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Baseline study for the integration of novel treatments, vaccines and diagnostics into Animal African Trypanosomosis control programmes

Zambia Field Study Report

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Foreword

Animal African trypanosomosis (AAT) is an important constraint of livestock production and threat to food security in sub-Saharan Africa [1]. Of the 37 sub-Saharan African countries affected by trypanosomosis, 21 are among the world's 25 poorest [2]. Reduced productivity of cattle due to trypanosome infection has been estimated at approximately 10-20% across a range of parameters including mortality, calving rate, meat production, milk production and draft power. It also reduces the area which could potentially be used for livestock production, as cattle density is very low in areas with a high tsetse-trypanosome burden. In these areas farmers are often more reliant on crop farming however trypanosomosis reduces the availability of draught animals to plough fields and manure for fertiliser.

This is one of five country specific sub-Saharan African studies (conducted in Zambia, Ethiopia, Uganda, Burkina Faso and Cameroon) aimed at generating baseline information that could inform the integration of novel treatments, diagnostics and vaccines (should they become available) into control programs for AAT. A previous systematic review of recent and on-going Trypanosome & Tsetse control programs has been the basis for the geographic focus of the five studies [3].

This report summarizes the results of the study which was carried out in Zambia (Eastern Province). Trypanosomosis is considered endemic in the Eastern Province of Zambia and there have been reports of human 'sleeping sickness'. There is also some evidence that resistance to existing trypanocides is developing [4]. Two districts, Lundazi and Mambwe were divided into three study areas; semi-valley (Lundazi District), plateau (Lundazi District) and valley (Mambwe District) on the basis of environment (including ecoregion).

The study results will inform the refinement of existing decision support tools to aid evidence-based decisions on the use of novel drugs, diagnostics and vaccines as part of integrated Trypanosome & Tsetse control programs.

Acknowledgements

We wish to thank the team at the University of Zambia (UNZA) who helped coordinate the field activities, particularly Dr. Sulani Nyimbili. We would like to thank Dr. Martin Simunza, also from UNZA, for supporting the project. We would also like to thank Dr. Kelvin Kampamba and Dr David Mweemba, the District Veterinary Officers for Lundazi and Mambwe regions for their corporation and support and the various Veterinary assistants who were involved in the fieldwork.

Study Aims and Methodology

1. Introduction

1.1 Aim of the study and approach

The aim of the study was to assess the current perceived impact of AAT in the selected study areas and the scope for improving AAT control by introducing or integrating new control measures into future or existing AAT control programs or activities.

The relative extent to which AAT constrains livestock production in the study areas was ascertained by comparing farmers' perceptions of AAT frequency and economic impact (mortality, loss of production and cost of treatment) with their perception regarding general livestock diseases in their herds. Successful control of AAT is dependent on farmers' motivation to control the disease individually, and to cooperate with externally-led control programs. The scope for improving AAT control in the study areas was assessed and the demand for, and likely uptake of, new treatments, diagnostics and preventative measures was inferred from data regarding existing control and consumer willingness to use and pay for new trypanocides, diagnostic tests and vaccines.

1.2 Background

Trypanosomosis is considered endemic in the Eastern Province of Zambia and was identified as a moderate risk area for AAT from a systematic review conducted prior to the fieldwork . The Luangwa valley runs through the Eastern province, which has 3.84 million ha of national park (46.9%) and 0.41 million ha dedicated game management area. The valley slopes are composed of Mopane woodlands, whilst the banks of the valley consist of thick Miombo forest. The study was conducted in two districts in

this province (Figure 1); one covering the valley slopes and plateau (Lundazi) and the other in the banks of the valley (Mambwe). The Luangwa valley lies in the "common tsetse belt" which is an ecological niche for trypanosomes allowing vector-host interaction; due to favourable conditions for tsetse in terms of vegetation, climate and abundance of wildlife hosts [5-7]. In the last 30 years the government turned areas surrounding the national park into game management areas and there has been an expansion of the human population into the valley fringes expanding the human-wildlife interface which has increased the risk of trypanosomosis in both animals and humans [5, 8].

Previous studies have estimated the prevalence of trypanosome infections in cattle in districts in the plateau at around 13.5% and Trypanosoma vivax, T. congolense and T. brucei are all present [9]. Prevalence of AAT in the valley is likely to be even higher as it is a more favourable area for tsetse. There have also been reports of human 'sleeping sickness' in the Eastern Province [10]. A study conducted between 1995 and 1997 found evidence of trypanocide resistance in the Eastern province [4]. Approximately a third of trypanosomes stabilates were resistant to isometamidium chloride and 11.3% were resistant to diminazene aceturate. Although this resistance did not appear to be widespread and only 1.4% of stabilates were resistant to both drugs, the study was conducted over 10 years ago and this may not reflect the current situation [4].

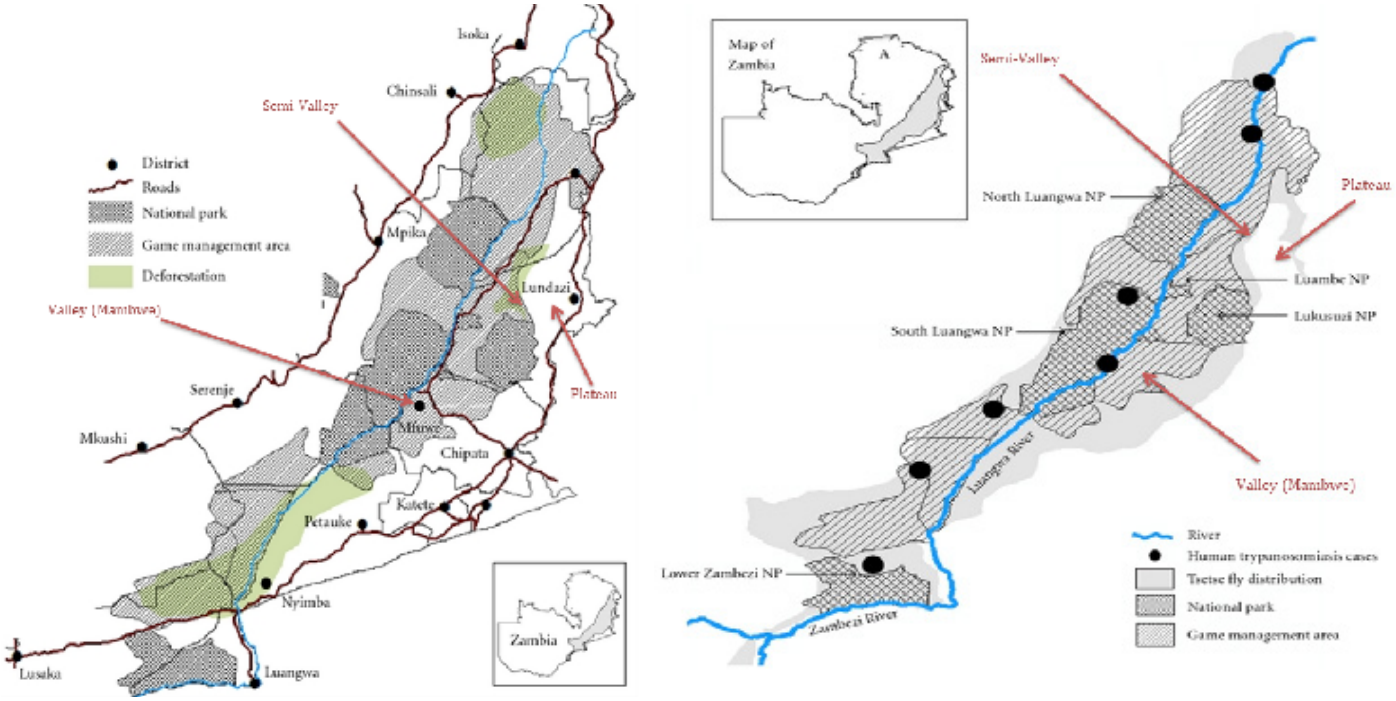

Figure 1: Maps of the study areas from Munang'andu et al. (2012) showing tsetse distribution, National Parks and Game Management Areas. Black dots on the left map show district capitals and on the right map show areas of clinical human trypanosomosis cases. The study was conducted in Lundazi and Mambwe (labelled Mfuwe) districts [5].

Study Aims and Methodology

2. Methods for data collection

2.1 Sampling of the study areas and households

The study was conducted in June 2013 in two districts; Lundazi (plateau and semi-valley) and Mambwe (valley). Lundazi contains approximately 25,680 households and has a population of roughly 315,000, with a human population density of 22.4 people/km2 [11]. Mambwe is a smaller district which has a population of approximately 75,000 with 14,620 households and has a population density of approximately 13.4 people/km2. These districts were sampled because there were reports of AAT, and cooperation with District Veterinarians.

Within the district a list of village names were obtained for each study area and these villages were selected for incorporation in the study using random sampling. In the Lundazi area, there was no list of villages available so surveys had to be carried out

[1] The study was selected because it was estimated to be a moderate risk area for AAT from a systematic review of AAT literature [3].

beforehand to obtain village names. The village chief of each village was then contacted in order to gain permission to work in the village.

The sampling unit was a household (or homestead), defined as a group of people who normally cooked, ate and lived together. As the human and cattle density in the valley and semi-valley area and road networks were poor rendering accessibility difficult in many areas our target sample size was 50 households in each of these areas. Our target sample size for the plateau area was 100 households (See section 1.2 for sampling results). In each village households were selected using systematic sampling; a central point and random direction was chosen and sampling interval was calculated by dividing estimated number of households by the target sample size (N=10). If the household selected did not own cattle the next closest household owning cattle was studied instead.

