Economics of brucellosis impact and control in low-income countries

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Summary

Most data and evidence on the economic burden of brucellosis and the benefits of its control are from high-income and middle-income countries. However, the burden of brucellosis is greatest in low-income countries. This paper focuses on estimating the economic burdens of brucellosis in low-income countries in tropical Asia and Africa. The prospects for national, technically feasible, and economically viable, national brucellosis control programmes in most low-income countries are limited. However, some targeted control programmes will be beneficial and can probably be feasibly managed and provide good economic returns. More ambitious control will require a more general strengthening of Veterinary Services and livestock-sector capacity, using risk-management-based approaches.

Keywords

Africa – Asia – Brucellosis – Costs – Economics – Low-income countries – One Health – Programme impact – Zoonosis.

Introduction

Brucellosis is consistently ranked among the most economically important zoonoses globally (11, 27, 28, 37). It is a 'multiple burdens' disease with economic impacts attributable to human, livestock and wildlife disease. The epidemiology and economic impact of brucellosis vary by geography and livestock system. In many high-income countries, brucellosis has been successfully controlled or eliminated in livestock populations. Where it persists, wildlife populations have become the main reservoirs (for example, bison and elk in North America). In emerging middle-income countries, the brucellosis picture is much more variable. Middle-income countries tend to report the greatest number of outbreaks and animal losses (see 36). Economic impacts vary depending on the main livestock species, management systems, and on the capacity of the country's veterinary and medical systems. In low-income countries, brucellosis is endemic and neglected, with large disease and livelihood burdens in animals and people and almost no effective control (15, 21, 28).

This article provides an overview of the burden and economic impact of brucellosis in animal and human populations and economic considerations for the prevention and control of brucellosis. While examples and approaches are drawn from different countries, the focus is on endemic brucellosis in the low-income countries of tropical Africa and Asia. These regions are characterised by large numbers of poor livestock keepers in both extensive (often pastoral and semi-pastoral) and intensifying smallholder livestock systems.

This assessment of the economic aspects of brucellosis, with emphasis on the low-income countries of Africa and Asia, is structured in three main parts. The first describes an overall framework for economic assessment of disease burdens and the impacts of potential control programmes. The second part systematically reviews available animal, human and joint burden estimates from studies conducted in these regions. The third section provides estimates, when available, of different costs associated with brucellosis illness and its control. This section also comments on tools and approaches for assessing control programmes that are of particular relevance to low and middle-income countries. The paper will conclude with some general recommendations for economic assessments and decision-making for control of brucellosis and other zoonoses.

Framework for the economic assessment of brucellosis

Endemic brucellosis in low-income countries of sub-Saharan Africa and South Asia has multiple economic implications across agriculture and public health and broader economic and social development sectors. Efforts to control the disease in low-income countries must take a different approach. Simply replicating past successes in brucellosis control and eradication in high-income countries will not work.

Low-income countries have at least a ten-fold higher burden of infectious diseases from a wide variety of pathogens (16). Given the close relationship between people and animals, zoonoses and other animal-associated foodborne diseases are particularly important. In most low-income countries, there is much less public investment in veterinary and health services, with weaker surveillance and operational capacity. On the positive side, increasing access to new technologies and more sophisticated tools for surveillance and targeting responses offer opportunities for improved disease control.

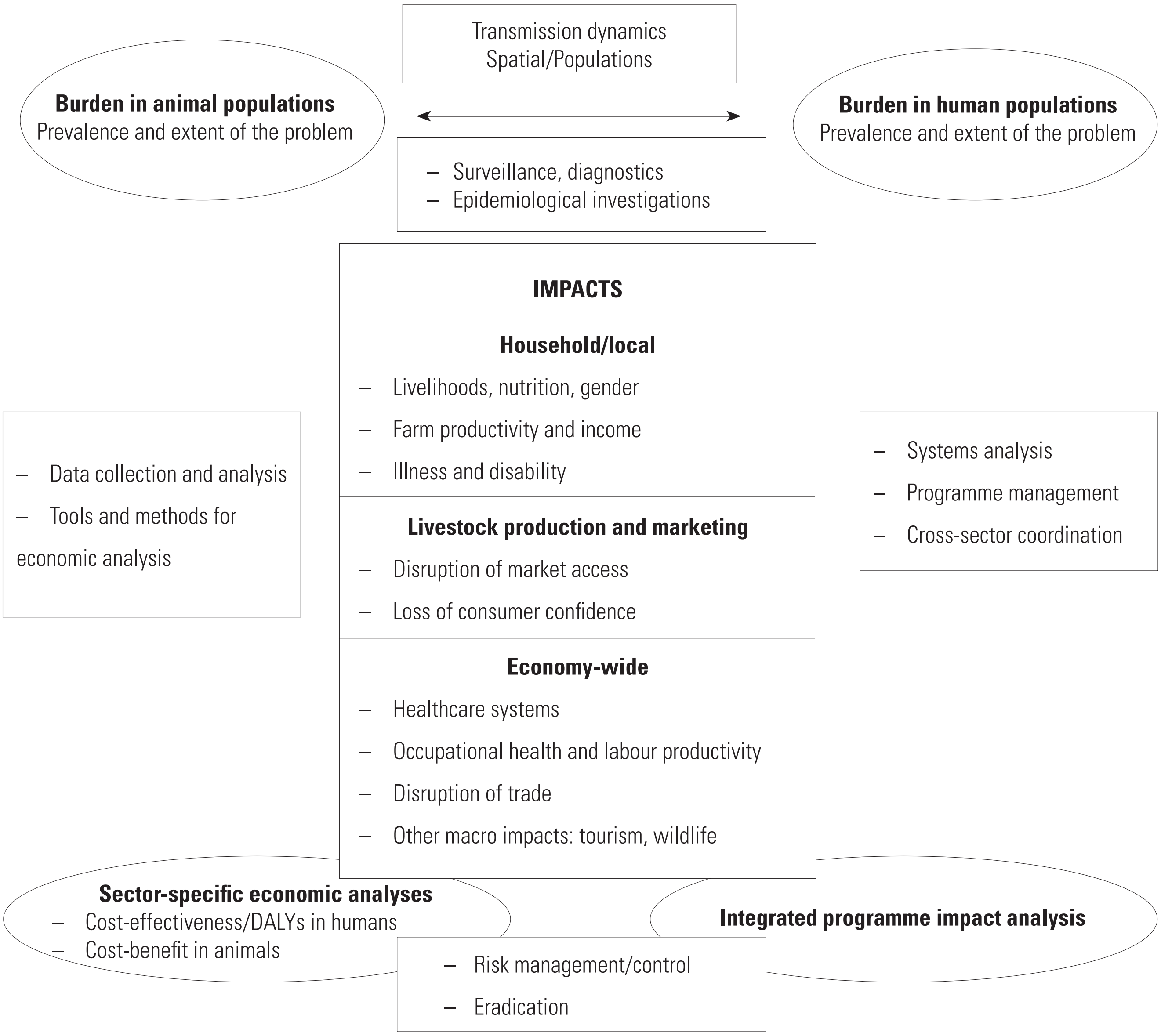
Economically, low-income countries of both South Asia and sub-Saharan Africa are growing relatively rapidly (5%–10% increase in gross domestic product annually), much more so than global averages, although from a much lower base. Government decision-making focuses on economic growth and employment, and any investment arguments for control programmes need to highlight economic returns. This can sometimes be a problem for animal disease control because in low-income countries the monetary value of animals and animal products is much lower than in high-income countries. Similarly, the indirect impacts of diseases on other economic sectors, such as tourism, are much smaller in developing countries than in developed countries (consider the massive indirect costs of the foot and mouth disease outbreak in the United Kingdom in 2002). In low-income countries, economic growth is very unevenly distributed. There is much faster growth in urban areas and rural areas connected by markets to towns and cities. Disconnected and remote areas have been left behind. In more dynamic areas, economic growth is reflected in improvements in private provision of health and veterinary services and opportunities for mixed public–private service provision.

