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Qualitative and quantitative impacts assessment of contagious bovine pleuropneumonia in Fulani pastoral herds of North-central Nigeria: The associated socio-cultural factors

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ABSTRACT

Contagious bovine pleuropneumonia is one of the most important trans-boundary disease affecting Fulani cattle herds of Nigeria and whose control is urgently needed. A Participatory Epidemiology approach and cross-sectional study were concurrently conducted to investigate qualitative and quantitative impacts of CBPP, respectively and associated socio-cultural factors that influenced exposure of Fulani nomadic pastoral communities to its risk in Niger State, North-central Nigeria between January and December 2013. A total of nine pastoral communities were purposively selected for qualitative impact assessment using Participatory Rural Appraisal tools, while 765 cattle randomly sampled from 125 purposively selected nomadic herds were analyzed using c-ELISA. Data on socio-cultural characteristics were collected using structured questionnaires administered on nomadic herd owners of the 125 selected herds. Kendall's Coefficient of Concordance W statistics and OpenEpi 2.3 were used for statistical analyses. Pastoralists' dependent factors associated with their socio-cultural activities were tested using Chisquare tests and likelihood backward logistic regressions. The mean proportional piles (relative qualitative impact) of CBPP was 12.6%, and nomads agreement on this impact was strong ($W = 0.6855$) and statistically significant ($P < 0.001$). This was validated by 16.2% (95% CI: 13.7, 19.0) sero-positive (quantitative impact). Highest sero-prevalence of 25.3% was observed in Northern agro-ecological zone, while lowest of 6.2% was in Eastern zone. Pastoralists in the age groups 51–60 and 61–70 years were more likely (OR 13.07; 95% CI: 3.21, 53.12 and OR 7.10; 95% CI: 1.77, 28.33, respectively) to have satisfactory information/awareness on CBPP and lowland transhumance pastoralists were more likely (OR 5.21; 95% CI: 2.01, 13.54) to have satisfactory information. Socio-cultural activities of extensive husbandry system was six times more likely (OR 5.79; 95% CI: 2.55, 13.13) to be satisfactory practice that influenced CBPP occurrence in herds, while culture of borrowing and loaning of cattle was twenty times more likely (OR 19.94; 95% CI: 6.36, 62.48) to be satisfactory practice that influenced CBPP occurrence in herds. Also, sharing a water source that caused concentration of stocks in one point was fifty three times more likely (OR 53.08; 95% CI: 14.91, 189.00) to be satisfactory practice that influenced occurrence of the disease in herds. This study highlighted the critical gap that exists in terms of significant influence of socio-cultural factors on CBPP occurrence in pastoral herds in Nigeria. Thus, CBPP surveillance, control and prevention programs that take these factors into consideration will be beneficial to the livestock industry in Nigeria, and indeed Africa.

1. Introduction

Contagious bovine pleuropneumonia (CBPP) is an infectious and contagious respiratory disease of cattle caused by *Mycoplasma mycoides* subsp. *mycoides* (*Mmm*) (Tardy et al., 2011), previously further specified as Small Colony (SC) type (Manso-Silván et al., 2009). It is characterized by sero-fibrinous interlobular edema and heparization of lung in acute to sub-acute cases and capsulated lesions (sequestra) in chronically infected cattle (Vilei and Frey, 2010).

CBPP is an OIE listed disease and second most important trans-boundary disease of cattle after rinderpest (Tambi et al., 2006). It

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is insidious in nature with the majority of cases remaining subclinical (Amanfu, 2009; Kassaye and Molla, 2012). Once CBPP is introduced into a naïve cattle herd, it causes high morbidity and mortality and those animals that survive remain chronic carriers (Schubert et al., 2011). The disease represents a major constraint to cattle production in sub-Saharan Africa and has ability to compromise food security through loss of protein and draft power by infected cattle (Amanfu, 2009; Morobela, 2011; Kassaye and Molla, 2012). With increasing globalization and continued presence of CBPP in cattle herds in African countries, it constitutes a serious threat to their food security and international trade (Obi, 2005).

CBPP is associated with massive economic losses for cattle keepers in many parts of the world (Windsor, 2000; Tambi et al., 2006; Jiuqing et al., 2011). It impacts animal health and poverty of livestock-dependent people through decreased animal productivity, reduced food supply for households, and the cost of control measures in Africa (Tambi et al., 2006). With rinderpest eradicated, CBPP is the most important trans-boundary animal disease of cattle, and a barrier to trade in many African countries as it reduces the value of livestock and the income of many value chain stakeholders (Jores et al., 2013). While the disease was eradicated from the United States by mid-20th Century, it was not eradicated from Europe until end of 20th Century, and still persists in many African countries, especially in the West, Central, East and parts of Southern Africa (Nicholas et al., 2008). The declined in CBPP outbreaks and burden reports in Nigeria and other affected African countries does not augur well for the implementation of internationally coordinated control programs due to absence of science based evidence for the disease impact assessment, which underpins control and preventive actions (Amanfu, 2009).

Nomadic pastoral communities in Africa live in some of the most underdeveloped environments in the world. Although these communities are reliant on their livestock as a source of social and economic well-being, conventional veterinary services are poor and basic information on the epidemiology of important livestock diseases is limited. Epidemiological research and disease surveillance in such pastoralist areas are difficult because human populations are relatively small and highly mobile, and they move their livestock across large areas with few roads and means of modern communications (de Leeuw et al., 1995; Catley, 2006). In such situations, conventional approaches to veterinary research and disease surveillance require considerable flexibility and commitment. Given the resource and logistical constraints in such pastoral areas, pastoralists themselves are a valuable source of disease information (Thrusfield, 2009).

The main biophysical determinants of CBPP occurrence in herds are the presence of infected animal with *Mmm*, susceptible cattle and the environment for interface. However, social determinants of health that include socio-cultural factors of income, education, occupation, sex, tribe, and cultural practices have the potentials to influence the outcomes of disease (Rutto et al., 2013; Alhaji and Kabir, 2015). Cattle managed under pastoral extensive system are persistently at risk of contracting contagious diseases, including CBPP, due to continuous mixing of herds at grazing and watering points, and as well as socio-cultural practices of giving out cattle as dowry and gifts (FAO, 2000; Mariner et al., 2006). These practices inhibit CBPP control strategies. Information on socio-cultural factors that could influence pastoral cattle herds and expose them to risk of CBPP is not readily available. Therefore, understanding these characteristics of pastoralists that include their demography, disease epidemiology, husbandry practices, physical environment that could predisposed to occurrence of CBPP is necessary. Availability of such science based information would assist in the development of surveillance and control strategies for the disease in Africa.