2.2 Data collection

The head of the household was contacted and asked if they would be willing to take part in a study which aimed to collect data on cattle production and livestock disease in the area. If the head of the household was unavailable then another household would be sampled and the house was re-visited once the member had returned. There were no refusals to participate in the study. The study was conducted by trained enumerators who were usually veterinary assistants using a structured questionnaire. Veterinary assistants are veterinary para-professionals employed by the government, usually full time, and trained to carry out diagnostic, preventive, curative and advisory tasks in livestock, and are under the supervision of veterinarians. Once sampling of the village was completed the enumerators would provide verbal information, including public health risks regarding AAT and information on other livestock diseases relevant to the community. They would also answer questions the farmers had regarding livestock production and disease. This was particularly important in the semi-valley area in Lundazi where many livestock owners had reduced access to veterinary healthcare (See section Results Section 2).

Image 1: Enumerators conducting interviews, Zambia June 2013 in Semi-valley (left) and plateau (right) area in the Lundazi district.

Study Results

3. Zambian Profile

3.1 Description of the study areas and summary of the results

Many households in the Eastern Province rely on crop farming as a major source of income, and there is a lot of cotton production. Therefore the majority of cattle are used for draught power with approximately 23% of households owning cattle [3]. There have been reports of droughts in the Eastern Province in recent years. The study area contains two major ecoregions; both of which are found in the Tropical and sub-tropical grasslands, savannah and shrublands ecosystem. The Southern Miombo woodland ecoregion contains trees and shrublands in the valley slopes; however, these have been cleared for farming in much of the plateau. Therefore this ecoregion in Lundazi was sub-divided into semi-valley and plateau. Mopane woodland generally occurs in hotter areas and replaces Miombo woodland on the valley floor, this ecoregion was found in Mambwe district. All three study areas are summarised below.

Image 2: Cotton plantations of Lundazi District, Zambia June 2013.

Image 3: Landscape of the Semi-Valley study area in Lundazi, Zambia June 2013.

Semi-Valley (Southern Miombo woodland: Lundazi)

An increase in pressure on natural resources in the plateau area of the district has led to the relocation and expansion of the human population into the edges of the Luangwa valley. As this shift has only occurred in recent years, the human population density is lower than the plateau area. As access to markets are poor and farmers co-exist with an expanding wildlife and tsetse population; there is little livestock production in the area. Those households that do keep cattle tend to be used almost solely for draught power. Many farmers rely on crop production and cotton is grown as the predominant cash crop in the area. The Lundazi region is prone to both extremes of droughts and floods.

Image 4: Landscape of the plateau study area in Lundazi, Zambia June 2013.

Plateau (Sandveld plateau/Southern Miombo woodland: Lundazi)

As this area is further away from game management areas and is higher altitude there are less tsetse and more favourable conditions for livestock production. These households have better access to facilities compared to the semi-valley healthcare and

veterinary services. The plateau contains many smallholder farmers with maize and sorghum produced as the staple food crop. Contract cotton is the most important cash crop followed by cassava. In contract systems private companies provide farmers with credit, inputs and technical assistance; at harvest they purchase the commodity at an agreed price, thereby providing access to markets, costs are then recovered when the produce is sold [12]. Cowpeas, beans, sweet potatoes, pumpkins, groundnuts and sunflower are also produced in relatively small quantities, primarily for home/local consumption. Small-scale farming is prominent in most of the area and more than 21% of the Miombo woodland has been cleared for crop farming [5], therefore livestock are less likely to interact with tsetse habitats in comparison to cattle in the other two study areas.

Image 5: Landscape of the valley study area in Mambwe, Zambia June 2013.

Valley (Mopane woodland: Mambwe)

Tourism is the major source of income in the area due to the close proximity to the South Luangwa National Park. In addition to being officially employed game scouts, some people living in the area supplement income by poaching (trapping or hunting). Many livelihoods in this area are reliant on maize production at subsistence level; again cattle are predominantly used for draught power and cotton production is done through contract farming.

Results summary

An overall summary of the findings from each study area are presented in the table on the following page. The report then goes into a comprehensive detail of the results in the sections that follows.

The semi-valley (Lundazi district) was considered the highest priority for AAT control of the study areas; in this study area the risk of AAT was high, knowledge appeared to be low and there were no existing control programs in place in the villages visited. Any AAT prophylactic measures in place (insecticide treating cattle and prophylactic treatment using isometamidium) were carried out by individuals acting independently, or occasionally as part of a community. Even though the impact in this area was perceived to be low to moderate the knowledge of the disease was lower than in other areas so the impact may have been underestimated. Only 33.9% of those interviewed knew AAT was spread by vectors compared to 55.6% in the plateau area (Lundazi) and 85.0% in the valley area (Mambwe) and only 26.8% were able to list AAT control measures.

The valley area (Mambwe) appears to have a high risk of disease but did have some existing control programs in place and knowledge of the disease was better. In addition, cattle are not of high economic importance in the area; few households kept cattle (apart from those studied). The main source of income is tourism, crop production etc. therefore, this was considered less of a priority for control. However, one of the main restrictions of livestock production in the area is the tsetse/trypanosome burden; which also reduces draught power available for crop production. Therefore, perceived AAT impact would be higher if potential production which could be achieved in the absence of AAT was considered. The plateau area was not a suitable habitat for tsetse populations; therefore this area was considered low priority.

Ecological System and District

	Semi-valley Southern Miombo woodland (Lundazi)	Plateau Southern Miombo woodland (Lundazi)	Valley Mopane woodland (Mambwe)
General livestock keeping data			
Primary source of income	Mixed farming (68%)	Crop farming (63%)	Crop farming (90%)
Median no. of cattle (lower & upper quartile: Q1 & Q2)	6 (3 & 12)	7 (4 & 12)	5 (2 & 10)
Predominant cattle breed	Angoni (Trypanosensitive)	Angoni (Trypanosensitive)	Angoni (Trypanosensitive)
Predominant cattle rearing system	Free-grazing	Free-grazing	Free-grazing
Other species livestock	Goats (56%), Poultry (96%)	Goats (55%), Poultry (92%)	Goats (74%), Pigs (60%), Poultry (92%)
Impact of AAT			
Perceived AAT occurrence in herd/ disease ranking	Frequent (71%) Ranked no. 1	Very rare (Never: 91%) Ranked no. 4	Constant (56%) Ranked no. 2
Perceived AAT impact on income	Low/moderate	Low	Low/moderate
Main losses in livestock outputs due to AAT	Draught power	Draught power & milk production	Draught power & milk production
AAT treatment failure/perceived reason for failure	Moderate (33%)	Low (7%)	Low/moderate (21%)
Current AAT control			
Treatment of AAT	Diminazene aceturate > isometamidium farmers > vet assistant (or similar)	Diminazene aceturate > isometamidium vet assistant (or similar) > farmers	Diminazene aceturate > isometamidium farmers > vet assistant (or similar)
Cost per AAT treatment	US $1.45 ($1.13 to $2.81)	US $1.88 ($1.41 to $1.88)	US $1.54 ($0.94 to $2.81)
Level of knowledge about AAT prophylactic measures	Low (26.8%)	Low/moderate (35.4%)	Moderate (48.2%)
Point of sale of veterinary products	general shop > vet > vet pharmacy nearby town > other village	vet pharmacy > general shop > vet nearby town > other village	travelling salesman > shop > vet pharmacy nearby town > village > local market
Control programmes for AAT/facilitators	19.6% / individuals > communities	27.3% / individuals	63% / officials, individuals > communities
Future AAT control			
Awareness of AAT & knowledge of epidemiology	Aware: 81.8%: Lower knowledge	Aware: 81.8%: Moderate knowledge	Aware: 74.1%: Good knowledge
Willingness to use/pay higher price for new AAT drugs	89.5%/86%	97.1%/90.9%	77.8%/77.8%
Willingness to use/pay for new AAT diagnostic	94.7%/84.2% - median: $1.88	97%/95% - median: $1.88	79.6%/64.8% - median: $1.88
Willingness to use/pay for novel AAT vaccine	98.3%/94.7% - median: $1.88	97%/96% - median: $1.88	81.5%/59.3% - median: $1.88
Problems with AAT treatments	Consumables, preparing drugs	Consumables, preparing drugs, dosing, weight estimation	Consumables, dosing
Perception of fake AAT drug circulation	Low: some anecdotal evidence	Low: some anecdotal evidence	Low
PRIORITY AREA FOR AAT CONTROL (based on farmers' perceptions)	**Moderate-high priority (high risk/no exisiting control/poor knowledge)**	**Low priority (low risk/low perceived impact)**	**Low-moderate priority (high risk/low perceived impact/ good knowledge/exising control)**

3.2 Study population characteristics

A total of 210 households were included in the study (57 in semi-valley, 99 in the plateau and 54 in the valley). The number of households studied according to study area is presented in Table 1. In the study population, the median number of active household members (aged 6 to 50) was 6 (upper quartile (Q1) & lower quartile (Q2): 4 & 8) and the median number of dependent household members (≤ 5 and > 50) was 3 (2 & 4). Households in the Lundazi district (semi-valley and plateau) appeared to be larger on average than households in the Mambwe district (valley).

