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ZOONOTIC ENCOUNTERS AT THE SLAUGHTERHOUSE: PATHWAYS AND POSSIBILITIES FOR THE CONTROL OF CYSTIC ECHINOCOCCOSIS IN NORTHERN MOROCCO

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Summary. This study traces the biosocial dynamics of *Echinococcus granulosus* – a zoonotic tapeworm spread between dogs, livestock and people – at slaughterhouses in Morocco. One of the most important parasitic zoonoses worldwide, this neglected cestode is responsible for a debilitating, potentially life-threatening, human disease and significant livestock production losses. Transmission can be interrupted, among other ways, by restricting dogs from eating cyst-infected livestock viscera. Recent epidemiological studies in Sidi Kacem province, northern Morocco, found that government-operated slaughterhouses were 'hotspots' for hydatid cysts in livestock and infection in dogs. An ethnographic approach was used to compliment these studies, exploring 'how' and 'why' cysts were being openly discarded. All seven visited slaughterhouses had low levels of hygiene, oversight and infrastructure. This was described locally as perpetuating a sense of 'chaos' that normalized (un)hygienic practices and justified the ignoring of state rules and regulations. However deference to 'poor' infrastructure, both physically and symbolically, served to under-emphasize local institutional logics, which were mediated by prevailing risk perceptions, economic practices and local socio-political norms. These included inter-departmental government relationships, the motivation of veterinary technicians, the political lobbying of butchers and market-based

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mitigation strategies. The study shows the importance of understanding *E. granulosus* from a biosocial perspective, and the need for more long-term, participatory and integrated 'One Health' approaches for neglected zoonotic diseases.

Introduction

Echinococcus granulosus is a zoonotic tapeworm with a worldwide distribution. Although there is a sylvatic cycle, most transmission occurs between dogs, livestock and people. Mature tapeworms, 2–7 mm in length, live in the small intestine of dogs (their definitive hosts). When gravid proglottids release eggs (which move down the intestines due to peristalsis) they are shed in dog faeces. Small ruminants and cattle grazing on contaminated pastures then ingest these eggs; immature tapeworms migrate to the visceral organs of these animals, notably the liver and lungs, where they form large, thick-walled cysts. The dog–livestock transmission cycle is complete when these infected organs are not safely disposed of, and are consumed by dogs. Budke *et al.* (2006) estimated the annual economic impact of organ condemnation and associated production losses at US$2.19 billion.

Transmission to humans leads to the development of hydatid disease, also known as cystic echinococcosis (CE). This occurs when tapeworm eggs are accidentally ingested through water, vegetables or close contact with dogs. Cystic echinococcosis is of significant public health importance in certain endemic communities – for example pastoralists in temperate and semi-arid range lands where prevalence can be as high as 5–10% (Budke *et al.*, 2004; Gavidia *et al.*, 2008). The disease is associated with significant morbidity (persistent abdominal pain, weight loss, chest pain and other symptoms) and death in approximately 5% of cases (Craig & Larrieu, 2006). In some countries the parasite has been shown to disproportionately affect women and children; studies in Kenya and Ethiopia have related high transmission rates to 'nurse dogs' trained to lick children after defecation, as well as the use of dog faeces in medicines and cosmetics (Fuller & Fuller, 1981; French & Nelson, 1982). Cyst growth averages 7–29 mm per year in human liver and lungs, but symptoms take many years to develop. The need for imaging diagnostics, such as ultrasonography and radiography, as well as complicated treatments like surgery and repeat dosing of antiparasitic drugs, present major treatment obstacles for resource-limited communities (McManus *et al.*, 2012).

Controlling poverty-related zoonotic diseases like CE, which circulate between animals, people and the environment, poses conceptual and operational challenges. These relate to complex policy processes and organizational demands to bring about collaboration and prioritization between different disciplines and sectors (Okello *et al.*, 2014). But they also involve many other factors that are, for the most part, marginalized in much of the biomedical literature: the embedded nature of risk behaviours in local livelihoods, animal market routines, community values and norms, existing service delivery networks and the politics of infrastructure, among others (Mahmoud, 2008; Leonard *et al.*, 2009; Porter, 2013; Paige *et al.*, 2014; Bardosh *et al.*, 2014a, b). In short, zoonotic disease control adds additional layers of complexity to public health, precisely because they span different spatial and temporal relations between people, animals, micro-organisms and ecologies (Nading, 2013).

For these reasons, designing interventions at the 'human–animal–ecosystem' interface would benefit substantially from integrating perspectives from the social and biological sciences (Bardosh, 2015). *Echinococcus granulosus* is an interesting, challenging and relevant parasite in this regard, partially because it is one of the most costly and difficult to treat and prevent (Maudlin *et al.*, 2009). Most studies show low levels of knowledge in endemic communities, and there are very few national control programmes. The nature of *E. granulosus* control tools, and the timeframe needed to see a human health impact, present their own unique difficulties (Craig & Larrieu, 2006; McManus *et al.*, 2012). The most widely accepted public health strategy includes state-led testing and regular treatment of dogs with the antiparasitic drug praziquantel (every 6–8 weeks), the quarantine of infected livestock herds and the elimination of stray dogs, all of which have to be maintained for 5–10 years to impact substantially on parasite prevalence (Craig & Larrieu, 2006; Kachani & Heath, 2014). These are normally accompanied by what Gemmell *et al.* (2001) called 'horizontal' strategies: the upgrading of slaughterhouse infrastructure and protocols, legislative development (dog taxation and registration) and health education to change behaviours around dog management, livestock husbandry, personal hygiene and home-based slaughter practices. More recently, others advocate for the use of new vaccines for dogs and livestock to 'fast-track' CE control (Lightowlers, 2013), but which to date have been used only in small-scale trials.

History is informative, offering important insights into how this small cestode is interwoven into complex, non-linear and challenging biosocial dynamics. Craig and Larrieu (2006) reviewed thirteen prevention programmes, including the successful elimination from a few island countries: over nearly 100 years in Iceland (1863–1960), 70 years in New Zealand (1938–2002) and 30 years in Tasmania (1964–1996). Several programmes have reduced prevalence for more than a decade (in Chile and Uruguay) while others (in Wales, Kenya and Italy) have shown little impact. These programmes have been plagued by a host of context-specific problems: funding shortfalls, inadequate veterinary capacity, dispersed settlement areas, poor road networks, high stray dog populations, socioeconomic and political instability, existing husbandry practices and socio-cultural norms that surround cyst disposal. Outside of formal control programmes, *E. granulosus* is also influenced by changes in the relationships between humans, animals and ecosystems, including climate change (Atkinson *et al.*, 2013). Shaikenov *et al.* (2003) described an increase in Kazakhstan in the post-Soviet era caused by the breakdown of the traditional nomadic system, as well as large Soviet-style collective farms and state slaughterhouses. In contrast, farm economics and wider social changes in Iceland led to shifts in sheep husbandry away from older male sheep, who are more prone to infection given their age and grazing routines, and in favour of fat lambs, which helped to reduced prevalence over the long-term (Craig & Larrieu, 2006).

A major focus of veterinary and public health control efforts has been attempts to restrict access of dogs to livestock cysts. The setting in which livestock are slaughtered – divided between informal (home and clandestine slaughter) and formal (private and government slaughterhouses) – influences the social processes that mediate cyst disposal, with important consequences for CE. However, deference to 'ignorance' as the main driver of informal (and 'unhygienic') slaughter practices is greatly reductionist; such perspectives overlook the local logics (forms of cognitive reasoning that justify certain pathways of action and response), infrastructures and rationales that mediate and

reproduce these practices. 'Top-down' disease management techniques aimed at addressing informal practices can be very ineffective, predominately due to divergences between mainstream biosecurity narratives and approaches and the local interests and routines of smallholder farmers (Leach & Scoones, 2013). The experience of anti-contamination campaigns, such as mass poultry culling and attempts to replace informal 'wet bird markets' with formalized market structures, in the control of Avian Influenza in Asia is one good example (Scoones, 2010; Porter, 2013).

However, in many low- and middle-income countries, established government slaughterhouses retain a major role in animal slaughter, providing economies of scale by bringing together livestock keepers, butchers and consumers during market days. Interestingly, most studies on CE prevalence are conducted at rural and urban government slaughterhouses, suggesting that these facilities can also amplify disease transmission (Dakkak, 2010; Cardona & Carmena, 2013). While epidemiological studies comment on the 'unco-operative' behaviour of butchers, the 'very poor' inspection procedures of veterinary staff and the 'inadequate' infrastructure contributing to *E. granulosus* transmission (Biu *et al.*, 2006; Kebede *et al.*, 2009; Komba *et al.*, 2012), social science studies are, for the most part, absent from the literature (Bardosh, 2014). This suggests that the associated global and national policy spheres that surround CE may be under-appreciating some important alternative perspectives (Bardosh, 2015). To address this research gap this paper takes an ethnographic approach, tracing the biosocial dynamics of *E. granulosus* at government-operated slaughterhouses in one province (Sidi Kacem) in northern Morocco.

