

Comparing smallholder poultry husbandry practices between adopters and non-adopters of Newcastle Disease vaccine in Tanzania

A GALVmed Monitoring and Evaluation Study



Strategic context

Is there a relationship in smallholder farming between the use of a key animal health input and the wider use of other essential inputs and husbandry practices? The study examined this basic question by looking for any relationship between the use of the Newcastle disease (ND) vaccine by smallholder poultry farmers and other poultry inputs and practices that are considered important in a smallholder setting. The information from this study could be useful for GALVmed in two important areas:

- i) Informing a strategy for market development: should market development initiatives for improving animal health be accompanied by wider husbandry extension activities, or does this occur 'naturally' to any extent?
- ii) Understanding impact: when comparing the productivity of adopters and non-adopters of an essential animal health input, is any observed difference likely to be significantly influenced by the usage of other products and practices?

These questions are important for GALVmed and represent an area where many contrasting opinions and anecdotal observations are offered. This study is a first step in bringing quantitative evidence to the debate. However, it does not address any aspects of causation behind the possible relationships; this is therefore a potential area for future studies.

Executive summary

- This study was set up to establish whether there are measurable differences in observable husbandry practices between Newcastle disease vaccinating and non-vaccinating poultry-keeping households in Tanzania.
- Differences were evaluated using a questionnaire survey of smallholder chicken farmers. The questionnaire was implemented in the mobile phone app ODK Collect and included 90 different questions. Certain questions were only asked if they were relevant; this was determined by the responses to previous questions. The questions addressed all aspects of poultry management and uses of ND vaccines (questionnaire in Appendix 1).
- The study was implemented during March and April 2017 in the Babati, Hanang and Mbulu districts of Manyara Region in Tanzania, where GALVmed has been developing structures for distributing ND vaccines for a number of years. Four hundred and forty-seven chicken-farming smallholders were surveyed in these areas. One hundred and four smallholders households were also surveyed in Handeni District (Tanga Region) – an area where no GALVmed programme has been in place.
- Enumerators were instructed to select smallholders such that 50% of those enrolled in each survey village were vaccinating against ND and 50% were not using vaccines. Upon analysis of the data, the respondents fell into three categories:
 - **Non-adopters**, who had never vaccinated their chickens against ND and comprised 259 respondents (47%).
 - **Bad adopters**, who had vaccinated their chickens against ND, but during 2016 had not vaccinated, or had only vaccinated on one occasion. This comprised 174 respondents (31.6%).
 - **Good adopters**, who had vaccinated their chickens on at least two occasions during 2016. This comprised 118 respondents (21.4%).
- The good adopters were principally in Babati (59/142 respondents) and Handeni (27/104) districts and less commonly in Hanang (23/152) and Mbulu (9/153). The only detectable difference between Handeni and the areas in which the distribution of ND vaccine has been actively improved by GALVmed was that in the latter, it was primarily community vaccinators that distributed vaccines through market development initiatives.
- Significantly fewer ND outbreaks were reported among the good adopters (Figure 5).
- The good adopters' chicken flocks were significantly larger (mean 29.9 chickens) than the non-adopters' (18.9 chickens) and bad adopters' (21.7 chickens) flocks (Figure 6).
- In comparing the different categories of ND adoption, a number of differences in husbandry were observed. However, these were not universal and were typically common only among a proportion of good adopters. Specifically:
 - The good adopters were more likely to use dewormers on their chickens: 54% of good adopters used dewormers, compared to 10.4% of non-adopters. Also, expenditure on medicines and treatments (excluding ND vaccines) was three times greater among good adopters compared to non-adopters. There was relatively little use of fowl pox, Gumboro and fowl coryza vaccines: only 27 (4.9%) overall vaccinated against these other diseases.
 - The majority of flocks of all types were fed through scavenging with supplementary feeding; however, 22% of the good adopters only fed their chickens, with no scavenging. There was relatively little use of commercial feed, with 69 flocks (12.4% overall) given commercial feed: this was 31.4% of good adopters but less than 10% of bad adopters and non-adopters. Mineral supplementation was very unusual, and was only used by 24 respondents, primarily good adopters.
 - 59.3% of good adopters used formal poultry housing, compared to less than 40% of bad adopters and non-adopters. Those that did not use poultry housing instead housed their poultry in the family home, with few leaving the chickens to nest outdoors.
- Good adopters sold, consumed and gifted significantly more chickens than non-adopters. They also received more at sale than non-adopters and adopters; a cock from a good adopter sold for an average of 12,451 TSh (5.59 USD), compared to 11,920 TSh (5.35 USD) from a bad adopter and 10,908 TSh (4.89 USD) from non-adopters.
- There is no evidence that smallholders are using their chicken flocks as a gateway to farming larger livestock species: none cited this as an ambition. Rather, the evidence is that those only farming chickens are trying to become more professional in their chicken production, and that those farming other livestock species regard chickens as a less important part of their business.

Contents

Strategic context	2
Executive summary	2
Background	4
Materials and methods	4
Hypothesis	4
Study design	4
Sample size	4
Survey team	4
Questionnaire	5
Implementation	5
Results	5
Summary of results	5
Detailed results	6
Newcastle disease	6
Chicken flock	7
Other vaccines and treatments	9
Feeding	10
Housing	11
Consumption and sales	12
Uses of revenue	13
Secondary results	13
Other livestock	13
Newcastle disease vaccination practices	14
Respondent characteristics	15
Future ambitions for the flock	15
Conclusions	16
Lessons learned	16
Acknowledgements	16
Reference	16
Appendix 1	17

Background

There is a fundamental question when considering the beneficial impact of vaccination for major diseases such as Newcastle disease (ND) – to what extent are observed gains attributable to improved husbandry practices and to what extent are they attributable to the reduced incidence of disease? This study attempts to bring a new level of understanding to this question by ascertaining whether there are measurable differences in observable husbandry practices between vaccinating and non-vaccinating poultry-keeping households.

The objective of the study was to collect quantitative comparative data to assess the adoption of improved inputs and management practices following vaccination against Newcastle disease in Tanzania. The study was a comparison of ND vaccine adopters versus non-adopters, where adopters had reported using ND vaccines and non-adopters did not use vaccines.

