Zoonotic brucellosis from the long view

Zoonotic brucellosis in long view: can the past contribute to the present?

Robin Bendrey PhD[1] and Guillaume Fournié PhD[2]

[1]School of History, Classics and Archaeology, University of Edinburgh, William Robertson Wing, Old Medical School, Teviot Place, Edinburgh EH8 9AG, UK.

[2]Veterinary Epidemiology, Economics and Public Health group, Department of Pathobiology and Population Sciences, Royal Veterinary College, University of London, Hawkshead Lane, North Mymms, Hatfield AL9 7TA, UK.

Author for correspondence:

Robin Bendrey

School of History, Classics and Archaeology, University of Edinburgh, William Robertson Wing, Old Medical School, Teviot Place, Edinburgh EH8 9AG, UK.

Email: robin.bendrey@ed.ac.uk

Telephone: +44 (0)7403754892

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To the Editor—Zoonotic brucellosis is an endemic disease in many regions of the world, including the Zagros Mountains of Iran and Iraq as Abdi and colleagues lay out in volume 41 of *Infection Control & Hospital Epidemiology*.[1] Abdi *et al*. touch upon the history of farming in the Zagros Mountains to contextualise the potential for the deep time dimension of brucellosis risk for communities within this region. Building on this, here we highlight the context of this early history and the contribution that long-term perspectives of evolving human-caprine relationships and zoonotic brucellosis epidemiology may make to current challenges.

Sustained zoonotic brucellosis risk probably emerged in the Near East region during the Early Neolithic (*c*.9000-8000 BC), with the increased contact between humans and animals associated with the origins of farming. Domestication caused fundamental shifts in human and animal ecological dynamics, with potential major health consequences for both parties. The domestication of goats, sheep, cattle, and pigs occurred in a number of locations in the Near East at this time, with one of the early centres of goat husbandry being in the Zagros Mountains.[2] Archaeological research on skeletal pathology identifies an early possible case of human brucellosis in this context.[3] The link between brucellosis and the intensification of human-goat relationships in the Neolithic of the Zagros Mountains has been investigated via simulation modelling of the transmission of *Brucella melitensis* (the main causative agent of brucellosis in humans) within early domestic goat populations described by zooarchaeological data.[4] The simulations indicate that the pathogen could have been sustained, even for low levels of transmission, in small domestic goat populations that lie within the likely ranges estimated for these early farming settlements. This resulted from the creation of dense domestic goat populations, but also the decisions made by early goat farmers on the demographic composition of their herds. As goat farming evolved, some

communities began to preferentially retain domestic female goats into adulthood in herds, and selectively cull male goats at a younger age. In this way people inadvertently created population demographic structures which would have increased the transmission potential of the pathogen, thereby exposing themselves to greater risk of infection.

Archaeological research can also contribute to understanding the long-term evolutionary trajectory of zoonotic pathogens. To date, genetic analyses of archaeological strains of *Brucella* organisms are relatively few.[3] The first sequenced draft genome of *Brucella melitensis*, deriving from a human skeleton from medieval Sardinia (*c.*1350-1400 AD), shows a close relationship with modern Italian strains indicating continuous circulation of this pathogen in the region.[5] Future genomic analysis of diachronic strains in relation to long-term changes in cultural practices will enable understanding of the socio-ecological relationships that are influencing pathogen emergence, evolution and spread.[5]

Understanding socio-ecological drivers of emergence and reemergence in the distant past can help contextualise modern changes in human-animal-environment relationships. Changing population sizes and proximity are an aspect of evolving human-animal-pathogen relationships. Contemporarily, the global goat population has almost trebled in size since the early 1960s, with the most dramatic increases taking place in Asia and Africa.[6] This likely altered the dynamics of *Brucella* infection in humans. Indeed, in a longitudinal study of the incidence and spatio-temporal distribution of human brucellosis in China from 1955 to 2014, Lai *et al.* identified the growing demand for meat in China, and the resulting dramatic increase in livestock density as a likely factor behind the reemergence of human brucellosis from the mid-1990s.[7]

Goat herds can also be considered at the very local level, at the scale of the family. Goats' abilities to subsist in arid and marginal environments and their high milk yields mean that they offer food security, income and greater gender equality for poor families in the developing world. Animal husbandry decisions are often implemented at the local level, based upon immediate needs and circumstances. Incorporation of families and their herds into wider social and economic networks significantly influences the potential for disease outbreak and endemicity.[4] It is also at the family level that zoonotic diseases often have their most acute impact: poorer, rural communities involved in animal husbandry are those that suffer directly both medically and economically.[8]

Engaging with how contextualised actions in the past effected disease emergence and risk can help inform current behaviours and decisions and local-level mitigation strategies. For example, despite the significant economic and health impacts, public awareness and cooperation with brucellosis eradication programmes has often been limited.[9,10] There is often conflict with cultural and economic practices, such as traditional dairy production.[10] This may be linked to failures of didactic approaches relying on the assumption that providing generic knowledge about disease risk and cost-effective measures to mitigate it will result in behavioural change. More creative approaches to educational and preventative programmes are needed to improve effective communication. We propose that archaeological knowledge has the potential to offer historically-distinct contexts to inform and educate, avoiding the situation of portraying risks as imminent, which can lead to defensive responses. Appropriately designed educational strategies could therefore more effectively engage audiences about brucellosis risks and local-level mitigation strategies.

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