Methods

Study area

Morocco is endemic for CE with significant variation across different regions: from 1% to 85% in cattle, 0.5% to 59% in sheep, 2% to 22% in camels and 0% to 7% in goats; dog studies show rates between 22% and 63% (Azlaf & Dakkak, 2006). In 2004, 1701 human cases of CE were reported in the country (5.6 cases per 100,000 inhabitants) with a 2% mortality rate (CILCH, 2007). However, large-scale active surveillance studies using ultrasound in the Middle Atlas Mountains have shown a much higher 1% human prevalence (Kachani *et al.*, 2003).

Sidi Kacem province (3094 km^2) is located in northern Morocco between Rabat and Fez in a rural, fertile agricultural zone with a predominantly Muslim population of some 500,000 people. Although it has paved roads and many farmers have access to modern agricultural equipment and facilities (tractors, irrigation and electricity), Sidi Kacem is one of the poorest provinces in Morocco (poverty rate of 21.4% compared with 14.2% country-wide) with large wealth discrepancies. This is visible in the contrasts between large industrialized crop farms and living conditions in the more remote *douars* (villages), where people practise mixed-crop livestock farming.

Between 2003 and 2008, 192 people were diagnosed with, and underwent surgery for, CE in Sidi Kacem (average of 32 cases per year and 6.4 cases per 100,000 people). According to provincial records, 77% of cases were female in 2008. The livestock population, in 2010, included 120,000 cattle, 380,000 sheep and 20,000 goats which, according to state law, all had to be slaughtered at one of ten provincial slaughterhouses:

five rural, four town and one municipal. Home slaughter is largely restricted to festivals and ceremonies (such as the major Muslim religious holiday, *Eid El Kebir*) where young sheep and not cattle (which have a higher CE prevalence in Sidi Kacem) are preferentially eaten. The clandestine sale of meat (as opposed to home-based slaughter and consumption) is, for the most part, done only on an *ad hoc* basis, and is considered relatively rare.

Unlike previous studies in the Middle Atlas Mountains where CE prevalence is related to pastoralism and home slaughter (Kachani *et al.*, 2003), research in Sidi Kacem appears to show that most transmission is driven by practices at local slaughter-houses. Recent epidemiological studies undertaken as part of the EU-funded Integrated Control of Neglected Zoonoses (ICONZ) project (http://www.iconzafrica.org) included: a slaughterhouse-based study (2009–2013) that found 42.9% of cattle, 11% of sheep and 1.5% of goats were infected with hydatid cysts; a parasitological survey showing a 9.24% infection rate in dogs (which number roughly 20,000 in the province as a whole); and an additional parasitological study where a strong correlation between high infection rates in dogs and proximity to slaughterhouses was observed (unpublished data, ICONZ). This study was informed by, and aimed to complement, these epidemiological studies.

Ethnographic methods

This study was grounded in an ethnographic approach. The aim was to use ethnographic methods to investigate a specific health problem – the disposal of hydatid cysts – over a short period of time (Mignone *et al.*, 2009). Semi-structured and unstructured interviews, focus group discussions and direct and participant observation were applied to explore local perceptions, current practices and their drivers and logics related to cyst disposal. This included the relationships between *E. granulosus* and prevailing risk perceptions, social norms, local livelihoods, infrastructure and wider socio-political realities. The research strategy was informed by social constructivist perspectives that highlight the divergences, conflicts and congruencies between different social groups (Long, 2001) and recent work on the role of non-human 'actors' (things, animals, etc.) in structuring social relationships (Prout, 1996).

The study was designed with iterative reflection and close engagement with emerging data. Different sampling strategies were employed (snowball, purposive and convenience sampling) with a range of local people (see below for details). Fieldwork was continued until 'theoretical saturation' was achieved (Yardley, 2000).

Data analysis borrowed from modified approaches to grounded theory to identify themes and relationships (Cutcliffe, 2005; Charmaz, 2006). The approach included several different steps. The first was an iterative process of documentation and reflection during data collection itself, which allowed the research themes to stay 'close to our data.' After interviews and field visits, emerging data were explored and reflected on through discussion and analysis. This involved open coding (the labelling and categorization of phenomena from data), which generated key conceptual labels as well as memo writing. Memos included case-based memos (reflecting on particular field days and interviews) and conceptual memos, sometimes arranged in matrixes. This helped shape future lines of inquiry and analysis, including the selection of key informants (based on theoretical sampling) and new lists of interview questions.

This iterative analysis slowly built up conceptual understanding, interpretation and validation as data were collected, which were preserved in the field notes.

Initial codes and reflections were then re-visited by the author KB during more formal data analysis at the end of the study period. This process allowed the exploration of the relationships and connections between different themes and subthemes, which generated the analytical interpretations. The major themes that emerged from the analysis centred on: (a) infrastructure; (b) social relationships and politics; (c) economic mitigation strategies; and (d) risk perceptions. These were reviewed by other team members and conceptually validated, forming the subheadings for this article.

Fieldwork

The study was undertaken between December 2013 and April 2014. The field research team included the first two authors (KB and IEB). A Moroccan veterinary epidemiologist, IEB, had been collecting hydatid cyst samples from Sidi Kacem since 2009. The author KB is a UK-based social scientist with expertise in development studies, anthropology, sociology and public health. These two researchers, from very different backgrounds, worked together. Research was conducted in French (KB and IEB) and Arabic (IEB), manually recorded into notebooks and then transcribed into English. Following accepted practices, the research paid particular attention to the use of language, the social context of data collection, the positionality of the informants, the social relationships between different informants and how the researchers' possible biases may be influencing data collection and interpretation (Singer & Erickson, 2011).

It is important to note that this fieldwork was part of an interdisciplinary research project (ICONZ) that had operated since 2009 in Sidi Kacem. Repeated epidemiological data collection conducted in these same slaughterhouses (collection of hydatid cyst samples for genetic screening and categorization) had generated much prior, albeit unsystematic, tacit knowledge. This built rapport between Moroccan researchers and butchers, veterinary technicians and local politicians. In the context of Moroccan society, discussion about politics, government services and social conflict with a 'foreigner' (whether from the UK or from an urban centre) is generally avoided in public. Hence without these personal relationships, cultivated over five years, access to informants, slaughterhouses and nuanced local information would have been much more difficult, if not impossible, in the short study timeframe.

Much of the research data were generated during visits to the largest seven slaughterhouses in the province during and after *souk* days. This allowed for both short unstructured, and lengthier semi-structured, interviews to be guided by observations of the physical setting of the slaughterhouse. Additional research was done in two rural villages and in one town with a high *E. granulosus* prevalence in dogs (as per the ICONZ epidemiological study). In total, data analysis included 69 unstructured and semi-structured interviews with a wide range of local informants: meat and viscera sellers (21), restaurant owners (8) and carcass cutters (8) (all referred to as 'butchers'); veterinary technicians (7); dog owners (6); livestock keepers (5); *souk* cleaners (3); politicians (2); provincial veterinarians (2); NGO workers (2); medical officers (2); researchers (2); and one individual who had recovered from surgery for hydatid disease. Tailored to participants, these interviews explored different aspects of livestock keeping, dog

management, disease knowledge, veterinary policy, slaughterhouse practices, social norms and environmental change as relevant to CE control. Interviews lasted from 20 minutes (butchers interviewed, and observed, during busy market days) to two hours, and were done both in public and private. Fieldwork also involved four focus group discussions: one each with local political authorities, children and rural and town dog owners and livestock keepers. These focused on the challenges of engaging different social groups in *E. granulosus* prevention (i.e. what reasonable structures or interventions could be implemented to prevent open disposal of cysts). Finally, interviews were also conducted during a two-day integrated control intervention organized in the small town of Khenichet as part of ICONZ; these activities combined a large street parade with dog owners, education at schools, mass deworming, vaccination and blood sampling of dogs and ultrasound testing of people for CE.

Research activities were approved by the ethical committee of the Institut Agronomique et Vétérinaire Hassan II in Rabat as part of the ICONZ project. Approval was also obtained by all relevant commune and provincial authorities, whilst verbal informed consent was gained from all research participants.