Invariably, the epidemiological and economic assessments of the different forms of brucellosis in ruminants highlight the importance of controlling the disease in the animal reservoir. In low-income countries, both opportunities and strategies for brucellosis control will vary by livestock production system. In South Asia and sub-Saharan Africa, they vary between the two extremes of the intensification gradient of livestock production systems in which brucellosis is important: intensifying smallholder dairy systems and extensive pastoral and semi-pastoral systems.

Given this context, the authors have developed a framework for the economic assessment of brucellosis in low-income countries (Fig. 1). The basic building blocks are *(i)* information on the burden of brucellosis in different systems and *(ii)* details of the epidemiology and transmission dynamics of the disease. Obtaining this information enables us to understand how this burden might change under different control options (9). A second level of economic assessment is to look at the sector-specific impacts of brucellosis and its control to engage livestock and public health administrators. A third level is then to look at the potential for integrated programme-impact analysis, given the double or triple benefits of brucellosis control on animal populations, human populations and the overall economy. Very few of these analyses have been done for any zoonotic disease. The best documented example for brucellosis is the work of Roth, Zinsstag and colleagues in the extensive livestock system of Mongolia (31, 40). Finally, to engage policy-makers and investors effectively, it is important to assess the overall impacts at different levels of economic interest from households through market chains, and up to national and regional economies.

The burdens of endemic brucellosis in animal and human populations

This section focuses on the upper part of the framework, the estimation of the burden of brucellosis in animals and humans. Historically, estimates of the prevalence and other burden estimates of brucellosis have been relatively rare from tropical Africa and Asia as compared to temperate regions of Asia and Europe. In addition, when disease does occur it is rarely officially reported. The World Livestock Disease Atlas (36), based on official reports to the World Organisation for Animal Health (OIE), has few data from tropical Africa and Asia and does not show these as the highest-risk countries. However, it is clear that the degree of under-reporting of brucellosis is enormous. Even the most conservative prevalence estimates (calculated on the basis of the number of ruminants in Asia and Africa [Table I]) suggest that the number of cases is far higher than reported.



DALYs: disability-adjusted life years

Fig. 1
Framework for assessing economic impacts of brucellosis linked to burden of disease, diagnostics, epidemiology and control programme considerations

Table I
The number of predicted brucellosis cases per year compared to the number of outbreaks reported to the World Animal Health Organisation in 2010
Source: Based on a literature review in a report to the International Livestock Research Institute, Nairobi (11)

Region	Livestock prevalence %	Number of ruminants	Predicted cases per year	Outbreaks reported in 2010
East Africa	8.2	257,377,760	21,104,976	12
West Africa	15.5	197,716,517	30,646,060	37
South Africa	14.2	59,806,724	8,492,555	6,305
North Africa	13.8	57,629,367	7,952,853	1,073
South Asia	16.0	683,181,040	109,308,966	156
South-East Asia	2.9	21,247,586	616,180	164

