale of quality drugs.

Bechir et al., 2004

In Sudan, Vétérinaires Sans Frontières (VSF) provides information, education and communication (IEC) for HIV/AIDS alongside its animal health work.

While recognizing that existing approaches to the control of and research into zoonotic diseases will continue to benefit from their current vertical or horizontal structure, the meeting noted that there is growing evidence for the benefits of a joint human and animal health approach, and recommended the adoption of the 'one health' concept, because many zoonoses, particularly neglected zoonoses, can be better surveyed, diagnosed and controlled by considering human and animal health together.

In the light of the fact that veterinarians can be the only medically trained persons in remote rural areas, the importance that livestock farmers give to animal health and, in sub-Saharan Africa, the accentuating human resource crisis which threatens the breakdown of public health systems, animal health is a valuable entry point for providing social services to neglected populations.

The meeting **recommended** the development of novel, adapted joint human and animal health delivery systems, described as "one health" systems.

1. Clearly, clinical work on humans and animals should be strictly undertaken only by those qualified to treat them.
2. The scope is really for coordinated public and animal health action within a health system that comprises both the public health and animal health systems as an inseparable entity on an equal partner basis.

This approach would greatly facilitate detecting and dealing with zoonoses, while at the same time ensuring better overall access to health inputs for both poor people and their livestock. Encouraging cost-sharing in proportion to the benefits gained by each sector could be an enabling component of a 'one health' approach.

The meeting further **recommended** that this joint approach be extended to cover diagnosis, data sharing, monitoring and surveillance systems, training, interventions and delivery.



© Photo: Sarah Cleaveland

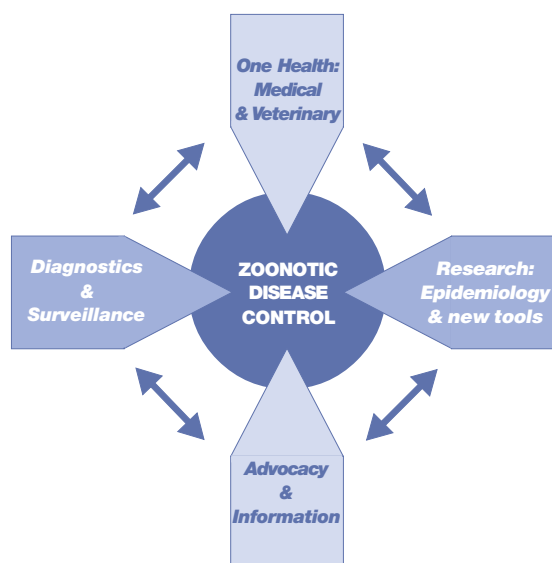
Pastoralist peoples can benefit from a unified 'one health' approach to health-care delivery. Masai herders in the United Republic of Tanzania.

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Action points

*Our objective:
“to work towards global control and elimination of diseases transmitted from animals to people.”*

During the course of the meeting it became very clear that there were five main areas where work needed to be done if the neglected zoonoses were to be effectively tackled. These inter-connected themes emerged from and were addressed by the working groups. Following their reports, the meeting made a number of recommendations which are listed below.



(1) Linking veterinary and medical aspects of disease control

The meeting recognized that the need to actively involve both the veterinary and the human medical sectors is at the core of successful zoonotic disease control, because control activities need to cover both people and animals, and benefit both the human health and veterinary sectors. **For this reason, the meeting’s overarching recommendation, given in the previous section, was to work towards the concept of ‘one health’.**

(2) Advocacy and information

In order to ensure that the importance of zoonotic diseases is recognized by decision-makers and donors, effective advocacy, firmly grounded in evidence-based assessments of the burden of these diseases on people, animals and poor livestock-keeping communities, is needed.

1. The meeting **recommended** the establishment of a scientific advisory committee for neglected zoonotic diseases to share and communicate information.
2. The meeting **recommended** that measures be taken to raise awareness among decision-makers at all levels about the impact of zoonoses.
 - Evidence should be submitted to the WHO Commission on the Social Determinants of Health on: (a) the disproportionate burden on health imposed by zoonotic diseases on the poor; (b) the dual

burden which results from the effects of zoonoses on livestock, with chronically lowered productivity, reinforcing the cycle of poverty and ill health.