Results

Infrastructure: the 'chaos' of the slaughterhouse

Rural *souks* are weekly open markets at the centre of the agrarian economy in Morocco. All seven visited slaughterhouses were situated in the farthest corner of the *souk*, next to piles of bones, animal parts, plastic bags and scattered garbage. As with other studies (Adeyemi & Adeyemo, 2007), the slaughterhouse was considered to 'contaminate' the local environment while also being aesthetically unappealing (especially after *souk* days). Although all had roofs, walls, doors and piped water, most were more than 40 years old, in various degrees of disrepair and lacking infrastructure components deemed essential for CE control (Table 1). These were well known to the local veterinary technicians, employed by the Ministry of Agriculture (these actors are not fully trained veterinary surgeons but have undergone a variety of diploma-level professional training courses; they are all known locally as 'vets' due to the lack of trained veterinary professionals). These technicians were tasked with

Table 1. Characteristics of the seven local slaughterhouses, Sidi Kacem province, northern Morocco

Visited slaughterhouse:	1	2	3	4	5	6	7	Total
Cattle slaughtered	16	33	9	13	6	13	59	149
Sheep slaughtered	14	41	14	18	10	9	17	123
Room divisions			1				1	2
Entrance/exit doors in use								0
Fence						1		1
Septic tank			1		1			2
Incineration tank			1		1			2

Note: The numbers of cattle and sheep slaughtered were counted once per visit.

managing the slaughterhouse and inspecting meat according to government regulation (they were never directly involved in the slaughter process), and went to great lengths to stress the physical characteristics of slaughterhouses, specifically the gulf between existing infrastructure and established guidelines, as the *main* driving force behind the open disposal of cysts. As one stated:

> Hygiene stops at the door [in these slaughterhouses] …You cannot have meat inspection without first having the proper infrastructure. You need proper, modern buildings. See how crowded it gets with people moving in and out? There is no order. We really need better buildings and infrastructure to control [cystic echinococcosis]. (Interview, Veterinary Technician)

This lack of infrastructure extended to multiple physical particularities, outlined in policy documents: a separate entrance and exit door; separate rooms for different livestock (cattle and sheep) and activities (i.e. slaughter, skinning, hair removal and visceral removal and cleaning); septic and incineration tanks; a perimeter fence; and functioning drainage. These standards were considered to be 'European' and 'modern' in contrasts to the colloquial terms used by veterinary technicians, politicians, NGOs and butchers to describe local slaughterhouses: 'catastrophes', 'noisy', 'overcrowded', 'ungovernable', 'dirty' and 'chaotic'. However, despite this emphasis on disorder, slaughterhouses all had local logics and routines that governed how they worked.

Animal slaughter was undertaken, for the most part, on the day of the *souk* when animals were brought in by truck, or on foot from surrounding villages. This allowed butchers to easily purchase livestock from the surrounding animal market, bring the animal for slaughter and then sell the meat and viscera directly at the market to customers. The number of animals slaughtered (per market day) at each slaughterhouse ranged from roughly 10 to 60 cattle (Table 1), with roughly the same number of sheep; provincial records obtained from the veterinary office showed 6588 cattle, 9594 sheep and 2590 goats slaughtered in 2009, nearly half at the municipal slaughterhouse in Sidi Kacem town.

Beginning in the early morning, animals were purchased by butchers from the animal market and brought into the slaughterhouse. Two to three men, with a clear division of labour between them, were then directly involved with each cattle carcass. The local term *boucher* in French (butcher in English), which was used to describe anyone involved in the slaughterhouse economy, actually referred to four different sub-groups: the wealthier meat sellers (رازج in Moroccan Arabic), the viscera sellers (السقيطية), makeshift restaurant owners (الكفيتية) and the 'carcass cutters' (السالخة). While these actors were involved, in one way or another, with the slaughtering process and were physically in and out of the slaughterhouse, it was mostly up to the latter group to butcher the animal and parcel it – in exchange for the more undesirable animal parts, which could then be sold to customers in the *souk*.

Once inside the slaughterhouse, livestock were slaughtered on the floor, with their legs tied, according to 'Halal' Muslim ritual slaughter practices – requiring that the throat be cut to sever the artery, vein and windpipe and allow blood to drain. The heads and hoofs were removed and the body hung on makeshift hocks to be skinned and parcelled (in most slaughterhouses veterinary technicians had to create their own pulley and hook systems using wood because the original steel systems were at the wrong height). This was done in small, overcrowded rooms full of body parts and blood, and

with poor drainage. Men conversed, and argued with each other, about roles, responsibilities and profits, racing in and out of the slaughterhouse to negotiate business deals in the surrounding *souk*. Waste was funnelled into drains, often forming streams directed out towards the street and nearby houses, where dogs congregated.

Like building regulations, there were also a set of government meat inspection procedures aimed at preventing dogs from eating cysts, and to inspect carcasses for zoonotic diseases: mainly CE, bovine tuberculosis and fasciolosis. These were all well known to the veterinary technicians: carcasses had to be inspected with the slaughterhouse door closed, butchers physically outside and the head and major organs (i.e. heart, liver and lungs) attached. Organs with more than three cysts were to be fully condemned while, in other cases, cysts were to be physically removed by the technicians. These were then meant to be denaturalized (using a bleaching agent), discarded into incineration tanks and burnt.

Interviews and observations showed that it was difficult for veterinary technicians to follow these prescriptions. Officially, carcasses (including viscera) were not to be removed from the slaughterhouse until the carcass was inspected and stamped with red ink to symbolize that they had been inspected (or blue, for lesser quality meat). Directly after slaughter, most butchers quickly put the viscera into large bags and brought them outside for sale or swiftly moved them to makeshift tables directly outside to drain intestinal contents onto the ground – due to the lack of space in the slaughterhouses themselves. Most cysts were deliberately removed by butchers within, or just outside, the slaughterhouse. Within the building, cysts were discarded onto the floor, then removed together with other livestock waste by pitchfork and wheelbarrow in the late morning or, for the municipal slaughterhouse, placed in waste bins to be brought to the municipal garbage dump (where packs of dogs gathered and ate the scraps).

Apart from the municipal slaughterhouse, animal parts (livers and lungs) that were heavily cyst-infested were thrown directly outside in close proximity to groups of between ten and twenty free-roaming dogs. This was observed on multiple occasions at each *souk*. Such market days were known as 'festival days for dogs'. This meant that most viscera were never inspected, and often not seen, by the veterinary technicians during market days; butchers emphasized that the ink stamp only required the presence of the carcass since 'only the meat is stamped, not the viscera' (Interview, Butcher).

Paradoxically, CE was nonetheless considered the 'most important disease' to be inspected by the veterinary technicians at the slaughterhouse. Even when inspected (which only happened a few times during this research), viscera were observed only by eye (and not palpated to find smaller cysts inside the organ meat), and summarily cut off and dropped onto the slaughterhouse floor. Discussions with butchers and observations inside the slaughterhouses revealed that the butchers carefully removed cysts in order to maintain the integrity of the organ meat, for subsequent sale. In contrast, the veterinary technicians were perceived to be careless, accused of hastily cutting much larger pieces and causing greater economic losses. Attempts by technicians to remove cysts were perceived as a threat to the profits of local butchers, who would resist inspections to maintain their own informal practices. Technicians explained this in more apolitical terms: cysts were not burnt owing to the difficulties of drying them over 24 hours, the unpleasant smell of burning meat, absence of 'quarantine boxes', and lack of denaturalization chemicals and incineration tanks. Only one slaughterhouse was

found to denaturalize cysts with household cleaning products – which were then dumped outside – but only for heavily infected viscera. In other circumstances, even when incineration tanks and denaturalization chemicals were available, they were not used: one technician, after claiming he used the incineration tank regularly, was unable to locate it!

Technicians and slaughterhouse politics

Although veterinary technicians, politicians and others attributed the open disposal of cysts to 'poor infrastructure', such material realities were intimately related to wider socio-political processes. This is best explained by the difficult social position of the veterinary technicians tasked by the state to inspect, and condemn, livestock.