Most households in Lundazi received their primary income from crop farming (plateau: 63.3%, valley: 90.4%), whereas most households interviewed in Mambwe district were mixed farmers (crop and livestock: 68.4%). For one of the households in the valley, the primary source of income was working for a missionary. Most households (98.1%) had access to land; households in the semi-valley and valley were more likely to use communal land, whilst households in the plateau were more likely to report owning the land (67.7%). In Zambia communal land is distributed amongst villagers by the village chief, therefore it is very similar to owning land as most of them retain their land. However, it is technically not owned by the household and could be removed from them. Only two out of 210 (~1%) households had occupants which moved outside the household for long periods, one owned a shop in another village and another produced crops in another area as the land was more favourable for crop production.

	Semi-valley (Lundazi)	Plateau (Lundazi)	Valley (Mambwe)
Household members median (Q1 & Q2)	8 (6 to 10)	9 (6 to 13)	9 (7 to 13)
Primary source of income N (%): Crop farming Mixed farming Livestock farming	 18 (31.6%) 39 (68.4%) 0 (0%)	 62 (63.3%) 5 (5.1%) 31 (32.6%)	 47 (90.4%) 3 (5.8%) 1 (1.9%)
Land use N (%): Use communal land Own land Rent land	 46 (80.7%) 11 (19.35%) -	 16 (16.2%) 66 (67.7%) 15 (15.2%)	 41 (75.9%) 11 (20.45%) -

Table 1: Number of households studied and median (second quartile) household size with lower (first) quartile and upper (third) quartile (Q1 & Q3) in each study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).[2]

Household amenities according to study area are presented in Figure 2. Households located in the semi-valley (Lundazi) and valley (Mambwe) appear to have access to more utilities in the home than those in the plateau. More than half of those interviewed in valley (Mambwe) had electricity in the home (solar powered), compared to 17.5% and 2.0% in semi-valley (Lundazi) and plateau, respectively. In the semi-valley 77.2% of households had water supply to the home and around 80% of those interviewed in the semi-valley and valley had toilets (pit latrines) in the house, compared to 33% in the plateau. Most households had water in the community and the majority of households in semi-valley and plateau had toilets in the community. Median walking distance and between households which did not have water in the home and the nearest water point was 10 minutes in all areas. Similar percentages of households in all areas reported having mobile phones (~60%) and bicycles at home (~80% for bicycles).

[2] Quartiles are equal divisions of an ordered set of data values. The lower quartile (Q1) is the midpoint between the smallest value and the median (lowest 25% of data). The upper quartile (Q3) is the midpoint between the median and highest value (highest 25% of data).

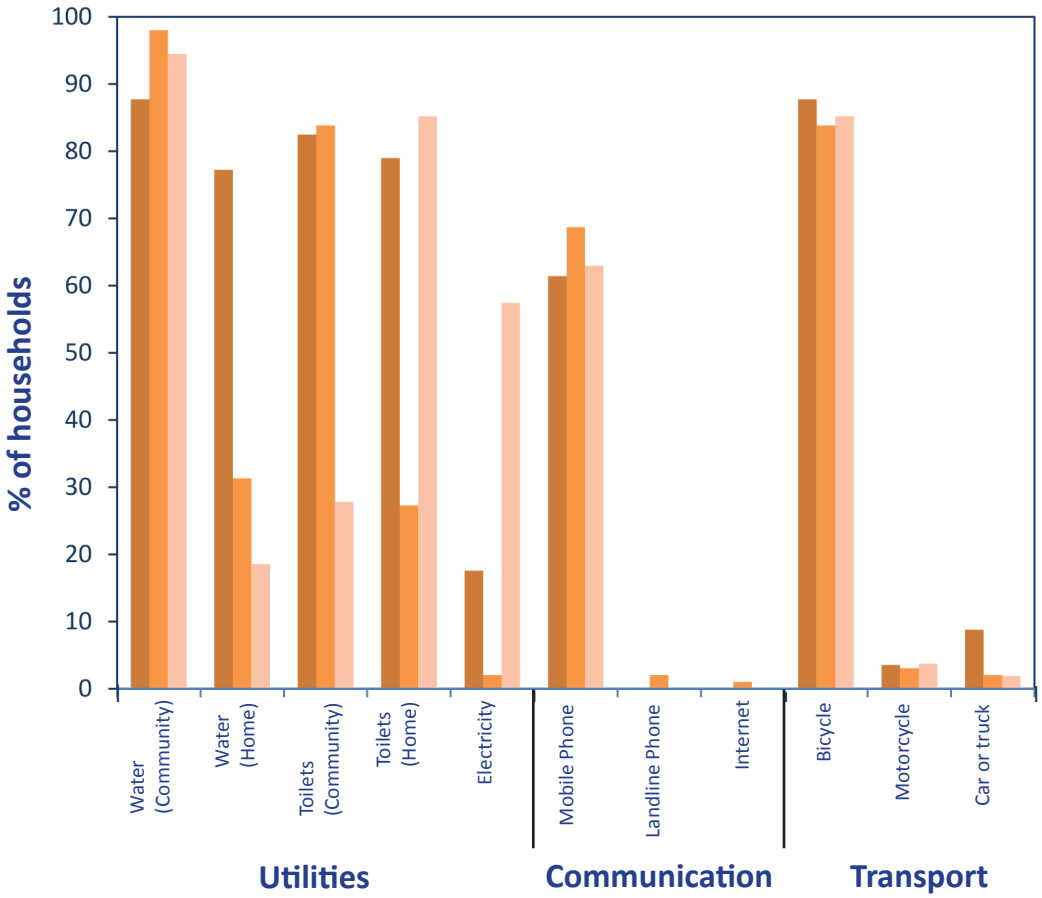

Figure 2: Percentage of households with each amenity, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

Image 6: Village in the Semi-Valley study area in Lundazi, Zambia June 2013.

Households in all areas had access to health care: most households (96.2%) said they would visit a local medical centre for the first opinion regarding health problems. If this did not resolve the problem, they would usually visit a hospital (87.4%). Some households in semi-valley (8.9%) and valley (9.6%) would visit a local tribal healer as a second opinion. This was probably due to reduced access of these households to healthcare centres. When asked about the main issues they face, health of household members was mentioned by 25%, 50.9% and 18.5% in semi-valley, valley and plateau, respectively (Figure 3).

Health of livestock and crops was a particular problem in the plateau (53.7% and 47.2% respectively) and 22.2% of households in

the valley mentioned health of livestock as a problem, compared to only 8.3% in semi-valley. This may reflect the level of livestock production in the semi-valley. Paying school fees was mentioned as a problem in most areas (34.3%). Water supply was more likely to be mentioned as a primary problem in the semi-valley (16.7%), during the fieldwork farmers' constantly mentioned that this area had suffered from recent droughts. Many of the households in all areas are heavily reliant on crop production, not just to generate income but also for home food consumption. Therefore droughts threaten food security in the region.

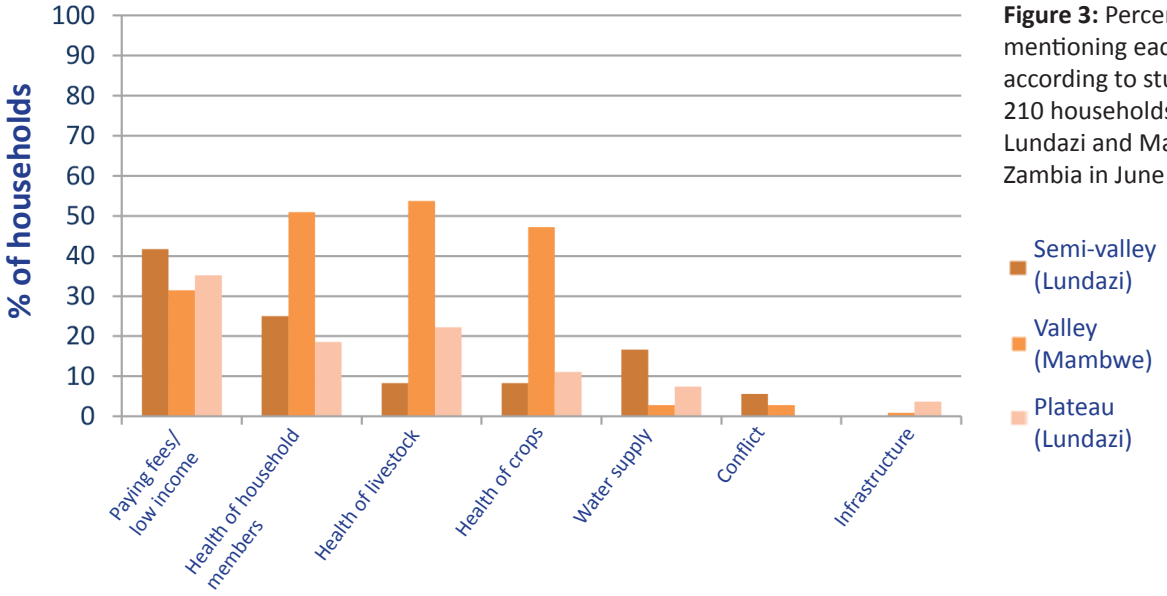

Figure 3: Percentage of households mentioning each major issue, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

Image 7: Angoni breed of cattle in shared kraal, Zambia June 2013.

3.3 General livestock keeping data

Cattle and small ruminants were mostly free-grazed and most villages had a shared kraal (corral) where cattle are housed overnight. Often, cattle from several households were grazed together and livestock owners would alternate between watching the herd. Additional livestock species owned were poultry in all study areas (92.3%), goats in all areas (~55 to 75%), pigs particularly in the valley (60.4%) and sheep in the semi-valley and plateau (~20%) (Table 2).