Materials and methods

Hypotheses

The premise of the study is that smallholders that vaccinate against Newcastle disease (ND) will also adopt improved husbandry practices such as improved feeding, housing and measures to prevent diseases other than ND. The hypotheses are:

- H_0 (Null hypothesis). There are no differences in the husbandry practices of adopters of ND vaccines and those of non-adopters of vaccines.
- H_1 (Alternative hypothesis). There are significant differences in the husbandry practices of adopters of ND vaccines and those of non-adopters of vaccines.

For comparative purposes, we also considered adopters versus non-adopters in an area where no market development initiatives for ND vaccines had taken place.

Study design

The study took the form of a single questionnaire survey. It was implemented in areas that have had supply chains for ND vaccines for at least two years. The study was implemented in the districts of Babati, Hanang and Mbulu in Manyara Region as well as Handeni District in Tanga Region. Districts in Manyara Region were included as areas that have had market development initiatives for ND vaccination (hereafter called intervention areas) and Handeni District was included as a comparison district that has never implemented any market development initiatives for ND vaccination (Figure 1). Within these areas, rural villages were selected based on their accessibility.

Figure 1. Study areas in Tanzania. The red area is the three intervention districts and the blue area is the control district.



The intervention areas have distribution networks for ND vaccines. However, not all poultry-farming households necessarily have easy access to vaccines, or households may choose not to purchase the vaccines. Thus, the study was based on visiting villages in the intervention and control districts and surveying similar numbers of adopter and non-adopter households.

Sample size

The sample size calculations were based on a mean flock size of 13 chickens among non-adopters and 20 chickens among adopters, with 15% of non-adopters and 42% of adopters owning poultry houses: this is based on Bessell et al, 2017. With a significance level (alpha) of 95% and a power (1-beta) of 90%, the minimum sample size was 124 (62 smallholder flocks in each group). However, given that the analysis is of a range of indices that are relatively unknown, this was increased to 225 in each group (450 in total). The survey was divided up so that 20 flocks were sampled in eight villages for each of the three intervention areas. However, as this gives a total sample size of 480, only 10 flocks were sampled in the final village. In the non-intervention area, 100 households keeping flocks were selected at random from five survey villages.

Survey team

The survey was implemented in the field by Dr Jaribu Sultan. Dr Sultan recruited survey teams in each district from people known to him – local veterinary workers, community animal health workers and retailers of agro-veterinary products.

Questionnaire

The questionnaire was developed in paper form in English in consultation with GALVmed. This was then further developed in consultation with Dr Sultan prior to translation into Swahili by Dr Sultan. The questionnaire was then imported into the Android app ODK Collect. The questionnaire was organised into the following sections:

1. Respondent details.
2. Questions about how often meat and eggs are consumed.
3. Details of the size and composition of the flock, causes of loss in the flock, constraints on growing the flock, and ambitions for the flock.
4. Details of other species that are owned by the smallholder.
5. Knowledge, history and practices of vaccinating against ND.
6. Details of other treatments that are used.
7. Details of poultry housing.
8. Details of chicken feeding.
9. Details of chickens and eggs that were consumed and sold in the past three months, broken down by indigenous and exotic chickens.
10. Income received for the sale of chickens, where the chickens are sold and how the revenue is used.

Five Huawei Y-3 Android smartphones were purchased in Tanzania. This model was selected because of its cost (around 80 USD), its screen size, its in-built Global Positioning System (GPS) and the currency of the Android operating system. The ODK Collect app was loaded and the Swahili questionnaire uploaded to the devices. The ODK Collect app recorded the GPS coordinates of the surveyed household as well as the start and end time of the questionnaire. During training in Babati District in January 2017, in the village of Galappo, the questionnaire was tested and further revised.

At the end of each survey day, the data were uploaded to a Google-hosted server by connecting the survey smartphones to the smartphone owned by Dr Sultan, which was used as a wireless hotspot. The data coming in was monitored by Mr Paul Bessell

Implementation

Prior to carrying out the survey, the survey team of four local enumerators and Dr Sultan assembled in Galappo Village and was trained in use of the survey smartphones, the ODK Collect app and the questionnaire. The group then practised using the smartphones and the ODK Collect app before visiting households. After speaking with villagers who were involved with the sale of vaccines, households that kept chickens and were adopters or non-adopters of ND vaccines were identified.

The households were visited by an enumerator who administered the questionnaire. If the smallholder was unwilling to participate or the person responsible for looking after the chickens was not available for interview, the enumerator moved on to the next household. Initially, whilst the enumerators were becoming familiar with the ODK Collect app, they visited the households in pairs. Thereafter, the enumerators worked as individuals, but were accompanied occasionally by Dr Sultan for quality control. The surveys were carried out during March and April 2017. This was at the end of the dry season and coincided with the beginning of delayed rains that interfered with access to some villages.

Results

Summary of results

Table 1 Summary table of results described in this paper. *P*-values represent the *p*-values of Fisher's exact test for categorical variables and the Wilcoxon signed rank test for continuous variables.

Outcome	Non-adopters	Good adopters	Statistical significance
Mean flock size	18.9	29.9	$p < 0.001$
Keeping improved breeds	2.7%	21.2%	$p < 0.001$
Treating chickens with dewormers	10.8%	54.0%	$p < 0.001$
Vaccinating against Gumboro disease or fowl pox	1.1%	15.3%	$p < 0.001$
Mean investment in medicines or dewormers (three months' expenditure)	0.8 USD	2.37 USD	$p < 0.001$
Providing supplementary feed	89.2%	99.2%	$p < 0.001$
Mean expenditure on feed during the previous three months	1.56 USD	10 USD	$p < 0.001$
Using a poultry house	32.4%	60.1%	$p < 0.001$
Mean number of chickens consumed during the previous three months	5.35	8.91	$p < 0.001$
Mean number of chickens sold during the previous three months	4.55	10.91	$p = 0.001$

Detailed results

A total of 447 smallholders were enrolled in the intervention areas of Manyara Region (142 in Babati, 152 in Hanang and 153 in Mbulu). One hundred and four smallholders were enrolled in Handeni District. The distribution of the enrolled households is shown in Figure 2 and Figure 3; note that the locations of 25 households were not recorded due to occasional problems with the GPS.

Figure 2. Map showing the location of the enrolled households in Manyara Region.