Veterinary technicians emphasized a reluctance to openly confront butchers about the presence of cysts in their meat and viscera. Butchers were considered 'difficult people…they are so pushy and become aggressive if you confront them [about infected viscera]' (Interview, Veterinary Technician). Such individual aggressiveness extended to a collective willingness to protect their independent interests, as butchers were also a powerful lobby group – most *souks* had 'butcher associations' that could represent them at meetings with local commune leaders; some informants claimed that they could even remove technicians from their posts. Efforts to reform the slaughterhouse, from time-to-time implemented by different veterinary technicians, met with stiff political resistance; local politicians quickly informed the veterinary staff to 'be relaxed with the regulations…don't cause problems for the butchers' (Interview, Veterinary Technician). This was best shown in the attempts of a young veterinary officer in Sidi Kacem town (where the municipal slaughterhouse was found) to institutionalize a series of regulations to upgrade hygienic norms to the 'European' standards found in other major urban centres in Morocco (i.e. Fez, Meknes, Rabat, Tangier and Casablanca): proper clothing (i.e. boots), medical certification showing negative tuberculosis test results, butcher association cards to restrict the number of people in the building, the need to leave the major organs (i.e. liver and lungs) attached to the carcass for inspection, and others. Implemented in mid-2011 when there was social and political upheaval in the neighbouring North African countries of Tunisia, Libya and Egypt during the Arab Spring, this resulted in three days of small-scale street protests around the municipal *souk* culminating in the governor of Sidi Kacem province informing the Ministry of Agriculture to 'let them be…do not rock the boat' (Interview, Government Official). According to one official:

> Butchers work in chaos – so disordered – and they benefit financially [from not having proper inspections] so they want to make our work hard…we need to privatize the slaughterhouses [so they are away from political lobbies] for this to work. We tried but no one wants to make the initial investment for infrastructure. (Interview, Government Official)

In contrast, veterinary technicians in more rural slaughterhouses offered more sympathetic perspectives. Butchers were 'poor people', and '[seizing meat] from those with little money is not right…I cannot do that. It is a moral issue…they are my friends' (Interview, Veterinary Technician). In a rural agrarian landscape dominated by small-scale crop and livestock production, it was considered 'unrealistic' to impose strict food

safety measures for endemic diseases like cystic echinococcosis, at least outside an epidemic situation and/or significant project funding. Hence technicians not only felt 'blocked by butchers' in a political sense but also, to some degree, morally bound as well.

The 'disorganized nature' of the slaughterhouse, as often mentioned, was linked to its physical characteristics (i.e. lack of hygiene and infrastructure), which made it 'impossible to chase everyone [i.e. impossible to inspect for cysts]' (Interview, Veterinary Technician). In this way, the inadequate physical design of these buildings was widely discussed, and located within political 'tensions' between the Ministry of Agriculture and the Ministry of the Interior. Owned and managed by local communes governed by the Interior Ministry (who were tasked with cleaning the *souk* and building the slaughterhouses), it was the Ministry of Agriculture who paid the salaries of veterinary staff. Building specificities of the most unhygienic slaughterhouses, two of which had been renovated in the last ten years, was attributed to the local communes not consulting vet technicians over building needs: buildings were too small, lacked hooks on which to hang carcasses, had no water and lacked proper drainage. The local vets explained this exclusion by reference to the nature of local commune politics: specifically issues of resource allocation, construction contracts and timelines, and the generally dismissive perception of local leaders towards soliciting veterinary expertise. As one technician stated:

> These are essentially viewed as political decisions with motivations [to gain politically]. Constructing slaughterhouses is a political process. They think veterinarians are not 'real doctors' like human doctors…they degrade us…[and] think that technical experts have nothing significant to contribute. So we are excluded. (Interview, Veterinary Technician)

As noticed in the Avian Influenza response in Asia (Porter, 2013), there was a tendency for veterinary expertise to be considered 'second-rate' to human biomedicine and public health and for infrastructural projects to be dominated by politics rather than expert advice. For example, efforts by veterinary staff to improve the structure of the slaughterhouses met with little support from these same government departments; as one of the more motivated technicians stated:

> I informed the MoA office [in the capital] and the commune of this unhygienic situation [and the problem with the lack of veterinary input into its design]. It is truly unacceptable! We even had the newspapers and television stations here [for publicity]. This made the politicians angry! But I have heard nothing…They only cooperate in high offices [in Rabat] but never on the ground!' (Interview, Veterinary Technician)

However, this emphasis on the need for improved infrastructure – represented in statements like: 'Only money can fix this pathetic situation' and 'how can we inspect cysts when we do not even give input into building the slaughterhouse facilities?' (Interviews, Veterinary Technicians) – also served to excuse the technicians for their lack of personal initiative in efforts to organize local control efforts. As one stated, 'We have to wait until they build a new slaughterhouse. There is no option [for control], we have to wait. What can we do? Nothing!' (Interview, Technician).

To community members, however, the lack of infrastructure was only one part of the 'unhygienic' situation of slaughterhouses; the other major driver related to the attitudes of the technicians themselves. For example, *souks* were opened by a local (unofficial)

'manager'; in most cases technicians (dressed in laboratory white gowns with suit and tie underneath) arrived *long after* all animals had been slaughtered; most remained seated in a small office to the side of the slaughterhouse for most of the morning. There was clearly a lack of motivation. Some butchers, including the father of a teenage boy who had three hydatid liver cysts surgically removed in Rabat (Morocco's capital where most patients are referred for treatment in complicated cases), accused technicians of corruption:

> …they are being given [meat] by the butchers to keep quiet so they do not want to make them angry and do their job properly. They are just lazy! (Interview, Butcher)

One technician candidly admitted, 'It is simply because it is extra work [that the cysts are not properly disposed].' Such attitudes were explained by reference to the limited veterinary capacity at the provincial level as well as low salaries and outreach funds. Curiously, technicians made much of the need to routinely stamp carcasses with red or blue ink. This was done not so much because of its public health benefit but because of the need to maintain a semblance of authority, oversight and hence power and influence as 'inspectors'. The butchers had to play the game and comply; all consumers expected that 'good meat' would have a stamp.

Given discrepancies between regulations and actual practices, veterinary technicians emphasized that instead of concentrating on restricting access of dogs to cysts (which was not considered feasible without improvements in infrastructure as a pre-requisite to reorganizing slaughterhouse procedures), the most acceptable CE control strategy would be to regularly kill free-roaming dogs at *souks*. Even though they recognized that 'new dogs always come to take their place' and that the approach was 'limited…killing dogs will only reduce the disease so much', the technicians believed that supporting weekly elimination of dogs would be effective as a method to indirectly enforce dog owners around *souks* to restrict the movement of their dogs during *souk* days. This idea has some merit; humane euthanasia combined with fertility control has been recommended for CE control (Kachani & Heath, 2014). At present, however, dog control is done a few times per year around each slaughterhouse using strychnine; despite technicians acknowledging that this was technically illegal and not considered 'humane' euthanasia. Provincial records showed that 913 dogs were officially killed in 2013, but most were in response to rabies cases, and dog culling is *not* considered effective to control the rabies virus.

Local economics and the viscera sellers

Given that hydatid cysts generate economic losses by reducing livestock productivity and affecting meat market chains, this research also explored how economic incentives in the *souk* market system could play a role in CE control. The idea was that by motivating local market actors to recognize future financial benefits, they may be willing to participate, or institute, self-regulations for safe cyst disposal. A complex market chain was observed, which fostered specific mitigation strategies to reduce the financial burden of CE. These also generated their own problems in terms of current, or future, efforts to control the parasite.

As noted above, the term 'butcher' was used to refer to four categories of market actors: meat sellers, viscera sellers, makeshift restaurant owners and carcass cutters (Table 2). Using makeshift wooden stalls, these various traders were clustered together

Table 2. Numbers of different types of butchers at study slaughterhouses, Sidi Kacem province, northern Morocco

Visited slaughterhouse:	1	2	3	4	5	6	7	Total
Meat sellers	9	33	12	13	8	11	34	120
Viscera sellers	11	41	9	16	7	7	40	131
Restaurant owners	9	21	11	13	8	12	17	91
Total	29	95	32	42	23	30	91	342

Note: The number of butchers was only noted once per slaughterhouse. This figure excludes the number of carcass cutters due to the difficulties encountered in locating many of them away from their activities at the slaughterhouse.

at the *souk*, and paid tax and a small fee to the veterinary technicians for use of the slaughterhouse. Representing the divergent interests between butchers and state authorities, newly government-constructed cement stalls – which attempt to regulate sellers and improve *souk* hygiene – were rarely used because they were considered 'unnatural…they upset the way we do business…we prefer our wooden structures' (Interview, Butcher). Most butchers were illiterate and none used soap or disinfectants when preparing or handling meat; they travelled to various *souks* each week, and the wealthier meat sellers kept small shops or restaurants in rural towns.