All cattle kept were Angoni, which are generally considered a trypanosensitive breed. Only households in semi-valley (19.3%) and valley (24.1%) reported having chosen this breed for a particular reason. Many interviewees simply stated that Angoni was the only breed they had access to. Those that did give reasons for choosing this breed mostly mentioned traditional preference. Two interviewees mentioned disease resistance and one household in the semi-valley mentioned improved draught power.

	Semi-valley (Lundazi)	Plateau (Lundazi)	Valley (Mambwe)
Total number of cattle: Median (Q1 & Q2)	6 (3 to 12)	7 (4 to 12)	5 (2 to 10)
Adult Female cattle: % households owning at least 1 Median (Q1 & Q2)	85.6% 2 (1 to 5)	90.1% 3 (1 to 6)	61.4% 3 (2 to 5)
Adult Male cattle: % households owning at least 1 Median (Q1 & Q2)	92.8% 3 (2 to 4)	93.46% 3 (2 to 5)	92.5% 2 (0 to 4)
Calves: % households owning at least 1 Median (Q1 & Q2)	49.1% 0 (0 to 2)	66.7% 1 (0 to 2)	18.9% 0 (0 to 0)
Cattle rearing system: Free grazing Tethered Zero grazing Combination	47 (82.5%) 1 (1.8%) 1 (1.8%) 8 (14%)	99 (100%) - - -	36 (92.3%) - - 3 (7.7%)
Other species: Sheep Goats Pigs Poultry	22.2% 56.1% 33.3% 96.4%	22.1% 54.5% 43.2% 91.9%	0% 74.1% 60.4% 92.4%

Table 2: Cattle herd composition median household size with Q1 & Q3 of each type of cattle, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

4. Access to veterinary services and products

Veterinary services

Lundazi District (semi-valley & plateau) had one trained veterinarian (the district vet), 9 veterinary assistants (VAs) and 28 animal health workers. Animal health workers were nominated to attend a 2 week course on behalf of the community and a further week refresher course, they then learnt from experience. In many communities in the semi-valley areas an animal health worker was the only veterinary service farmers had access to. In addition district veterinarians could be appointed to any district in Zambia; they did not necessarily know the area or speak the local language. Veterinary services and medical services were free; people only pay for drugs and transport. However, funding for vets was lacking and they were not always paid in a timely manner. Mambwe District (valley) had one trained district veterinarian, one livestock officer, 9 tsetse control assistants (TCAs) and 2 veterinary assistants (VAs). There are more TCAs than VAs because the area has lots of tsetse flies which limit cattle rearing; reducing draught power available for crop farmers. However, TCAs reside in veterinary camps and hence also function as veterinary assistants.

Veterinary practises

Around 81% of the households in both regions reported consulting a VA or similar when their livestock were sick. Participants were asked to present drugs that were currently in the household's possession; they were then asked about any other drugs they regularly use which were not currently in the household. The livestock drugs mostly kept in the house were: antibiotics (38.4%), trypanocides (36.4%), antihelmintics (10.6%) and insecticides/acaricides (10.6%).

Results according to study area are presented in Table 3. Households located in the valley were most likely to keep trypanocides at home (75.9%). In the semi-valley and plateau 26.3% and 7.1% kept trypanocides in the home, respectively. Most trypanocides kept were diminazene aceturate or Isometamidium chloride, which were often referred to as Berenil® or Samorin® but different brands were available and observed. More households had diminazene aceturate and tended to keep isometamidium in addition to, rather than instead of, diminazene.

	Semi-valley (Lundazi)	Plateau (Lundazi)	Valley (Mambwe)
Trypanocides	26.3%	7.1%	75.9%
Diminazene aceturate	22.8%	5.1%	75.9%
Isometamidium	19.3%	2.0%	54.4%
Insecticides/Acaracides	10.5%	11.1%	13.8%
Not effective against tsetse	7%	9.1%	13.8%
Effective against tsetse	3.5%	2.0%	0%
Dewormer	10.5%	6.1%	9.3%
Antibiotics	29.8%	22.2%	64.8%
No drugs in households	57.9%	69.7%	13%

Table 3: Main livestock drugs kept in the house, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

The main point-of-sale of livestock treatments for each study area are presented in Figures 4 and 5. Households in semi-valley bought veterinary products in general shops, vet pharmacies or directly from the veterinarian (or similar). Households in the plateau tended to buy them in a general shop or in a vet pharmacy and households in the valley bought them from a vet pharmacy or directly from the veterinarian (or similar). Most households bought the drugs in a nearby town.

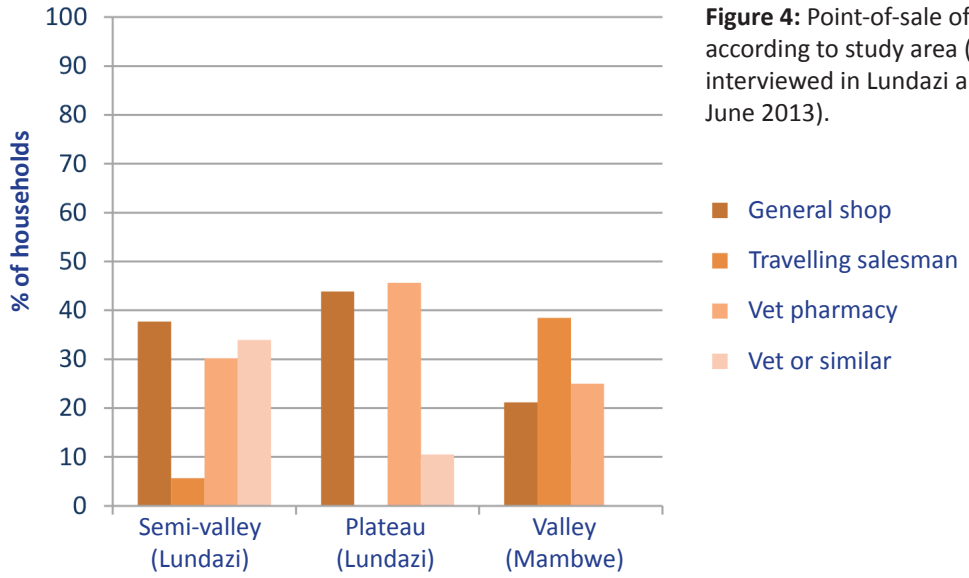

Figure 4: Point-of-sale of veterinary drugs and products, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

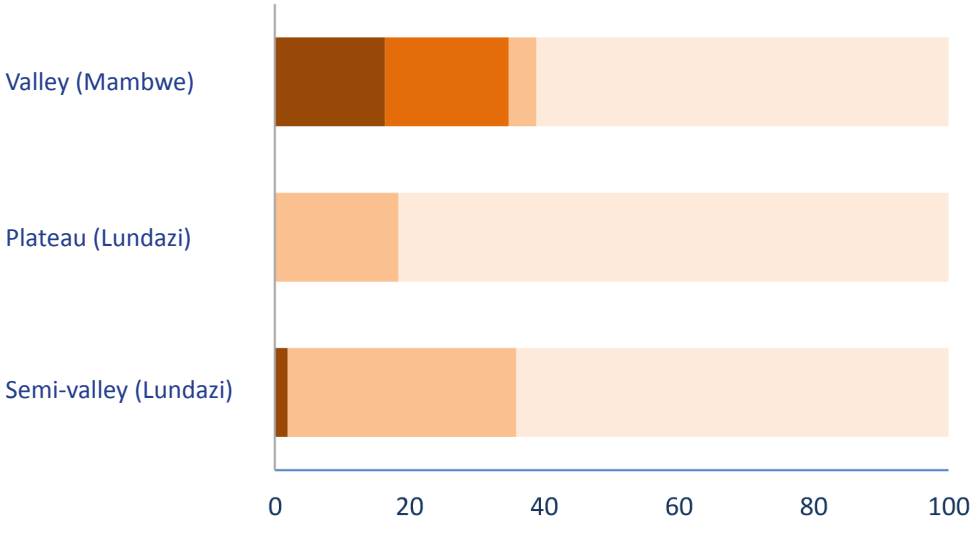

Figure 5: Location of veterinary drug point-of-sale, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

Some households (39.4%) reported vaccinating their livestock against certain diseases, generally only when official programmes were active (32.3%). Very few households in the semi-valley and valley reported vaccinating their livestock individually; one household in semi-valley vaccinated against ECF, three and six households said they vaccinate against AAT in the semi-valley and plateau and two, respectively, despite there being no AAT vaccine currently available. Upon discussion with households and veterinarians this was due to the residual prophylactic effects of isometamidium chloride. Households did not appear to distinguish between vaccines and treatments which have a residual but usually short-term prophylactic effect.

In the plateau 57.6% of households reported vaccinating their cattle against east coast fever (ECF). Many of the cattle in this area were observed to have the ear tags for the prophylactic ECF infection-treatment method (ITM). This could be related to the plateau area having better access than the other areas meaning it was well serviced by VA's. However, ECF was mentioned as a big disease problem in this area but the other areas did not report ECF as causing problems in their livestock. All these households except for one said they only vaccinate when official control campaigns were active. Official control programmes increase awareness and achieve greater coverage; but when they are free or heavily subsidised individuals may be reluctant to implement control measures such as vaccination once they are responsible for the costs, unless the perceived benefits are high.