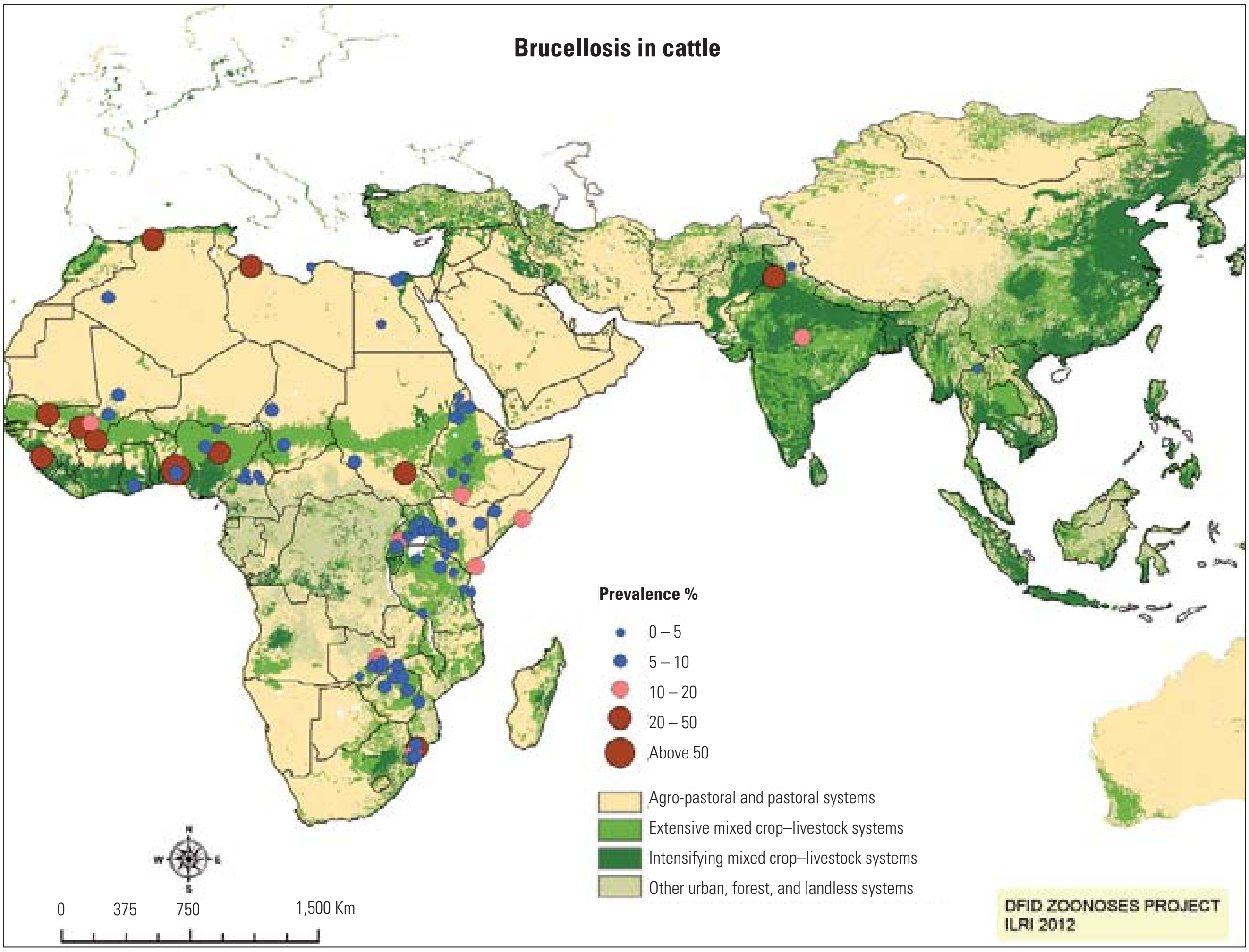


Fig. 2
Results of a systematic review showing brucellosis prevalence estimates in cattle on a map of livestock production systems in Asia and Africa

The results on prevalence and trends in brucellosis presented here were part of a larger review of the impact of 13 of the most important zoonoses in South and South-East Asia and Africa (11). Abstracts of recent articles were searched through PubMed (www.ncbi.nlm.nih.gov/pubmed/), CABDIRECT (www.cabdirect.org/) and Google (www.google.co.ke/) (including Google Scholar).

From this review (additional details of methods in 11), the authors created a database that included:

– the country where the study was done or where the results apply
– geo-spatial location (the specific location or coordinates, if given)
– number of herds studied
– number of samples analysed
– the specific diagnostic test(s) done
– subjects (livestock species, food, humans)
– individual prevalence
– herd prevalence
– the year the data were collected
– a description of the study population.

Where multiple surveys were reported in one study, each survey was listed separately (e.g. if prevalence was estimated in cattle and sheep, these were considered as two different surveys, each with an associated sample size, species and prevalence). The authors distinguish between 'community studies', which are conducted in the community and can be considered representative of it, and 'high-risk studies', which are conducted in high-risk populations (sick people in hospitals, malnourished children, cattle which failed ante-mortem inspection, samples taken during an outbreak, etc.).

In total, 259 studies were assessed covering 476,067 animals (244 studies) and 31,842 people (13 studies) and 537 food samples (two studies). Eleven studies were from high-risk groups (mainly people in hospitals) and 248 were from communities. Of the

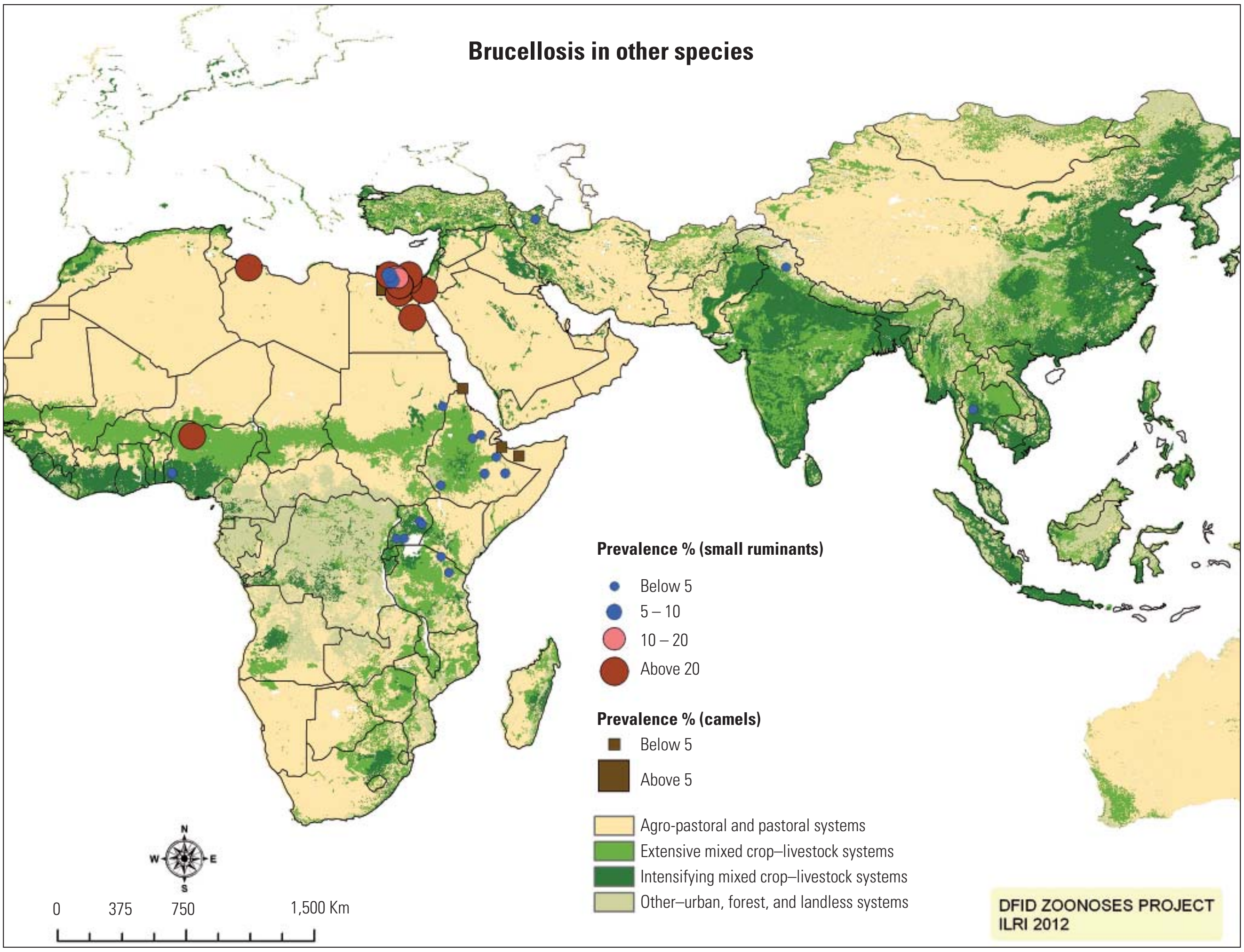


Fig. 3
Results of a systematic review showing brucellosis prevalence estimates in small ruminants and camels on a map of livestock production systems in Asia and Africa