Butchers were considered by veterinary technicians and politicians to be 'poor people' with multiple vulnerabilities. The informants roughly estimated that the number of butchers and animals slaughtered in Sidi Kacem had declined by more than half over the last ten years. Reduced demand for cattle and sheep meat was attributed to environmental and socioeconomic changes, specifically the proliferation of fish and chicken sellers (who sold at a quarter to half the price of meat per kilogram) and climate change, believed to have caused years of inadequate rains that had significantly cut grain harvests. Although there were conflicting accounts of how these socio-environmental drivers impacted the prevalence and intensity of hydatid cysts, they were perceived to have significantly influenced the local farm-based economy. As one butcher stated:

> People are poorer now than before…some things have improved like electricity and water but people are not buying meat because of the bad rains, and we [the butchers] have suffered. (Interview, Butcher)

Although prices for beef and sheep are set by the state – 60 dirham (US$7.50) per kilogram for beef, weighed on a steel scale – butchers had particular ways of doing business to retain their established clientele through offering extra pieces, making jokes and playing the 'diplomat' during the sometimes lengthy price bargaining that is a well known cultural tradition in Morocco (Rosen, 1984). Such sellers had a difficult balancing act, as being 'too generous' could quickly reduce profits given the small margins involved, especially if one was not a popular seller. Veterinary technicians emphasized that butchers were:

> …not rich people. They have big families…their work is tough, sometimes they can even lose money depending on how much meat is on the carcass and how many customers they have that day. (Interview, Veterinary Technician)

This division of labour in the market chain, often handed down from father to son, was socially negotiated. Important economic drivers structured how cysts were removed and who lost out financially. This shaped the incentives that market actors had, or did not have, to control CE. Preferences and prices for different classes of livestock and viscera were important to consider. The more expensive young bulls (15,000 dirham or US$1875) were purchased at market solely by the wealthier meat sellers because of their favourable quality (tender and easily cooked) and were considered to rarely, if ever, have cysts. Cheaper and older cows, sold at 7000 dirham or US$875, were purchased by makeshift restaurant owners who used the meat for minced grilled sandwiches. Older sheep were purchased by those with less capital at a cost of 400 dirham, or US$50. Local knowledge of butchers confirmed the high prevalence of cysts in older cattle (found in the liver and lungs), which was reflected in the colour of meat sold: yellow-coloured fat was only on older cows (believed to be caused by grazing on certain local plants) while the fat of bulls was white, signifying a younger age at slaughter (18 months to two years) and being kept in a barn after one year of age, where they were fattened with hay and collected grass.

In most instances, the meat sellers and restaurant owners (with more capital) were the ones who physically purchased live animals at the *souk* and then agreed on a price with the visceral sellers before slaughter. There were two types of viscera sellers: those who sold viscera to customers (head, hoofs, intestines, heart, brains, rumen and liver and lungs) and those who specialized, like restaurants, in selling roasting cattle hearts and liver with sheep fat. However, butchers all confirmed that although thinness and physical health of an animal were considered in the price negotiations for live animals, 'you cannot see the viscera [physically assess risks of an animal having cysts]…you [have to] speculate on the market' (Interview, Butcher). Prices for older cows and sheep had to consider the fact that the liver and lungs could be completely infested with hydatid cysts, as well as the fact that older meat (more likely to be infected) was of lesser quality. Based on their social networks, most of the economic losses from hydatid cysts were absorbed by the less-wealthy viscera sellers. This group always bought viscera from the less-wealthy restaurant owners who, in turn, solely purchased older cows. Selling viscera was:

> …dirty and heavy…cleaning [the viscera] is so hard, it is not nice work like selling meat. It is less profitable too…those [people] are the poorer group [of butchers]. (Interview, Butcher)

Interviews with viscera sellers, as well as carcass cutters, emphasized the low start-up and running capital available to them in comparison to other market actors.

The costs of CE to this local market chain were estimated during fieldwork. It was found that the potential losses from infected viscera were reflected in their wholesale market costs, which decreased with age and type of animal. A full sheep viscera would cost a viscera seller between 60 (female) and 140 dirham (male) (US$7.5 to US$17.5), while cattle viscera were sold for between 700 (US$85.7 USD) (for an older female cow) and 1600 dirham (US$200) (for a bull). Using the prevalence data found at the ten slaughterhouses in Sidi Kacem (2009–2013) – 43% of cattle and 11% of sheep (as part of an ICONZ-based slaughterhouse study conducted by author IEB) – the total economic losses of CE to these poorer viscera sellers can be estimated. Using the 2009 provincial-level slaughterhouse data, it is conservatively estimated that the livestock-related

Table 3. Number of infected carcasses and estimated economic losses from hydatid cysts in livestock, Sidi Kacem province, northern Morocco

	Study slaughterhouses per week	Provincial level per year
100% infested organs (sheep)	1 (US$9)	106 (US$928)
10–20% infested organs (sheep)	13 (US$11.00–22.75)	949 (US$830–1661)
100% infested organs (cattle)	6 (US$345)	283 (US$16,273)
10–20% infected organs (cattle)	58 (US$334–740)	2550 (US$14,663–32,513)
Total economic losses	US$699–1116	US$32,693–51,373

Note: The estimates of the frequency, intensity and economics of infection were derived from interviews with butchers and veterinary technicians, as well as repeated observation and cyst collection at the observed slaughterhouses between 2009 and 2014. The following data were used on price: the market value of the liver and lungs alone was worth an average of 350 dirham (US$43.75) and 110 dirham (US$13.75) for cattle, and roughly 60 dirham (US$7.5) and 10 dirham (US$1.25) for sheep. Butchers all emphasized that small cysts typically resulted in 10–20% of such income being lost and that roughly 10% of infected organs were too heavily infested to sell, and were fully discarded. For the sake of estimation, it was assumed that all livestock infected with cysts were infected in both liver and lungs. Economic losses from organs that were only 10–20% infested were calculated solely based on the actual incurred losses from cutting off visible cysts and selling the remaining viscera. The estimates are based on the number of sheep and cattle observed at the study slaughterhouses at one point in time (123 cattle and 149 sheep per week) and from provincial-level statistics of the total number of slaughtered animals (9594 cattle and 6588 sheep per year). Any impact on goats was excluded due to their small population in Sidi Kacem. Infection rates at provincial level were extrapolations based on weekly estimates of the visited slaughterhouses.

losses from CE at slaughterhouses alone are between US$32,693 and US$51,373 per year in Sidi Kacem, most of which involves older female cattle and impacts the poorer groups of viscera sellers (Table 3).

Governed by these informal practices, this questions the assumed narrative that CE creates standardized economic losses across geographical space, which is typically the case with most financial burden estimates of the disease (Budke *et al.*, 2006); instead, market actors adapt mitigation strategies with different consequences and for different reasons. To these viscera sellers, such economic losses were understood through recourse to the difficult, everyday economic realities they faced in obtaining animal meat, selling to a dwindling customer-base and securing their livelihoods. But while there were risks with purchasing viscera from older female cows, most viscera sellers preferred them precisely because they were, despite this risk, still able to make more profit. As one reflected:

> We win more money [with old livestock viscera because they are cheaper to buy] but there is always the risk of losing [all the viscera] from the cysts. Last year, I lost the whole [liver and lungs]. It was totally infested…I had to go home empty handed [since I lost money that day]. (Interview, Butcher)

Purchasing viscera from old female cows was spoken about as a ‘risk’, ‘gamble’ and ‘lottery’ where you needed to remain ‘optimistic’. The fact that heavily infected viscera were only encountered occasionally and that most losses were perceived to be

'endemic' to the market system normalized an accepted degree of risk. Price differences based on age, gender and type of animal served as an economic mitigation strategy, helping to buffer the losses of having heavily infected liver and lungs from hydatid cysts. This allowed the poorest segments of the market chain to purchase viscera at lower prices, but through an occasional misfortune they knew they could endure significant losses.

That the economic consequences of cysts largely affected only the poorer viscera sellers clearly served to downplay the importance of addressing *E. granulosus*. This more marginalized group was less educated and thus less likely to organize themselves to address a collective problem than the meat or restaurant sellers. However, all types of butchers tended to abdicate responsibility to the state, emphasizing that it was 'the state's responsibility,' that 'the technicians are paid to do that…they have to make sure it is good meat' and that, once outside the slaughterhouse building, it was 'not my responsibility to find cysts' (Interviews, Butchers). This disjuncture between personal and public responsibility was best expressed in the local saying: 'Each for themselves and God for all.'

Risk perceptions in an 'unhygienic' environment

Prevailing notions of risk also served to downplay the importance of safely disposing of cysts. This included: ambiguous understandings of transmission pathways, reference to local immunity and the low possibility and consequences of human infection. The majority of butchers, including viscera sellers, as with over half of the interviewed technicians (3/7), thought that only the human consumption of cysts equated to a disease risk. Other technicians knew the scientific CE cycle but considered the disease 'rare and insignificant…you only find maybe one case a year from that disease…it is not important' (Interview, Veterinary Technician). With roughly 32 reported and treated cases each year in Sidi Kacem, it was not unusual for informants to mention that they knew or had heard of someone who had undergone surgery for cysts, albeit in many cases they were unable to differentiate cancers or general cysts from CE. According to one rural doctor, who had referred two hydatid patients for treatment over the last decade:

> Cysts take a long time to develop, so people are relaxed. They are more interested in rabies due to the fear of dogs…also the cycle is simpler for people to understand. (Interview, Medical Officer)

Knowledge of the more abstract transmission cycle involving three hosts (people, dogs and livestock) was largely absent, except for a few of the more educated technicians, medics and politicians. As one butcher stated:

> I am not sure if dogs become sick after I give them cysts, I never see those dogs becoming sick. I think it is OK. (Interview, Butcher)

Hence most butchers believed that human transmission could only take place from getting pieces of cysts in a person's fingernail and then inadvertently consuming them. This was because religious, social and food preparation norms in Sidi Kacem made the consumption of cooked cysts unacceptable, even for poor households.