5. Perceived impacts of AAT in the study areas

5.1 Perceptions of AAT occurrence

The following results were obtained when interviewees were asked non-specific questions regarding livestock diseases in the area, with no mention of AAT. Figure 6 displays the top 10 livestock diseases in the study areas; ranked in accordance with the percentage of households reporting them as important livestock diseases (in terms of monetary losses). Lumpy Skin Disease (LSD) was ranked the highest (41.4%) in the area; there was a countrywide outbreak of LSD the previous year (2012) and this occurs approximately every four years in Zambia (personal communication: C. Mumba). AAT (26.7%) was ranked second overall but was the most important disease in the semi-valley, a further 8 households in plateau did mention 'rough coat' as causing problems in their cattle which is a classical sign of AAT.

Around 45.7% and 52.9% of interviewees mentioned tsetse and ticks as insects causing problems to their livestock respectively (Figure 7). Some households (15.7%) mentioned biting flies as causing problems with their livestock, particularly in the valley (25.9%). More than 70% of households located in the semi-valley said tsetse was causing a problem to their cattle.

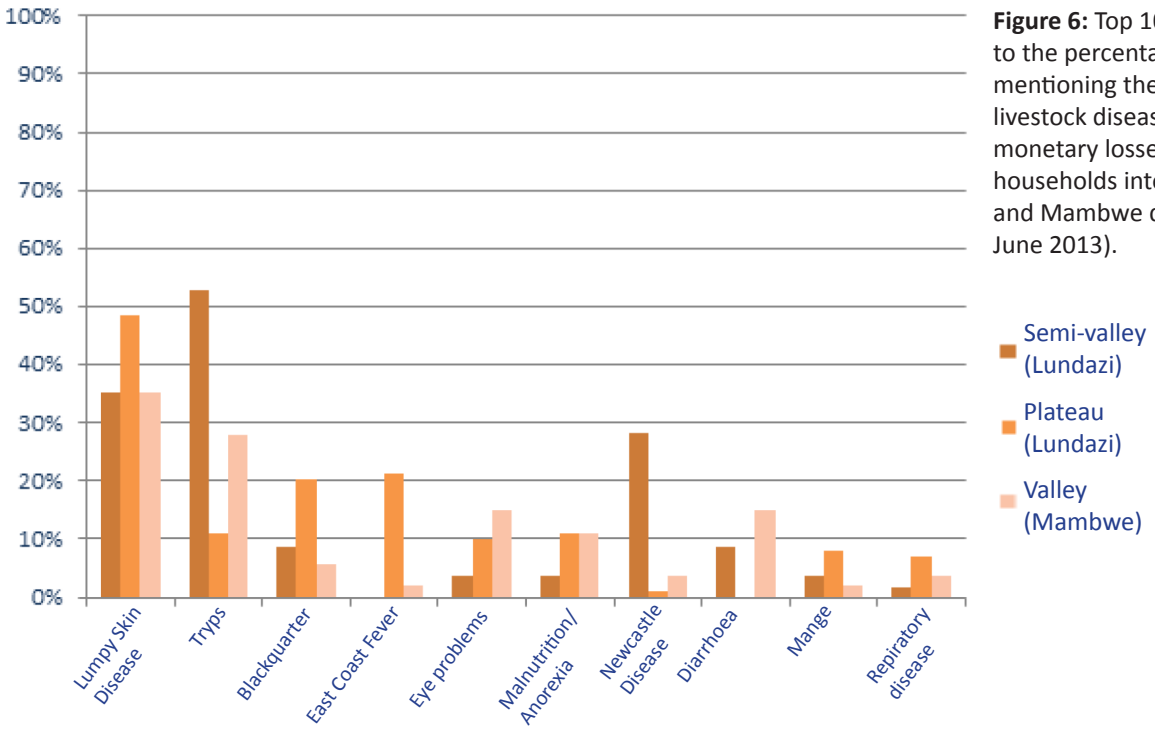

Figure 6: Top 10 diseases, according to the percentage of households mentioning them as 'important livestock diseases in terms of monetary losses' (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

Disease	Rankings
Lumpy Skin Disease	1
AAT	2
Blackquarter	3
East Coast Fever	4
Conjunctivitis	5
Malnutrition/Anorexia	6
Newcastle Disease	7
Diarrhoea	8
Paralysis (limbs)	9
Mange	10

Figure 6 continued: Top 10 diseases, according to the percentage of households mentioning them as 'important livestock diseases in terms of monetary losses' (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

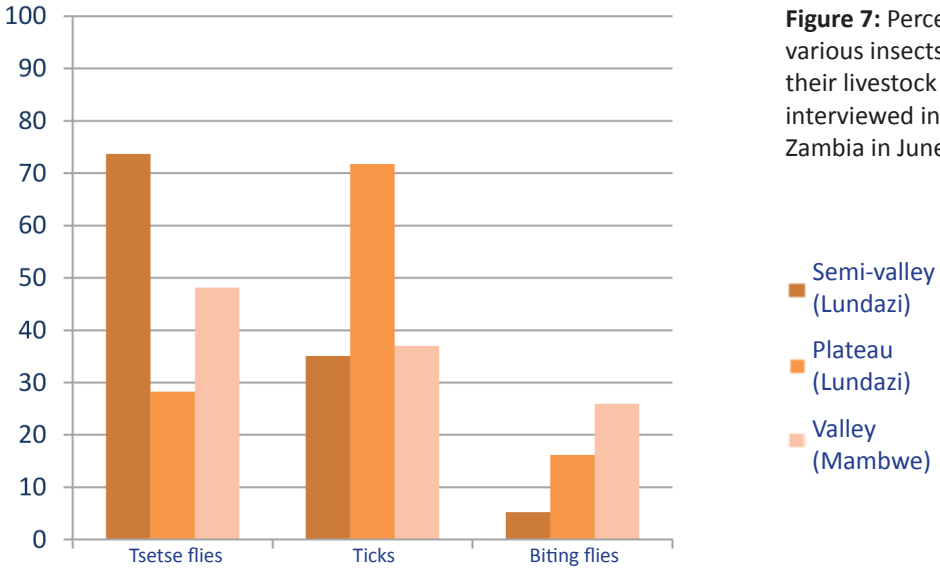

Figure 7: Percentage of households reporting various insects as causing problems in their livestock (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

Image 8: AAT infected cow showing typical wasting signs, interviewees were asked to suggest what was wrong with the cow (shown to 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

Households were shown a picture of a cow suffering from AAT (Image 8), although the clinical signs exhibited by the cow were non-specific and asked what they thought was wrong with the cow. This information was used as an indication of the relative importance of AAT in the different areas i.e. in areas where AAT was a major problem a household would be more likely to suggest the cow was suffering from AAT.

Overall 36.7% of the households thought the cow may be affected by AAT; more households (43.9%) in the semi-valley (Lundazi) suggested the cow had AAT compared to valley (Mambwe)(33.3%) and plateau (15.2%)(Table 4). Alternative suggestions were mainly worms or malnutrition. Other reasons mentioned by a small number of households were LSD, ECF, worms and helminths. Further one household suggested that the animal had malaria, another that the animal had no blood and one that the cow had HIV/AIDS. Some farmers mentioned that AAT was caused by tsetse draining animals' blood so this may have been why this farmer suggested that the animal had no blood left.

	Semi-valley (Lundazi)	Plateau (Lundazi)	Valley (Mambwe)
AAT	43.9%	15.2%	33.3%
Malnutrition	14.3%	14.1%	22.2%
Unknown	24.6%	44.4%	20.4%
Other	17.2%	26.3%	24.1%

Table 4: Disease suggestions when shown a picture of a cow with clinical signs compatible with AAT, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

After non-specific disease questions were posed to interviewees; the interviewer then asked whether they had heard of AAT, those that had were then asked a series of specific questions to acquire further information on the relative impact of AAT in the areas. Most interviewees had heard of AAT; 80.1%, 81.0% and 74.1% in Areas 1, 2 and 3, respectively.

Most livestock keepers in the semi-valley considered AAT to be a frequent problem in their livestock (one to five occurrences per year) (Figure 8). In the plateau, households reported AAT as a rare or a frequent problem. In the valley, most households said AAT was a constant problem. AAT occurrence seems to be the lowest in the plateau and the highest in valley. Around 60% of households reported a seasonal influence on AAT occurrence; most people said the period of higher AAT occurrence is during rainy season (November to April).