- WHO, FAO and OIE should take the lead in sensitizing the donor communities and other stake-holders.

3. The meeting **recommended** that an international resource centre under the aegis of WHO, FAO and OIE gathering existing educational and advocacy material for zoonotic diseases, such as booklets, leaflets, handbooks, health education posters, etc, be established.

(3) Diagnosis and surveillance

The underpinning for both successful advocacy and for targeting and planning control activities is disease surveillance, based on effective diagnostics.

4. The meeting **recommended** that steps be taken to ensure that data on the incidence of these diseases in people and animals is systematically collected and assimilated.
 - Effective surveillance systems for each of the diseases should be established, or maintained where they already exist.
 - Local level registration and reporting systems for zoonotic diseases containing both veterinary and medical data should be developed.
 - The use of existing databases should be promoted (e.g. ARIS – Animal Resource Information System – developed by the PACE programme and other organizations’ databases).
5. The meeting **recommended** that health ministries, donors and NGOs make concerted efforts to ensure that diagnostic facilities for the neglected zoonoses are made available at local level in the endemic areas.

(4) Research

The meeting recognized that whereas many of the tools for controlling the neglected zoonoses were available, there are some notable gaps, particularly in the field of diagnostics. In the field of applied research, epidemiological studies are urgently needed to support advocacy and the design of control strategies.

6. The meeting **recommended** that a system for recognizing and funding centres of excellence in zoonotic disease research, which are linked to local public health systems, be developed.
7. The meeting **recommended** that small-scale focused epidemiological studies be undertaken to gather basic information for the design of control programmes, awareness generation and to support advocacy. Such studies should focus on the following:
 - Assessment of the DALY burden borne by individuals affected by the diseases.
 - Assessment of the cost of the disease to livestock production.
 - Study of risk factors in both people and animals with a view to successfully targeting at-risk groups for high priority intervention.
 - Investigation of methods for quantifying the rate of under-reporting of these diseases in humans.

8. The meeting **recommended** that research to improve and develop new disease control, prevention and monitoring tools adapted to the conditions prevailing in developing countries be supported. Such research should be tackled at international level and be multidisciplinary, involving both human and animal health research groups and relevant stakeholders.

(5) Control

Control measures already exist for several neglected zoonotic diseases such as rabies, anthrax, echinococcosis, cysticercosis, and brucellosis, which have a substantial disease and socioeconomic burden in poor communities. Interventions can be packaged through existing veterinary and public health structures. Several examples of major successful control programmes indicate that rational regional or even global control/elimination should be possible. This integrated approach can be extended to incorporate non-zoonotic public health problems prevalent in the same impoverished communities.

9. The meeting **recommended** that, depending on the characteristics of the human and zoonotic diseases prevailing in the area, control of the zoonotic diseases should be integrated and should be viewed within existing health systems.
 - ‘Control packages’ for animal diseases similar to school-based programmes for the control of certain human diseases in children should be developed. These should reflect a change from single disease/vertical approaches to more integrated health promotion by development of new control packages addressing several disease/health problems.
 - The development of such packages should be supported by operational research to assess their impact, safety and cost-effectiveness and by disease control and cost modelling exercises where appropriate.
 - These packages should target certain human populations such as: i) pastoral communities and remote sedentary rural populations in Africa and Asia and ii) marginalized urban livestock producers. Together these represent a substantial proportion of the world’s 600 million poor livestock keepers.
 - Where single disease control programmes are in place, or can be implemented in a cost-effective manner and in close collaboration between the human and animal health sectors, they should be supported.



Joint programmes targeting an animal population which is implicated in the transmission of more than one locally important zoonosis can be very effective. Here dogs are being both de-wormed to control cystic echinococcosis and also vaccinated against rabies.