The objectives of this study were, to assess qualitative impacts of CBPP in Fulani nomadic herds, validate with quantitative sero-prevalence burdens, and investigate associated socio-cultural characteristics of Fulani nomadic pastoralists that could influence exposure of their cattle herds to risk of the disease in North-central Nigeria. Our null hypothesis was that socio-cultural practices of the Fulani nomadic pastoralists cannot have influence on their herds and therefore could not predispose the animals to CBPP. Also, a concentric convergence model of biological, physical (environmental), and socio-cultural interface was postulated for the disease occurrence and likely intervention points for its mitigation. The studied herds were under zero vaccination status because the last CBPP vaccination campaign in the state was carried out in November 2011. The T1/44 vaccine used in Nigeria has limited efficacy as it conferred relatively short period of six months immunity (Egwu et al., 1996). For vaccination to be effective, it must be repeated initially at short intervals of six months and thereafter annually over 3–5 years (FAO, 2002; FAO, 2004a,b). Based on these reports, protection of cattle populations in the state against *Mmm* infection by vaccination was considered to be zero status during the period of survey beginning from January 2013. Even the previous campaigns before the 2011 exercise were irregular due to logistic problems.

2. Materials and methods

2.1. Study area

The study was conducted in Niger State, located in the North-central geopolitical zone of Nigeria, between latitude 8° 20′N and 11° 30′N, and longitude 3° 30′E and 7° 20′E. According to the Nigerian Livestock Resources Survey, the state has an estimated cattle population of about 2.4 million cattle in 2012 (MLFD, 2013), mostly in the custodies of Fulani nomadic pastoralists. It has three Agro-ecological zones with variable climatic conditions; which are: Agro-ecological zone A or Southern zone with eight local governments areas (LGAs) and many rivers and fadamas; Agro-ecological zone B or Eastern zone with nine LGAs, many mountains, trees, and few rivers; and Agro-ecological zone C or Northern zone with eight LGAs, large grazing areas, many stock routes, and an international border with the Republic of Benin, which is porous (MLFD, 2013). The state also provides transit routes for nomadic pastoralists on seasonal migrations from the northern parts to the south-western and south-southern parts of Nigeria.

2.2. Social structure of populations surveyed and study design

The target populations were Fulani nomadic pastoral communities, who are seasonally mobile, with scattered herds of local breeds of cattle (Bunaji, Rahaji and Bokoloji), domiciled in remote areas of the state during the study period. Average number of herds that formed a nomadic pastoral community was 28, each managed by herd head or owner (a man, his wives and children, or an elderly widow and her children). Average number of animals in a herd was 82 cattle of variable ages.

Participatory Epidemiology (PE) approach was conducted using participatory rural appraisal (PRA) tools in nine Fulani nomadic pastoral communities of Lapai, Eyagi, Lemu, Paiko, Kuta, Bosso, Wushishi, Bobi grazing reserve and Borgu between January and December 2013. PE approach was applied in this survey to collect semi-quantitative data from piled and ranked cattle diseases relative to their impacts in the nomadic pastoral communities. A cross-sectional study was carried out on 765 cattle selected in 125 Fulani nomadic herds from the nine pastoral communities in the three Agro-ecological zones. A questionnaire-based interview was administered on the selected herds' owners at the community levels and relevant information collected. Inclusion criteria for the herders administered questionnaires were, that he/she must be a cattle herd owner, and aged above 30 years. Pastoralists above this age were traditionally considered to possess existing veterinary knowledge and traditional oral history about cattle diseases and management because of their long time relationships with livestock. These surveys were concurrently conducted.

2.3. Definitions

In this study, Fulani nomadic herd was defined as cattle herd in Fulani ethno-cultural group that keeps mainly cattle, usually large herd of fifty cattle and above, and takes part in year-round long movements on large range for grazing and in search for water, without permanent homestead.

Qualitative (semi-quantitative) impact was the pastoralists' perceived effects of CBPP on their cattle, characterized by such indicators as production losses (milk and meat production), reduced draught power, costs of treatment and mortality. Quantitative impact was the proportion of number of identified sero-positive cattle with *Mmm* infection to the total number of cattle sampled during the survey.

2.4. Sample size determination and sampling procedure

For Participatory Epidemiology approach, nine Fulani nomadic pastoral communities were purposively selected across the state, three in each Agro-ecological zone, in a manner that allowed for adequate spread in each zone. Key criteria for selection of the communities included nomadic herding of cattle as main source of livelihood and remoteness of the settlements. Also, three pastoral key informants were purposively selected in each community to organize and lead other pastoralists for action-oriented exercises. However, for each pastoral community the number of other participants was not restricted.

For cross-sectional study, simple random sampling method (Thrusfield, 2009) was used and sample size was determined using expected CBPP prevalence of 8.7% (Alhaji, 2011) at 95% confidence level. The sample size $(n) = Z^2 \times P_{exp}(1 - P_{exp})/d^2$, where: n is the required sample size, Z^2 is the standard deviation or 1.96 p is the expected prevalence, and d is the desired absolute precision. One hundred and twenty-five nomadic herds were purposely selected across the state because sampling frame for the herds could not be obtained at the time of sampling. Sample size for the cattle was determined at 2% margin of error, giving size of 765. However, 1% design effect was used, which is for cross-sectional study at a single-level random sampling. Further, questionnaires were administered on 125 nomadic herd owners, who were purposively selected across the three zones from the pastoral communities.

Two-stage sampling procedure was used. In the first stage, herds were selected in the three existing Agro-ecological zones (AEZs) using purposive sampling procedure because of their scattered and mobile nature. In the Southern and Eastern AEZs, 40 herds were selected in each, while 45 were selected in the Northern AEZ. In the second stage, seven cattle were randomly selected and sampled in each herd, and a total of 765 cattle were sampled in all herds by card balloting.

2.5. Ethical approval

The study protocols for the various surveys were approved by the Niger State Ministry of Livestock and Fisheries Development, Minna Research Ethics Committee (reference MLFD/NGS/671). Participants were provided with verbal information on the objectives of the study. Informed consents of respondents were verbally obtained before commencement of each section of participatory exercise in a community and questionnaire administering and none declined to participate in the study. They were assured of voluntary participation, confidentiality of responses and the opportunity to withdraw at any time without prejudice in line with the Helsinki Declaration (WMADH, 2001). Verbal information and informed consent were deemed necessary due to the very low literacy levels among pastoralists.