244 studies in which animals were tested, most (193) were on bovine brucellosis (mostly caused by *B. abortus*, although *B. melitensis* is becoming more important), 35 studies were on sheep or goat brucellosis (*B. melitensis*), and the other 16 studies were on brucellosis in camels, swine and other animal species. Commonly used tests for brucellosis in these studies detect antibodies produced in response to infection. A combination of tests may be used to improve accuracy or ability to detect. Given the endemic nature of brucellosis, positive test results are strongly correlated with infection burden. Depending on the sensitivity and specificity of individual and combined testing regimes, and the true prevalence of disease within a country, test results may under- or over-estimate the true prevalence but usually provide a rough guide. In community surveys, the average prevalence was 13% (0–88.8%) in sheep and goats, 13% (0–68.8%) in bovines, 7% (0.4–20%) in camels, and 5% (0–12.9%) in other species (pigs, dogs). Only three studies (1%) found no evidence of brucellosis, but 33% reported low prevalences greater than zero but less than 5%. The results from this review were then used to map the prevalence of bovine (Fig. 2), caprine/ovine (Fig. 3), camel (Fig. 3) and human brucellosis (Fig. 4) by livestock production systems in tropical Asia and Africa.

These results provide strong evidence that brucellosis is a major problem in low-income countries. This is consistent with a previous review for sub-Saharan Africa (15) and not unexpected, given the overall higher burden of infectious diseases in tropical Asia and Africa. Regarding epidemiology, increasing intensification of small and medium-sized livestock enterprises in which livestock movement is relatively uncontrolled is associated with increasing prevalence owing to increased livestock density and contact rates. Brucellosis in traditional pasture-based systems is important and relatively stable. However, higher prevalences are seen in some pastoral systems around wildlife reserves with increased livestock

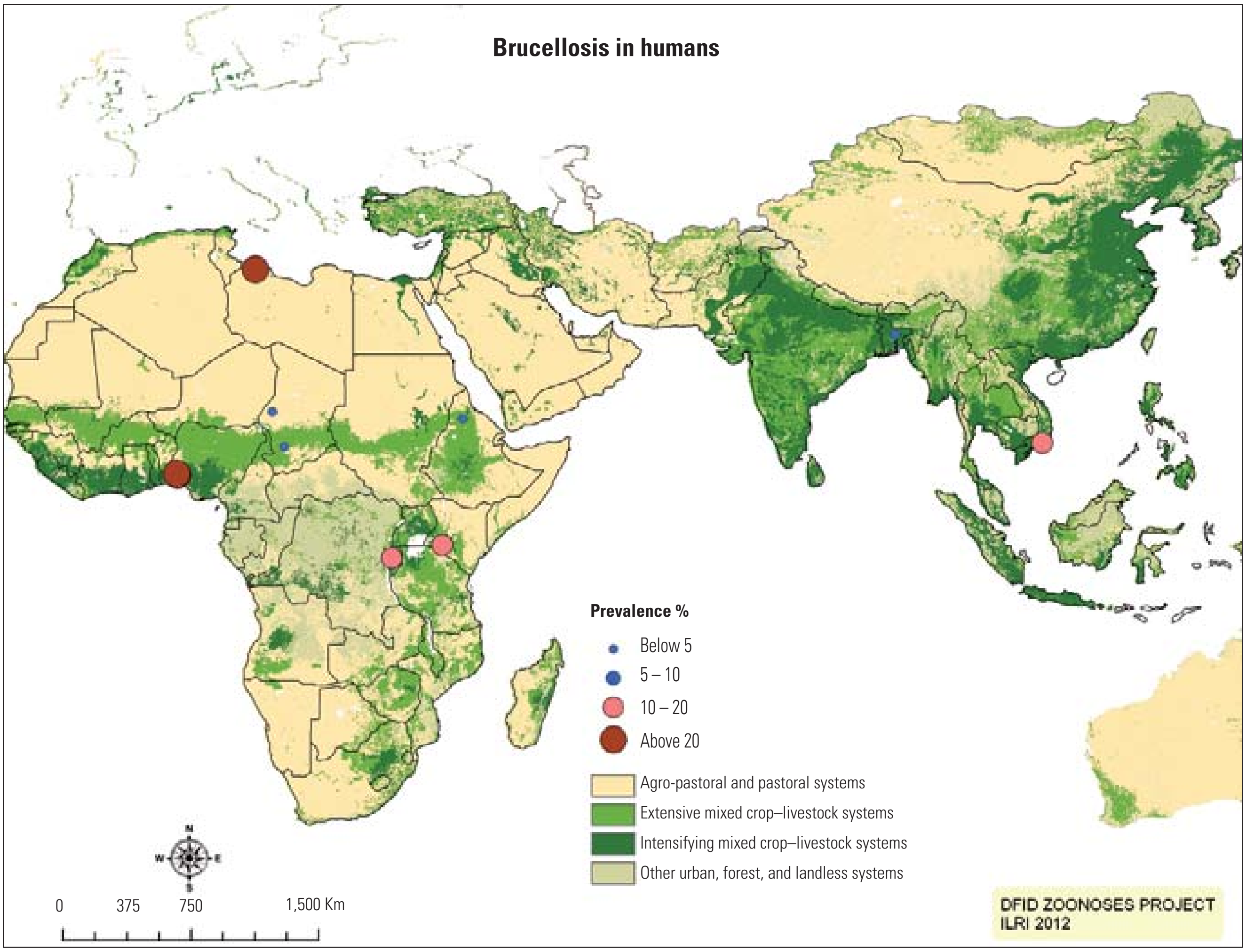


Fig. 4
Results of a systematic review showing brucellosis prevalence estimates in humans on a map of livestock production systems in Asia and Africa

densities and mixing rates. In confined smallholder dairy systems, animals do not mix and the prevalence is very low (12).

Higher productivity losses are associated with higher prevalence. Seropositive animals have higher rates of abortion, stillbirth, infertility and calf mortality, as well as reduced growth and longer calving intervals. Often, infected females will abort only once, although they may remain infected their entire life. Long-standing infections can result in arthritis and hygromas (a useful marker for brucellosis at herd level). Older literature in high-income countries found that aborting cows kept for milking produced 20% to 25% less milk for that season, while seropositive non-aborting cows produced 10% below potential (summarised in 11). Several studies in Africa have shown an association between seropositivity and abortions: around one fifth of cows may abort where seroprevalence is high (>30%) compared to less than 5% of cows in low-prevalence (<5%) areas or non-affected herds (24, 35). However, the impacts of brucellosis infections are less marked when overall production is low (7, 18).

