**Efficient mass rabies vaccination campaigns in rural Mpumalanga, South Africa: management and costs**

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**Abstract**

Rabies is a fatal viral disease that is maintained in various mammal hosts across the globe. Dogs remain the most worrisome host of rabies, since spillover from dogs to humans is a common occurrence resulting in an estimated death rate of 60 000 people per year. Mass dog vaccination programs remain the most cost effective way to limit the impact of rabies. This study investigates the associated costs of running mass rabies vaccination campaigns and examines the cost benefits of different equipment and recording techniques. Results…results…results.

**Literature**

Dog and human populations are highly connected the world over. This association is mutually beneficial for both species and social contact between humans and dogs is frequent and intense (Coppinger and Coppinger, 2001). Rabies is transmitted through contact with infected saliva, mostly via bites (World Health Organization, 2013). Yet, all exposures to virus don’t lead to disease but when disease occurs, the case fatality rate approaches 100% (Swanepoel, 2004). Despite the great burden of dog rabies, it is completely preventable through vaccination (Davlin and Vonville, 2012; World Health Organization, 2013). Mass vaccination campaigns of dogs not only prevent disease in the individuals but are able to eliminate rabies from dog populations (Coleman and Dye, 1996; Lapiz et al., 2012; Vigilato et al., 2013; World Health Organization, 2013). The probability of success of a campaign depends on the coverage achieved which is a function of the intensity of the campaign. Literature frequently suggests that campaigns achieving 70% coverage should give reasonable assurance of local elimination (Coleman and Dye, 1996; Knobel et al., 2013; World Health Organization, 2013).

Practical considerations of campaign planning has received considerable research attention (Kaare et al., 2009; Knobel et al., 2013) Many single campaigns have evaluated for the efficiency to deliver vaccine and efficacy to decrease incidence (Cleaveland et al., 2003; Muthiani et al., 2015; van Sittert et al., 2010). Nonetheless, little effort has been devoted how to increase the number of dogs vaccinated per unit of effort. Instead, mentioned approaches on how to increase the coverage al imply increased effort. Examples include increasing the magnitude of the campaign, improving public sensitization and increasing resources through a multi-sectoral approach and gaining more political support (Belotto, 1988; Davlin and Vonville, 2012; Tenzin and Ward, 2012). Large campaigns can be logistically challenging and can therefore benefit from being optimized in terms of efficiency, measured as the number of vaccination per unit of effort.

Cost!!

**Methodology**

The study region is tribally owned, rural villages from three municipalities in the Ehlanzeni district of Mpumalanga, South Africa. Dogs are typically owned, but free roaming and rabies is highly endemic, reporting 51 animal-cases in 2014 (Conan et al., 2015; Rabies Advisory Group, 2015). Firstly, the relationship between effort and the number of dogs contacted was examined. The process we followed here is analogous to catch-per-unit-effort (CPUE) standardization routines that are common in the fisheries and wildlife management literatures (Maunder and Punt, 2004). The basic process takes data from a series cross-section of separate efforts and models success as a function of various covariates. The data is then standardized by taking the estimated model and fitting it for some baseline value of the covariates. In our case, data was collected during mass vaccination campaigns. The dataset contained 196 data entries taken from 37 different villages in the Bushbuckridge and Mbombela municipalities. Observations were taken on 32 different dates during 2015.

The dependent variable is the number of dogs vaccinated by a particular team at some village on some day. The regressorsare the set of explanatory variables hypothesized to affect the number of dogs vaccinated. Our dependent variable is a discrete count. Two regression models for counts are common: Poisson and negative binomial. Both models have been applied extensively in the context CPUE standardization (Maunder and Punt 2004). The variance of was tested for overdispersion using the test described by Cameron and Trivedi (1990). We strongly rejected the null hypothesis of equidispersion under both common specifications of the Cameron and Trivedi test and therefore proceeded to the negative binomial regression model. The model was estimated with the glm.nb function of the MASS package in R.