It was found, however, that not all cysts had been properly removed either in the slaughterhouse, or immediately outside, by the butchers. Smaller cysts were observed in the lungs and liver being sold by viscera sellers at least once per *souk* – likely to be either cooked or thrown to the household dog once customers returned home. Viscera sellers also emphasized that they would throw cysts if they found them since they 'fear God'. Heavily infected organs were summarily thrown away. Pointing to a large and heavily infested cattle liver that was discarded outside the abattoir, a viscera seller emphasized that such meat was 'inconsumable…how can a human being eat that!? It is impossible, so I have no choice but to throw [it]' (Interview, Butcher). Risk perceptions, therefore, emphasized the non-consumable nature of cysts for humans, but not for dogs. Removing cysts was as much about pleasing customers than acting as stewards of public health, and discarding, or condemning, a liver due to a few small cysts was counter-intuitive.

Most people did not associate what they called the 'unhygienic conditions' of the slaughterhouse, or the direct handling of meat outside of state-promoted food safety measures, as causes of any type of illness. Modern notions of 'meat hygiene' and 'food safety' were rarely alluded to. Interviews with butchers as well as technicians, who had received training on food-borne diseases in the past, emphasized the link between livelihoods and immunity. As one mentioned:

> You see, we are not like you [in Europe]. We have developed resistance to any microbes that may be in the *souk*…no one gets sick from handling meat or not washing their hands…if you play in the dirt, then you will be healthy – your body knows the germs and can fight them. (Interview, Veterinary technician)

Revealing the links between local experiences, observations and risk perceptions, the fact that slaughterhouse workers and butchers had never been diagnosed with CE reinforced the notion that they were immune and had 'nothing to worry about'. Likewise, the cause of cysts in livestock was similarly related to naturalistic concepts (Green, 1999). Rather than parasites, cysts in livestock were believed to be caused by stagnant water that changed their body composition as well as chemical run-off from large irrigated industrial farms. Butchers associated higher prevalence of CE in livestock with greater precipitation and hot summers that made stagnant water 'dangerous for the body of the animal' (Interview, Butcher). Others associated dogs with cysts, revealing that health messages are curiously diluted over time: a popular explanation involved cysts occurring due to livestock consuming the grass that was grown around the body of a dead dog, which had been 'heard from medical people long ago' (Interview, Butcher).

Despite estimates that CE causes economic losses in milk (7–10%), meat (5–20%) and wool (10–40%) in Morocco (CILCH, 2007), cysts were not considered dangerous to livestock. They were:

> …not a big concern for us…there is no medicine for cysts. You only notice when the animal is killed, which is only a loss to the butchers not to the farmer. (Interview, Livestock Keeper)

The use of anti-parasitic drugs (albendazole) was believed to be increasing with an expanding private veterinary market, but ethno-veterinary beliefs appeared to be strong, with most interviewed livestock keepers reporting that they used de-wormers not to

target invisible parasites or pathogens, but to address the toxic effects of certain grasses and bushes caused by seasonal changes.

Discussion

Building on epidemiological studies, this article explores the biosocial dynamics of *E. granulosus* transmission: the embedded spatial, material, cognitive and social interactions between people, animals, environments and cysts. Although restricted to one province, the findings have much wider applicability to the 182 municipal and 722 rural slaughterhouses throughout Morocco (CILCH, 2007). Within a broader policy context aimed at controlling and eliminating NTDs, it also has relevance to other low- and middle-income countries where CE in endemic. Currently, the WHO and other stakeholders are pushing to:

> …pilot projects to validate the effectiveness of cystic echinococcosis/hydatidosis control strategies…by 2015 [and to] scale-up…interventions in select countries in Central Asia, North Africa and Latin America for control and elimination [of it] as a public-health problem…by 2020. (WHO, 2012)

The focus of these prevention programmes will focus on deworming dogs, improving slaughterhouse practices, public education and dog population management, with a possible role for the vaccination of lambs. As this article has shown, ensuring the optimization of these pilot interventions, as well as their scale-up, will not only require biomedical expertise but also sensitivity to local social determinants, relations, logics and conditions (Bardosh, 2015). This final section discusses the relevance of this study, and of a biosocial perspective more generally, to this wider policy and control context.

The first major point relates to relationships between infrastructure, hygiene and social contexts. While the notion that slaughterhouses were 'chaotic' was consistently invoked, fieldwork actually showed the opposite: that there was clearly an institutional, economic and socio-cultural logic that governed local practices. This was revealed in the ways in which the meat chain was organized as well as the rationale for butchers to resist new regulations. Butchers wanted to maintain informal practices to minimize hindrances to established working norms, dictate the terms of cyst removal and protect their autonomy from state interference. Invested interests helped to maintain the *status quo*.

Slaughterhouse reform has long fostered socio-political tensions (Fitzgerald, 2010). Such reform processes represent both the need to engage, and the wider societal difficulties of, addressing social determinants for zoonotic disease (Aagaard-Hasen & Claire, 2010). Policy challenges not only relate to the resistance of market chain actors but also the conflicts of interest in cross-departmental relationships in supporting infrastructural and procedural changes. In Sidi Kacem province, gaps in collaboration between the Ministry of Interior, the Ministry of Agriculture, local commune leaders and veterinary technicians have led to newly renovated slaughterhouses lacking basic infrastructure components. This lack of cross-departmental co-ordination was driven by pre-existing institutional relationships, political tensions and a devaluation of veterinary expertise. If One Health requires a 'realignment of professional values, interests and goals between [animal, human and environmental health], underpinned by institutional factors such as authority and resources allocation', then wider economic and political

changes are needed to drive these governance reforms (Lee & Brumme, 2013). For example, efforts to abide by European Union regulations catalysed slaughterhouse reforms in the 1980s in Spain that have probably been central to the significant drop in CE (Carmena *et al.*, 2008).

The article also shows the variations between biomedical notions of risk and local perceptions and practices in relation to zoonoses, and how these differences create challenges for behaviour change. Structured by ambiguity and notions of 'immunity' and 'resistance' to food-borne diseases, risk perceptions of cysts have been tied to local contagion theories (Green, 1999). As a chronic and endemic disease, infection risk in Morocco was observed to be diffused over space and time in ways that diluted local prioritization by abstracting links to community health and social pressure to maintain disease-free animals. The relative invisibility of direct economic losses reduced local prioritization. In this context, the poorer viscera sellers, who lost economically, had little authority or capacity in the market chain to enact change. Furthermore, any noticeable impact for this group, or other groups, would take many years to become apparent.

This reveals a larger challenge for 'invisible' public health challenges without simple cause and effect narratives: economic and social concerns invariably shape the willingness and ability of people to engage in self-regulation and collective action. Where the benefits are not directly visible, even for activities that may seem easy and straightforward, more structural approaches are required. For example, Varcasia *et al.* (2011) discussed the limitation of 20 years of CE education of sheep farmers in Sardinia using simple messages like 'do not practise home slaughter' and 'do not feed cysts to dogs.' They argued that the continued practice of home slaughter (which facilitated the feeding of offal to dogs) was due to the lack of an economic and policy framework to support farmers bringing older sheep (more likely to be infected) to local slaughterhouses in order to safely dispose of cysts.

Cystic echinococcosis is 'chronic, complex and still neglected', predominately because 'breaking the cycle in practice is difficult and requires long-lasting efforts. Control programs are expensive to set up and sustain…[and require] 20 years…to reach elimination' (Brunetti *et al.*, 2011). Without quickly discernable and quantifiable 'low-hanging fruit', it is important to think carefully about the relationships between operational costs and intervention strategies.