Studies on the economic production losses of bovine brucellosis are reasonably consistent across a range of production systems in Africa, with losses estimated at 6% to 10% of the income per animal (3, 7, 21). At the end of the last century, economic losses for Argentina were estimated at US$60 million per year or US$1.20 per bovine when the prevalence was around 5% (32), and in Nigeria losses were estimated at US$575,605 per year or US$3.16 per bovine (prevalence 7% to 12%) (1).

Productivity losses resulting from *B. melitensis* infection are less well documented in tropical Asia and Africa. One study in India estimated the annual economic loss at Rs.1180 and Rs.2121.82 (current exchange rate US$1 = Rs.56) per infected sheep and goat respectively (34). In animals, brucellosis caused by *B. melitensis* usually occurs in outbreaks rather than in a more regular endemic pattern, as is frequently found when *B. abortus* is established (2). Brucellosis in pigs has productivity and economic impacts but there is little information on their magnitude in low-income countries.

The authors' review included 13 studies in human populations. Several studies in vulnerable populations found high seroprevalences: an average of 11% among livestock keepers/abattoir workers, and 7% among suspect hospital patients. One large study in India found that 2% of patients in the general hospital population tested positive for brucellosis (22). As in other regions, the main risks for people are occupational (contact with livestock) and consumption of dairy products. Economic losses caused by the disease in humans are a consequence of the cost of hospital treatment, cost of drugs, patient out-of-pocket treatment expenses, and loss of work or income due to illness. In Spain, losses from hospital costs and lost pay were estimated at 787.92 pesetas per patient (5), while estimated costs per case in New Zealand were NZ$3,181 (33).

Broader human disability-adjusted life year (DALY) burdens for brucellosis are yet to be estimated globally or across low-income countries (38). This reflects the fact that human brucellosis is even more under-reported than animal brucellosis. It usually presents as an acute febrile illness, often mistaken for malaria or typhoid (see Ref. 19 as an example, with further references in 15). There is a great need to introduce earlier differential diagnosis for brucellosis in high-risk populations (20). Chronic complications are not uncommon when diagnosis is delayed.

Economics of control and estimating control programme impacts

Multiple costs (and benefits) of brucellosis and its control

As described in the earlier section on the framework for economic assessment, endemic brucellosis in low-income countries has a range of economic implications. The technical and economic feasibility of different control options with different assumptions requires estimation of all potential costs. Figure 5 provides an overall costing framework that considers costs of illness, costs of prevention, and opportunity costs (both public and private) at household, livestock sector, health sector and broader societal levels.

The degree to which this level of detailed costing is required depends on the nature of the economic impacts of brucellosis. In high-income countries that have controlled and eventually eradicated brucellosis in livestock populations, livestock-sector benefits alone were usually sufficient to justify public and private investments. Given the much lower monetary value (as opposed to real value) of livestock production in developing countries, a more comprehensive inclusion of economic costs is required. Roth *et al*. (31) provide the most comprehensive costing estimates for low-income countries, calculating many of the

	Actors	Cost of illness	Cost of prevention	Intangible and opportunity costs
Private	Individuals and households	Treatment (e.g. medication), loss of household production	Risk mitigation such as boiling milk	Disutility of ill health per individual (DALYs) Disutility of ill health for friends, family, etc.
Private	Livestock sector	Treatment, herd slaughter, market loss due to risk of infected meat and milk, mortality, morbidity, lower production, loss of exports	Increased biosecurity, vaccination*, and procedures to control disease along the value chain (e.g. pasteurisation)	Future emerging disease Loss of animal genetic resources Loss of opportunities occasioned by spending on disease prevention and cure
Public	Health sector (human and animal)	Treatment (hospital provision, etc.) Outbreak costs, movement restrictions, culling, vaccination	Risk mitigation such as movement control and vaccination* Disease surveillance Research	
Public	Economy	Indirect effects on economic development, ecosystem services and tourism	Biosecurity, avoiding wildlife and vectors Disease surveillance Research	

Dark grey boxes: market prices available and commonly included in economic assessments of disease
Light grey boxes: market prices not available so costs need to be estimated through other methods
White boxes: prevention costs reflect efficiency and effectiveness of public and private service provision. Usually there are few data and only rough estimates are made
Black box: included in health metrics (DALYs),
*a number of costs (for example, vaccination) produce benefits for both the private sector (better livestock production) and the public sector (fewer human infections)
DALYs: disability-adjusted life years

Fig. 5
Costs to be considered and estimated in planning brucellosis control and eradication programmes

costs of illness and prevention in animals and people. It was the combination of individual and joint benefits that made brucellosis control attractive to government decision-makers. Shepherd *et al*. (33) used government budget numbers to estimate programme costs over a 10-year period (both veterinary and public health). Disease losses in the animal sectors were estimated using market prices. In addition to DALY estimates, direct and indirect costs were estimated through a survey, including opportunity costs of non-agricultural labour and care. Another example of detailed costing of healthcare is the costing undertaken by Kaufmann *et al*. as part of their estimation of the costs of responding to the deliberate introduction of brucellosis by bio-terrorism (13).

In low-income countries, it is essential to include all potential benefits of brucellosis control in economic assessments. For example, in the Mongolia study carried out by Roth *et al*., reduced public health department costs provided only 11% of the overall benefits (39). However, when adjusted for livestock-sector benefits and other hospital and healthcare benefits, the cost per DALY averted was estimated at US$19.1. As a rule of thumb, interventions that cost less than US$150 per DALY averted are 'attractive' from a public health perspective, while those that cost US$25 per DALY averted are 'highly attractive' (39).

A key challenge in economic estimation of the feasibility of proposed control programmes, and of the possible returns on investment, is to have a credible *ex ante* analysis using two or three different scenarios (see, for example 4, 33). Depending on the main burdens to be prevented, cost-effectiveness analysis (if human health impacts are important) or cost–benefit analysis (if only livestock-sector benefits are needed to justify control) can be undertaken. In the Mongolia study, given the importance of livestock-sector benefits, much care was taken in their *ex ante* estimation. Key parameters were estimated from the literature and expert opinion was used in a herd dynamic and productivity model (see 40). When joint animal and human costs and benefits of control are being estimated, modified cost-effectiveness analysis is the standard approach (31). In analyses limited to livestock-sector costs and benefits, classical cost–benefit analysis can be done (4). As will be highlighted in the next section, appropriate and rigorous *ex ante* analysis of potential control costs and benefits is usually not done, or if done, key elements and potential problems are ignored, providing overly optimistic projections.