2.6. Participatory data collection

Advocacy visits were made to each community two weeks prior to the proposed participatory exercise and the necessary permission was obtained from *Dikko* (Fulani community leaders). Key informants were told that the survey was only meant to investigate impacts of cattle diseases in pastoral communities, in relation to the effects on stock productive performances, using their existing veterinary knowledge and perceptions about livestock diseases, which will be used for design of control strategies. However, CBPP was not specifically mentioned to avoid bias, especially where it is not a major challenge. The PE was conducted by an appraisal team trained on participatory methods as described (Catley et al., 2002; Catley, 2005) and participatory rural appraisal tools of semi-structured interview, key informants, proportional piling, triangulation, and key biological sampling were used. Qualitative and semi-quantitative data were collected by used of these PE techniques as previously described (Mariner and Paskin, 2000).

2.6.1. Key informants and semi-structured interview (SSI)

Key informants were the traditional Fulani pastoral leaders or elders in the communities. According to Fulani tradition, they are considered to be more knowledgeable than other community members on animal health and production. They led other pastoralists in their respective communities to the group participatory exercises. SSI began with introduction of the appraisal team and explanation the purpose of the visit to the whole participants. During each session of the SSI, which ran for about three hours, general information about cattle diseases encountered in the communities was discussed. In order to facilitate discussion, appraisal team asked questions that began with more general topics on cattle management followed by areas on specific cattle diseases. These were guided by a pre-tested checklist of open-ended questions that standardized discussions, and questions were probed depending on the key informants' response. Mentioned diseases were probed and expanded descriptions of their clinical and epidemiological manifestations obtained. Interviews were conducted using the local languages of *Hausa* (local languages used for communication in the study area) and *Fulfulde*, and detailed descriptions of CBPP and other cattle diseases in each pastoral community were collected and recorded.

2.6.2. Proportional piling

Materials used in this exercise included counters (pebbles), flip charts, and permanent markers. In each community, pastoralists were asked to give a list of ten most important diseases perceived to be affecting their cattle within a ten-year period preceding the time of the interview. The pastoralists often used the local disease names to identify diseases. When the pastoralists provided syndromes rather than specific names of diseases, probing using open-ended questions was done to characterize the syndrome whilst trying not to guide them. The names of the diseases and descriptions given by the pastoralists were later validated at the Zonal Veterinary Offices. Once the respondents and the appraisal team had compiled the list of diseases, ten circles were drawn on flip charts, each representing a mentioned disease. Pastoralists were given 100 pebbles and instructed to pile in the circles proportionally according to perceived impact of each disease to the herders, in terms of loss in milk and meat production, to mention few. The appraisal team then counted pebbles placed in each circle to give a proportion that determined impact and rank of the disease in that community.

2.6.3. Triangulation and key biological sampling

Data obtained from each participatory exercise in each community were cross-checked and compared and, if inconsistent, were further debated among the participants until a consensus view or agreement arrived at. The studied nine pastoral communities' results were also compared, triangulated, at the end of the participatory exercises, analyzed and mean outcomes of perceived impacts of CBPP and other important cattle diseases were obtained. Key biological sampling was the final method of triangulation in participatory epidemiology (Mariner and Paskin, 2000). The participatory (qualitative) reports obtained from the Fulani participants were finally validated by collected and analyzed 'serum' samples in the form of sero-prevalence (quantitative).

2.7. Serum samples collection and enzyme immunoassay

Ten (10) ml of whole blood was taken from jugular vein of each selected cattle with a sterile 10 ml syringe and 18 × 1½" gauge needle for each cattle. These were immediately placed into an ice bath slant and transported to the laboratory within seven hours. The clot was allowed to form in syringe in the field, which was later transferred into plastic tubes and centrifuged at 3000 rpm for 20 min, decanted and stored at −20 °C until analyzed.

A competitive Enzyme Linked Immunosorbent Assay (c-ELISA) was used. It detected antibodies in infected herd even if they persist for a longer period of time (FAO 2003; Niang et al., 2006). The test performance has sensitivity of 99.9% and greater specificity of more than 63.8% (OIE, 2014). The c-ELISA was conducted using commercial *Mycoplasma mycoides* subsp. *mycoides* Antibody Test Kit CBPP, ELISA version: P05410/02 (CIRAD/IDEXX, Institut Pourquier Laboratories, Montpellier, France) according to manufacturers' instructions. Optical densities (OD) were measured at 450 nm using the Spectrophotometer Fluor (Tecan, Crailsheim, Germany). The cut-off for positive samples was set at ≥50% inhibition (INH) value.

2.8. Questionnaire design, pretesting and data collection

The questionnaire was designed to collect individual pastoralist's data on the aspects under investigation and contained mostly close-ended questions to ease data processing, minimize variation, and improve precision of responses (Thrusfield, 2009). The questions focused on various sub-themes like the pastoralists' demographic characteristics of gender, age, tribe, occupation and formal education; CBPP epidemiological factors that included clinical signs, post-mortem lesions, common sources of infection into herds, and common season of occurrence; socio-cultural practices of husbandry management system, daily grazing system, keeping of healthy cattle with sick ones within herds, and introduction of new cattle bought at livestock market into herd. Others were on giving out of cattle as gifts and payments for dowries, grazing in an area of CBPP outbreak, among others.

The questionnaire was pre-tested prior to the study on few Fulani nomadic herders on whom the actual study was conducted. It was designed in English but verbally translated into *Hausa* language during the process of administering since many of the respondents do not possessed formal education. Data were collected by interviewer-administered, paper-based questionnaires on herd owners. Data collections were completed at the selected herd sites on a single visit.

2.9. Defined variables for questionnaire responses

In this study, covariates (hypothesized explanatory variables) were assessed. The demographic characteristics of respondents, CBPP epidemiological factors, and socio-cultural activities practiced by pastoralists were the explanatory (independent) variables. However, pastoralist's information/awareness about the disease, existing veterinary knowledge, and practice of socio-cultural activities, respectively constituted the outcome (dependent) variables. To assess association of independent characteristics with outcome variables a unique scoring system was used. Each respondent was assigned a score that reflected the stringency of his or her levels of information/awareness of CBPP, existing knowledge about its occurrence, and practice of activities. To measure responses to the independent factors, the scoring system for the dependent variables range between 1 and 20 points, which were converted to 100%. The score range was further categorized into 'poor' (≤10 points, ≤50%) and 'satisfactory' (≥11 points, ≥51%) to keep them as binary variables.

2.10. Conceptual convergence model

A Conceptual Convergence Model (CCM) was postulated and adopted to study interactions of various socio-cultural, biological and physical factors that could predisposed to occurrence of CBPP in pastoral cattle herds. The conceptual model was developed to illustrate how the convergence of factors in three domains of biological-environmental-sociocultural characteristics interfaced to influence occurrence of CBPP in herds (Fig. 1). We believe that convergence of these interfacing factors can create a platform in which infectious contagious diseases, such as CBPP, can emerge and become rooted in cattle herds.

