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Reprint of "Epidemiology of brucellosis, Q Fever and Rift Valley Fever at the human and livestock interface in northern Côte d'Ivoire"☆

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ABSTRACT

Northern Côte d'Ivoire is the main livestock breeding zone and has the highest livestock cross-border movements in Côte d'Ivoire. The aim of this study was to provide updated epidemiological data on three neglected zoonotic diseases, namely brucellosis, Q Fever and Rift Valley Fever (RVF). We conducted three-stage cross-sectional cluster surveys in livestock and humans between 2012 and 2014 in a random selection of 63 villages and a sample of 633 cattle, 622 small ruminants and 88 people. We administered questionnaires to capture risk factors and performed serological tests including the Rose Bengal Plate Test (RBPT), *Brucella* spp. indirect and competitive ELISAs, *Coxiella burnetii* indirect ELISA and RVF competitive ELISA. The human seroprevalence for *Brucella* spp. was 5.3%. RBPT-positive small ruminants tested negative by the indirect ELISA. The seroprevalence of *Brucella* spp. in cattle adjusted for clustering was 4.6%. Cattle aged 5–8 years had higher odds of seropositivity (OR = 3.5) than those aged ≤4 years. The seropositivity in cattle was associated with having joint hygromas (OR = 9), sharing the pastures with small ruminants (OR = 5.8) and contact with pastoralist herds (OR = 11.3). The seroprevalence of Q Fever was 13.9% in cattle, 9.4% in sheep and 12.4% in goats. The seroprevalence of RVF was 3.9% in cattle, 2.4% in sheep and 0% in goats. Seropositive ewes had greater odds (OR = 4.7) of abortion than seronegative ones. In cattle, a shorter distance between the night pens and nearest permanent water bodies was a protective factor (OR = 0.1). The study showed that the exposure to the three zoonoses is rather low in northern Côte d'Ivoire. Within a One Health approach, cost-benefit and cost-effectiveness of control measures should be assessed for an integrated control.

1. Introduction

Zoonotic diseases arise from infections transmitted from vertebrate animals to humans or vice versa. Neglected zoonotic diseases (NZDs) are not adequately addressed by health systems nationally and internationally (WHO, 2015). Brucellosis, Q Fever and Rift Valley Fever (RVF) are NZDs that have been largely eliminated in industrialised countries, but under-diagnosed and under-reported in resource-poor countries (WHO, 2015).

Brucellosis is caused by *Brucella* spp. with *Brucella melitensis* being assigned to small ruminants and *Brucella abortus* to cattle. *Brucella suis, Brucella ovis* and *Brucella canis* are mainly associated with pigs, sheep and dog brucellosis, respectively (Seleem et al., 2010). In sub-Saharan Africa, the exposure to the disease is highest in pastoral and agro-pastoral systems where the seroprevalence in cattle is commonly greater than 5% and decreases as herd size decreases (McDermott and Arimi, 2002). A few bacteriological studies have demonstrated the existence of *B. abortus* in cattle and sheep, but evidence for *B. melitensis* in small ruminants of West Africa is unclear (Ducrotoy et al., 2014). Q Fever is caused by *Coxiella burnetii*, an obligate intracellular gram-negative bacterium (Maurin and Raoult, 1999). It has been reported all over the African continent with the highest seroprevalences occurring in sub-Sahara and in West Africa, where it induces significant production losses (Vanderburg et al., 2014). The exposure to Q Fever was also shown to be higher in pastoral systems than in other communities (Mazeri et al., 2012). RVF is caused by a *Phlebovirus* in the family of

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Bunyaviridae (Daubney et al., 1931). The disease is widespread in sub-Saharan Africa and in Egypt, from where several outbreaks have been reported (Caminade et al., 2014; El Mamy et al., 2011; WHO, 2007; Abd el-Rahim et al., 1999). Mosquitoes of the genera *Aedes* and *Culex* uptake RVF virus by biting infected vertebrate animals and further transmit it transovarially and infect livestock and humans (Diallo et al., 2000; Fontenille et al., 1995; Meegan and Bailey, 1988). In contrast to East and South Africa, where epidemic outbreaks are observed after heavy rainfalls and flooding, in West Africa outbreaks can occur during years of rainfall deficit (Caminade et al., 2014; Fontenille et al., 1998). The three NZDs are transmitted to humans through the consumption of uncooked dairy products, contact with infected animals and contaminated carcasses or abortion materials. Additionally, humans and animals can be infected with *C. burnetii* through aerosols and ticks (Vanderburg et al., 2014; Franco et al., 2007). The most common symptoms of the three zoonoses in livestock are abortions and weak new-borns; whilst in humans, nonspecific febrile diseases, headache, musculo-skeletal pains, malaise and body wasting are found (Vanderburg et al., 2014; Dean et al., 2012; WHO, 2007). Test and slaughter are a suitable control approach in countries with animal tracking systems and low prevalences, but are not feasible in resource-poor countries due to the mobile pastoral systems and lack of proper compensation of herders. In endemic areas, control and elimination is almost only possible by interventions that simultaneously assess animal reservoirs and interactions with humans in a One Health perspective (Zinsstag et al., 2007; Roth et al., 2003). This assessment should lead to concerted efforts against several zoonoses and non-zoonotic infections, bringing together human and animal health professionals who can share the delivery infrastructure (Schelling et al., 2003). Furthermore, the identification of a cost-effective intervention requires representative quantitative data from both human health and livestock production systems; however, this is hardly available for any neglected zoonosis in resource-poor countries (Zinsstag et al., 2007; Bogel and Meslin, 1990).