Options for and experiences of endemic brucellosis control in low- and middle-income countries

Most successful efforts to control, and in many cases eradicate, brucellosis have been in high- and middle-income countries (and one low-income country – Nigeria) (see Table II). In general, successful control (and usually elimination in the livestock population) has led to positive benefit–cost ratios (even when public health benefits and the additional longer-term benefits of reducing control costs are not taken into account). The general pattern of control has been to establish a diagnostic and surveillance system and estimate the prevalence and distribution of brucellosis. From this diagnostic base, initial control measures, including vaccination, may be implemented to reduce an initial high prevalence. From there, testing, quarantine and slaughter with compensation policies are established. Sometimes special measures are required in late stages for high-risk populations. Often, the final stages are most difficult, when prevalence rates are low and the cost of finding the final positive animals is very high. The principles for these control and eradication programmes can be found in standard reference materials (6). Complications arise in eradication programmes if wildlife reservoirs exist. These are the topic of other papers in this volume.

However, attempts to control and eradicate brucellosis in middle-income countries using these classical approaches have been much less successful. These include the attempt to control brucellosis in Mongolia, which progressed at a very slow pace, as well as less than successful control programmes in Egypt, Israel (*B. melitensis*), Macedonia, India and the Azores (8, 23). Disease control and eradication are either probably not feasible or probably not economically viable in countries with inadequate veterinary resources, an inability to control livestock movement, widespread brucellosis in feral animals or wildlife, and farmers who are not strongly committed to public disease control efforts. These factors are often not considered in superficial *ex ante* economic analyses and ignoring these provides an investment picture that does not reflect reality.

In low- and middle-income countries, more targeted control measures may be more realistic and useful. Reduction of prevalence through targeted and time-bound vaccination campaigns may be economically beneficial as it could stop the spread of an outbreak of *B. melitensis*. Such an approach is reported to have been successful in Tunisia and Morocco (2). In slower-moving, more endemic situations, treatment can successfully eliminate shedding of organisms from long-term carriers (29), but it is believed to be economically unviable. Likewise, more targeted efforts at diagnosis, and treatment of occupational and other higher-risk human populations, will be more cost-effective than trying to implement human diagnosis and treatment programmes more generally.

For most of these more targeted control approaches, there is some information available on the success and failure factors, but very little on economic costs and benefits. Clearly, larger national control programmes will need to be justified through estimates of the longer-term economic benefits that

Table II
Summary of studies assessing benefit–cost ratios for brucellosis control programmes

Study topic	Country	Benefits considered	Authors	Summary
Brucellosis control	Nigeria	Livestock sector	Rikin, 1988 (30)	*Ex ante* estimate Ten years' control followed by 5 years' eradication BC 3.2 (10% discount*)
Brucellosis control	Mongolia	Human health and livestock sector	Roth *et al.*, 2003 (31)	*Ex ante* estimate Vaccination campaign (10 years) BC 3.2 (5% discount)
B. abortus eradication	England and Wales	a) Direct loss including veterinary costs, not human health costs b) Including less measurable costs (human health, trade, etc.)	Hugh Jones, 1976 (10)	*Ex ante* cost Testing and removal of reactors a) BC 1.1 (high discount rate) b) BC 2.2 (high discount rate)
B. melitensis vaccination	Portugal	Savings on compensation to farmers and hospitalisation versus cost of vaccine	Coelho *et al.*, 2011 (4)	*Ex post* estimate Vaccination Vaccination resulted in an average annual reduction of costs of US$603,714
B. abortus eradication	Czech Republic	Livestock sector, no human health costs	Kouba, 2003 (14)	*Ex post* estimate Depopulation and replacement BC 7.1 (simple, undiscounted)
B. abortus eradication	New Zealand	Livestock sector (Milk fat, calves, culling), human health costs of vaccination	Shepherd *et al.*, 1979 (33)	*Ex post* estimate With and without vaccination BC 1.74 (5% discount) BC 1.03 (10% discount)
B. melitensis control	Northern Cyprus	Not specified	Pasa, 2011 (26)	*Ex ante* cost–benefit ratio within 5 years for serological surveillance, compensations, and fixed costs BC 21.7 assuming herd prevalence <2% Test & slaughter for 5 years BC 10.2 assuming herd prevalence 5% to 20% Vaccinate females 4 to 6 months for 3 years BC 6.5 assuming herd prevalence >20% Vaccinate females 4 to 6 months for 5 years (Simple, undiscounted)

BC: benefits/cost ratio calculated as the present value of control benefits divided by present value of control costs
* the discount rate of interest used in converting future values and costs to present values and costs

accrue when eradication is achieved. In addition, long-term control without eradication is very difficult to maintain. Thus, for most low-income countries, more targeted control interventions will be the initial approach.

Conclusions and future approaches

In general, there is reasonable evidence that the overall burden of brucellosis in animal and human populations in low-income countries of tropical Asia and Africa is large. The challenge is to establish the evidence required to appropriately plan and economically assess more targeted control efforts that might be feasible and economically beneficial. From the evidence to date, there are a few main lessons and indications for future strategic control. The first is that national control programmes in low-income countries are unlikely to succeed when national Veterinary Services are weak and livestock movements are uncontrolled. In such cases, targeted efforts are much more likely to be technically feasible and economically justifiable. Such efforts might include vaccination when *B. melitensis* outbreaks are starting, or vaccination in high-prevalence populations which have potential for high productivity. To reduce human burdens, improving diagnosis and treatment in high-risk populations, and improving control along the food value chains when possible (for example, boiling milk), are both examples of potential targeted interventions.

As veterinary capacity and general livestock-sector management improve, economic methods such as those applied in the *ex ante* assessment of brucellosis control in Mongolia (33, 39, 40) should be applied. It is important to anticipate potential logistical problems and to deploy resources and invest quickly to establish and maintain momentum, as speed is critical to success.

Given the importance of endemic as well as emerging zoonoses to economic development and public health, 'One Health' risk-management frameworks for veterinary and veterinary public health will have broader benefits. A proposed framework has been provided (25). The approach is to build capacity and improve epidemiological and economic decision-making and to effectively communicate risk assessment results and risk management practices to maximise the uptake and rapid adaptation of control interventions. The delivery of such beneficial public systems could be through a combination of public and private service providers (17). There is an urgent need to build these capacities, as livestock systems are intensifying due to rapid increases in demand for livestock products in low- and middle-income countries.