2.11. Data management and analysis

Data arising from each PE exercise were recorded in a field notebook and the results of exercises that created visual representations were captured on a digital camera. Data obtained were qualitative and semi-quantitative in nature; the former were discussed during SSI without being subjected to formal statistical analyses while the later (mostly from the piling and ranking exercises) were entered into a Microsoft Excel® 7 database (Microsoft Corporation, Redmond WA, USA) stored and analyzed using Kendall's Coefficient of Concordance *W* statistic, a non-parametric statistics, (Kendall and Smith, 1939; Siegel and Castellan, 1988; Legendre, 2010) was used to assess levels of agreements among the key informants and other participants at 95% confidence level. Descriptive statistics of rate and mean were used to describe the relative impact of CBPP among other cattle diseases from proportional piles in the pastoral communities. $P < 0.05$ indicates statistical significance of the agreements.

Pastoralists' responses from the questionnaires were first summarized into Microsoft Excel® 7 (Microsoft Corporation, Redmond, WA, USA) spreadsheets, exported and analyzed using the Open Source Epidemiologic Statistics for Public Health (OpenEpi) version 2.3 (Dean et al., 2009). Descriptive and analytical statistics were used to describe the obtained data. In the descriptive analysis, frequency and proportion were used. At univariate analysis, chi-square test was used to examine associations of agro-ecological zones with CBPP occurrence, as well as pastoralists' demographic characteristics, the disease epidemiological factors and socio-cultural activities, respectively with information/awareness, existing veterinary knowledge, and practices that could influence on herds and predisposed them to CBPP. Further, likelihood stepwise backward multivariate logistic regression models were used to determined final associations on only factors that were

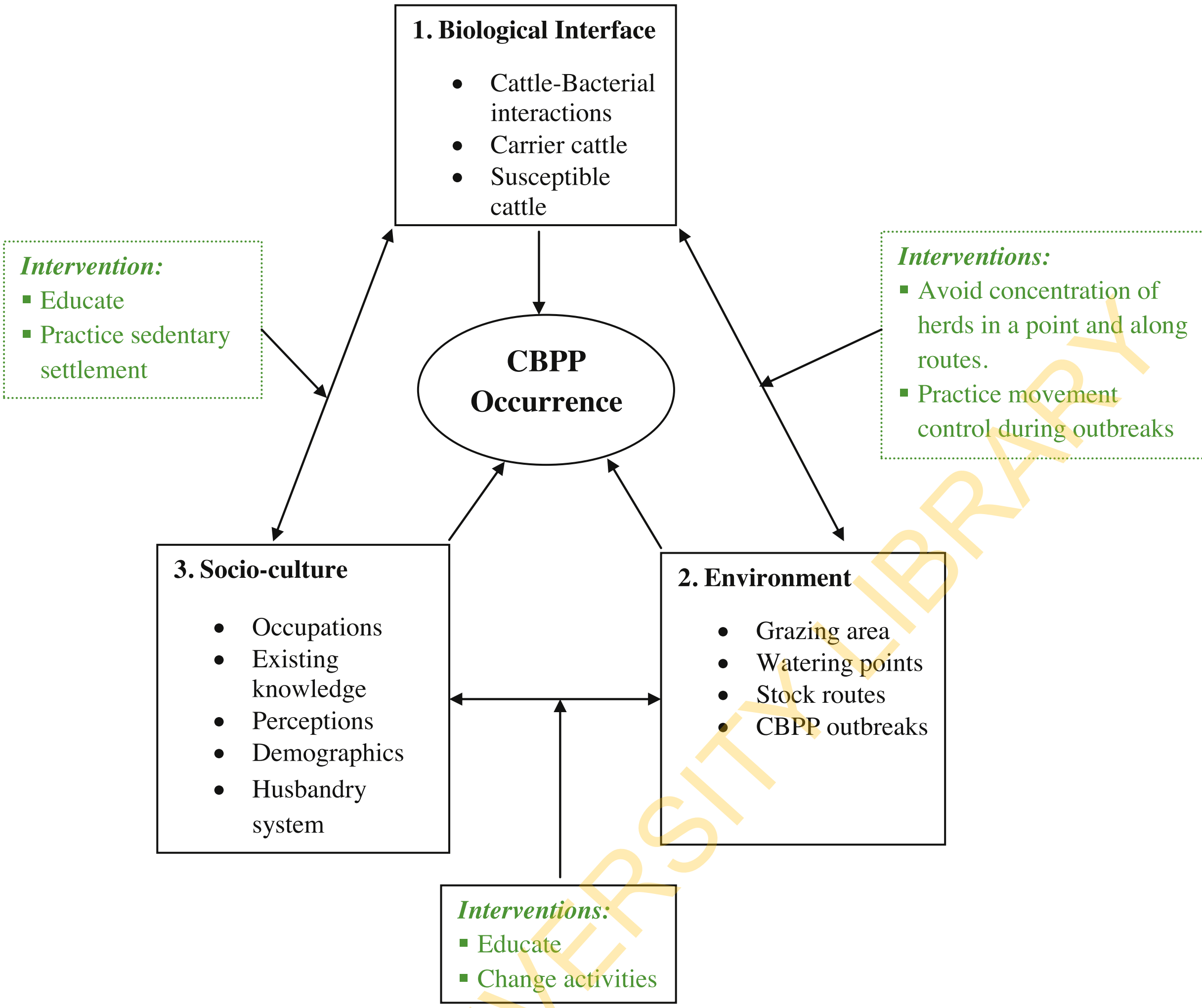

Fig. 1. A Conceptual Convergence Model of pastoralists' socio-cultural characteristics that influenced CBPP occurrence in pastoral cattle herds of Niger State and the interventions.

significant at P < 0.05 during univariate analysis. Outcomes with P < 0.05 were considered statistically significant in all analyses. The goodness-of-fit of the model was assessed using the Hosmer–Lemeshow test statistic. Variables remained in the model if they significantly improved the fit (P < 0.05).

3. Results

3.1. Proportional piling for CBPP relative impact

Key informants and other pastoralists in this study demonstrated detailed existing veterinary knowledge of cattle diseases in their communities. However, among the 27 key informants and other pastoralists in the PE study, the cattle diseases that were averagely ranked as priority in the nine Fulani nomadic communities with regard to effects on cattle productive performances (draught power, meat and milk production, and reproduction) were FMD, trypanosomoses, CBPP, fascioliasis, bovine brucellosis, dermatophilosis, among others (Fig. 2). The proportional piles (relative impact) of CBPP among other cattle diseases in Lapai, Lemu, Eyagi, Paiko, Kuta, Bosso, Wushishi, Bobi Grazing Reserve, and Borgu Fulani nomadic pastoral communities were 10.0%, 14.0%, 12.0%, 10.0%, 13.0%, 20.0%, 10.0%, 12.0% and 12.0%, respectively. The mean proportional pile (relative impact) of CBPP among other diseases in the nine pastoral communities was 12.6%, which was judged by herders to be third most important cattle disease in negative impact only to FMD and trypanosomiasis. The agreement of the pastoralists on CBPP impact in Niger State was strong (W = 0.6855) and statistically significant (P < 0.05). Pastoralists called CBPP *Ciwonhuhu* in *Hausa* language and *Huttu* in *Fulfulde,* denoting lung disease associated with respiratory distress and cough.

