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The economic efficiency and equity of government policies on brucellosis: comparative insights from Albania and the United States of America

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Summary
Brucellosis is a zoonotic bacterial disease that causes recurring febrile illness in humans, as well as reproductive failure and reduced milk production in livestock. The cost of brucellosis is equal to the sum of lost productivity of humans and animals, as well as private and public expenditures on brucellosis surveillance, prevention, control and treatment. In Albania, *Brucella abortus* and *B. melitensis* affect humans, cattle and small ruminants. In the United States, *B. abortus* affects cattle and wild ungulates in the Greater Yellowstone Area. These two case studies illustrate the importance of place-specific context in developing sustainable and effective brucellosis mitigation policies. Government regulations and mitigation strategies should be designed with consideration of all costs and benefits, both to public agencies and private stakeholders. Policy-makers should, for example, weigh the benefits of a regulation that increases epidemiological certainty against the costs of compliance for producers and households. The distribution of costs and benefits amongst public agencies and private individuals can have important implications for a policy's economic efficiency and equity quite apart from their total magnitude.

Keywords
Albania – *Brucella abortus* – *Brucella melitensis* – Externalities – Greater Yellowstone Area – Human brucellosis – Livestock brucellosis – United States – Wildlife – Zoonotic disease mitigation.

Introduction

Brucellosis is amongst the most economically important zoonotic diseases globally (1, 2, 3). This bacterial disease causes recurring febrile illness in humans, as well as reproductive failure and reduced milk production in livestock. Government regulations to control brucellosis, such as livestock test-and-slaughter, can also be devastating to households, especially the rural poor who may be the least economically resilient (1). Brucellosis can be caused by any one of ten different species of *Brucella*, which affect numerous hosts, including people. In some areas, more than one *Brucella* species is circulating (e.g. *Brucella melitensis* and *B. abortus* in Albania), and transmission can occur between multiple hosts (e.g. at the human–livestock–wildlife interface), making disease control more complex. The epidemiology and economic impacts of brucellosis vary widely depending on the geographical location, predominant *Brucella* species, and host species involved.

Here, the authors examine two case studies, one in Albania and one in the United States (US), which involve two *Brucella* species that affect several hosts. In Albania, both *B. abortus* and *B. melitensis* are circulating in cattle and small ruminants, and human cases are common, but wildlife is not thought to play a major role in transmission (4). In the US, *B. abortus* is found almost exclusively at the wildlife–livestock interface in the Greater Yellowstone Area (GYA),

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where brucellosis persists in wild elk (*Cervus canadensis*) and bison (*Bison bison*), with occasional transmission to domestic bison and cattle, but rarely to humans (5, 6, 7).

The historical and economic contexts for these two case studies differ in interesting ways. Albania's battle against brucellosis began in the 1950s with widespread test-and-slaughter and mass vaccination. In 1989, the country was declared free of bovine brucellosis and also achieved reductions of *B. melitensis* infection in small ruminants (4). Political upheaval in the 1990s, however, resulted in a resurgence of brucellosis (8). The current government is now battling to regain control over *B. abortus* and *B. melitensis*, subject to limited funding and resources (4).

The US, in contrast, has been able to consistently fund an 80-year campaign against brucellosis. The State–Federal Brucellosis Eradication Program, initiated in 1934 and federally funded in 1954, has involved surveillance testing, individual test-and-slaughter (previously whole-herd depopulation with producer compensation), and vaccination to eliminate *B. abortus* from all cattle, with the occasional exception of those in the GYA (9, 10). The cumulative cost of this campaign, last measured in 1998, exceeded US \$3.5 billion dollars (or \$4.9 billion when adjusted to 2015 US\$) (11). Additional resources have been invested since 1998, further increasing the cumulative cost. Economic studies from the 1970s to 1980s suggested that the eradication programme would generate positive net benefits to society (12, 13), but more recent programme assessments have not been conducted. Today, the brucellosis debate in the US focuses on whether eradication from the GYA is technically possible and economically justifiable and, if not, how government policies can be revised to minimise the cost of this stubbornly endemic disease.

Though the historical paths of these two countries have caused their brucellosis management outcomes to diverge, they provide common insights about the unique challenges of managing an endemic zoonotic disease. First, they highlight the importance of biological and socio-economic contexts in policy design and effectiveness. Secondly, they reveal opportunities to improve the economic efficiency of existing or future government mitigation policies. This paper focuses on a need, in Albania and the US alike, to fully enumerate not only the magnitude of costs and benefits from brucellosis mitigation strategies, but also their distribution across society, particularly for strategies enacted through government policies.

Economic framework

The primary focus of economics is on the efficient use of scarce resources. In particular, economists are often concerned about reaching socially efficient outcomes. But this can only be achieved when all parties' costs and benefits are considered in the decision-making or policy-making process. Beyond efficiency, economics is increasingly interested in the equity of costs and benefits distributed amongst different groups within society (14, 15). Equity is not guaranteed to occur just because a government policy has achieved economic efficiency at the social level (16). Additional analyses are therefore needed to determine who benefits from or bears the costs of brucellosis mitigation policies.