Economics are important to public health, and estimating the economic burden of CE can help promote policy interest and inter-sectoral collaboration by justifying costs and effort. But this needs to account for the 'dual' societal burden and benefit to animal and human health (Narrod *et al.*, 2012). In relation to CE, significant estimates have recently been made for Iran (US$232.25 million) and India (US$212.35 million) (Fasihi *et al.*, 2012; Singh *et al.*, 2014). Here we can approach an estimate at a more localized level, using data that account for how market actors negotiate risk. It is conservatively estimated that the livestock-related losses to the meat value chain (excluding livestock production losses) are between US$32,693 and US$51,373 per year. Taking estimates for simple, non-repeated surgery cases previously estimated for Morocco (cost €1500 per case, provided in CILCH, 2007), treatment costs for an average of 32 CE cases treated per year in Sidi Kacem would equal US$67,200, excluding inflation, under-reporting, reduced quality of life and the fact that repeat surgery as well as mortality in Morocco are both roughly 3%. Hence the combined livestock and human health costs for CE in

Sidi Kacem are at least between US$99,895 and US$118,573 per year. As has been shown, much of it is absorbed by the poorer segments of the rural population.

This is not an insignificant amount of money, especially when we consider the fact that transmission appears to be clustered around cyst disposal practices at only ten slaughterhouses. But, in the light of this research, what kind of 'intervention(s)' would be most appropriate, feasible and locally acceptable? The lack of basic awareness about CE surely merits the implementation of some form of health education – for example, using laminated posters, group education workshops and/or videos to engage butcher associations, technicians and consumers. But this research, like other ethnographic research on neglected zoonoses (Bardosh *et al.*, 2014b), also suggests that there are important limitations to acknowledge in this regard. Operationally, many butchers are illiterate, often in a rush after the *souk* day and difficult to organize. Community outreach would also need to address the fact that, unlike rabies, CE is considered 'insignificant' by both butchers and medical doctors. One way to personalize the seemingly abstract disease repercussions of CE would be to involve past CE sufferers in outreach and education.

However, education efforts are unlikely to have much impact without addressing other systemic barriers highlighted during this research. There is clearly a need to prioritize the (de-)motivation of veterinary technicians, a key determinant in the low quality of medical and veterinary services in developing economies (Mathauer & Imhoff, 2006; Bardosh *et al.*, 2014b). Any CE intervention that does not address the low pay, professional incentives and existing social ties between veterinary technicians and butchers would, as this article shows, be inadequate. Outside the construction of new slaughterhouses, veterinary technicians also need access to a supply of basic equipment to contain cysts: holding containers, denaturalization chemicals and material to safely burn cysts. A consistent supply of cyst disposal equipment could possibly be organized with the owner and cleaning staff of each *souk*. Establishing a reporting structure whereby technicians report cysts, to *souk* owners and the veterinary office, could also be an important component of this system, maintaining technical interest and involvement. Lastly, although dog culling is often opposed by scientists and animal welfare groups (especially as regards to its impact on controlling rabies) CE experts maintain that controlling the parasite 'requires rapid reduction in the biomass of unwanted dogs' (Kachani & Heath, 2014). While dog culling would elicit some resistance from dog owners around the *souk,* more formal channels of support could improve current practice with possible effects on CE (as recommended by the veterinary technicians in this study).

There are, of course, other avenues for CE control. Interventions could focus on education at schools surrounding slaughterhouses, more formalized media education before Muslim festivals (i.e. *Eid El Kebir*) to address home slaughter, and ultrasound surveys to assess under-reporting in villages with high dog infection rates, as undertaken by Kachani *et al.* (2003) in the Middle Atlas Mountains. Presently, the economics and efficacy of an integrated dog-zoonoses control strategy is being evaluated in Sidi Kacem by the ICONZ project, using rabies vaccination, long-acting insecticidal collars for leishmaniasis and anthelmintic treatment for CE (http://www.iconzafrica.org).

Whatever the approach, this article has shown that, in light of the complex biosocial relationships that mediate CE spread and control, a co-ordinated and long-term plan is

key. To date, Morocco has already drafted a comprehensive, multi-sectoral CE roadmap in the mid-2000s to guide a national control programme, but these recommendations were never formally adopted (CILCH, 2007). There remains a fragmentation of leadership and few concrete implementation pathways to move policy 'off the shelf'.

Cystic echinococcosis control fits well with the mantra of One Health, which proposes new ways of linking disciplines, expertise, local authorities and populations in animal and human health (Scoones, 2010; Lee & Brumme, 2013; Okello *et al.*, 2014). Central to the concept is the need to bring disparate actors, from the national, district and local level, into new forms of relationship. Joshi *et al.* (2012) provided a compelling example of the benefits of more participatory, action-research approaches for CE in urban areas of Nepal over more than 10 years. Based at an academic institution, but engaging a local NGO, different stakeholders (government authorities, community leaders and a wide variety of those involved in animal slaughter) were enrolled as 'co-researchers'. Sustainable platforms were established to enhance the local capacity of these diverse social groups in ways that incentivized participation. This led to a significant drop in CE, as well as improvements in garbage collection, the aesthetics of the urban environment and livelihood impacts for butchers and reductions in caste-based discrimination.

Although participatory epidemiology has gained currency in the veterinary sciences (Catley *et al.*, 2012) and the perils of non-participatory planning are well known in the livestock development sector (Kibreab, 1999; Omore *et al.*, 2009), integrating social and biological perspectives in zoonotic disease control continues to be relatively rare (Crawshaw *et al.*, 2014; Sripa *et al.*, 2015). Examples are few and far between, especially those that go beyond the typical short funding cycle of most donor-funded initiatives (Bardosh, 2015). Clearly, more long-term, participatory and integrated efforts are needed for CE, and other neglected zoonoses. Trialling these efforts and evaluating their feasibility, costs and impact ought to become a major focus for funding leading up to the WHO's 2020 CE control goals, and beyond.

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References

Aagaard-Hansen, J. & Claire, L. (2010) Neglected tropical diseases: equity and social determinants. In Blas, E. & Anand, S. K. (eds) *Equity, Social Determinants, and Public Health Programmes*. WHO Press, Geneva, pp. 2135–2157.

Adeyemi, I. G. & Adeyemo, O. K. (2007) Waste management practices at the Bodija abattoir, Nigeria. *International Journal of Environmental Studies* **64**, 71–82.

Atkinson, J. A., Gray, D. J., Clements, A. C., Barnes, T. S., McManus, D. P. *et al.* (2013) Environmental changes impacting Echinococcus transmission: research to support predictive surveillance and control. *Global Changes in Biology* **19**, 677–688.

Azlaf, R. & Dakkak, A. (2006) Epidemiological study of the cystic echinococcosis in Morocco. *Veterinary Parasitology* **137**, 83–93.

Bardosh, K. (2014) Global aspirations, local realities: the role of social science research in controlling neglected tropical diseases. *Infectious Diseases of Poverty* **3**, 35.

Bardosh, K. (2015) Deadly flies, poor profits and veterinary pharmaceuticals: sustaining the control of sleeping sickness in Uganda. *Medical Anthropology* (in press).

Bardosh, K., Inthavong, P., Xayaheuang, S. & Okello, A. L. (2014a) Controlling parasites, understanding practices: the biosocial complexity of a One Health intervention for neglected zoonotic helminths in northern Lao PDR. *Social Science & Medicine* **120C**, 215–223.

Bardosh, K., Sambo, M., Sikana, L., Hampson, K. & Welburn, S. C. (2014b) Eliminating rabies in Tanzania? Local understandings and responses to mass dog vaccination in Kilombero and Ulanga districts. *PLoS Neglected Tropical Diseases* **8**, e2935.

Biu, A. A., Ahmed, M. I. & Mshelia, S. S. (2006) Economic assessment of losses due to parasitic diseases common at the Maiduguri abattoir, Nigeria. *African Scientist* **7**, 143–145.

Brunetti, E., Garcia, H. H. & Junghanss, T. (2011) Cystic echinococcosis: chronic, complex, and still neglected. *PLoS Neglected Tropical Diseases* **5**, e1146.

Budke, C. M., Deplazes, P. & Torgerson, P. R. (2006) Global socioeconomic impact of cystic echinococcosis. *Emerging Infectious Diseases* **12**, 296–303.

Budke, C. M., Jiamin, Q., Zinsstag, J., Qian, W. & Torgerson, P. R. (2004) Use of disability adjusted life years in the estimation of the disease burden of echinococcosis for a high endemic region of the Tibetan plateau. *American Journal of Tropical and Medical Hygiene* **71**, 56–64.

Cardona, G. A. & Carmena, D. (2013) A review of the global prevalence, molecular epidemiology and economics of cystic echinococcosis in production animals. *Veterinary Parasitology* **192**, 10–32.

Carmena, D., Sanchez-Serrano, L. P. & Barbero-Martinez, I. (2008) Echinococcus granulosus infection in Spain. *Zoonoses and Public Health* **55**, 156–165.

Catley, A., Alders, R. G. & Wood, J. L. (2012) Participatory epidemiology: approaches, methods, experiences. *Veterinary Journal* **191**(2), 151–160.

Charmaz, K. (2006) *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*. SAGE Press, London.