Outcomes from the cross-sectional study indicated that of the 765 nomadic cattle sampled and sera examined for quantitative impact validation to pastoralists' perceived negative effects of CBPP, 124 (16.2%; 95% CI: 13.7, 19.0) were sero-positive of antibodies to *Mycoplasma mycoides* subsp. *mycoides* infections and the result was statistically significant (P < 0.05). The geographical pattern of the disease sero-prevalence in the state is shown in Table 1.

3.2. Association of agro-ecological zones with CBPP occurrence

Highest CBPP sero-prevalence of 25.3% (62/245; 95% CI: 20.2, 31.0) was observed in Northern agro-ecological zone, while lowest of 6.2% (17/275; 95% CI: 3.8, 9.5) was in Eastern zone (Table 1). At the multivariate logistic regressions, Northern agro-ecological zone was five times more likely (OR 5.14; 95% CI: 2.91, 9.08) to have factors that predisposed to the occurrence of CBPP than Eastern zone. Also, Southern agro-ecological zone was three times more likely (OR 3.42; 95% CI: 1.90, 6.15) to have factors that predisposed

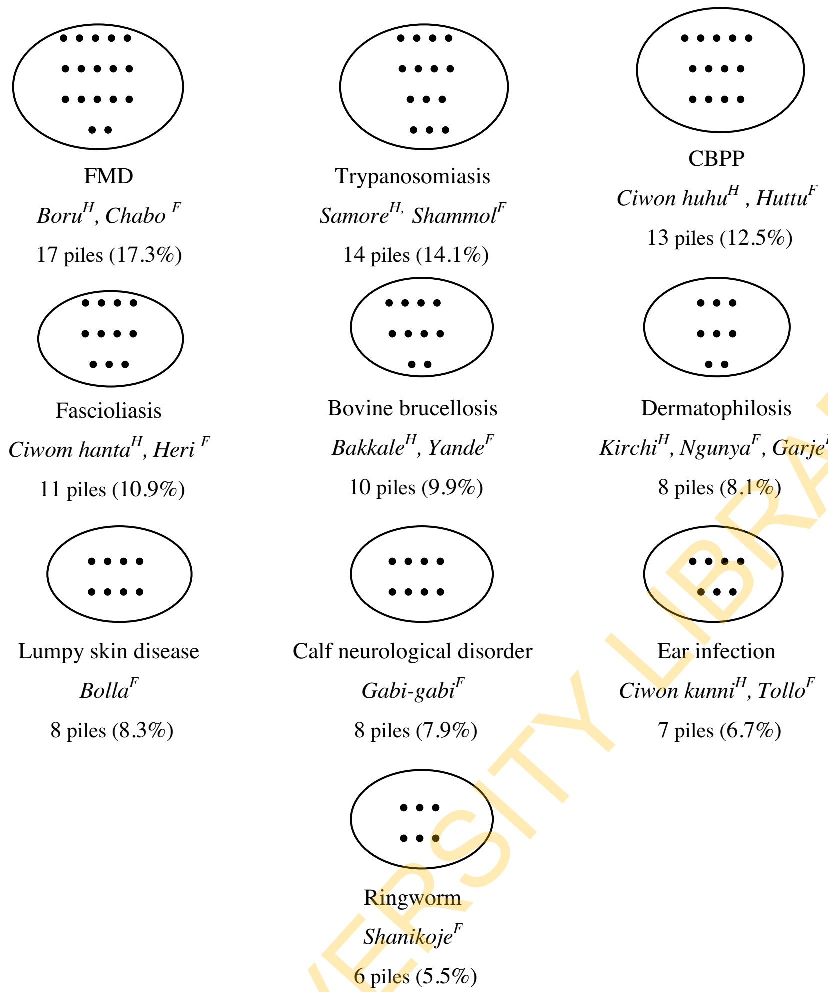

Fig. 2. Mean proportional piles (rank order) of relative burden of CBPP and some cattle diseases/conditions in pastoral communities of Niger State, Nigeria, 2013. Numbers in parenthesis are average proportions of each disease/condition. Superscripts *H* (*Hausa*) and *F* (*Fulfulde*) are the local names for the diseases/conditions presented during the Participatory Epidemiology exercises.

Table 1
Cattle and herd levels CBPP sero-prevalence in Fulani nomadic herds of Niger State, Nigeria, 2013.

Agro-ecological zone	Number sampled	Number positive	Prevalence (%)	95% CI
A (Southern)	245	45	18.4	13.9, 23.6
B (Eastern)	275	17	6.2	3.8, 9.5
C (Northern)	245	62	25.3	20.2, 31.0
Overall	765	124	16.2	13.7, 19.0

CI—confidence interval.

Table 2
Association of agro-ecological zones with CBPP sero-prevalence in Fulani nomadic cattle populations of Niger State, Nigeria, 2013.

Agro-ecological zone	Number of cattle sampled	Number negative (Row%)	Number positive (Row%)	Odds ratio(OR)	95% CI	P-value
B (Eastern)	275	258 (93.8)	17 (6.2)			
A (Southern)	245	200 (81.6)	45 (18.4)	3.42	1.90, 6.15	0.001
C (Northern)	245	183 (74.7)	62 (25.3)	5.14	2.91, 9.08	<0.001

Statistical significance at $P < 0.05$; CI—confidence interval.

to occurrence of the disease in Fulani nomadic cattle populations in the state than Eastern zone (Table 2).

3.3. *Pastoralists' demographic factors that influenced level of information/awareness about CBPP occurrence in herds*

A total of 125 nomadic pastoral herd owners participated in the questionnaire-based survey, with a mean age of 52.1 ± 10.9 SD. Age group of 41–50 years constituted 30.4% of the respondents. Males constituted 97.6% of gender and all respondents were married. However, 64.8% of them were of main Fulani tribe while other dialects of the tribe constituted 35.2%. It was observed that 70.0% never had formal education, while 12.0% possessed formal tertiary education (Fig. 3).