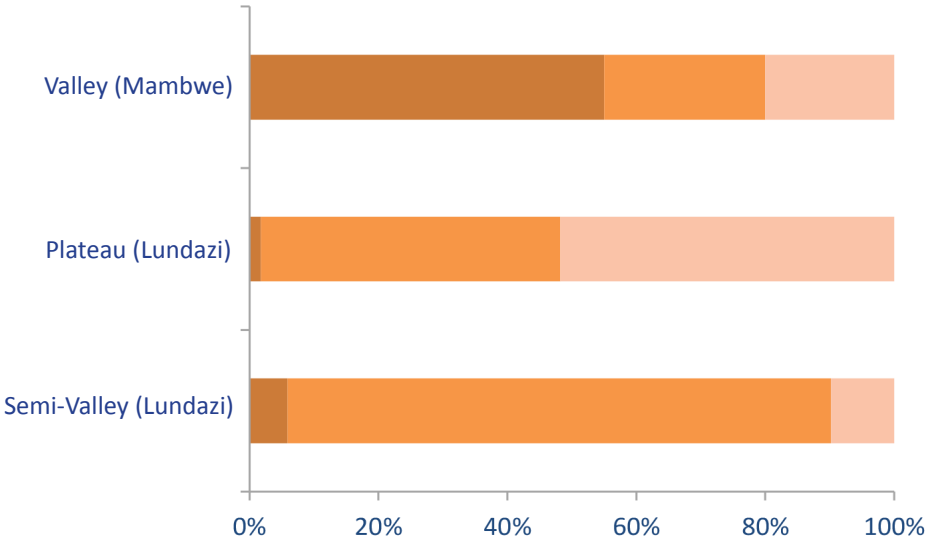

Figure 8: Reported frequency of AAT in livestock, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

5.2 Perceptions of AAT economic impact

The perceived impact of AAT on household income is presented in Figure 9. This was mainly estimated to be negligible in the plateau (81.5%) and valley (70%). In the semi-valley 41.3% of households did mention some losses in income due to AAT. In terms of losses to production in the semi-valley these were mainly reduced draught power (10.9% estimated as severe and 15.2% as very severe), as this is the main reason for keeping cattle in this study area. Losses in meat production were negligible therefore the results of this were not presented. Some households reported losses in milk; this production is small-scale and mainly for home/local consumption. Access to markets, particularly in the valley (Mambwe) and the semi-Valley (Lundazi) is poor and no milk from the areas enters formal supply chains.

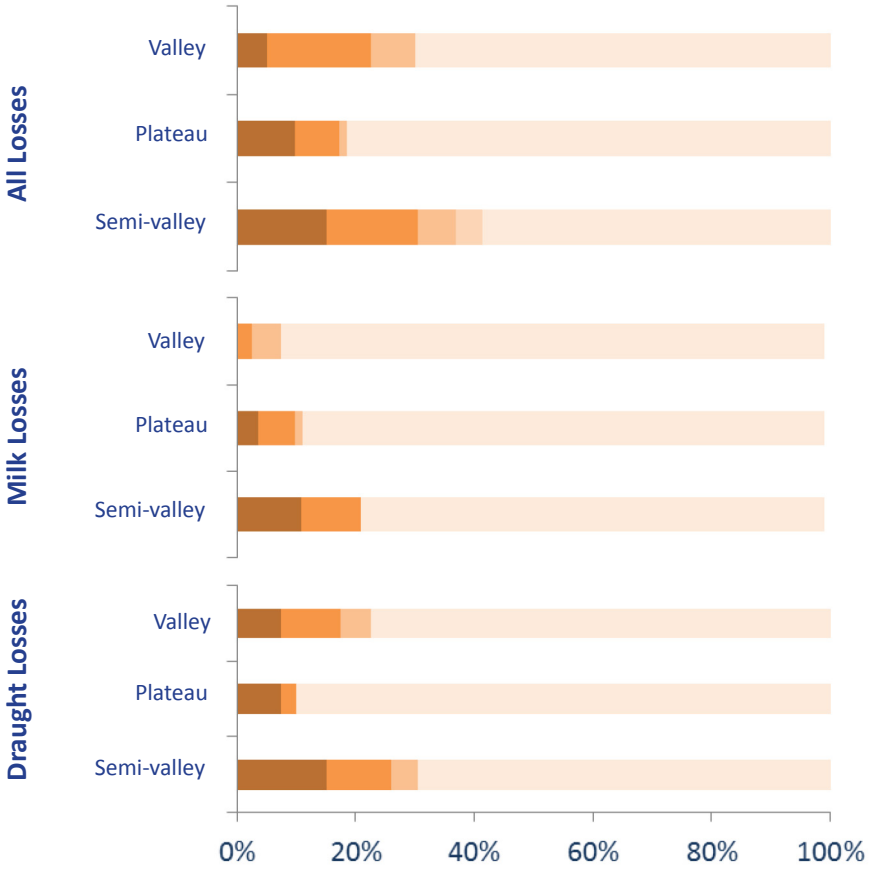

Figure 9: Perception of production losses due to AAT, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

Image 9: Preparing cattle for ploughing, Zambia June 2013.

Information on total costs of diagnosing and treating all diseases in general and specifically AAT, per household, is presented in Table 5. Just under a third of households in the valley areas have spent money treating AAT in the last two years, compared to only 14.1% of households in the plateau. Households in the Valley appeared to have spent more money for diagnosing and treating livestock diseases, in comparison with those in Semi-valley and Plateau.

	Semi-valley (Lundazi)	Plateau (Lundazi)	Valley (Mambwe)
Cost (US$) per individual AAT treatment: Median (lower & upper quartiles)	US$1.45 (1.13 & 2.81)	US$1.88 (1.41 to 1.88)	US$ 1.54 (0.94 to 2.81)
Total cost (US$) AAT diagnosis & treatment: % households > 0 Median (quartiles)	28.1% US$9.9 (1.8 to 36.6)	14.1% US$9.4 (7.5 to 16.9)	27.8% US$16.9 (8.4 to 46.9)
Total cost (US$) disease diagnosis & treatment: % households > 0 Median (quartiles)	59.2% US$18.8 (1.9 to 46.9)	58.3% US$18.8 (7.8 to 37.5)	82.7% US$28.1 (9.4 to 56.2)
Cattle deaths AAT: % households > 0 Median (quartiles)	28.3% 1 (2 to 3)	18.5% 1 (1 to 2)	30% 2 (1 to 2.25)
Cattle deaths (all disease): % households > 0 Median (quartiles)	61.4% 2 (1 to 3)	51.5% 2 (1 to 4)	38.9% 2 (1 to 2)

Table 5: Direct losses of AAT and all disease in terms of treatment costs in US$[3] and mortality, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

5.3 Attitudes and practices towards AAT diagnosis and treatment in cattle

Diagnosing and treating AAT

The variables associated with AAT treatment practices are presented in Figure 10. The majority of people reported consulting a veterinarian or similar if they suspect their animal had AAT, especially in the plateau. However, in the semi-valley and valley, almost half of households interviewed reported treating AAT themselves. This is probably because AAT occurrence is more common and they know how to treat the disease.

Regarding treatment administration for AAT, more than half of households always used veterinarians or similar to treat the animals (57.1%), but 34% reported that they treated livestock themselves (usually the head of the household) (Figure 11). Those that self-treated reported dosing treatment 'by eye' i.e. they assessed animals' weight just by estimating correct dosage based on visual size which could lead to misdosing and potentially resistance. Main inconveniences with current AAT treatment are presented in Figure 12. Most households mentioned preparing the drugs, acquiring consumables, correct dosing and correct animal weight estimation.

[3] The study was conducted in June 2013 and at this time the exchange rate of the Zambian Kwacha (ZMW) to the Unites States Dollar (USD) according to www.xe.com was ZMW 5.33 = USD 1.00.

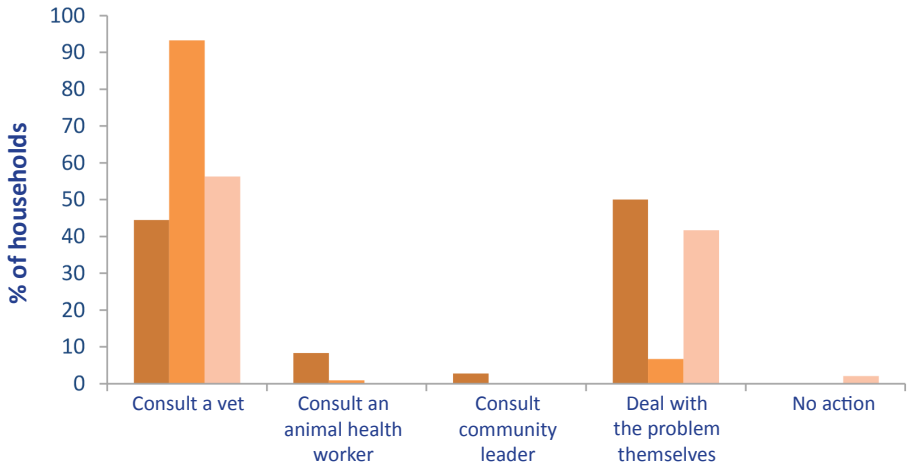

Figure 10: Household action in case of AAT suspicion, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

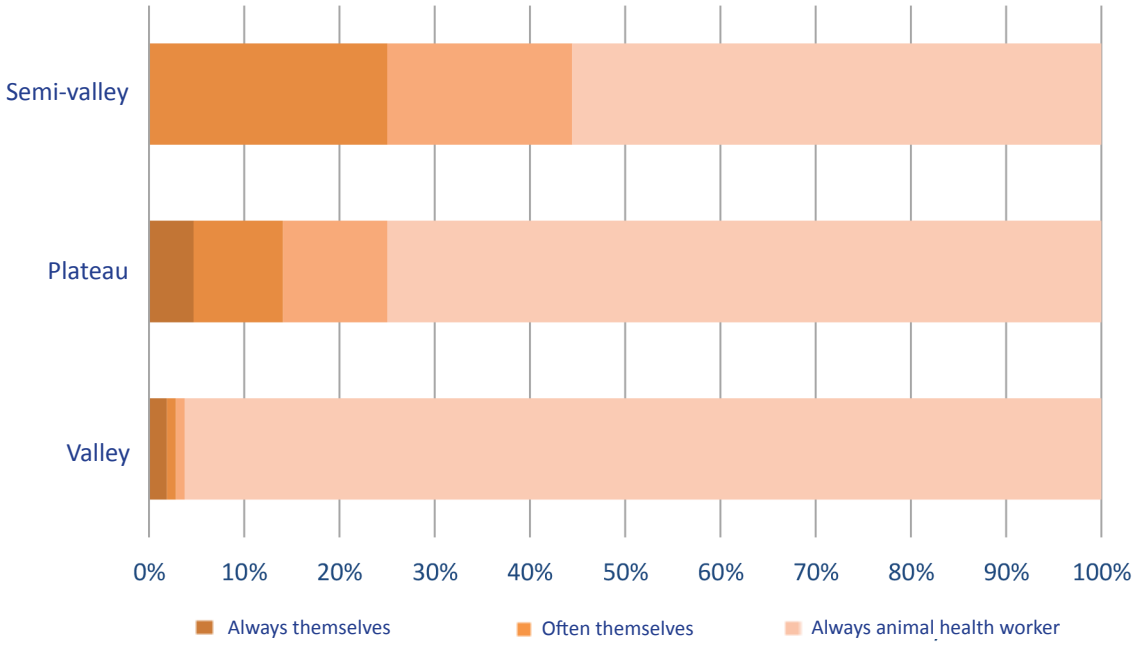

Figure 11: Who treats cattle against AAT, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