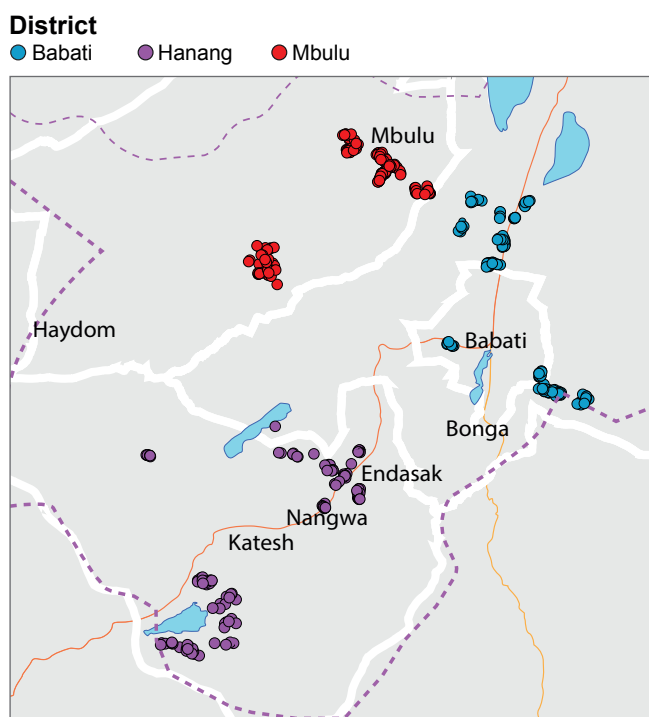
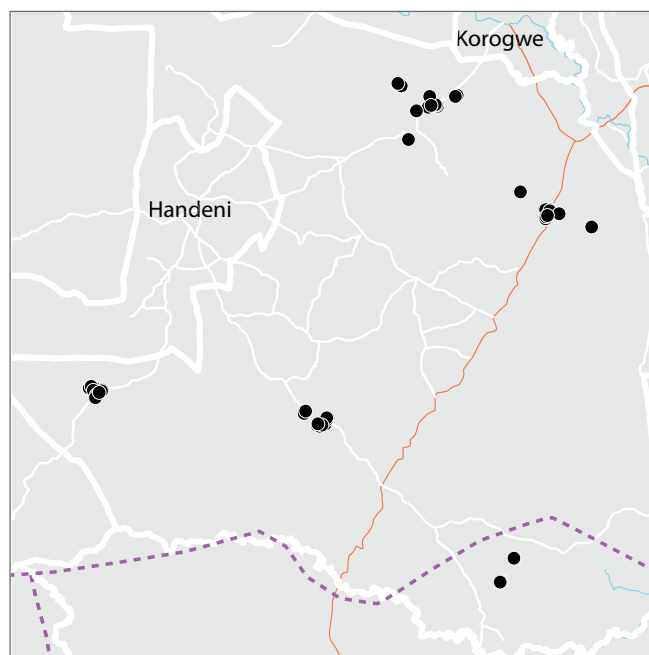


Figure 3. Map showing the location of the enrolled households in Handeni District.



Newcastle disease

Only nine households (1.6%) claimed to have no knowledge of ND. In all districts, around 50% of smallholder households were vaccinating against ND; this conclusion is based on responses to the question "Have you ever vaccinated your chickens against Newcastle disease?" (Table 2).

Table 2. Number of households vaccinating or not vaccinating flocks in each district, according to responses to the question "Have you ever vaccinated your chickens against Newcastle disease?"

District	Non-adopters	Adopters
Babati	68	74
Hanang	72	80
Mbulu	73	80
Handeni	46	58

Of the 292 respondents that reported never having vaccinated, 174 (59.6%) reported that they either did not vaccinate during 2016 or only vaccinated once. Based on these variations, respondents were reclassified as:

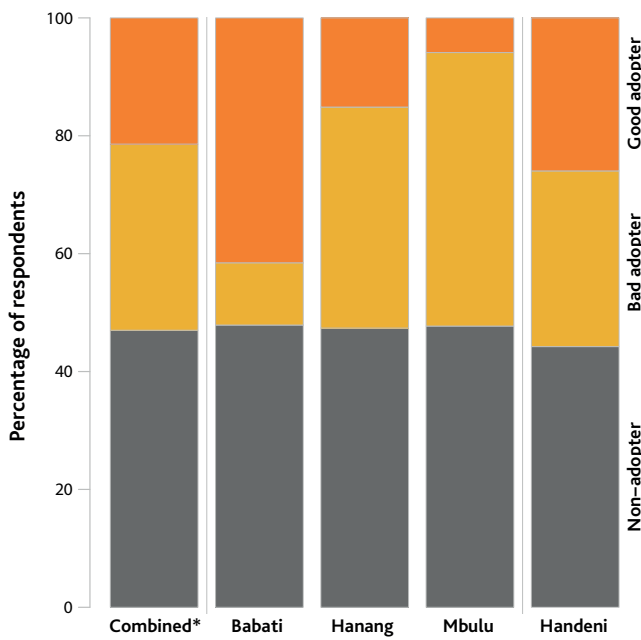
- **Non-adopters**, who reported never having vaccinated.
- **Bad adopters**, who had vaccinated but during 2016 vaccinated only once or not at all.
- **Good adopters**, who vaccinated at least twice during 2016. NB. Vaccination of all chickens is recommended every three to four months.

In Babati District, the majority of adopters were good adopters; this proportion was also high in Handeni District. However, in Hanang and Mbulu districts, most adopters were bad adopters: in these districts, smallholders had used little vaccine during 2016 (Table 3, Figure 4).

Table 3. Percentage of households vaccinating flocks in each district by the standards with which they use vaccines.

