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Spatial and temporal risk as drivers for adoption of foot and mouth disease vaccination

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ABSTRACT

Identifying the drivers of vaccine adoption decisions under varying levels of perceived disease risk and benefit provides insight into what can limit or enhance vaccination uptake. To address the relationship of perceived benefit relative to temporal and spatial risk, we surveyed 432 pastoralist households in northern Tanzania on vaccination for foot-and-mouth disease (FMD). Unlike human health vaccination decisions where beliefs regarding adverse, personal health effects factor heavily into perceived risk, decisions for animal vaccination focus disproportionately on dynamic risks to animal productivity. We extended a commonly used stated preference survey methodology, willingness to pay, to elicit responses for a routine vaccination strategy applied biannually and an emergency strategy applied in reaction to spatially variable, hypothetical outbreaks. Our results show that households place a higher value on vaccination as perceived risk and household capacity to cope with resource constraints increase, but that the episodic and unpredictable spatial and temporal spread of FMD contributes to increased levels of uncertainty regarding the benefit of vaccination. In addition, concerns regarding the performance of the vaccine underlie decisions for both routine and emergency vaccination, indicating a need for within community messaging and documentation of the household and population level benefits of FMD vaccination.

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1. Introduction

Uncertainty surrounding health decisions stems from unknown gains in personal wellbeing relative to the perceived costs of undertaking the intervention. This is specifically applicable to vaccination decisions. For example, the decision to be vaccinated against seasonal influenza weighs perception of individual risk of disease against the direct costs of the vaccination, the indirect costs of the time necessary to be vaccinated (lost opportunity), and any concerns about adverse vaccination effects [1]. The implications of individual vaccination in contributing to population immunity further complicates the decision. Importantly, perceptions of disease risk are dynamic and may markedly increase as disease outbreaks are reported closer to the individual [2–4]. However, by this time much of the potential for inducing population

immunity is lost, and vaccination benefits may only extend to the recipient.

Understanding the drivers of vaccination decisions and how these are influenced by proximity of perceived risk is a significant gap in vaccine knowledge relevant to increasing vaccination and decreasing the burden of infectious disease. We chose to address this knowledge gap by estimating pastoralist adoption of a livestock vaccination against foot-and-mouth disease (FMD). Similar to seasonal influenza, FMD is episodic and not precisely predictable in either spatial or temporal spread or in its severity [5], thus creating uncertainty of disease risk. Furthermore, there are multiple FMD virus serotypes with each serotype characterized by evolving strains. FMD vaccines vary in their effectiveness depending on the “match” between the vaccine and the circulating serotype and strain [6,7], require repeated immunization to achieve optimal protection, and are similar to seasonal influenza vaccines in having effects at both the individual and population levels [8–10]. Unlike human vaccination or vaccination for zoonotic livestock diseases that have human health implications, the decision to vaccinate for FMD solely fixates on livestock health, and thus focuses our

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analysis on externally influenced, dynamic risk perceptions [11]. Importantly, in households that are characterized by high dependence on livestock, vaccination decisions have broad impacts on household income and wealth, food security, and expenditures on human health and education [12]. For FMD specifically, reductions in milk production, lost animal draught power, and closure of livestock markets threaten household income and nutritional security [13].

We surveyed 432 pastoralist households in northern Tanzania to identify determinants of FMD vaccination decisions relative to temporal and spatial risk based on two immunization strategies. We extended a commonly accepted survey method for inferring preferences, willingness to pay (WTP), to elicit decision responses for two hypothetical vaccination scenarios. The first is “routine” vaccination in which households would vaccinate cattle biannually, a proactive and planned approach that would support immunity at population scale. The second is “emergency” vaccination in which households would vaccinate in the face of a current nearby outbreak, a situation that presents heightened, individualized risk introduced by spatial proximity and temporal immediacy. In each scenario, the stated efficacy of the vaccine was also varied to reflect the uncertainty of the vaccine matching process and to assess sensitivity to improvements in vaccine risk reduction. Herein we present the results of the study and discuss the findings in the context of identifying approaches to influence household vaccine uptake and subsequent improved disease control.

2. Materials and methods

2.1. Household survey and data

The survey questionnaire that was used for data collection targeted key decision makers in cattle owning households to identify behavioral responses and to increase accuracy and precision of

those responses. The cross-sectional survey was conducted in April through July 2016 in the Serengeti and Ngorongoro districts of northern Tanzania (Fig. 1) and contained questions designed to capture household characteristics hypothesized to influence vaccination WTP, including household demographics, livestock management practices, and knowledge of and history with FMD. Within the two districts, a two-stage sampling procedure randomly selected first clusters, then households with the Serengeti district more intensively sampled for analysis purposes (Supplementary material) [14]. Design and piloting of the survey instrument followed standard statistical practices [14]. Informed consent was obtained after the nature and possible consequences of the study had been explained by local enumerators who were trained and monitored throughout the collection process.