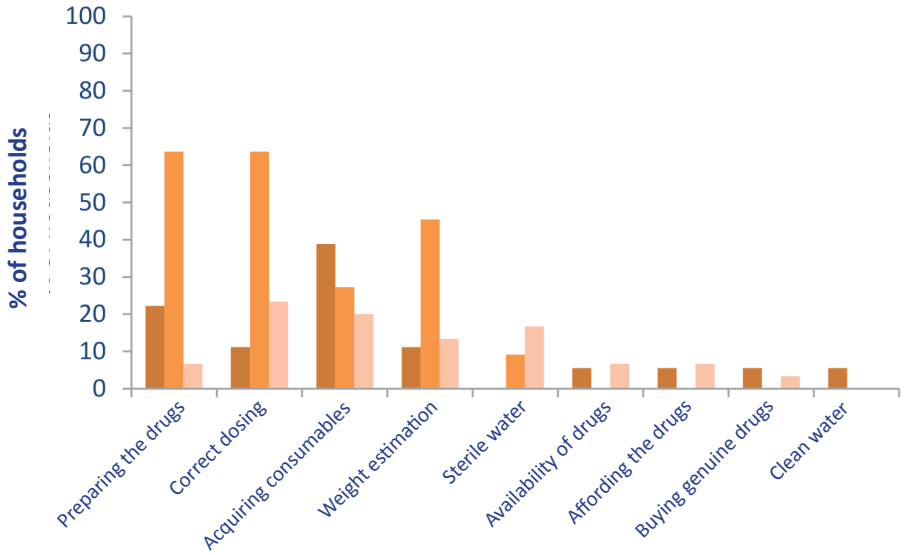

Figure 12: Main inconveniences with current AAT treatment, according to study area (data from 210 households interviewed in Zambia in June 2013).

Treatment failure

Households reporting treatment failure were mainly located in semi-valley (33.3%) and valley (21.4%). Only 7.1% of households in the plateau had experienced failure. Reasons given were mainly that AAT was not the cause of sickness (13 households), there was resistance (9 households) or that the drug bought was wrong and ineffective (9 households). Under-dosing and treatment delay were also mentioned by several households. A few interviewees, particularly in the semi-valley area, also mentioned that the "Berenil®" sachet had recently changed and it was much less effective than the previous one. However, these interviewees did not have the sachet to hand so the manufacturer could not be identified. There is a problem with fake, sub-standard or diluted trypanocides in sub-Saharan Africa which could potentially have been a problem in this area [13], although, households did not mention that they were worried about fake drugs per se. The information regarding treatment failure in this study is simply household's perceptions therefore we cannot be sure whether this is due to misdiagnosis, under-dosing, resistance, sub-standard or falsified drugs, other reasons or a combination of factors.

6. Knowledge of AAT

The ability of the interviewees to give accurate information regarding the current AAT situation in the area is dependent on their awareness and knowledge of the disease. Therefore, knowledge of AAT transmission, clinical signs and control was assessed alongside these questions. Poor knowledge of the disease and control measures could be hindering AAT control in the area. Although, knowledge is likely to be highly correlated with incidence i.e. the more disease incidents the more aware farmers are and the better their knowledge of the disease, and vice versa. Households were firstly asked if they were aware of AAT; in the study areas 81.8% of households in both the semi-valley and plateau (Lundazi) said they had heard of AAT, compared to 74.1% in the plateau. These households were then asked to describe the disease; this was an open ended question.

When asked to describe AAT; some households mentioned classic symptoms of disease, mainly in the plateau area; including; weight loss, malaise and loss of tail brush (Table 6). Household knowledge of AAT is presented in Table 6. Households located in the semi-valley and plateau were less likely to mention AAT transmission, with only around 30% of households naming tsetse as the insect vector. Those that said other species could be infected mentioned mainly sheep and goats; although 4 households in the plateau and 4 households in the semi-valley mentioned dogs, one household in the plateau mentioned pigs and one household in the semi-valley mentioned wild animals. Interestingly, some households in the plateau mentioned that biting flies e.g. stoxmosis, tabanids spread AAT.

Awareness of prophylactic measures appears to be very limited, especially in the semi-valley and plateau (Table 7); when asked about preventative measures for AAT. Overall, only 22% of people could identify a picture of a tsetse trap; however, there was a huge discrepancy between study areas as 67% of households interviewed in the valley could identify the tsetse trap whereas less than 10% identified it in semi-valley and plateau. During informal discussions with villagers after the interviews had been completed it appeared that some of them remembered that they had seen tsetse traps before, but not everyone knew what they were for. The villagers (and enumerators) also stated that many of the tsetse traps are destroyed and the material is used for clothes, school uniforms and blankets.

AAT control appears to be poor in all studied study areas (Table 7). When control measures were used, they were insecticides, treatment of sick animals and treatment of all animals. Studied households reported individuals and communities as leaders of AAT control.

Some households in the valley area mentioned district officials carrying out control (22.2%); it may be that households in this area have experienced not having to pay for control measures and therefore had lower willingness to pay. In the other areas (particularly semi-valley) there did not appear to be any recent or on-going official control programs and if any AAT control did occur it had been facilitated by individuals, therefore they are used to paying for control themselves.

AAT knowledge	% of households
Aware of AAT	
Semi-valley (Lundazi)	82.1%
Plateau (Lundazi)	81.8%
Valley (Mumbwe)	74.1%
Mentioned clinical signs	
Semi-valley (Lundazi)	26.1%
Plateau (Lundazi)	35.8%
Valley (Mumbwe)	22.5%
Mentioned that it is spread by vector	
Semi-valley (Lundazi)	33.9%
Plateau (Lundazi)	55.6%
Valley (Mumbwe)	85%
Mentioned that it is spread by tsetse	
Semi-valley (Lundazi)	28.3%
Plateau (Lundazi)	39.5%
Valley (Mumbwe)	82.5%
Mentioned that it is spread by biting flies	
Semi-valley (Lundazi)	0%
Plateau (Lundazi)	16.1%
Valley (Mumbwe)	0%
Mentioned that it affects other species	
Semi-valley (Lundazi)	8.7%
Plateau (Lundazi)	13.6%
Valley (Mumbwe)	27.5%
Think that AAT is zoonotic	
Semi-valley (Lundazi)	23.9%
Plateau (Lundazi)	30.9%
Valley (Mumbwe)	80%

Table 6: General knowledge about AAT, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

	Semi-valley (Lundazi)	Plateau (Lundazi)	Valley (Mambwe)
Said they knew how to control AAT: % households	26.8%	35.4%	48.2%
Could identify a picture of tsetse trap: % households	8.9%	27.3%	79.6%
Control measures mentioned (awareness):			
Any	26.8%	35.4%	48.2%
Tsetse traps	-	-	7.4%
Insecticide treated cattle	16.1%	18.2%	37%
Select resistant breeds	-	-	3.7%
Treat sick cattle	10.7%	9.1%	79.6%
Treat all cattle	3.6%	13.1%	-
Facilitators of control:			
None mentioned	80.4%	72.7%	37%
Communities acting together	7.1%	2%	18.6%
Independent individuals	10.7%	23.2%	22.2%
District officials	1.8%	2%	22.2%

Table 7: Awareness of the existence of AAT control measures, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

7. Attitudes towards future AAT control

7.1 Consumer willingness to use and pay for new treatments

Most households in the study area felt there was a need for new drugs and were ready to pay a higher price than current AAT treatment, providing it was more effective (Table 8). The willingness to pay was slightly lower in valley. During informal discussions most households said they needed more choice of drug or that the disease was still prevalent so better control is needed.

	Think there is a need for new AAT treatments	Would be willing to pay for a new treatment
Semi-valley (Lundazi)	89.5%	86%
Plateau (Lundazi)	97.1%	90.9%
Valley (Mambwe)	77.8%	77.8%

Table 8: Proportion of farmers who think there is a need for new AAT drugs and would be ready to pay a higher price for it, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

7.2 Consumer willingness to use and pay for diagnostic tests

Most households interviewed would use an AAT diagnostic test, especially in the semi-valley (97.2%) and the plateau (96.3%). Fewer households (79.6%) would use a diagnostic test in the valley, although the majority would. Data regarding prices households would be willing to pay for an individual AAT diagnostic test are presented in Tables 8, 9 and Figure 13. Willingness to pay was lower in the valley, although the prices households were willing to pay were similar across the study areas.