Acronyms

AHP	Animal Health Programme (DFID)
AIDS	Acquired Immune Deficiency Syndrome
APHCA	Animal Production and Health Commission for Asia
ARC	Alliance for Rabies Control
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASEAN	Association of South-East Asian Nations
AU-IBAR	African Union – Inter-African Bureau of Animal Resources
BSE	Bovine spongiform encephalopathy
CE	Cystic echinococcosis
CWGESA	Cysticercosis Working Group in Eastern and Southern Africa
DALY	Disability-Adjusted Life Year
DFID	Department for International Development (UK)
EPI	Expanded Programme on Immunization
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GALV	Global Alliance for Livestock Vaccines
GFTADs	Global Framework for Trans-boundary Animal Diseases
GIS	Geographical information systems
GTZ	Gesellschaft für Technische Zusammenarbeit (Germany)
HAT	Human African trypanosomiasis
HIV	Human Immunodeficiency Virus
IEC	Information, education and communication
ILRI	International Livestock Research Institute
IUCN	International Union for the Conservation of Nature and Natural Resources
MZCP	Mediterranean Zoonoses Control Programme
NCC	Neurocysticercosis
OIE	World Organisation for Animal Health
PACE	Pan-African Programme for the Control of Epizootics
PAHO	Pan American Health Organization
PCR	Polymerase chain reaction
PEP	Post-exposure prophylaxis
SADC	Southern African Development Community
SSA	Sub-Saharan Africa
TDR	UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR)
TB	Tuberculosis
VPH	Veterinary Public Health
VSF	Vétérinaires Sans Frontières
WHO	World Health Organization



References

Listed here are documents referred to in the text as well as a number of key texts on the burden posed by and the control of endemic zoonoses.

While this report does not aim to give a full set of academic references, these documents will provide the reader with background information and list many further references.

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Meeting agenda

Opening

Welcome

Denis Aitken, Assistant Director-General, WHO

Scene-setting

François Meslin

Over-arching presentations

Zoonotic diseases: what are they and why they matter

Elizabeth Miranda

A problem of under-diagnosis: why we see only the tip of the iceberg

Eric Fèvre

Divided constituencies: why zoonoses often fall overlooked into the gap between veterinary responsibilities and medical needs

Winyi Kaboyo

Zoonoses control: a cost-effective opportunity for poverty alleviation

Alexandra Shaw

Success story presentations

Transforming a dual burden into a dual benefit: quantifying the economic impact of brucellosis in people and livestock in Mongolia

Jakob Zinsstag

Going global: extending a methodology for quantifying under-reporting of rabies from Tanzania's Mara District to Africa and Asia

Sarah Cleaveland

From PCR to policy: a novel control strategy for zoonotic sleeping sickness

Sue Welburn

Transforming research cooperation between medics and vets into a national control strategy: first steps in controlling bovine tuberculosis in Tanzania

Rudovick Kazwala

Engaging stakeholders: creating regional and international networks to combat cysticercosis

Samson Mukaratirwa

Taking things a step further: the programme for cysticercosis elimination in northern Peru

Hector Garcia

Effective surveillance and control templates: helping countries set up cost-effective strategies for detecting and controlling anthrax

Peter Turnbull

Combating a hidden threat: finding ways of reducing the burden of cystic echinococcosis in poor communities

Malika Kachani

Working groups

(1) Advocacy and prioritization: how can we raise awareness about the importance of zoonoses and the rationale for their control?

Helène Carabin, Eric Fèvre (Rapporteur), Mauro Ghirotti, Maria Vang Johanssen, Malika Kachani, Gunnar Nylén, Anil Patil, Mark Rweyemamu, Tom Randolph (Moderator) and Christina Schneider

(2) Institutional issues: what are the organizational and institutional elements for effective zoonoses control?

William Amanfu, Jean-Luc Angot, Sarah Cleaveland (Rapporteur), Olivier Fletchner, Jeffery Gilbert, Winyi Kaboyo, Samson Mukaratirwa (Moderator), Aristarhos Seimenis and Hiko Tamashiro

(3) Sustainability and resources: what measures are needed in order to ensure sustainable implementation of zoonoses control strategies?

Kate Aultman, Philippe Ankers, Nicolas Denormandie, Willem Droppers, Rosina Krecek (Moderator), Jean-Baptiste Roungou, Alexandra Shaw (Rapporteur), Peter Turnbull, Lee Willingham and Jakob Zinsstag

(4) Missing tools: what new information and/or methodologies are still needed for effective control?

Chris Bartlett, Phil Craig, Pierre Dorny (Moderator), Dirk Engels, Hector Garcia, Rudovick Kazwala, Deborah Kioy, Isabel Minguez-Tudela, Elizabeth Miranda, Craig Packer and Sue Welburn (Rapporteur)

Formulation of draft recommendations

Plenary session



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