Households in both study districts engage in livestock and agricultural activities for subsistence and income, with some additionally earning income from off-farm activities (Table 1). Households practice open grazing and own 20 cows compared to the national average of 4 cows [15], in addition to owning sheep, goats, and poultry. Consistent with previous estimates of FMD occurrence in these areas, 69% of the households reported infection within the past year [16] and expected reductions in milk production during outbreaks. All households recognized the clinical signs of FMD, but of the 19% who had vaccinated for any livestock disease in the past year, none reported vaccinating for FMD. This reflects the situation of FMD in East Africa as characterized by poor surveillance systems and limited availability of FMD vaccines (Supplementary material).

2.2. Double bounded dichotomous choice contingent valuation

The absence of FMD vaccines in Tanzania during the time of the study led to the use of the stated preference methodology to infer the value households place on vaccination. We used the double

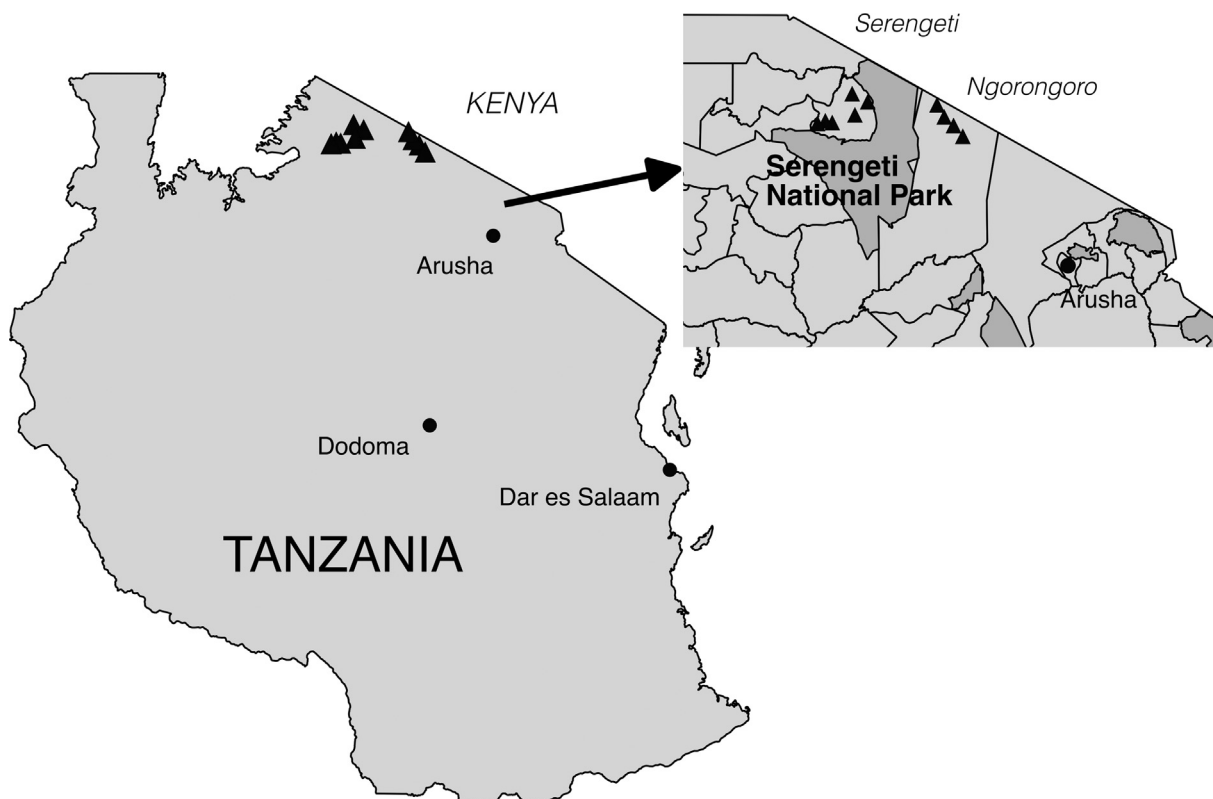


Fig. 1. Location of the 10 study sites (triangles) within the Serengeti and Ngorongoro districts in relation to major Tanzanian cities (circles) and parks (dark grey).

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