	Want diagnostic	Willing to pay >0	Median cost (IQR) in US$[4]
Semi-valley (Lundazi)	94.7%	84.2%	1.88 (0.94 to 3.8)
Plateau (Lundazi)	97%	95%	1.88 (0.94 to 2.8)
Valley (Mambwe)	79.6%	64.8%	1.88 (0.94 to 3.75)

Table 9: Distribution of the cost (in US$) households would be willing to pay for an individual AAT diagnostic test, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

Table 9 and Figure 13 show the willingness to pay at each price interval (% households willing to pay each price, or higher). Household in the valley were consistently willing to pay slightly less for a diagnostic test and a higher percentage of interviewees in the semi-valley were willing to pay the highest prices.

[4] The study was conducted in June 2013 and at this time the exchange rate of the Zambian Kwacha (ZMW) to the Unites States Dollar (USD) according to www.xe.com was 5.33 ZMW = 1USD.

Figure 13: Cost (in dollars) households would be willing to pay for an individual AAT diagnostic test at each price interval (% of households that said they would pay that price, or a higher price) (data from 225 households interviewed in Burkina Faso in June 2013).

Cost per diagnostic test	% Willing to Pay Semi-Valley	% Willing to Pay Plateau	% Willing to Pay Valley
≥ $0.10	84.2%	95.0%	64.8%
≥ $0.25	80.7%	89.9%	57.4%
≥ $0.50	77.2%	88.9%	53.7%
≥ $0.75	77.2%	87.9%	53.7%
≥ $1.00	61.4%	64.7%	42.6%
≥ $1.25	59.6%	64.7%	42.6%
≥ $1.50	56.1%	64.7%	42.6%
≥ $1.75	56.1%	64.7%	42.6%
≥ $2.00	29.8%	26.3%	24.1%
≥ $3.00	22.8%	15.2%	18.5%
≥ $5.00	8.8%	6.1%	9.3%

Table 10: Cost (in US$) households would be willing to pay for an individual AAT diagnostic test, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

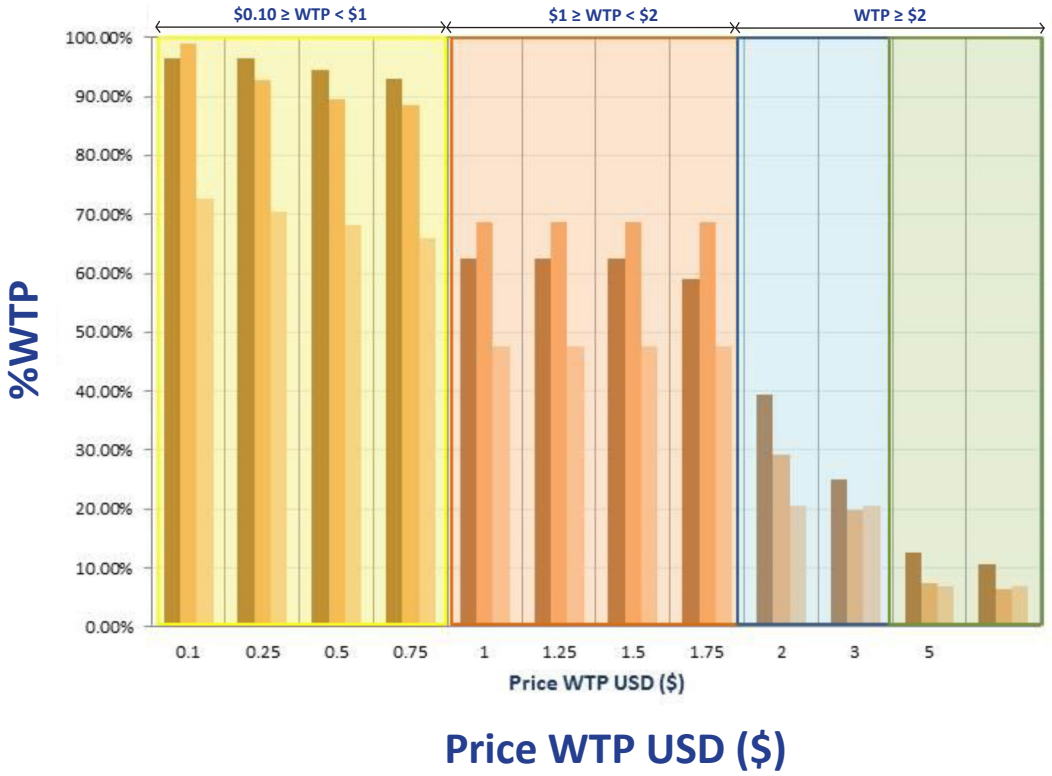

Table 9: Cost (in USD$) households would be willing to pay for an individual AAT diagnostic test, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

Price WTP USD ($)

7.3 Consumer willingness to use and pay for an AAT Vaccine

Most households interviewed stated they would vaccinate their livestock against AAT if a vaccine was available to provide long-term immunity, especially in semi-valley and plateau (Table 10). In addition to cattle, a few households said they would vaccinate goats. The vast majority of households (>95 %) would be willing to use and pay for a vaccine in the semi valley and plateau areas, however only 59.3% of households would be willing to pay for a vaccine in valley.

	Semi-Valley	Plateau	Valley
Would vaccinate	98.5%	97%	81.5%
Willing to pay > 0	94.7%	96%	59.3%
Median cost (IQR) in US$[5]	$1.88 (0.94 to 3.8)	$1.88 (0.94 to 2.8)	$1.88 (0.94 to 2.8)
Additional species they would vaccinate:			
Sheep	8.9%	-	11.4%
Goat	17.9%	1%	38.6%
Pigs	3.6%	-	15.9%

Table 10: Interviewees willingness to use and pay for a vaccine against AAT and species of livestock they would vaccinate (in addition to cattle).

When asked about price interviewees would be willing to pay for a vaccine the results were very similar to that of diagnostics tests (median = 0.4). Intuitively, you would expect that farmers would be willing to pay more for an efficacious vaccine then they would pay for a diagnostic tool. The interviewers found it quite difficult to explain the concept of a vaccine to the interviewees, particularly in the semi-valley area. This area lacked a lot of infrastructure such as veterinary services and education appeared to be poorer. Also, some participants believed a trypanocide was a vaccine because of the prophylactic effects. If a vaccine was made available it would be necessary to spend time working with farmers to teach them about the benefits of vaccination.

Table 13 and Figure 14 show the willingness to pay that price (or a higher price) at each price interval. Households in the valley were consistently willing to pay slightly less for a vaccine and a higher percentage of interviewees in the semi-valley were willing to pay the highest prices.

Cost per vaccine	%Willing to pay Semi-valley	%Willing to pay Plateau	%Willing to pay Valley
≥ $0.10	96.4%	99.0%	72.7%
≥ $0.25	96.4%	92.7%	70.5%
≥ $0.50	94.6%	89.6%	68.2%
≥ $0.75	92.9%	88.5%	65.9%
≥ $1.00	62.5%	68.8%	47.7%
≥ $1.25	62.5%	68.8%	47.7%
≥ $1.50	62.5%	68.8%	47.7%
≥ $1.75	58.9%	68.8%	47.7%
≥ $2.00	39.3%	29.2%	20.5%
≥ $3.00	25.0%	19.8%	20.5%
≥ $4.00	12.5%	7.3%	6.8%
≥ $5.00	10.7%	6.3%	6.8%

Figure 13 (corresponds with figure 14): Cost (in US$) households would be willing to pay for an individual AAT vaccine, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

[5] The study was conducted in June 2013 and at this time the exchange rate of the Zambian Kwacha (ZMW) to the Unites States Dollar (USD) according to www.xe.com was 5.33 ZMW = 1USD.

Figure 14 (corresponds with figure 13): Cost (in USD$) households would be willing to pay for an individual AAT diagnostic test, according to study area (data from 210 households interviewed in Lundazi and Mambwe districts of Zambia in June 2013).

Conclusions

The Valley area (Mambwe) appears to have the highest tsetse/trypanosome burden in terms of tsetse populations and frequency of occurrences in herds. However, cattle are of less economic importance than in the semi-valley and plateau area and there are some on-going AAT control programs for AAT. Therefore, the semi-valley (Lundazi) has a higher risk in terms of susceptibility as there are no control programmes in place and interviewees were less knowledgeable of the disease compared to other areas.

Consumer willingness to use and pay for new drugs, diagnostics and novel vaccines was high in all areas. However, fewer farmers would be willing to pay in the valley (Mambwe) area which may be because AAT control has been carried out by officials in the past.

Around a third of households reported treatment failure in the semi-valley area, this area (and the valley study area) were more likely to self-treat animals, which may result in under-dosing as most households estimate correct dosage by visually assessing animals' weight; which could contribute to resistance. Methods of reducing under-dosing should be considered if new drugs are to be distributed to prevent resistance to new drugs developing.

The study areas, in particular the semi-valley, were reliant on community animal health workers (CAHWs) to diagnose and treat their animals. These receive very short training courses if new treatments and diagnostics for AAT were to made available then investing in further training for the CAHWs could help increase awareness of the disease and new treatment options.

Farmers in the semi-valley and plateau area were not aware of AAT control options. Information regarding the epidemiology of AAT, useful methods of control (depending on area) and the potential improvement for livestock and crop production in the area in the absence of AAT should be disseminated. This may encourage individuals and communities to control the AAT without further contributing to trypanocide resistance. One would expect this to reduce the destruction of tsetse traps; however this still occurs even in areas where there is better awareness of their function.

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