

Abstract of Thesis/Dissertation

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Title: Economics-Epidemiology integrated approach for bovine brucellosis control and eradication in Sri Lanka

(スリランカにおける牛のブルセラ病コントロールおよび撲滅に関する経済疫学的統合研究)

Abstract

Brucellosis is considered as one of the most economically important zoonosis in the world. It is termed as a neglected zoonosis; the term “neglected” highlights that it affects mainly poor and marginalized populations. It is an infectious disease and causes reproductive related disease problems, mainly abortions in cattle. It causes flue like symptoms in human. Economic impacts due to brucellosis in animals and human populations in low income countries are large. Brucellosis is endemic in Sri Lanka for forty years specially in the rural areas of the dry zone. Lack of comprehensive surveillance, high vaccination coverage and infective culling policy, brucellosis is persistent in the country for decades. Also, it seems that socio-cultural set up favor the persistent of infective cattle in all over the country. Because, farmers depend on animals economically, socially and culturally in rural areas. Buddhists and Hindus totaled up to 90% of the total population and shows prohibition for cattle slaughter. Therefore, it seems that farmers tend to sell infected animals to another farmer to refrain from slaughtering; therefore infected animals are likely to be moved between

farms and across areas. Even if animal health regulation prevents movement of infected animals (Animals Act No.29 of 1958), illegal transportation is possible due to various socio-cultural settings and, knowledge and information gaps. Therefore, it was assumed that long establishment of brucellosis in Sri Lanka is significantly backed by socio-economics and farmers' behavior, besides a sound technical plan.

Literature review says animal disease management and control is a social problem. Because cattle farming practices are related to farmers' socio-economic factors and, also exposure of livestock to infections is potentially influenced by farmer's social factors viz. ethnicity and culture. Knowledge gaps and uncertainties together with asymmetric access to relevant information by farmers, government, and consumers are challenges in optimal disease control policy implications. Hence, understanding of farmers' behavior is crucial in prevention and control of animal diseases, since they are typically the first to respond to diseases. Brucellosis was extensively studied in the light of different disciplines such as microbiology, epidemiology, surveillance techniques, integration of human-animal-wild life interface, transmission modelling, vaccine development, economic impact so on. Yet, literature on farmers' socio-economic behavior on brucellosis spread and disease control is extremely limited. It was highlighted that diseases control strategies could integrate disease epidemiology with farmers' socio-cultural behavior for success; the inter-disciplinary approach is still not well studied in practice. The overall objective of this dissertation was to analyze farmers' behavior related to brucellosis bio-security decisions to provide inputs for integrated brucellosis control strategy in Sri Lanka.

The specific objectives were 1) Study about brucellosis epidemiology and its association to farmers' socio-economic factors, 2) Study the gaps on knowledge, attitudes and practices of brucellosis, and factors affecting knowledge sharing on animal diseases, 3) Study the farmers' behavior towards milk incentive based cattle culling policy to eradicate brucellosis in Sri Lanka, and 4) Study the economic feasibility and efficiency of control approach.

Ampara district of the dry zone was selected as the study area, since it showed high brucellosis prevalence and, it is multi-ethnic, multi-cultural area. A cross sectional survey was carried out in cattle farms (n=155) in three veterinary surgeon's (VS)

divisions namely Kalmunai, Navithanveli and Mahaoya of Ampara district with respect to Muslim, Tamil and Sinhala ethnicities which are the three main ethnicities in the country. A total of 1153 blood samples from all three VS divisions were collected to study the disease prevalence. And also, it was collected socio-economic characters of the farmer, farming practices and knowledge about brucellosis using structured questionnaire to study first two objectives in year 2016. In the year 2017, contingent valuation survey was carried out to study feasibility of using economic incentives linked to milk payment system to motivate farmers to cull *Brucella* infected animals. Apart from the Ampara district in the dry Zone it was selected Kandy district in Central province of Sri Lanka for comparison sake in this study.

In the first analytical chapter, association of brucellosis epidemiology with farmers' socio-economic factors was studied. Data on blood samples were analyzed using epidemiological methodologies. The relationships of cattle brucellosis (positive/negative) to social characteristics were analyzed using probit model. Results revealed that farming behavior such as free grazing ($p < 0.01$), and animals brought in to the farm from outside were significantly ($p < 0.05$) related to disease prevalence. It was found that poverty, and ethnicity are significant determinants ($p < 0.05$) of brucellosis.

The second analytical chapter was on Knowledge, Attitudes, and Practices (KAP) on brucellosis. KAP was studied using descriptive statistics. Knowledge index was computed using knowledge related questions on brucellosis and foot and mouth disease, and those were compared using t test. Also, farmers' knowledge (knowledge index) on brucellosis in relation to the socio-economic factors were studied using tobit model. Results revealed that farmers' knowledge, attitudes and practices related to brucellosis was extremely poor. Only 8.5% of farmers knew that brucellosis causes cattle abortions. Only 10% of the farmers knew that brucellosis could be spread from one animal to another. Around 96% of the farmers did not know that it is zoonotic. Nearly 80% farmers had neutral attitude about concerning veterinary certificate when buy an animal from outside. Practices related to within-herd transmission such as separation of diseased animals and animals that had abortions from healthy animals were 47.9% and 20.6%, respectively.

In the third chapter, Contingent Valuation Method (CVM) was used to elicit farmers willingness to accept (WTA) of *Brucella* infected cattle culling policy. A hypothetical scenario of milk testing for brucellosis through milk collecting network with milk penalty-premium payments was proposed in the CVM. Farmers were given a choice to accept voluntary slaughter of infective with compensation if there is any. Also, milk penalty price of Rs.2/litre was introduced if farmer does not accept voluntary slaughter. This government policy of economic incentives to change the farmer's behavior in controlling brucellosis was analyzed using principal-agent (PA) theory. Because of the new intervention with milk testing, information about diseased animals becomes frequently available; thus information asymmetry becomes less. Therefore, nearly 90% of the farmers showed willingness to accept the culling policy. Also, voluntary culling of infected cattle with 68.8 % of market value of cow is accepted by the farmer when the compensation amount is equal/more to farmers' expected utility of keeping an infected animal. Based on above information it was revealed that proposed new intervention of brucellosis control in Sri Lanka is capable of reducing information asymmetry and changing farmers' socio-economic behavior.

In the final analytical chapter, several alternative brucellosis control strategies for the dry zone were set using results of above three analyses. Epidemiology-economic simulation model integrating farmers' behavior was developed to analyze epidemiology, costs and benefits for each strategy to surface the best for Sri Lanka. It was uncovered that investment on brucellosis control as a phased out program with single mass vaccination at first phase and combining annual culling of 50% infective after 20 years as second phase gains high returns (>30%) and high B/C (> 22). If control program can go together with farmer trainings and knowledge improvement strategies it would enhance benefits; thus B/C ratio will be further increased.

It was concluded that brucellosis control and eradication is an epidemiologically feasible, economically viable and profitable investment when farmer's social behavior is well considered. Also, factor "farmer" or 'farmer's behavior' in animal disease transmission and its control decisions is crucial and has to be well thought in animal disease control policy planning.