High proportions (89.1% and 81.6%) of Fulani pastoralists in the age groups 51–60 and 61–70 years, respectively possess significant

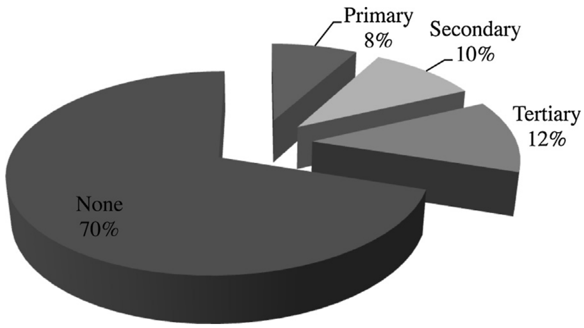

Fig. 3. Fulani nomadic pastoralists' demographic distribution by formal education status in Niger State, Nigeria, 2013.

(P < 0.05) satisfactory information and awareness about CBPP in herds, while 62.5% and 75% of those in age groups 41–50 and 71–80 years, respectively do not possess significant awareness about the disease. Generally, high proportions of respondents in these four age groups do possess satisfactory information about the disease in the herds, unlike those in the 31–40 years age group with less than half (38.5%) of its population possessing satisfactory information of CBPP. The highest proportion (92.0%) of the Fulani nomads with significant satisfactory information and awareness about the disease do not have formal education. On the occupational status, 63.3% of highland pastoralists and 91.0% of lowland pastoralists possessed significant satisfactory information and awareness (P < 0.05) about the disease in herds.

On the association of pastoralists' demographic characteristics with awareness about CBPP, only respondents in the age groups 51–60 and 61–70 years were more likely (OR 13.07; 95% CI: 3.21, 53.12 and OR 7.10; 95% CI: 1.77, 28.33, respectively) to have satisfactory information about CBPP occurrence than those in 31–40 age group. Fulani nomadic pastoralists without formal education were more likely (OR 11.43; 95% CI: 2.65, 49.24) to possessed satisfactory information about the disease than those with primary education. Also, lowland transhumance pastoralists were more likely (OR 5.21; 95% CI: 2.01, 13.54) to have satisfactory information than the highland pastoralists (Table 3).

3.4. *Pastoralists' levels of existing veterinary knowledge associated with CBPP epidemiological characteristics in herds*

Nearly two-third (71.4%) of the nomadic Fulani pastoralists had significant (P < 0.05) satisfactory existing knowledge about CBPP in herds, and over two-third (88.2%) of them possessed significant (P < 0.05) satisfactory existing knowledge about the post-mortem lesions of the disease in cattle. Most (71.7%) of the pastoralists had significant (P < 0.05) satisfactory existing knowledge about common source(s) of the infection into the herds. Further, 83.8% of them had significant (P < 0.05) satisfactory existing knowledge about most common season of CBPP occurrence in the herds.

Multivariate logistic regressions indicated that high proportions of pastoralists know about CBPP epidemiological characteristics and were all more likely to possessed significant satisfactory existing knowledge about the disease. Nomadic pastoralists who knew about CBPP clinical signs and its post-mortem lesions were more likely (OR 7.92; 95% CI: 1.37, 45.80 and OR 4.93; 95% CI: 1.60, 15.22, respectively) to possessed significant satisfactory existing knowledge about the disease. Also, pastoralists that know about common sources of CBPP into herds were nine times more likely (OR 8.86; 95% CI: 1.75, 44.94) to possessed significant satisfactory existing knowledge about its occurrence in the herds (Table 4).

3.5. *Socio-cultural practices the influenced CBPP occurrence in herds*

About 82.0% of the nomadic pastoralist significantly (P < 0.05) practiced satisfactory extensive husbandry system, and nearly two-third (76.8%) significantly (P < 0.05) practiced satisfactory long distance daily grazing. Also, very high proportions of the nomadic Fulanis significantly (P < 0.05) practiced satisfactory keeping of healthy cattle with sick ones within herds, sharing a water source that caused concentration of cattle in one point, mixed grazing and watering of cattle with small ruminants, culture of borrowing and loaning of livestock, introduction of new cattle into the herd, grazing in an area of CBPP outbreak, and giving out cattle as gift or payment for dowry.

All the cultural practices significantly had influence on occurrence of CBPP in pastoral cattle herds in the state. Extensive husbandry management system was six times more likely (OR 5.79; 95% CI: 2.55, 13.13) to influenced the disease occurrence in herds than the semi-extensive system, while culture of borrowing and loaning of livestock was twenty times more likely (OR 19.94; 95% CI: 6.36, 62.48) to influenced CBPP occurrence in herds. Also, sharing a water source that caused concentration of cattle in one point was fifty three times more likely (OR 53.08; 95% CI: 14.91, 189.00) to influenced occurrence of the disease in herds (Table 5).

4. Discussion

This survey was conducted in Fulani nomadic pastoral communities which have significant satisfactory existing knowledge of CBPP, though most of them do not possess formal education. CBPP is one of the few relatively surveyed cattle diseases in Nigeria, and to our knowledge, this study was the first to cover Fulani nomadic pastoral communities and their herds using qualitative and quantitative techniques to assess and validate impact levels of the disease at a time. Though the results generated cannot be generalized, the survey however provides a model on socio-cultural characteristics of pastoralists that be used for CBPP and other animal diseases intervention studies in transhumant pastoral communities of Africa.

Participatory Epidemiology (PE) is an emerging field that is based on the use of participatory techniques for systemic harvesting of epidemiological intelligence information contained within community observations, existing veterinary knowledge (clinical and epidemiological information of diseases) and traditional oral history to improve understanding of diseases and options for animal disease control (Catley, 2005; Catley, 2006; Jost et al., 2007; Thrusfield 2009; Catley et al., 2012), concurrently with key biological sampling for validation (Mariner and Paskin, 2000).

The PE techniques adopted in this survey were used to assess perceptive views of Fulani nomads on CBPP, which were validated with key biological samplings in cross-sectional study. This is in consonant with the works of Mariner and Paskin (2000) on PE approach. Pastoralists' existing knowledge of CBPP among other cattle diseases on this study was not poor, and collectively they were able to name and described clinical manifestations of cattle diseases and syndromes in remote rural areas at low cost. The resultant finding has identified major cattle diseases in the target communities and this can serve as potential active surveillance for control purposes. Pastoralists, as observed, can be a fulcrum for surveillance of livestock diseases in remote settlements, which was indicated by important roles they played in the identification of diseases affecting their cattle herds during the PE exercises. These role have been identified in previous studies on livestock diseases and management (Mariner, 2003; Allport et al., 2005; Swai and Neselle, 2010; Mlambo et al., 2011; Alhaji and Babalobi, 2015). Many pre-

Table 3
Pastoralists" demographic factors associated with level of information/awareness about CBPP in Fulani nomadic cattle herds of Niger State, Nigeria, 2013.