Northern Côte d'Ivoire, due to its rich grazing resources and water bodies, is the main livestock breeding zone in the country. Cross-border mobile pastoralists from Sahelian neighbouring countries are also found in the area each year from November to April (SARA, 1999; Diallo, 1995). However, no animal disease control program has been in place for the last 20 years and veterinary services have not been efficient since the armed conflicts in 2002 and 2010 (Yabouaffo Honoré, personal communication). Studies on brucellosis in the northern part were conducted between 1971 and 1984, where it was shown that up to 60% of milk products sold in the local markets were contaminated by *Brucella* spp. (Camus 1984, 1980; Camus 1984, 1980; Pilo-Moron et al., 1979; Gidel et al., 1976; hnel 1971). Q Fever was studied for the last time in 1996 (Boni et al., 1998). The last study on RVF was conducted in 1992 where 7% exposure was found in sheep (Formenty et al., 1992). This study aimed at generating updated epidemiological data on the three diseases for a better understanding of seroprevalences and transmission in northern Côte d'Ivoire. The study also looked into the discrepancies of different brucellosis serological test results. Information on the seroprevalences and major risk factors are useful to assess the economic impact of the three zoonoses on human health and animal production, and for the identification of suitable prevention and control options in Côte d'Ivoire.

2. Materials and methods

2.1. Ethical considerations

Approval was obtained from the National Ethics Committee of the "Ministère de la Santé et de la Lutte contre le Sida" of Côte d'Ivoire (N°71/MSLS/CNER-dkn) and the "Direction Générale de Recherche Scientifique et de l'Innovation Technologique du Ministère de l'Enseignement Supérieur et de la Recherche Scientifique" (N° 089/MESRS/DGRSIT/KYS/tm). The study was also approved by the Ethics Commission of the Cantons of Basel-Stadt and Basel-Land (ref. 146/10). District health and village authorities, study participants and parents/guardians of minor participants (< 18 years) were informed about the objectives and procedures of the study as well as the potential risks and benefits. A written or oral informed consent was asked from all participants and livestock owners or herders. In case of illiteracy, a thumb print was recorded, witnessed and signed by a literate acquaintance of the participant. Questionnaires were administered confidentially and participants knew that the participation was voluntary and they could withdraw from the study at any time without further obligation. All information, samples and results were coded and treated confidentially.

2.2. Study sites and populations

The field study sites were Korhogo and Niakaramandougou also called Niakara in northern Côte d'Ivoire (Fig. 1). Korhogo is the regional capital and a city in the Savanna district and the Poro region. Niakara is a department in the district of Vallée de Bandama and the Hambôl region. The climate is warm and dry (November to March), hot and dry (March to May), and hot and wet (June to October). The vegetation is dry and wet savanna used by extensive livestock grazing systems and crop farming. In 2014, a population of almost 760,000 was found in Korhogo (RGPH, 2014). About 60% of this population lived in rural areas with income from agro-pastoral activities (RGPH, 2014). In 2000, more than 60% of the national cattle population was found in northern Côte d'Ivoire (Le Guen, 2004). Cross-border pastoralism is practiced by Fulani herdsmen, who are based in Mali or in Burkina Faso but migrate seasonally with their livestock during the dry season towards Korhogo and Niakara to access pastures, water points and markets. Additionally, internal pastoralism is practiced by herders from one district/region to another northern Ivorian one.

The study populations consisted of all ruminants and livestock-keeping settled or mobile households in the study sites. Sénoufo and Tagwana were the most important sedentary ethnic groups in Korhogo and Niakara, respectively. Their cattle were kept by Fulani shepherds in cattle herds owned by several persons (Diallo, 1995). The night pens were usually several kilometres away from the villages. In Korhogo, up to 15% of the cattle herds were mixed with small ruminants and on average a village consisted of 5 cattle, 3 sheep and 3 goat herds. In contrast to Korhogo, in Niakara, cattle herds consisted almost always of more than 50 animals and intermixing between different livestock species was less practiced (Boubacary Barry, personal communication).

2.3. Cluster sample size calculation

The sample size calculation was based on the expected seroprevalence of human and livestock brucellosis as the main zoonosis under investigation. Considering that the study areas did not vaccinate against brucellosis in the last 20 years, we assumed that brucellosis has an apparent seroprevalence of 5% and 1% in cattle and small ruminants, respectively (McDermott and Arimi, 2002). The design effect (D) was derived from the formula $D = 1 + (b - 1) \times ICC$; where b is the number of animals sampled per cluster and ICC is the intra-cluster (intra-village) correlation coefficient (Bennett et al., 1991). We used an ICC of 0.1 for human and animal brucellosis (Newcombe, 2001; Otte and Gumm, 1997). Assuming a design effect of 1.9 and using the logit Wald method by Newcombe (2001), we calculated a required sample size of 630 cattle in 63 clusters (villages) to have an estimate between 3% to 8% (95% confidence interval). For sheep and goats, the respective 95% confidence interval would then be between 0.4% and 2.7% with the same number of sheep and goats together and assuming a design effect of 1.6. A seroprevalence of 3% was assumed for humans. Aiming for a 95% confidence interval of 1–9%, we obtained a required sample size of 145 people from 29 villages (the design effect was 1.4). As for Q Fever and RVF in livestock, we assumed that they share common epidemiologic patterns with brucellosis; therefore, the above