District	Non-adopters	Bad adopters	Good adopters
Babati	68 (47.9%)	15 (10.6%)	59 (41.5%)
Hanang	72 (47.4%)	57 (37.5%)	23 (15.1%)
Mbulu	73 (47.7%)	71 (46.4%)	9 (5.9%)
Handeni	46 (44.2%)	31 (29.8%)	27 (26.0%)

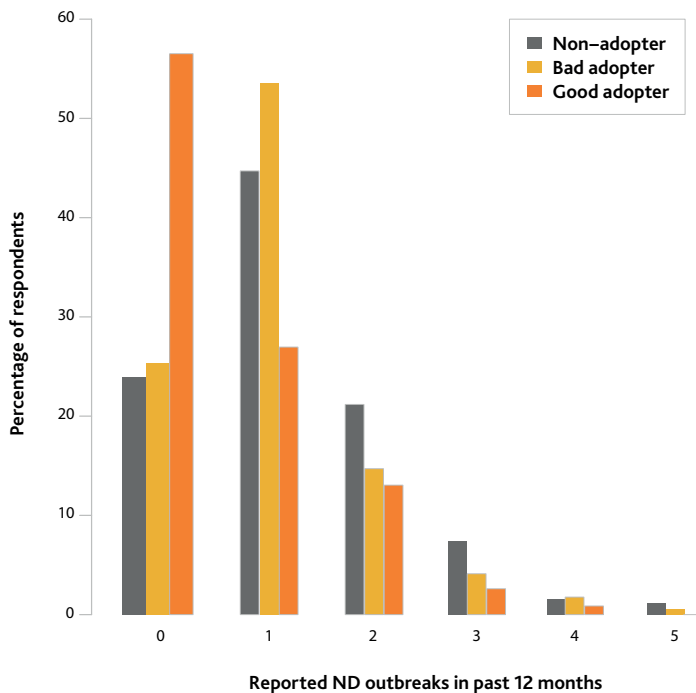
Figure 4. Barplot of vaccination adoption by district.



*Combined figures exclude Handeni.

Adopters of ND vaccines reported significantly fewer ND outbreaks than did non-adopters: non-adopters reported a mean of 1.22 outbreaks per year compared to 0.89 for those who vaccinated flocks (Figure 5). Adopters also reported fewer chicken deaths due to ND: 11.4 per year compared to 13.8 per year among non-adopters. This was also significant ($p < 0.001$).

Figure 5. Barplot of numbers of Newcastle disease (ND) outbreaks reported during the past 12 months by ND vaccine adoption.



The majority of the bad adopters had been vaccinating against ND for less than one year whilst among the good adopters, the greatest number had been vaccinating for more than two years (Table 4).

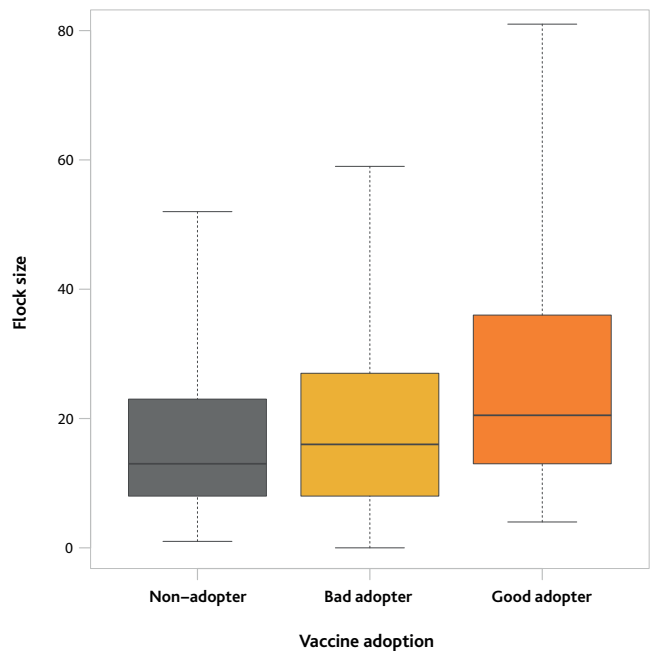
Table 4. The length of time that adopters had been practising vaccination against Newcastle disease.

Time vaccinated	Vaccine adoption	
	Bad adopter	Good adopter
Less than 1 year	91 (52.3%)	44 (37.3%)
1–2 years	50 (28.7%)	29 (24.6%)
More than 2 years	33 (19.0%)	45 (38.1%)

Chicken flock

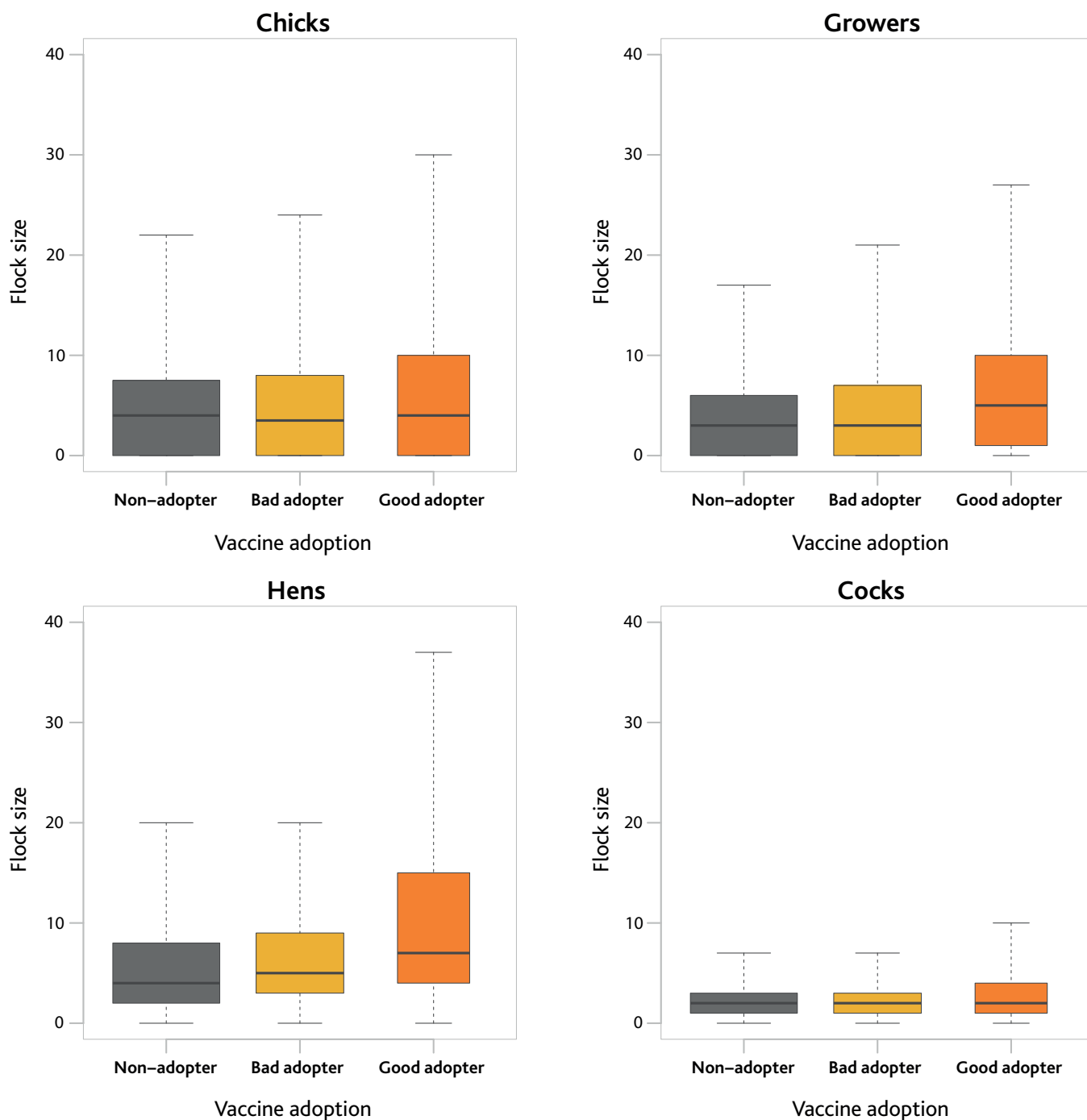
The mean flock size was 22.2 birds (median 15 birds), with significantly greater numbers in flocks of households that had adopted ND vaccination (Figure 6; $p < 0.001$).