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Aspects économiques de l'impact de la brucellose et de son contrôle dans les pays à faibles revenus

J. McDermott, D. Grace & J. Zinsstag

Résumé

La plupart des informations et des études relatives à l'incidence économique de la brucellose et aux bénéfices retirés des opérations de lutte émanent des pays à revenus élevés ou moyens. Or, l'impact de la brucellose est bien plus important dans les pays à faibles revenus. Les auteurs de cet article évaluent l'impact économique de la brucellose dans les pays à faibles revenus des régions tropicales d'Asie et d'Afrique. Il est rare que les pays à faibles revenus soient en mesure de mettre en œuvre des programmes nationaux de lutte contre la brucellose qui soient à la fois réalisables techniquement et rentables économiquement. Néanmoins, certains programmes ciblés de lutte s'avèrent intéressants et pourraient sans doute faire l'objet d'une gestion efficace, tout en offrant un bon retour sur investissement. Un objectif de contrôle plus ambitieux passe par le renforcement général des capacités des Services vétérinaires et du secteur de l'élevage, en recourant à des méthodes basées sur la gestion des risques.

Mots-clés

Afrique – Asie – Brucellose – Coût – Économie – Impact des programmes – Pays à faibles revenus – Une seule santé – Zoonose.

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Dimensión económica de los efectos y el control de la brucelosis en los países de ingresos bajos

J. McDermott, D. Grace & J. Zinsstag

Resumen

La mayoría de los datos y las pruebas sobre la carga económica de la brucelosis y los beneficios derivados de su control proceden de países de ingresos altos y medianos, pero en cambio la carga que supone la brucelosis alcanza sus máximas cotas en los países de bajo nivel de renta. Los autores se centran en la estimación de la carga económica de la brucelosis en los países de ingresos bajos de la franja tropical de Asia y África. En la mayoría de esos países hay escasas perspectivas de poder instaurar programas nacionales de control de la brucelosis técnicamente factibles y económicamente viables. Sin embargo, hay ciertos programas de lucha de carácter selectivo que serían beneficiosos, de gestión seguramente factible y económicamente rentables. En cambio, la aplicación de programas de control más ambiciosos exige potenciar de modo más general la capacidad de los Servicios Veterinarios y el sector ganadero aplicando planteamientos basados en la gestión del riesgo.

Palabras clave

África – Asia – Brucelosis – Costos – Economía – Efectos de los programas – Países de ingresos bajos – Una sola salud – Zoonosis.

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References

1. Ajogi I., Akinwumi J.A., Esuruoso G.O. & Lamorde A.G. (1998). – Settling the nomads in Wase and Wawa-Zange grazing reserves in the Sudan savannah zone of Nigeria III: estimated financial losses due to bovine brucellosis. *Niger. vet. J.*, **19**, 86–94.

2. Benkirane A. (2006). – Ovine and caprine brucellosis: world distribution and control/eradication strategies in West Asia/North Africa region. *Small Rum. Res.*, **62** (1–2), 19–25.

3. Camus E. & Landais E. (1981). – Methods of field evaluation of losses caused by two major diseases (trypanosomiasis and brucellosis) in cattle in the north of the Ivory Coast [in French]. *In* Proc. 49th General Session of the OIE, 25–29 May, Paris. Report No. 1.7. *Bull. Off. int. Epiz.*, **93** (5/6), 839–847.

4. Coelho A.M., Pinto M.L. & Coelho A.C. (2011). – Cost-benefit analysis of sheep and goat brucellosis vaccination with Rev. 1 in the North of Portugal from 2000 to 2005. *Arq. bras. Med. vet. Zootec.*, **63** (1), 1–5.

5. Colmenero-Castillo J.D., Cabrera-Franquelo F.P., Hernández-Márquez S., Reguera-Iglesias J.M., Pinedo-Sánchez A. & Castillo-Clavero A.M. (1989). – Socioeconomic effects of human brucellosis [in Spanish]. *Rev. clín. esp.*, **185** (9), 459–463.

6. Corbel M.J. (2006). – Brucellosis in humans and animals. World Health Organization, Geneva.

7. Domenech J., Lucet P., Valant B., Stewart C., Bonnet J.B. & Hentic A. (1982). – La brucellose bovine en Afrique centrale. 3. Résultats statistiques des enquêtes menées au Tchad et au Cameroun. *Rev. Elev. Méd. vét. Pays trop.*, **33**, 271–276.

8. Food and Agriculture Organization of the United Nations (FAO) (2010). – *Brucella melitensis* in Eurasia and the Middle East. FAO Animal Production and Health Proceedings No. 10. FAO, Rome.

9. Grace D. & McDermott J. (2011). – Livestock epidemics and disasters. *In* Handbook of hazards and disaster risk reduction (I. Kelman *et al.*, eds). Routledge, New York, 348–359.

10. Hugh-Jones M.E. (1976). – An assessment of the eradication of bovine brucellosis in England and Wales. *In* Proc. 1st International Symposium on Veterinary Epidemiology and Economics (ISVEE 1): New techniques in veterinary epidemiology and economics. University of Reading, Reading, 175–177. Available at: www.sciquest.org.nz.

11. International Livestock Research Institute (ILRI), Institute of Zoology & Hanoi School of Public Health (2012). – Mapping of poverty and likely zoonoses hotspots. Zoonoses Project 4. Report to the Department for International Development, UK. ILRI, Nairobi. Available at: www.dfid.gov.uk/r4d/Output/190314/Default.aspx (accessed on 5 July 2012).

12. Kadohira M., McDermott J.J., Shoukri M.M. & Kyule M.N. (1997). – Variations in the prevalence of antibody to *Brucella* infection in cattle by farm, area and district in Kenya. *Epidemiol. Infect.*, **118**, 135–141.

13. Kaufmann A.F., Meltzer M.I. & Schmid G.P. (1997). – The economic impact of a bioterrorist attack: are prevention and post-attack intervention programs justifiable? *Emerg. infect. Dis.*, **3** (2), 83–94.

14. Kouba V. (2003). – A method of accelerated eradication of bovine brucellosis in the Czech Republic. *Rev. sci. tech. Off. int. Epiz.*, **22** (3), 1003–1012.

15. McDermott J.J. & Arimi S.M. (2002). – Brucellosis in sub-Saharan Africa: epidemiology, control and economic impact. *Vet. Microbiol.*, **90** (1–4), 111–134.

16. McDermott J. & Grace D. (2012). – Agriculture-associated diseases: adapting agriculture to improve human health. *In* Reshaping agriculture for nutrition and health (S. Fan & R. Pandya-Lorch, eds). International Food Policy Research Institute, Washington, DC, 103–111.

17. McDermott J.J., Randolph T.F. & Staal S.J. (1999). – The economics of optimal health and productivity in smallholder livestock systems in developing countries. *In* The economics of animal disease control (B.D. Perry, ed.). *Rev. sci. tech. Off. int. Epiz.*, **18** (2), 399–424.

18. Magona J.W., Walubengo J., Galiwango T. & Etoori A. (2009). – Seroprevalence and potential risk of bovine brucellosis in zerograzing and pastoral dairy systems in Uganda. *Trop. anim. Hlth Prod.*, **41** (8), 1765–1771.