A successful investment strategy for reducing the impact of brucellosis on human and animal health requires economic assessment of disease losses, as well as the benefits and costs of both private and government expenditures on surveillance, prevention, control and treatment (17). A thorough assessment identifies costs and benefits to all parties – both public and private – to help ensure that disease interventions maximise society's well-being, rather than just a subset of society's well-being. Lastly, economic assessments should be translated into actionable recommendations for governments, including the type of brucellosis mitigation strategies to adopt, how they could be financed, and necessary public–private partnerships (18). Of course, optimal mitigation strategies will differ across countries, regions, and individual farms or households, varying with biological, environmental and social contexts (19). In all contexts, equity in the allocation of costs and benefits from interventions should be considered (20).

The cost (C) of brucellosis is a function of losses attributable to the disease itself (L), and expenditures on disease mitigation (E) (21, 22). The relationship between these components can be expressed as: $Cost = Losses + Expenditure$. Trade-offs often exist between L and E; for example, higher expenditure on mitigation usually results in lower losses, and vice versa (23). But these trade-offs are neither constant nor guaranteed to balance out. In the US, for example, early investments in brucellosis eradication dramatically reduced the number of cases in livestock and humans (9). But, as fewer cases remained, they became more difficult to detect and manage. Thus, larger increases in expenditures have been needed to achieve the same or smaller reductions in losses. Eventually, the marginal cost of additional mitigation efforts might exceed the marginal benefit, at which point the cure may actually become more costly than the disease. In such instances, net benefit from the mitigation effort is negative, and society may be better off without it.

In the presence of government policies for brucellosis, there are four specific components of cost (Fig. 1):

i) public/government expenditures on surveillance, prevention, control and treatment

ii) private expenditures or losses imposed on producers when they comply with government regulations or participate in mitigation programmes

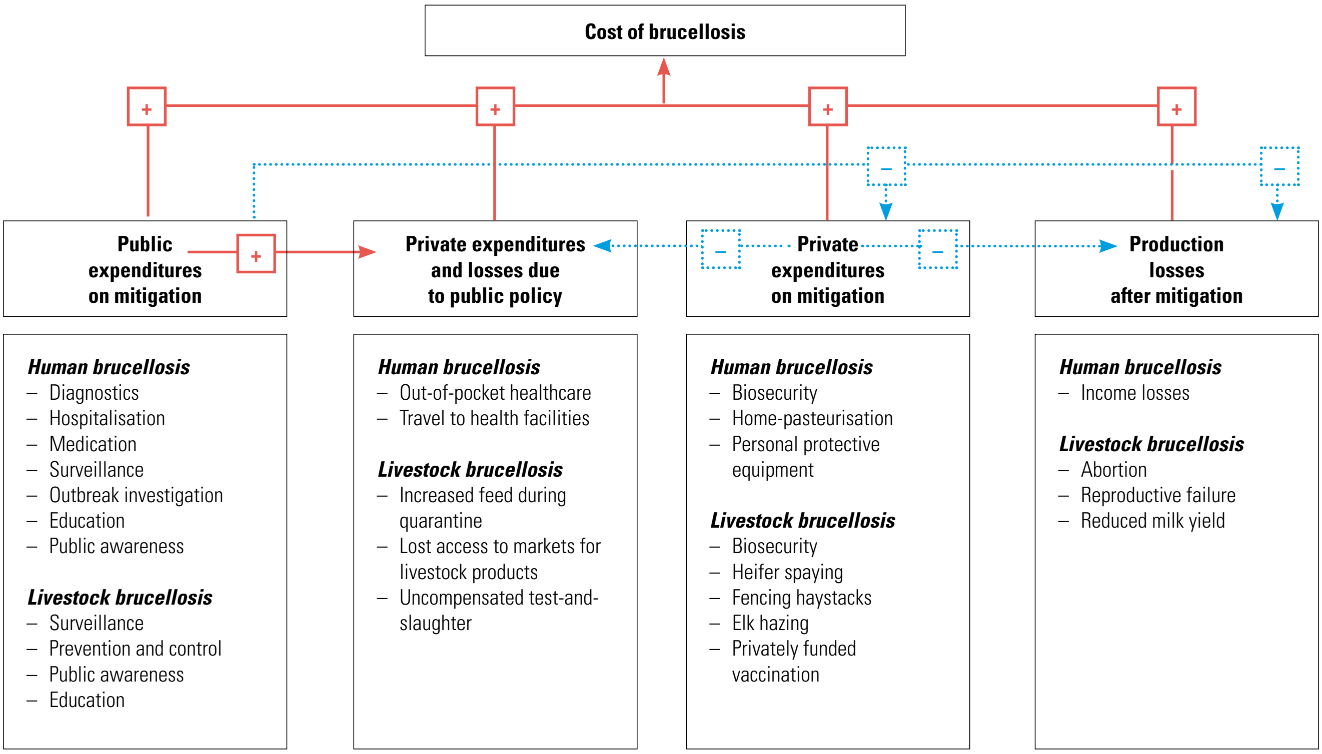


Fig. 1

A schematic diagram illustrating the cost of brucellosis, including the interaction between public and private expenditure and losses