Figure 6. Boxplot of flock size broken down by adoption of Newcastle disease vaccination. The centre line represents the median, and the extremes of the box the 1st and 3rd quartiles. The horizontal lines outside of the boxes represent twice the interquartile range or the most extreme data point; outliers are excluded. Note that the y-axis has been truncated at 80.



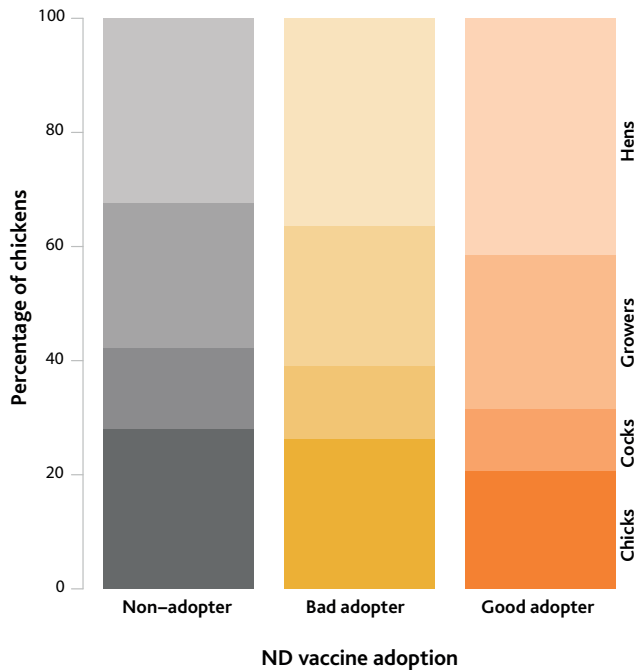
Flock sizes were smaller in Mbulu District (mean size 14.4 chickens) and larger in Babati (mean size 22.4 chickens), Hanang (mean size 28.2 chickens) and Handeni (mean size 24.4 chickens) (Figure 7); this is significant ($p < 0.001$). The principal difference in flock size was dictated by the extent to which households adopted ND vaccination (Figure 7).

Figure 7. Boxplot of flock sizes broken down by adoption of Newcastle disease vaccine and bird type. The centre line represents the median, and the extremes of the box the 1st and 3rd quartiles. The horizontal lines outside of the boxes represent twice the interquartile range or the most extreme data point; outliers are excluded. The width of the box represents the number of households in that group.



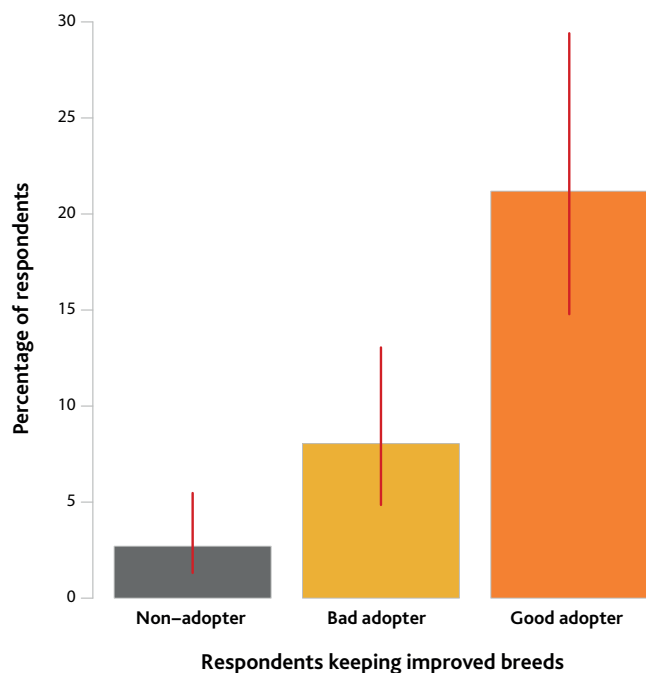
Unusually, the vaccinated flocks had a greater proportion of hens and smaller proportion of chicks (Figure 8). This is in contrast to the findings from Bessell et al (2017).

Figure 8. Stacked barplot of the different types of flock birds broken down by Newcastle disease (ND) vaccination practices.



The breeds of chicken that were kept were almost exclusively indigenous (505 flocks, 91.7%). Only 11 households (2%) reported that they kept exotic breeds. Analysing those that had either cross-breeds or exotic breeds compared to indigenous breeds showed that significantly more adopters kept improved breeds; these numbers remained small at 21.2% but are statistically significant (Figure 9; $p < 0.001$).