19. Maichomo M.W., McDermott J.J., Arimi S.M., Gathura P.B., Mugambi T.J. & Muriuki S.M. (2000). – Study of brucellosis in a pastoral community and evaluation of the usefulness of clinical signs and symptoms in differentiating it from other flu-like diseases. *Afr. J. Hlth Sci.*, **7** (18), 114–119.

20. Maichomo M.W., McDermott J.J., Arimi S.M. & Gathura P.B. (1998). – Assessment of the Rose Bengal plate test for the diagnosis of human brucellosis in health facilities in Narok District, Kenya. *East Afr. med. J.*, **75**, 219–222.

21. Mangen M.J., Otte J., Pfeiffer D. & Chilonda P. (2002). – Bovine brucellosis in sub-Saharan Africa: estimation of sero-prevalence and impact on meat and milk offtake potential. Livestock Policy Discussion Paper No. 8. Food and Agriculture Organization of the United Nations, Rome. Available at: ftp.fao.org/docrep/fao/009/ag274e/ag274e00.pdf (accessed on 10 July 2012).

22. Mantur B.G., Biradar M.S., Bidri R.C., Mulimani M.S., Veerappa K., Kariholu P., Patil S.B. & Mangalgi S.S. (2006). – Protean clinical manifestations and diagnostic challenges of human brucellosis in adults: 16 years' experience in an endemic area. *J. med. Microbiol.*, **55** (7), 897–903.

23. Martins H., Garin-Bastuji B., Lima F., Flor L., Pina-Fonseca A. & Boinas F. (2009). – Eradication of bovine brucellosis in the Azores, Portugal: outcome of a 5-year programme (2002–2007) based on test-and-slaughter and RB51 vaccination. *Prev. vet. Med.*, **90** (1–2), 80–89.

24. Matope G., Bhebhe E., Muma J.B., Oloya J., Madekurozwa R.L., Lund A. & Skjerve E. (2011). – Seroprevalence of brucellosis and its associated risk factors in cattle from smallholder dairy farms in Zimbabwe. *Trop. anim. Hlth Prod.*, **43** (5), 975–982.

25. Narrod C., Zinsstag J. & Tiongco M. (2012). – A one health framework for estimating the economic costs of zoonotic diseases on society. *EcoHealth*, **9** (2), 150–162. E-pub.: 7 March. Available at: www.springerlink.com/content/437606255x94124g/ (accessed on 9 July 2012).

26. Pasa D. (2011) – Bovine brucellosis in the northern part of Cyprus, control and eradication plan. Powerpoint presentation. *In* Proc. Zoonotic Diseases Symposium, 30–31 May, Lefkoşa, Cyprus. Available at: www.docstoc.com/docs/93215296/small-ruminant-brucellosis-in-the-northern-part-of-cyprus_-control-_2 (accessed on 10 July 2012).

27. Perry B. & Grace D. (2009). – The impacts of livestock diseases and their control on growth and development processes that are pro-poor. *Philos. Trans. roy. Soc. Lond., B, biol. Sci.*, **364** (1530), 2643–2655.

28. Perry B., Randolph T., McDermott J., Sones K. & Thornton P. (2002). – Investing in animal health research to alleviate poverty. International Livestock Research Institute, Nairobi, Kenya.

29. Radwan A.L., Bekairi S.I., al-Bokmy A.M., Prasad P.V., Mohamed O.M. & Hussain S.T. (1993). – Successful therapeutic regimens for treating *Brucella melitensis* and *Brucella abortus* infections in cows. *Rev. sci. tech. Off. int. Epiz.*, **12** (3), 909–922.

30. Rikin E.U. (1988). – Benefit-cost analysis for a brucellosis control program in Nigeria. *In* Proc. 5th International Symposium on Veterinary Epidemiology and Economics (ISVEE), 25–29 July, Copenhagen, Denmark. *Acta vet. scand.*, **84** (Suppl.) 371–373. Available at: www.sciquest.org.nz.

31. Roth F., Zinsstag J., Orkhon D., Chimed-Ochir G., Hutton G., Cosivi O., Carrin G. & Otte J. (2003). – Human health benefits from livestock vaccination for brucellosis: case study. *Bull. WHO*, **81** (12), 867–876.

32. Samartino L.E. (2002). – Brucellosis in Argentina. *Vet. Microbiol.*, **90**, 71–80.

33. Shepherd A.A., Simpson B.H. & Davidson R.M. (1980). – An economic evaluation of the New Zealand bovine brucellosis eradication scheme. *In* Proc. 2nd International Symposium on Veterinary Epidemiology and Economics (ISVEE), 7–11 May 1979, Canberra, Australia, 443–447.

34. Sulima M. & Venkataraman K.S. (2010). – Economic losses associated with brucellosis of sheep and goats in Tamil Nadu. *Tamil Nadu J. vet. Anim. Sci.*, **6**, 191–192.

35. Unger F. & Münstermann S. (2004). – Assessment of the impact of zoonotic infections (bovine tuberculosis and brucellosis) in selected regions of The Gambia, Senegal, Guinea, and Guinea Bissau – a scoping study. DFID [Department for International Development, United Kingdom] Animal Health Programme. International Trypanotolerance Centre, Banjul, The Gambia. Available at: www.itc.gm/downloads/scopingstudyonimpactofzoonoticinfections.pdf (accessed on 10 July 2012).

36. World Bank/Trust in Animals and Food Safety (TAFS) Forum (2011). – World livestock disease atlas: a quantitative analysis of global animal health data (2006–2009). World Bank, Washington, DC. Available at: www.tafsforum.org/livestock-disease-atlas.html (accessed on 5 July 2012).

37. World Health Organization (WHO) (2009). – Global health risks: mortality and burden of disease attributable to selected major risks. WHO, Geneva. Available at: www.who.int/healthinfo/global_burden_disease/global_health_risks/en/index.html (accessed on 5 July 2012).

38. World Health Organization (WHO) (2011). – The control of neglected zoonotic diseases. *In* Report of the 3rd WHO Conference on the control of neglected zoonotic diseases: 'Community-based interventions for prevention and control of neglected zoonotic diseases', 23–24 November 2010, Geneva. WHO, Geneva. Available at: www.who.int/neglected_diseases/zoonoses/en/.

39. Zinsstag J., Schelling E., Roth F., Bonfoh B., de Savigny D. & Tanner M. (2007). – Human benefits of animal interventions for zoonosis control. *Emerg. infect. Dis.*, **13** (4), 527–531.

40. Zinsstag J., Schelling E., Wyss K. & Mahamat M.B. (2005). – Potential of cooperation between human and animal health to strengthen health systems. *Lancet*, **366** (9503), 2142–2145.