Solid orange connections represent positive relationships (an increase in one increases the other)

Dashed blue connections represent negative relationships (an increase in one decreases the other)

iii) private expenditures that producers or households willingly make (even in the absence of government interventions) to reduce the risk of brucellosis, and

iv) private production losses that remain even after government and private mitigation efforts.

These four components highlight the reality that government policies not only generate potential benefits for individual producers, but also impose expenditures and losses. Conversely, individual producers' choices may affect the costs and benefits of government policy (18). As a result of the interdependence between private producers and government policy, the potential exists for brucellosis mitigation efforts to suffer externalities or exhibit public good characteristics (24). Externalities occur when someone makes a decision without considering all of the benefits and costs that it might impose on others. Their decision typically results in too much or too little of an activity or good, relative to the social optimum, hence a market failure. Public goods arise when a resource or service is either non-rival (i.e. one person's use does not preclude others from using it too), non-excludable (i.e. you cannot prevent another person from using it), or both. Depending on which of these two characteristics hold, a market failure may occur, such as free-riding, under-provision, or tragedy of the commons. Because of the potential for market failures in disease control, the US and Albanian governments have both instituted brucellosis mitigation policies that aim to maximise net benefits for society, rather than for any single stakeholder group.

Public expenditures on mitigation

Brucellosis mitigation strategies vary in complexity, but comprehensive strategies combine surveillance, prevention, and control in all affected species, as well as treatment of human cases (20, 25). Government resources to mitigate brucellosis are typically limited, so trade-offs must be made when policy is being developed. Furthermore, different components of government expenditures may be inherently linked; for example, some surveillance and intervention strategies may be complementary, whereas others are substitutes (26, 27). Here, the authors' interest in government expenditures focuses primarily on the resulting distribution of costs and benefits, on what these distributions imply about efficiency and equity, and how these insights could enhance future policy design.

Private expenditures and losses due to public policy

Owing to externalities and the public good characteristics of brucellosis mitigation, government intervention is needed to achieve socially optimal human health and animal production outcomes. Yet, to achieve the social optimum, government policies must be designed with consideration of all benefits and costs, both public and private. A proposed intervention, such as a prolonged restriction on animal movement, may seem attractive to an animal health agency because it minimises the risk of disease spreading from one farm to another, or from one region to another (28). But if it imposes large costs on producers, the benefits might not outweigh those costs. For example, if a movement restriction prevents livestock from being sold, the producer must feed and manage them for longer than usual, or instead slaughter them prematurely (29). These private costs should be considered when designing a movement restriction policy to achieve a socially optimal outcome. Additional examples of government policy imposing private costs on stakeholders are presented later for Albania and the GYA (US).

A country or region's political economy can also affect the magnitude of costs imposed on individual producers. In Albania, the bovine brucellosis control policy initially provided compensation payments for seropositive cattle that were culled. However, in 2013, the animal health budget was cut, so compensation was reduced to zero in some regions (30). Consequently, some producers received no compensation for seropositive cattle that were culled. Additionally, some producers' livestock were identified as seropositive but not culled, leaving the producers stigmatised and unable to sell their animals or dairy products (31). Such factors influence producers' willingness to participate in government programmes, and report when their animals are showing clinical signs of infection (24, 31, 32).

Private expenditures on mitigation

Individual producers or households are rarely able to directly influence public policy or the broader political economy. However, they can adopt specific biosecurity and behavioural changes to reduce disease costs at an individual level (33). These may complement (or substitute for) government policies, and potentially reduce the burden of compliance. For example, by reducing within-herd prevalence, a livestock producer might be allowed to cull fewer animals, or shorten movement restrictions on their herd (34). The extent to which producers allocate private funds for brucellosis mitigation depends on many factors, such as their herd's risk level, the mitigation activity's private cost, and the economic consequences of contracting the disease (19). More severe consequences increase a producer's incentives to mitigate brucellosis at their own expense.

In the GYA, producers can adopt several brucellosis mitigation activities to reduce their cattle's risk and the cost of government policy compliance, including: fencing haystacks, booster vaccination, spaying heifers, altering winter-feeding schedules, delaying grazing on high-risk allotments, and reducing the commingling of cattle and elk by hiring riders or requesting government personnel to haze elk away (34). In Albania, producers can isolate individual animals after they have aborted, and use gloves, masks and protective eyewear when milking or assisting animals during parturition. Better biosecurity practices would also reduce the risk of introducing brucellosis into susceptible herds (35).