CILCH (2007) *Comité interministériel de lutte contre l'Hydatidose/Echinococcose*. Ministry of Interior, Rabat, Royal Kingdom of Morocco.

Craig, P. S. & Larrieu, E. (2006) Control of cystic echinococcosis/hydatidosis: 1863–2002. *Advances in Parasitology* **61**, 443–508.

Crawshaw, L., Fèvre, S., Kaesombath, L., Sivilai, B., Boulom, S. & Southammavong, F. (2014) Lessons from an integrated community health education initiative in rural Laos. *World Development* **64**, 487–502.

Cutcliffe, J. R. (2005) Adapt or adopt: developing and transgressing the methodological boundaries of grounded theory. *Journal of Advanced Nursing* **51**, 421–428.

Dakkak, A. (2010) Echinococcosis/hydatidosis: a severe threat in Mediterranean countries. *Veterinary Parasitology* **174**, 2–11.

Fasihi, H. M., Budke, C. M. & Rostami, S. (2012) The monetary burden of cystic echinococcosis in Iran. *PLoS Neglected Tropical Diseases* **6**, e1915.

Fitzgerald, A. J. (2010) A social history of the slaughterhouse: from inception to contemporary implications. *Human Ecology Review* **17**.

French, C. M. & Nelson, G. S. (1982) Hydatid disease in the Turkana District of Kenya II. A study in medical geography. *Annals of Tropical Medicine & Parasitology* **76**, 439–457.

Fuller, G. K. & Fuller, D. C. (1981) Hydatid disease in Ethiopia: epidemiological findings and ethnographic observations of disease transmission in southwestern Ethiopia. *Medical Anthropology* **5**, 293–312.

Gavidia, C. M., Gonzalez, A. E., Zhang, W., McManus, D. P., Lopera, L. *et al.* (2008) Diagnosis of cystic echinococcosis, central Peruvian Highlands. *Emerging Infectious Diseases* **14**, 260–266.

Gemmell, M. A., Roberts, M. G., Beard, T. C., Campano, D. & Lawson, J. R. (2001) *WHO/OIE Manual on Echinococcosis in Humans and Animals: A Public Health Problem of Global Concern*. WHO Press, Geneva.

Green, E. C. (1999) *Indigenous Theories of Contagious Disease*. Altamira, Rowman.

Joshi, D. D., Sharma, M. & Waltner-Toews, D. (2012) Rebuilding urban ecosystems for better community health in Kathmandu. In Charron, D. (ed.) *Ecohealth Research in Practice: Innovative Applications of an Ecosystem Approach to Health*. Springer, Ottawa, pp. 191–201.

Kachani, M. & Heath, D. (2014) Dog population management for the control of human echinococcosis. *Acta Tropica* **139**, 99–108.

Kachani, M., Macpherson, C. N., Lyagoubi, M., Berrada, M., Bouslikhane, M. *et al.* (2003) Public health education/importance and experience from the field. Educational impact of community-based ultrasound screening surveys. *Acta Tropica* **85**, 263–269.

Kebede, W., Hagos, A., Girma, Z. & Lobago, F. (2009) Echinococcosis/hydatidosis: its prevalence, economic and public health significance in Tigray region, North Ethiopia. *Tropical Animal Health and Production* **41**, 865–871.

Kibreab, G. (1999) The consequences of non-participatory planning: lessons from a livestock provision project to returnees in Eritrea. *Journal of Refugee Studies* **12**(2), 135–160.

Komba, E. V., Mkupasi, E. M., Mbyuzi, A. O. & Mshamu, S. (2012) Sanitary practices and occurrence of zoonotic conditions in cattle at slaughter in Morogoro Municipality, Tanzania: implications for public health. *Tanzania Journal of Health Research* **14**(2).

Leach, M. & Scoones, I. (2013) The social and political lives of zoonotic disease models: narratives, science and policy. *Social Science & Medicine* **88**, 10–17.

Lee, K. & Brumme, Z. L. (2013) Operationalizing the One Health approach: the global governance challenges. *Health Policy and Planning* **28**, 778–785.

Leonard, D., Brass, J., Nelson, M., Ear, S., Fahey, D. *et al.* (2009) Does patronage still drive politics for the rural poor in the developing world? A comparative perspective from the livestock sector. *Development and Change* **41**, 475–495.

Lightowlers, M. W. (2013) Cysticercosis and Echinococcosis. In Mackenzie, J. S., Jeggo, M., Daszak, P. & Richt, J. A. (eds) *One Health: The Human–Animal–Environment Interfaces in Emerging Infectious Diseases*. Springer, Berlin, pp. 315–335.

Long, N. (2001) *Development Sociology: Actor Perspectives*. Routledge, London.

McManus, D. P., Gray, D. J., Zhang, W. & Yang, Y. (2012) Diagnosis, treatment, and management of echinococcosis. *British Medical Journal* **344**, e3866.

Mahmoud, H. (2008) Risky trade, resilient traders: trust and livestock marketing in northern Kenya. *Africa* **78**(4), 561–581.

Mathauer, I. & Imhoff, I. (2006) Health worker motivation in Africa: the role of non-financial incentives and human resource management tools. *Human Resources for Health* **4**, 24.

Maudlin, I., Eisler, M. C. & Welburn, S. C. (2009) Neglected and endemic zoonoses. *Philosophical Transactions of the Royal Society Series B* **364**, 2777–2787.

Mignone, J., Hiremath, G. M., Sabnis, V., Laxmi, J., Halli, S. *et al.* (2009) Use of rapid ethnographic methodology to develop a village-level rapid assessment tool predictive of HIV infection in rural India. *International Journal of Qualitative Methods* **8**, 68–83.

Nading, A. M. (2013) Humans, animals, and health: from ecology to entanglement. *Environment and Society: Advances in Research* **4**, 60–78.

Narrod, C., Zinsstag, J. & Tiongco, M. (2012) A One Health framework for estimating the economic costs of zoonotic diseases on society. *Ecohealth* **9**, 150–162.

Okello, A., Welburn, S. & Smith, J. (2014) Crossing institutional boundaries: mapping the policy process for improved control of endemic and neglected zoonoses in sub-Saharan Africa. *Health Policy and Planning* **30**(6), 804–812.

Omore, A., Kurwijila, L. & Grace, D. (2009) Improving livelihoods in East Africa through livestock research and extension: reflections on changes from the 1950s to the early twenty first century. *Tropical Animal Health and Production* **41**(7), 1051–1059.

Paige, S. B., Malave, C., Mbabazi, E., Mayer, J. & Goldberg, T. L. (2014) Uncovering zoonoses awareness in an emerging disease 'hotspot'. *Social Science & Medicine* **129**, 78–86.

Porter, N. (2013) Bird flu biopower: strategies for multispecies coexistence in Vietnam. *American Ethnologist* **40**, 132–148.

Prout, A. (1996) Actor-network theory, technology and medical sociology: an illustrative analysis of the metered dose inhaler. *Sociology of Health & Illness* **18**, 198–219.

Rosen, L. (1984) *Bargaining for Reality: The Construction of Social Relations in a Muslim Community*. University of Chicago Press, Chicago.

Scoones, I. (2010) *Avian Influenza: Science, Policy And Politics*. Earthscan Press, London.

Shaikenov, B. S., Torgerson, P. R., Usenbayev, A. E., Baitursynov, K. K., Rysmukhambetova, A. T. *et al.* (2003) The changing epidemiology of echinococcosis in Kazakhstan due to transformation of farming practices. *Acta Tropica* **85**, 287–293.

Singer, M. & Erickson, P. I. (2011) *A Companion to Medical Anthropology*. Wiley-Blackwell, Chichester, West Sussex, and Malden, MA.

Singh, B. B., Dhand, N. K., Ghatak, S. & Gill, J. P. (2014) Economic losses due to cystic echinococcosis in India: need for urgent action to control the disease. *Preventative Veterinary Medicine* **113**, 1–12.

Sripa, B., Tangkawattana, S., Laha, T., Kaewkes, S., Mallory, F. F., Smith, J. F. & Wilcox, B. A. (2015) Toward integrated opisthorchiasis control in northeast Thailand: the Lawa project. *Acta Tropica* **141**, 361–367.

Varcasia, A., Tanda, B., Giobbe, M., Solinas, C., Pipia, A. P. *et al.* (2011) Cystic echinococcosis in Sardinia: farmers' knowledge and dog infection in sheep farms. *Veterinary Parasitology* **181**, 335–340.

WHO (2012) *Accelerating Work to Overcome the Global Impact of Neglected Tropical Diseases: A Roadmap for Implementation*. WHO Press, Geneva.

Yardley, L. (2000) Dilemmas in qualitative health research. *Psychology and Health* **15**, 215–228.