As illustrated herein, evolving trends in resistance patterns may be easily identified, and this may lead to more targeted, robust infection prevention and control responses.[7] Individual facilities may also use these data to compare self-reported resistance rates with those in the region. Finally, institutions without access to local antibiograms, including certain outpatient centers and nursing homes, may find this tool especially beneficial to improve prescribing practices and antibiotic stewardship.[5]

Regional and statewide antibiograms have several limiations. Most of our data were gathered from hospitals; relatively few ambulatory antibiograms were submitted. Even though inpatient antibiograms include patients admitted with community-acquired infections, community resistance rates are likely underrepresented. These factors may have led to overestimated community rates, a relevant issue considering the growing concern of resistance in this setting.[1,6]

Despite efforts to standardize antibiogram creation procedures, little evidence supports adherence to these guidelines. Reports therefore undoubtedly vary across institutions, limiting the ability to compare interfacility susceptibility rates.[6,7] Furthermore, although antibiograms may provide general guidance, other patient-specific factors must be considered to make an informed clinical decision, including the type and severity of the current infection and previous antibiotic use.[7]

In conclusion, statewide and regional antibiograms may be effective strategies in targeting antibiotic resistance. Even though they must be viewed within the scope of their limitations, they should be considered valuable assets in future antibiotic stewardship endeavors.

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# Zoonotic brucellosis from the 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, Edinburgh, Scotland and [2]Veterinary Epidemiology, Economics and Public Health group, Department of Pathobiology and Population Sciences, Royal Veterinary College, University of London, Hatfield, England

*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 et al[1] lay out in a recent article in *Infection Control and Hospital Epidemiology*. Abdi et al touch upon the history of farming in the Zagros Mountains to contextualize the deep time dimension of brucellosis risk for communities within this region. Building on this, we highlight the context of this early history and the contribution that long-term perspectives of evolving

**Author for correspondence:** Robin Bendrey, E-mail: robin.bendrey@ed.ac.uk

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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 period (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. The domestication of goats, sheep, cattle, and pigs occurred in a number of locations in the Near East at this time, and one of the early centers of goat husbandry was in the Zagros Mountains.[2] Archaeological research on skeletal pathology has identified 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 modeling of the transmission of *Brucella melitensis* (the main causative agent of brucellosis in humans) in 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 not only from the creation of dense domestic goat populations but also from the decisions made by early goat farmers regarding the demographic composition of their herds. As goat farming evolved, some communities began to preferentially retain domestic female goats into adulthood in herds and to 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*, derived 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 analyses of diachronic strains in relation to long-term changes in cultural practices will elucidate the socio-ecological relationships that are influencing pathogen emergence, evolution, and spread.[5]

Understanding socioecological drivers of emergence and re-emergence in the distant past can help contextualize 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 tripled in size since the early 1960s, with the most dramatic increases taking place in Asia and Africa.[6] This increase likely altered the dynamics of *Brucella* infection in humans. Indeed, in a longitudinal study of the incidence and spatiotemporal distribution of human brucellosis in China from 1955 to 2014, Lai et al[7] identified the growing demand for meat in China and the resulting dramatic increase in livestock density as likely factors behind the re-emergence of human brucellosis from the mid-1990s.

Goat herds can also be considered at the very local level, at the scale of the family. The ability of goats 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] Also, at the family level, zoonotic diseases often have their most acute impact: poorer, rural communities involved in animal husbandry suffer directly both medically and economically.[8]

Engaging with how contextualized actions in the past affected disease emergence and risk can help inform current behaviors and decisions and local-level mitigation strategies. For example, despite the significant economic and health impacts, public awareness and cooperation with brucellosis eradication programs have often been limited.[9,10] Conflict often occurs with cultural and economic practices, such as traditional dairy production.[10] This conflict 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 behavioral change. More creative approaches to educational and preventative programs 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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