Secondly, the monetary costs of vaccinations were calculated from a second dataset that contained details on kilometers travelled. The dataset contained 24 observations from 6 villages in the Nkomazi municipality. The cost per kilometer driven was taken as the government reimbursement rate for privately owned, light delivery vehicles with a 2.0l petrol engine (a typical campaign vehicle). This rate includes fuel costs, vehicle maintenance and depreciation. At the time of the campaigns this rate fluctuated around R3.90c/km. A travel cost was calculated by multiplying the cost per kilometer driven by the kilometers spent per dog.

Labour costs were calculated by taking the average hourly salary of an Animal Health Technician and a non qualified assistant (R85.50/hour). Labour cost per dog was calculated as (hourly labour cost)\*(members per team)/(dogs vaccinated per hour per team).

Consumables per dog vaccinated included a vaccine dose, a needle and a 50th of a syringe (R1.80; R0.60; R0.03).

The costs per dog vaccinated was calculated as the sum of consumable, labour and transport costs.

A household survey was used to determine the human to dog ratio (to estimate the total dog population.)

Cost of volunteer organizations??? Total itemized budget for NGO. Subtracting equipment , needles, syringes etc we can show what the labour-cost is for NGO’s.

**Results**

Results from the regression model largely reflect a priori expectations. Loudhailers raised the rate of vaccination by 14% (IRR=1.14; CI=1.00-1.31; P=0.047). Handling equipment could not be shown to significantly affect the rate of vaccination. Using only a list to record vaccinations was borderline significant, yet the magnitude of this effect was very large (IRR=1.29; CI=0.98-1.68; P=0.058). Adding a fourth person to a team significantly improved their performance (IRR=1.25; CI=1.08-1.45; P=0.003) whereas adding a fifth person did not (IRR=1.03; CI=0.93-1.14; P=0.605). Adding more vaccination teams slightly reduced the efficacy of each team (IRR=0.94; CI=0.92-0.97; P<0.001). As can be expected, adding more working hours (IRR=1.37; CI=1.32-1.42; P<0.001) greatly improved vaccination rates.

From the second dataset the costs of vaccination was calculated. Travelling within a village from door to door by car, 0.32km was travelled per dog vaccinated (95% CI=0.25-0.39). When including the distances teams travelled to get to and from the campaign, the average distance traveled per dog was 0.75km (95% CI=0.55-0.97). The reason for the wider confidence intervals in the latter measure is that during mass campaigns some vehicles are brought in from neighbouring areas to assist with the campaign. This parameter will be lower with longer working hours (that minimize the proportion of the kilometers that are driven to and from campaigns) or higher with more vaccination teams (that require more visiting officials from further away). Hours spent vaccinating per day had a mean of 5h29 (95% CI 5h12 – 5h46) and the number of teams per day was commonly 5. The mean time spent on campaign to vaccinate one dog was 4.6 minutes (95% CI 3.7-5.5). The labour cost per dog was R21.38. The total cost per dog vaccinated was R26.77.

**Discussion**

The rate of vaccinations is strongly influenced by factors such as team composition, team size, available equipment and recording methods. These ultimately determine achieved annual coverage if available labour-time resources are held constant. We recommend that each team should have a loudhailer, consists of 4 people and make use of minimum recording methods as permitted by legal or bureaucratic limitations. These three interventions could potentially increase the achieved vaccination rates by 50%.

The effect of different campaign coordinators could not be modeled with this dataset. It has to be stated though, that the effect of the coordinator is perceived to be critical. The coordinator should ensure that each team is logistically equipped and that no team is ever idle waiting for instructions. It is therefore imperative that the coordinator be present in the field where hiccups can be swiftly solved. Coordinators can quickly become swamped with tasks if too many teams are present. The number of teams are recommended not to exceed 7.

Labour costs accounted for 79.9% of total cost. In areas where government employees already exist, the marginal cost of implementing mass rabies vaccination campaigns can therefore be very low. Another major cost of campaigns is transport. Surprisingly, driving to and from campaigns spent used more kilometers than driving whilst on campaign.

Where local government employees are not enough to make up team members, one of several NGO’s can be used to provide volunteers. Compare labour cost from NGO’s with local government employees. Advantage of employees is continuity and surveillance after the campaign. (Ref that shows how surveillance improves after campaigns. Townsend.)