Factor	Poor information N (Row%)	Satisfactory information N (Row%)	Odds ratio(OR)	95% CI	P-value
Age					
31–40	8 (61.5)	5 (38.5)	1.00		
41–50	6 (37.5)	10 (62.5)	2.67	0.60, 12.04	0.230
51–60	6 (10.9)	49 (89.1)	13.07	3.21, 53.12	0.001
61–70	7 (18.4)	31 (81.6)	7.10	1.77, 28.33	0.001
71–80	1 (25.0)	3 (75.0)	4.80	0.38, 59.89	0.270
Tribe					
Other dialects	6 (35.7)	29 (64.3)	1.00		
Fulani	7 (8.6)	74 (91.4)	2.19	0.68, 7.06	0.210
Formal education					
Primary	5 (50.0)	5 (50.0)	1.00		
Secondary	5 (38.5)	8 (61.5)	1.60	0.30, 8.49	0.610
Tertiary	6 (40.0)	9 (60.0)	1.50	0.30, 7.53	0.650
None	7 (8.0)	80 (92.0)	11.43	2.65, 49.24	0.001
Occupation					
Highland transhumance	16 (36.7)	28 (63.3)	1.00		
Lowland transhumance	8 (9.0)	73 (91.0)	5.21	2.01, 13.54	0.001

Statistically significant at P < 0.05.

Table 4
CBPP epidemiological factors associated with pastoralists' level of existing veterinary knowledge (EVK) on CBPP in Fulani nomadic cattle herds of Niger State, Nigeria, 2013.

Disease factor	Satisfactory EVK N (Row%)	Poor EVK N (Row%)	Odds ratio (OR)	95% CI	P-value
Know about CBPP					
Yes	75 (71.4)	30 (28.6)	3.01	1.15, 8.12	0.030
No	9 (45.0)	11 (65.0)			
Know clinical signs of CBPP					
Yes	95 (79.8)	24 (20.2)	7.92	1.37, 45.80	0.020
No	2 (33.3)	4 (66.7)			
Know its post-mortem lesions					
Yes	95 (88.2)	14 (11.8)	4.93	1.60, 15.22	0.001
No	9 (56.3)	7 (43.7)			
Know common source(s) of the infection into the herd					
Yes	81 (71.7)	32 (28.3)	8.86	1.75, 44.94	0.001
No	2 (22.2)	7 (77.8)			
Know most common season of occurrence					
Yes	88 (83.8)	17 (16.2)	9.61	3.35, 27.62	0.001
No	7 (35.0)	13 (65.0)			

Statistically significant at P < 0.05; EVK—Existing veterinary knowledge.

vious studies have also highlighted CBPP as an important cause of morbidity among cattle in Nigeria (Egwu et al., 1996; Alhaji, 2011, Billy et al., 2015), and this is consistent with the opinions of the participants in this PE study.

The observed CBPP sero-prevalence of 16.2% was meant to validate 12.6% mean relative qualitative impact assessment and not for comparison between the designs. Both were significant findings, though of different values and techniques. The cattle-level sero-prevalence of 16.2% indicated that there was considerable high level of cattle challenged with *Mycoplasma mycoides* subsp. *mycoides* infection when compared with earlier 8.7% sero-prevalence obtained from a similar investigation in mixed pastoral cattle camps in Niger State using c-ELISA (Alhaji, 2011). The obtained sero-prevalence was more than 10.6% reported in Kwara State, Nigeria (Olabode et al., 2013) but less than 32.0% sero-prevalence in a CBPP abattoir survey using c-ELISA in Nigeria (Aliyu et al., 2003) and 22.0% CBPP sero-prevalence using c-ELISA in a combined transhumant and sedentary cattle management systems in Kajiado District, Kenya (Matua-Alumira et al., 2006). The continued high CBPP prevalence in Nigeria could be linked to irregular annual vaccination campaign and continuous contacts of infected cattle with susceptible ones (Aliyu et al., 2000). Also, Nwanta and Umoh (1992) and Windsor and Wood (1998) have reported that prevalence rates of CBPP tend to be higher in extensive cattle production systems. The observed impacts cannot be unconnected with many predisposing factors prevailing in the state, which include high concentrations of Fulani nomadic cattle herds, many stock routes for cattle on seasonal movements, and high close contacts of cattle at grazing and watering points especially at dry season (Alhaji, 2011).

There were significant associations of agro-zone ecosystems with the occurrence of CBPP in Fulani nomadic cattle populations in the state. High sero-prevalence of the disease in Northern and Sothern agro-ecological zones are due to the fact that the two zones have high concentrations of pastoral cattle, many stock routes that traverse through them for cattle on seasonal movements from far north of Nigeria to the southern parts, and high close contacts of cattle at grazing and watering points due to availability of pastures (MLFD, 2013), contagiousness of the disease and point exposures at watering and grazing points, which are more available in these two zones, especially during dry seasons (Alhaji, 2011). Further, Northern agro-ecological zone particularly has common international border with the Republic of Benin, which is porous to cattle movements. Ecological factors that have to do with availability of water and grazing pastures have been reported to attract high density of cattle from long distances to the areas for pastures and water especially during dry season, with resultant exacerbation of CBPP due to stress and close contacts (Amanfu, 2009). Similarly, Teshale et al. (2015) has reported a significant (P < 0.05) association of CBPP sero-prevalence with the agro-ecology in Southern Zone of Tigray Regions in Northern Ethiopia.

Although a majority (70%) of the pastoralists does not have formal education in the questionnaire-based study, they still pos-

Table 5
Socio-cultural activities practiced by Fulani nomadic pastoralists that influenced exposure of their cattle herds to risk of CBPP in Niger State, Nigeria, 2013.

Socio-cultural activity	Satisfactory practice N (Row%)	Poor practice N (Row%)	Odds ratio (OR)	95% CI	P-value
Husbandry management					
Extensive system	66 (81.5)	15 (18.5)	5.79	2.55, 13.13	0.001
Semi-extensive system	19 (43.2)	25 (56.8)			
Daily grazing distance					
Long distance	76 (76.8)	23 (23.2)	8.97	3.35, 24.00	0.001
Short distance	7 (26.9)	19 (73.1)			
Keeping healthy cattle with sick ones within herds					
Yes	66 (86.8)	10 (13.2)	4.17	1.56, 11.13	0.001
No	19 (61.3)	12 (38.7)			
Sharing a water source that caused concentration of cattle in one point					
Yes	91 (95.8)	4 (4.2)	53.08	14.91, 189.00	0.001
No	9 (30.0)	21 (70.0)			
Mixed grazing and watering of cattle with small ruminants					
Yes	38 (73.1)	14 (26.9)	2.32	1.05, 5.09	0.040
No	34 (46.6)	39 (53.4)			
Culture of borrowing and loaning of livestock					
Yes	94 (94.0)	6 (6.0)	19.94	6.36, 62.48	0.001
No	11 (44.0)	14 (56.0)			
Introduction of new cattle into the herd					
Yes	75 (90.4)	13 (9.6)	4.91	2.05, 11.76	0.001
No	20 (54.1)	17 (45.9)			
Grazing in an area of CBPP outbreak					
Yes	99 (94.3)	6 (5.7)	24.75	7.34, 83.52	0.001
No	8 (45.0)	12 (55.0)			
Giving out cattle as gift or payment for dowry					
YES	51 (82.3)	11 (17.7)	4.43	1.83, 10.72	0.001
NO	22 (41.5)	31 (58.5)			