Production losses after mitigation

Even if socially optimal mitigation activities and policies are implemented, some disease will still occur and cause human and animal health losses. For example, even if all animals are vaccinated, resistance against *Brucella* species is not absolute (36). Calfhood vaccination with strain RB51 in the US increased the proportion of cattle resistant to *B. abortus* from 33–40% to 83–87%; an improvement, yet imperfect (37, 38). Most interventions are less than 100% effective, and suffer from both variability and uncertainty. Thus, as long as brucellosis is present in a region, losses will exist, despite economically efficient mitigations.

With an understanding of the public and private cost categories of brucellosis, the authors now apply this economic framework to the two case studies in Albania and the US.

Brucellosis in Albania

In Albania, brucellosis affects human health and farm livelihoods. After the collapse of the communist government in 1990, human cases of brucellosis rose rapidly, peaking at 1,149 in 2004; an incidence of 36.8 cases per 100,000 person–years (39). An effective and sustainable mitigation strategy is now a priority of the Albanian government (30, 40). Historically, the government has committed significant resources to brucellosis control. Over half of all variable costs in the state veterinary budget in 2010 came from brucellosis control (30, 31). In 2012, a new national brucellosis control programme (NBCP) was initiated, which is scheduled to operate for at least ten years.

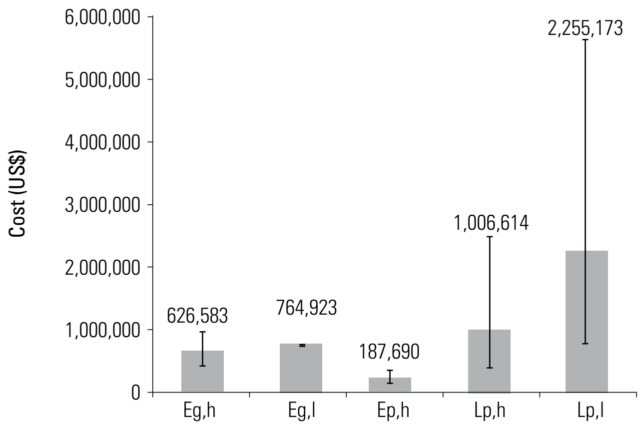
This programme involved vaccinating all adult and replacement sheep and goats, using *B. melitensis* Rev. 1, for two consecutive years (completed in 2012 and 2013), followed by annual vaccination of young replacement stock. A corresponding programme for cattle is not yet formulated. *B. melitensis* and *B. abortus* have both been isolated in cattle (41), but the two species' relative importance is unknown (4). Although *B. abortus* can be controlled by vaccine (RB51 or S19), there is no effective vaccine against *B. melitensis* for cattle (42).

The NBCP is co-financed by the European Union (EU) and supported by the 'Improving Consumer Protection Against Zoonotic Diseases – Albania' (PAZA) project. It has established an effective vaccine cold chain, launched public awareness campaigns, trained both private and state veterinarians, supplied Rev. 1 vaccine for small ruminants from 2012 to 2015, monitored vaccine delivery, and provided administrative support (30). In turn, the Ministry of Agriculture (MoA) financed vaccine delivery, and contracted private veterinarians to carry out small ruminant vaccinations. From 2016 onwards, the MoA is expected to be solely responsible for ongoing programme costs.

The NBCP's aim is to reduce the number of infected people and livestock, thus reducing brucellosis costs. A recent economic analysis estimated the annual costs of brucellosis in Albania before the current NBCP and then predicted the programme's net economic value over a ten-year period, from 2012 to 2021 (31). Economic costs included donor and government expenditures on brucellosis mitigation, private healthcare expenditures and illness-related income losses, as well as livestock production losses. Not included were private costs incurred to comply with government regulations, and private expenditures to mitigate disease risks. The distribution of costs and benefits amongst the EU, Albanian government, livestock sector, and households with human cases was assessed. Because the true prevalence of brucellosis in Albanian livestock is unknown (4), and human brucellosis is under-reported (2), inputs were modelled as probability distributions to account for uncertainty (31). Monetary costs were expressed in 2011 US$, where $1 = 102.7 Albanian lekë.

Brucellosis costs before the National Brucellosis Control Programme

The median annual cost of brucellosis in 2010, prior to the current NBCP, was US $4.84 million (range: $1.64 million to $18.33 million) (31). The distribution of costs is illustrated in Figure 2. Government expenditures on mitigation in livestock accounted for 15.8% of the median total cost ($0.76 million), compared to 12.9% on human diagnostics and treatment ($0.63 million). Private expenditure on human disease was 3.9% of the median total cost ($0.19 million), and private loss due to ill health was 20.8% ($1 million). The private loss due to livestock disease was 46.6% ($2.26 million); of this loss, 50% occurred in cattle, 33% in sheep, and 17% in goats. Even without private expenditures on mitigation efforts, or private costs due to government policies, the authors estimate that private costs far outweighed public costs (71.3% versus 28.7%). The distribution of benefits from historical government policies was unclear, so the authors can only estimate the potential benefits and costs of the current NBCP.