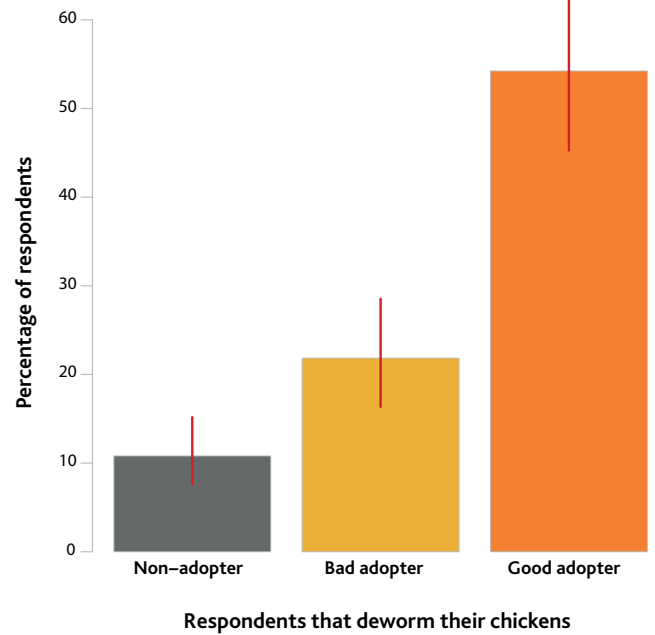
Figure 9. Proportion of respondents keeping improved breeds by vaccination status. Red lines represent the 95% confidence intervals.



Other vaccines and treatments

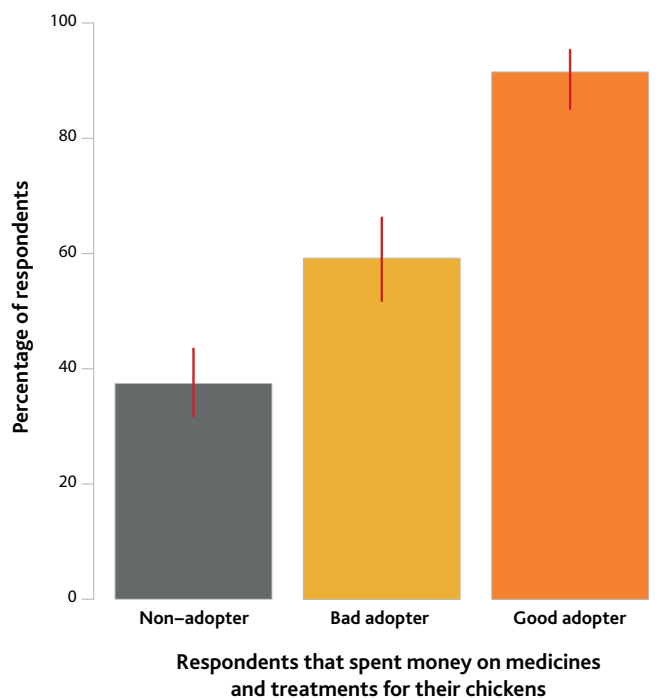
The good adopters were most likely to use dewormers on their chickens; 54% reported that they deworm their chickens, compared to only 10.8% of the non-adopters (Figure 10).

Figure 10. Barplot of the percentage of respondents that deworm their chickens. Red lines represent the 95% confidence intervals.



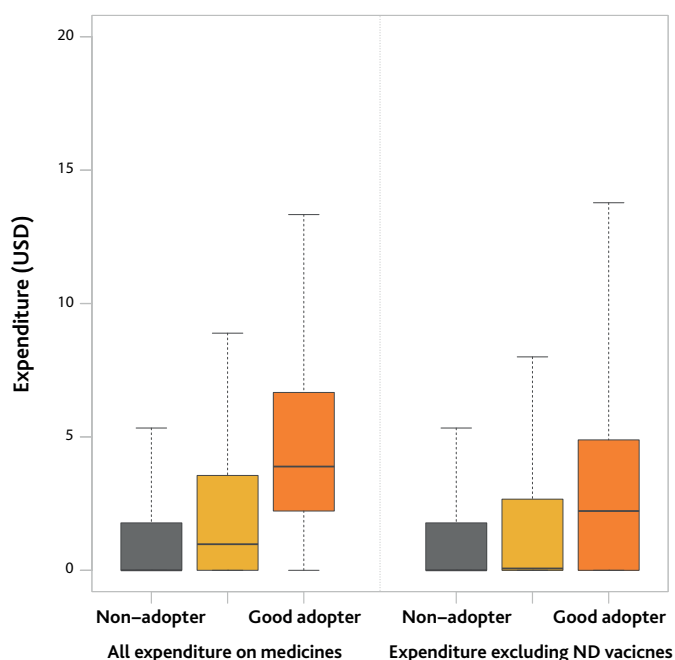
Only 27 respondents reported that they use vaccines against diseases other than ND: 20 vaccinated against fowl pox and 14 against Gumboro disease. Those that vaccinated against Gumboro disease and fowl pox had larger flocks (mean size 40 and 48 respectively) compared to those that did not (mean 22.1). However, 55.9% responded that they had spent some money on medicines, vaccines and dewormers during the past three months; this was significantly greater among good adopters than non-adopters (Figure 11).

Figure 11. Barplot of the percentage of respondents that had spent money on their chickens. Red lines represent the 95% confidence intervals.



The overall spend on medicines, vaccines and dewormers was higher among good adopters; this remains the case after expenditure on ND vaccines are excluded from the analysis (Figure 12). The median expenditure over the previous three months was zero among non-adopters, 0.07 USD among bad adopters, and 2.22 USD among good adopters. The adjusted mean to correct for outliers is 0.8 USD among non-adopters, 1 USD among bad adopters and 2.37 USD among good adopters. This means that expenditure on medicines other than ND vaccines was almost three times higher among good adopters compared to non-adopters (Figure 12).