Statistically significant at $P < 0.05$.

sessed significant satisfactory information and awareness about CBPP occurrence. However, possession of formal education creates opportunities for exchange of ideas and having up-to-date information on a disease pattern through seminars, workshops, and conferences. Formal education levels can. Therefore, contribute to increased perception of risks about CBPP. High proportions pastoralist without formal education was observed. These are consistent with the reports of Tambuwal et al. (2011) who observed low proportion (12.2%) of formal educational level and high proportion (88.9%) of CBPP awareness level of pastoralists in a study in Nigeria and attributed that to endemic nature of the disease in the country. Age and occupation also significantly influenced satisfactory possession of information about CBPP in herds. Fulani nomadic pastoralists in age groups 51–60 and 61–70 years are believed to possessed adequate information and awareness about CBPP through long time experience from close contact relationships with their cattle and through discussions and sanitizations from animal health authorities, unlike those in 31–40 age group who have relatively short relationship, and this vital in disease control. In a related study on the role of cattle in the transmission cycle of human African trypanosomiasis, gender and age were found to significantly influence the exposure to the disease (Alhaji and Kabir, 2015). The influence associated with age group and gender factors pertain to their socio-cultural activities and behavior.

Pastoralists' exiting veterinary knowledge on the epidemiology of the disease was significant, especially on clinical manifestations, post-mortem lesions, common sources of infection into herds, and common season of occurrence. High proportions of the nomadic pastoralists believed that CBPP occurrence in the state was more during the dry season due to increase socio-cultural activities. Nwanta and Umoh (1992) reported cases of CBPP to be more in dry season when CBPP infected cattle and susceptible ones converge at rivers and drinking pools. Contrary, Egwu et al. (1996) and Adamu and Aliyu (2006) reported the disease to occurs more in the rainy season due to high stocking and hurdling in groups because of increased crop farming with little spaces for grazing in the northern parts of Nigeria. Traditional knowledge and perceptions about CBPP epizootiology are required to safeguard against its occurrence in herds.

The study observed a number of socio-cultural practices that combined to explain occurrence of CBPP in nomadic pastoral cattle herds in the state. Herd composition of grazing cattle together with small ruminants, such as sheep and goats, was found to significantly influence CBPP occurrence in herds. Although the role of small ruminants in the epidemiology of CBPP remains unclear and despite the fact that *Mycoplasma mycoides* subsp. *mycoides* is specific for cattle, its isolates from small ruminants herd together with cattle have been reported (Tardy et al., 2011). The socio-cultural practices of giving cattle as dowries and gifts exacerbate the occurrence and distribution of CBPP in Africa (FAO, 2000).

This study observed special intervention challenges for CBPP in Nigeria, which are not only associated with biological and environmental factors but equally with important salient socio-cultural factors. The emergence and spread of microbial threats are driven by a complex set of these factors, the convergence of which can lead to consequences of disease much greater than any single factor might suggest (Fig. 1). At the center of the model is a circle representing the convergence of these factors leading to occurrence of CBPP in cattle population. The outer boxes are the factors in emergence, interlocking with one another and converging at the center circle. We believed that CBPP emergence in herds is influenced by the interlocking three domains of the determinants. Human socio-cultural and economic behavior is, perhaps, the most complex factor in the emergence of infectious diseases, especially animal diseases (Bell et al., 2010; Alhaji and Kabir, 2015). Emergence is especially complicated by socio-cultural activities, disruption of global ecosystems, and poverty, which ensure that infectious diseases occur (Smolinski et al., 2003). The principles of control and prevention of CBPP should then be geared towards attacking the sources, so as to interrupt the transmission cycle and protect susceptible cattle. Since disease prevention is the deliberate actions to halt its progression from one stage to the next, interventions in this model can be instituted along the interface links in the triad at nomadic pastoral level to control and prevent endemic CBPP in Africa.

The knowledge, perception and practice tool used was resourceful in outcomes. The measurement of knowledge, attitudes, perceptions, and practices of farmers in occurrence and control of a disease have been reported to be important for generating information that can be used in policy advice (Thomson, 2005).

Geographical bias in PE survey was reduced by making specific efforts to cover distant and difficult to access settlements. Season bias was reduced by conducting exercises across a whole year. Subject bias was minimized by giving no special attention to CBPP even in the introduction of objectives. Professional team bias was decreased through proper training of the appraisal team. 'Dominant-speaker' bias was reduced by allowing as many participants as possible to give their views on a certain issue, by also prompting rather silent participants during SSI. The relatively small sample size (125) of the herd owners in this study was a major limitation. This might have underestimated the effects of independent variables on the outcome variables. Also being a cross-sectional study, the survey does not show causal relationship but does demonstrated association of socio-cultural variables with CBPP occurrence in pastoral cattle herds in the state. Further, we were limited by lack of full adjustments for clustering in the designed random sampling. However, the used of central tendency measures, especially on sero-prevalence, would be valuable enough to tolerate the likely imperfections in the confidence intervals.

5. Conclusion

This study has shown that high proportions of Fulani nomadic pastoralists within the study area possessed satisfactory existing knowledge about CBPP and have perceived and identified it to be one of the most important cattle diseases in cattle herds of Nigeria. Its high impact was partly due to absence of effective approach to surveillance as well as prevention and control strategies in the marginalized rural areas. This study highlighted the critical gap that exists in terms of significant influence of socio-cultural factors that predisposed pastoral herds to occurrence of CBPP in Nigeria. The surveillance system and control programs for the disease that take these factors into consideration will be beneficial to the pastoralists. Further knowledge of interactions of pastoralists' socio-cultural factors under the platform of the postulated "Conceptual Concentric Model" is required. To achieve adequate protections for their animals from menace of CBPP and cattle diseases, there would be a need to sensitize Fulani nomadic pastoralists to bring modified changes to their socio-cultural practices. The combined use of Participatory Epidemiology techniques and conventional veterinary methods is essential for ultimate disease surveillance, reporting and control strategies of livestock diseases in Nigeria and therefore recommended.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.prevetmed.2016.04.004.

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