Eg,h: public expenditure on human illness
Eg,l: public expenditure on brucellosis mitigation in livestock
Ep,h: private expenditure on human illness
Lp,h: private income losses
Lp,l: private losses due to brucellosis in livestock

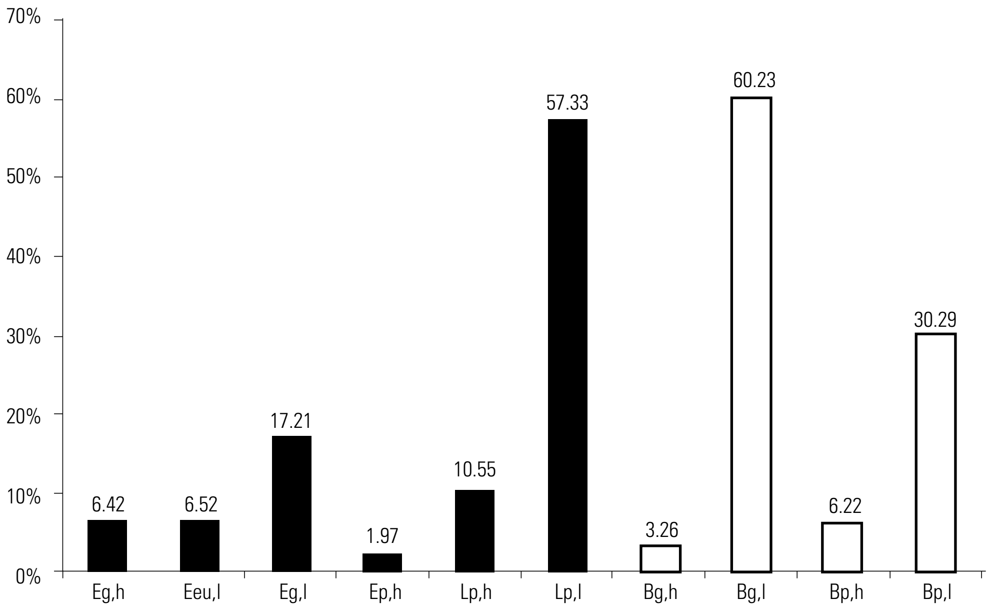
Fig. 2
Distribution of the annual cost of brucellosis in Albania, before the introduction of the current National Brucellosis Control Programme (in 2011 US$)

Bars represent the mean cost and whiskers represent the inter-quartile range
Source: unpublished data adapted from (31)

Net benefit of the National Brucellosis Control Programme

The distribution of the NBCP's predicted costs and benefits is illustrated in Figure 3. Discounted public expenditure on brucellosis mitigation over a ten-year period is predicted to be $9.71 million. The EU will contribute $2.10 million (21.6%) of this. The total expenditure by the MoA is $5.54 million (57.1%), whilst expenditure on human diagnostics and treatment by the Ministry of Health is predicted to be $2.07 million (21.3%). Public losses, such as effects on livestock trade and tourism, were not considered. Total private expenditures and losses are predicted to be $22.48 million. Private expenditure on human illness accounts for 2.8% ($0.63 million); private income loss is 15.1% ($3.40 million); and private livestock production loss is 82.1% ($18.5 million). Private expenditures on brucellosis mitigation in livestock were not calculated, nor were private expenditures and losses incurred by producers due to NBCP compliance.

The NBCP's median net present value (NPV) over a ten-year period, compared to the continuation of previous control efforts, was predicted to be $2.69 million (95% prediction interval [PI] of $1.25 to $4.74 million). It is therefore expected to provide a positive net benefit to society over ten years. Examining the distribution of benefits amongst various parties, the private benefits were $2.97 million from avoided livestock losses, and $0.61 million from income losses avoided and health expenditures saved. The public benefits were $5.91 million saved on MoA expenditures,



Eg,h: public expenditure on human illness
Eeu,l: European Union expenditure on brucellosis mitigation in livestock
Eg,l: public expenditure on brucellosis mitigation in livestock
Ep,h: private expenditure on human illness
Lp,h: private income losses that remain
Lp,l: private losses due to brucellosis in livestock that remain
Bg,h: public expenditure saved on human brucellosis
Bg,l: public expenditure saved on livestock brucellosis
Bp,h: private expenditure saved and losses avoided in human brucellosis due to the NBCP
Bp,l: private livestock brucellosis losses avoided due to the NBCP

Fig. 3
Predicted costs and benefits of the National Brucellosis Control Programme in Albania over a ten-year period
Measured in 2011 US$ but shown as a percentage of total costs and of total benefits. Costs are shown in black and benefits in white
Source: unpublished data adapted from (31)

and $0.32 million saved on Ministry of Health expenditures on human brucellosis. Although initial expenditure during the first two years of the NBCP was higher, total expenditure under the NBCP was considerably less over the ten-year period than that predicted in the absence of the NBCP.