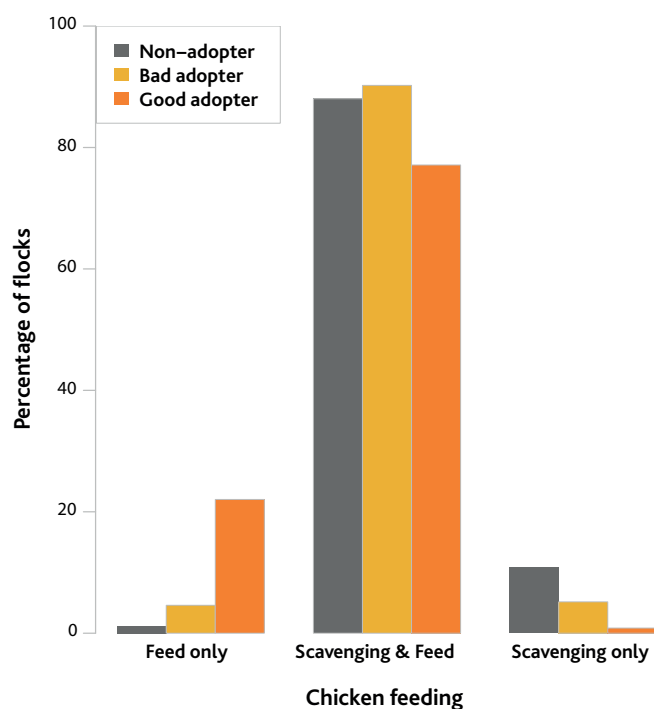
Figure 12. Boxplot of the expenditure on medicines, vaccines and dewormers during the past three months, for all medicines and excluding money spent on dewormers. The centre line represents the median, and the extremes of the box the 1st and 3rd quartiles. The horizontal lines outside of the boxes represent twice the interquartile range or the most extreme data point; outliers are excluded.



Feeding

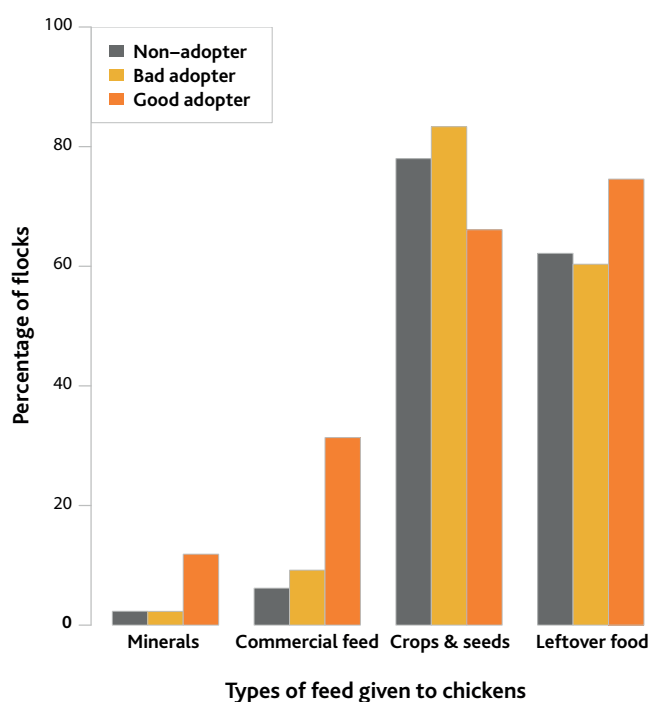
The majority of respondents (86.4%) allowed their chickens to scavenge but also gave some supplementary feeding (commercial, fodder, or leftovers). However, a small percentage (6.7%; 37 respondents) only fed their chickens and for 6.9% (38 respondents) chickens only scavenged with no supplementary feeding. The chickens that scavenged only were more likely to be owned by non-adopters, and were also more likely to be in Handeni (the comparison district): 73.6% of those that did not give any feed were in Handeni. Twenty-two per cent of good adopters' chickens were given feed only (Figure 13). The respondents that gave feed only were also significantly more likely to own larger flocks (median size 39 compared to 15 in other flocks; $p < 0.001$).

Figure 13. Barplot of the percentage of respondents giving different feeding regimes.



Whilst it was unusual for respondents to give mineral supplementation – it was given by only 24 respondents (4.4%) overall – 11.9% of good adopters gave minerals. The same is the case for commercial feed; this was used by 69 of respondents (12.5%) overall, but by 31.4% of good adopters (Figure 14). These differences are significant ($\chi^2_6 = 55.6$; $p < 0.001$).

Figure 14. Barplot of the percentage of respondents giving different types of feed. Note that respondents could give several different types of feed.



The majority of respondents that gave their chickens feed (81.7%) fed their chickens throughout the year. However, 5.7% fed their chickens only during agricultural activities, 5.5% only during the dry season and 7.2% (principally in Handeni District) only during the wet season. The median expenditure on feed during the past three months by non-adopters was 1.56 USD, compared to 10 USD among good adopters (Figure 15); these figures translate to 0.18 USD and 0.61 USD per chicken respectively (Table 5).

Figure 15. Boxplot of the expenditure on chicken feed during the past three months. The centre line represents the median, and the extremes of the box the 1st and 3rd quartiles. The horizontal lines outside of the boxes represent twice the interquartile range or the most extreme data point; outliers are excluded.