Very little is known about private expenditure on brucellosis mitigation in Albania. A study investigating Albanian livestock producers' mitigation strategies and risk perceptions revealed that their knowledge of brucellosis transmission and mitigation was sound, but biosecurity measures were perceived as too difficult or too costly to implement (31). This suggests that current strategies for Albanian producers to mitigate brucellosis are either inadequate or producers require more evidence that the benefits will outweigh the costs.

Brucellosis policy and costs in the United States

The political economy in the US, in contrast to that in Albania, has been stable enough to fund a long-term campaign against brucellosis, starting in 1934 and continuing today. As a result, *B. abortus* has been successfully restricted to a single region in the US, the Greater Yellowstone Area or GYA. The eradication of brucellosis from the GYA's complex livestock–wildlife system has proven elusive, due to its unique ecological, epidemiological and socio-political characteristics (5, 6).

Stakeholders in the GYA, including state and federal policy-makers, disagree on whether brucellosis can be eradicated from wild ungulates, and, if so, whether the benefits would outweigh the costs. For example, the test-and-slaughter of wild elk is highly effective at reducing brucellosis in wildlife, yet it is also one of the most expensive and controversial methods. During a five-year experiment, elk test-and-slaughter reduced seroprevalence in one elk herd from 37% to just 5% (43). However, the annual cost of conducting elk test-and-slaughter (at three of 23 relevant locations) is roughly $600,000 per year, with an estimated annual benefit of just $6,000 per year (44). This mitigation strategy, despite its technical effectiveness, imposes large negative net benefits on society, at least in the short run.

Despite public and private efforts to mitigate brucellosis in the GYA, the disease still spills over from wild elk into cattle. Between 2004 and 2011, 17 infected livestock herds were detected, roughly two herds per year (5). Historically, when an infected cow was detected, the government would depopulate the entire herd and compensate the producer. The social cost of such whole-herd depopulation, for a cow-calf (beef suckler) herd of 400 breeding animals, was $515,000 (2010 US$) (45). However, when government budgets declined, the policy was shifted to whole-herd quarantine, with little compensation to producers. Now, when an infected cow is detected, its herd is subject to movement restrictions (i.e. not allowed to be turned out for grazing near or with other herds), and seropositive animals are culled. The herd is conditionally released from quarantine (i.e. allowed to be turned out for grazing) after three consecutive, negative, whole-herd blood tests, spaced 30 to 60 days apart, with the third test occurring after calving (46, 47, 48). This quarantine policy accounts for variability in the incubation period of *B. abortus*, and imperfect diagnostic tests.

The costs of quarantine depend on how long it takes a herd to pass three consecutive blood tests. The longer the quarantine, the more certain government officials are that all seropositive animals have been culled. But epidemiological certainty imposes larger private expenditures. For example, if a herd is quarantined for 12 months (with no access to grazing resources), the animals would be fed hay an extra 215 days, beyond the usual 150-day winter feeding season. The total social cost for this quarantine – including extra hay, labour, testing, spaying of market heifers, and culling of seropositive animals – would be roughly $145,000 (2010 US$) (45). This policy is actually cheaper for society than whole-herd depopulation, but it is more expensive for the producer. Under the quarantine policy, a producer incurs roughly $134,000 in costs (primarily for hay and labour), whereas the government incurs $11,000 (for testing and spaying, plus compensation for selectively culled animals). Under the old depopulation policy, the producer incurred $40,000 in costs (largely for labour), whereas the government incurred $475,000 (for testing, plus compensation for culling the entire herd). This policy shift from whole-herd depopulation to whole-herd quarantine saves society $369,000 for each 400-head herd, yet increases the affected producer's costs by $94,000.

From a social perspective, this policy shift increased efficiency but raised new equity issues. Specifically, since it was declining budgets that necessitated the policy shift, there was little public discussion of how producers might be affected. This sudden recasting of financial roles left GYA producers feeling abandoned – left to fight a disease of national importance largely on their own.

The lack of public discussion also raised questions about the efficiency of the new policy's design. In particular, without significant producer input, it was unclear whether policy-makers had crafted an efficient set of rules governing quarantine length. Had they found a socially optimal balance between the greater epidemiological certainty that comes with longer quarantines, versus higher regulatory costs for quarantined producers? In the past, policy design in the US placed greater emphasis on epidemiological certainty, with less concern for producers' costs. If producers' costs were indeed underestimated or ignored, then a negative externality may have occurred, unintentionally leading to an inefficient quarantine policy.

Fortunately, policy-makers in the US have increasingly recognised the trade-offs between epidemiological certainty and regulatory cost. Recently proposed rules, if approved, will allow state and federal veterinarians to cooperate with producers to design individualised quarantine plans, more sensitive to the GYA's livestock production context (48). This will reduce the cost of quarantine by allowing it to overlap the cattle winter-feeding season as much as possible, and interfere with grazing as little as possible. Figure 4 shows quarantine cost as a function of the number of extra days on which cattle must be fed hay. Reducing the quarantine period by half, from 12 months to six months (still requiring three consecutive, negative, whole-herd tests), reduces quarantine's social cost by two-thirds, from $145,000 to $53,000 (unpublished data adapted from [45]). Additional adjustments that minimise interference with the grazing season reduce the cost to just $12,000. However, these private cost savings come at a potential public price – reduced epidemiological certainty and thus an increased risk of brucellosis spreading to other cattle herds.

Another potential side effect of quarantine policy improvement is that, by reducing the private costs of brucellosis, producers may have a weaker incentive to

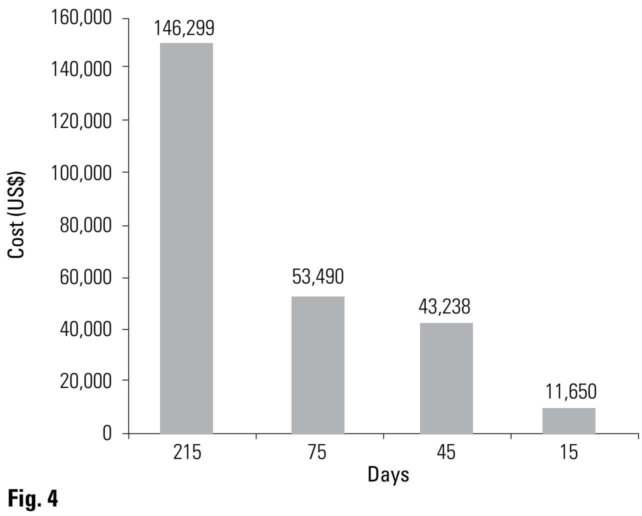


Fig. 4
Total cost (public and private; 2010 US$) of quarantine for a 400-head cow–calf herd in the Greater Yellowstone Area for brucellosis
Costs depend on timing and length of quarantine, i.e. the number of extra days on which hay must be fed, ranging from 15 to 215 days
Source: unpublished data adapted from (49)

invest in mitigation, such as cattle booster vaccination. If private investment declines, disease loss may rebound. This highlights again the importance of accounting for all costs of disease mitigation policy, including secondary costs arising from behavioural adjustments. In the GYA, preliminary analysis suggests that brucellosis quarantine policies are being modified in a way that should reduce expenditures more than it increases losses, thus reducing the total cost of brucellosis.

Discussion

Studies in both Albania and the US suggest that the battle against brucellosis is worth fighting. Yet it requires a sustained long-term effort, and careful consideration of benefits and costs, both public and private. Several tools and technologies are available to combat brucellosis, some more efficiently implemented by governments, and others willingly adopted by private producers or households (19). Successful mitigation requires an understanding not only of brucellosis epidemiology, but also of a region's unique context, and each mitigation policy's economic efficiency and equity (34).

These two case studies demonstrate, first, that mitigation strategies used in the US (e.g. whole-herd depopulation with compensation) might not be feasible or effective in Albania. Conversely, mitigation strategies used in Albania (e.g. vaccination of small ruminants against *B. melitensis*) might not be relevant at the GYA's livestock–wildlife interface. One common denominator between these case studies, however, is that management of an endemic zoonotic disease is biologically, politically and economically complex, especially when multiple hosts or causative species are involved. Given limited public and private resources for brucellosis mitigation, both studies demonstrate the need to enhance the economic efficiency (and, ideally, equity) of government mitigation policies. Opportunities exist to do so, regardless of whether a country is in the early stages of disease mitigation (e.g. in Albania, where the reduction of human cases is a top priority), or in the later stages (e.g. in the US, where eliminating the disease from a wildlife reservoir is a priority).

Meaningful differences also exist in these two case studies, particularly the barriers faced by each country in further mitigating brucellosis. In the US, progress towards eliminating brucellosis from wildlife, or minimising the cost of remaining brucellosis cases, depends heavily on technological advances in vaccination (for cattle or wildlife) and diagnostics (to eliminate quarantine). In Albania and other emerging economies, where zoonotic diseases perpetuate poverty, a more holistic strategy for governing and managing brucellosis is needed.

An holistic strategy would tackle the disease through multiple avenues: research and education about the benefits and costs of alternative mitigation tools; public investment in dairy pasteurisation; the availability of safe, stable and affordable vaccines; and the development of rapid, sensitive and affordable diagnostics. Any strategy must also recognise that, even when improved mitigation tools are available, some producers still will not implement them due to resource constraints. Producers contend every day with higher disease priorities, non-disease risks (e.g. scarce forage or water; predation losses; variable market prices), and priorities beyond, but inextricably linked to, livestock production (e.g. paying for their children's schooling; caring for elders; accessing medical care). Trying to fix one piece of this puzzle (e.g. improving brucellosis diagnostics) without addressing the others (e.g. the ability of producers to afford the test-and-slaughter of infected animals) may be an inefficient use of limited mitigation resources.

Trade-offs across the different components of an holistic mitigation strategy are beyond the scope of this paper. Instead, the authors provide an economic framework that emphasises the importance of quantifying both private and public costs and benefits in order to design socially efficient and equitable disease mitigation policies. The long-term success of these policies depends on our collective ability, as economists and policy-makers, to identify situations where people are being (or perceive themselves to be) unfairly disadvantaged by the costs of disease mitigation, especially when the benefits are enjoyed across society. When such inequities are occurring, disease mitigation policies are more likely to fail, regardless of their efficiency.

Efficacité économique et équité des politiques publiques contre la brucellose : un aperçu comparatif de la situation en Albanie et aux États-Unis d'Amérique

D. Peck & M. Bruce

Résumé

La brucellose est une maladie bactérienne zoonotique responsable d'épisodes fébriles récurrents chez l'être humain ainsi que d'infertilités et d'une baisse de la production de lait chez les animaux d'élevage. Le coût de la brucellose équivaut à la somme des pertes de productivité chez l'homme et chez les animaux et des dépenses privées et publiques engagées dans la surveillance, la prévention, la prophylaxie et le traitement de la brucellose. En Albanie, *Brucella abortus* et *B. melitensis* affectent aussi bien l'être humain que les bovins et les petits ruminants. Aux États-Unis d'Amérique, *B. abortus* affecte les bovins et les ongulés sauvages de la région du Grand Yellowstone. Les deux études de cas présentées dans cet article illustrent l'importance de prendre en compte le contexte spécifique de chaque site particulier lors de la mise en place de politiques durables et efficaces d'atténuation de la brucellose. La réglementation et les stratégies d'atténuation mises en œuvre par les pouvoirs publics doivent être conçues en considérant l'ensemble des coûts et des bénéfices induits pour les agences gouvernementales et les intervenants privés. Par exemple, les décideurs politiques devraient évaluer les avantages induits par une réglementation basée sur un accroissement des certitudes épidémiologiques, par rapport aux coûts supportés par les producteurs et les ménages se conformant à cette réglementation. La répartition des coûts et des bénéfices entre les agences gouvernementales et les individus privés peut avoir d'importantes répercussions sur l'efficacité économique et l'équité d'une politique sanitaire, indépendamment de leur amplitude totale.

Mots-clés

Albanie – Atténuation des maladies zoonotiques – *Brucella abortus* – *Brucella melitensis* – Brucellose animale – Brucellose humaine – États-Unis d'Amérique – Externalités – Faune sauvage – Région du Grand Yellowstone.

■

Eficiencia económica y equidad de las políticas públicas sobre la brucelosis: datos comparativos de Albania y los Estados Unidos de América

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Resumen

La brucelosis es una enfermedad bacteriana zoonótica que provoca dolencias febriles recurrentes en el ser humano, así como trastornos reproductores y una menor producción lechera en el ganado. Su costo es igual a la suma de las pérdidas de productividad en personas y animales, junto con el gasto público y privado dedicado a tareas de vigilancia, prevención, control y tratamiento de la enfermedad. En Albania, *Brucella abortus* y *B. melitensis* afectan a personas, ganado bovino y pequeños rumiantes. En los Estados Unidos, *B. abortus* afecta al ganado bovino y a ungulados salvajes de la zona del Gran Yellowstone. Los autores presentan dos estudios monográficos que ponen de relieve la importancia del contexto geográfico a la hora de definir políticas duraderas y eficaces para mitigar la brucelosis. Al elaborar tanto reglamentos como estrategias públicas de mitigación es preciso tener en cuenta la totalidad de los costos y beneficios, a la vez para los organismos oficiales y para el sector privado. Los planificadores deben, por ejemplo, sopesar los beneficios derivados de un reglamento que aporte mayor certidumbre epidemiológica en relación con los costos que entrañe su aplicación para productores y familias. La forma en que costos y beneficios se distribuyan entre organismos públicos y personas físicas puede influir sustancialmente en los niveles de eficiencia económica y equidad de una política, con independencia de su magnitud total.

Palabras clave
Albania – *Brucella abortus* – *Brucella melitensis* – Brucelosis del ganado – Brucelosis humana – Estados Unidos de América – Externalidades – Fauna salvaje – Mitigación de enfermedades zoonóticas – Zona del Gran Yellowstone.

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