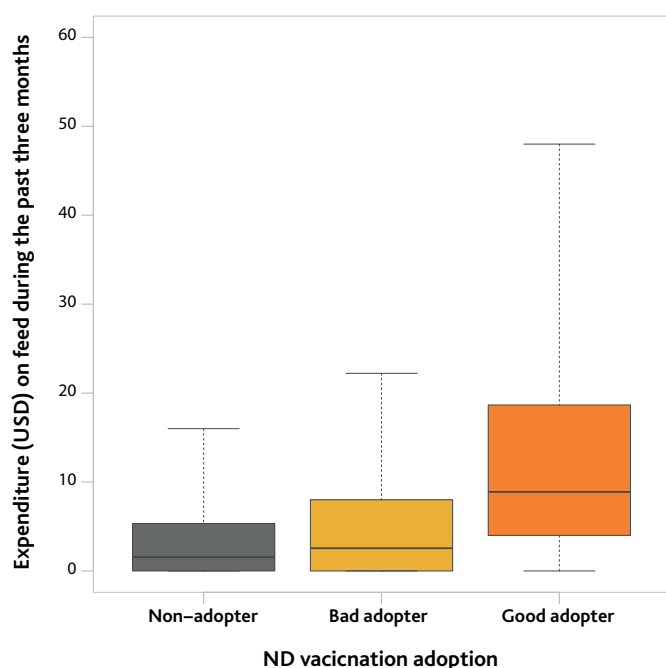


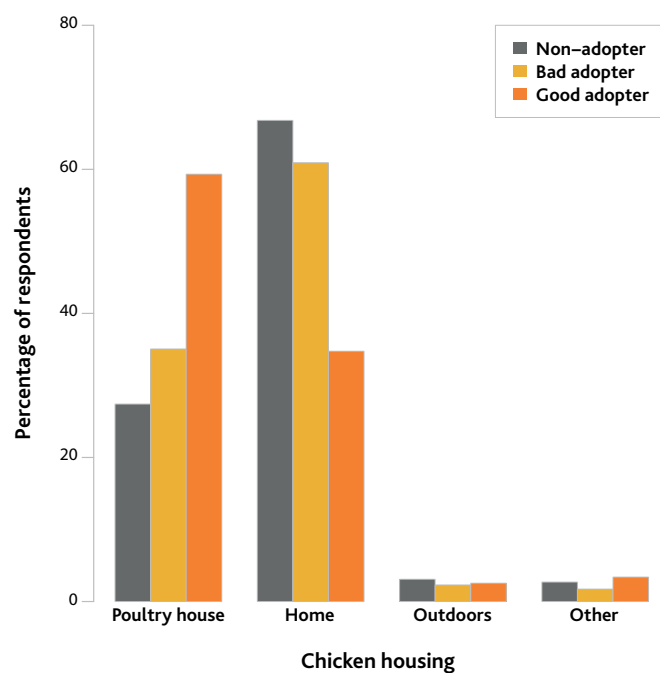
Table 5. Levels of expenditure on feed during the previous three months by the different vaccinator classes. Note that three respondents (two bad adopters and one good adopter) who reported spending 400,000 TSh or more have been excluded as outliers and most likely erroneous.

Adoption status	Expenditure (USD) on chicken feed		
	Mean spend	Median spend	Spend/chicken
Non-adopter	3.43	1.56	0.18
Bad adopter	6.75	2.56	0.31
Good adopter	17.96	10.00	0.61

Housing

The majority of good adopters (59.3%) used some sort of specialised poultry housing, whilst the majority of non-adopters and bad adopters (66.8% and 60.9% respectively) kept their chickens in the house where the family lived (Figure 16). Few left their chickens outdoors, whilst a small number of 'others' kept their chickens in the stalls with other livestock.

Figure 16. Barplot of the percentage of respondents giving different types of housing.



Examples of different types of poultry housing.



Consumption and sales

The total off-take (the combination of consumption and sales of chickens) was significantly greater for the good adopters (Figure 17; $p < 0.001$). The numbers of chickens sold and consumed were greatest among the good adopters. These numbers were also high among bad adopters but this is largely driven by some high values that may have been errors, but cannot be marked as errors with confidence (Table 6). Interestingly, there is no association between egg sales or consumption and adoption of the ND vaccine (Table 6).

Figure 17. Boxplot of the off-take of chickens by status of Newcastle disease vaccination. The centre line represents the median, and the extremes of the box the 1st and 3rd quartiles. The horizontal lines outside of the boxes represent twice the interquartile range or the most extreme data point; outliers are excluded.

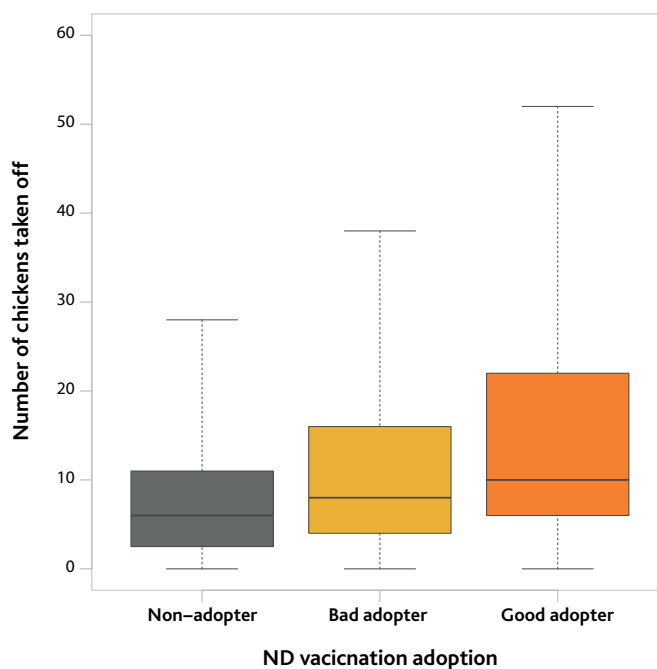


Table 6. Breakdown of off-take over the past three months by different categories of Newcastle disease vaccination. The respondents column relates to the number of households that had reported figures for that category.

	Adoption status	Mean number	Median number	Number/chicken	Respondents
Chicken off-take	Non-adopter	9.89	6	0.534	232 (92.4%)
	Bad adopter	14.70	8	0.666	157 (93.5%)
	Good adopter	19.82	10	0.666	107 (94.7%)
Chicken consumption	Non-adopter	5.35	4	0.288	226 (90.0%)
	Bad adopter	8.67	6	0.392	151 (89.9%)
	Good adopter	8.91	6	0.299	106 (93.8%)
Chicken sales	Non-adopter	4.55	0	0.245	107 (42.6%)
	Bad adopter	6.04	2	0.274	99 (58.9%)
	Good adopter	10.91	2	0.367	63 (55.7%)
Egg consumption (two weeks)	Non-adopter	12.6	6	0.680	180 (71.7%)
	Bad adopter	30.8	8	1.397	126 (75.0%)
	Good adopter	12.8	10	0.429	92 (81.4%)
Egg sales (two weeks)	Non-adopter	7.72	0	0.416	57 (22.7%)
	Bad adopter	17.5	0	0.792	47 (38.0%)
	Good adopter	13.8	0	0.465	28 (24.8%)

Furthermore, the good adopters realised greater values for selling hens and cocks (Table 7). The values realised for selling chicks and growers can be disregarded owing to the small sample sizes.

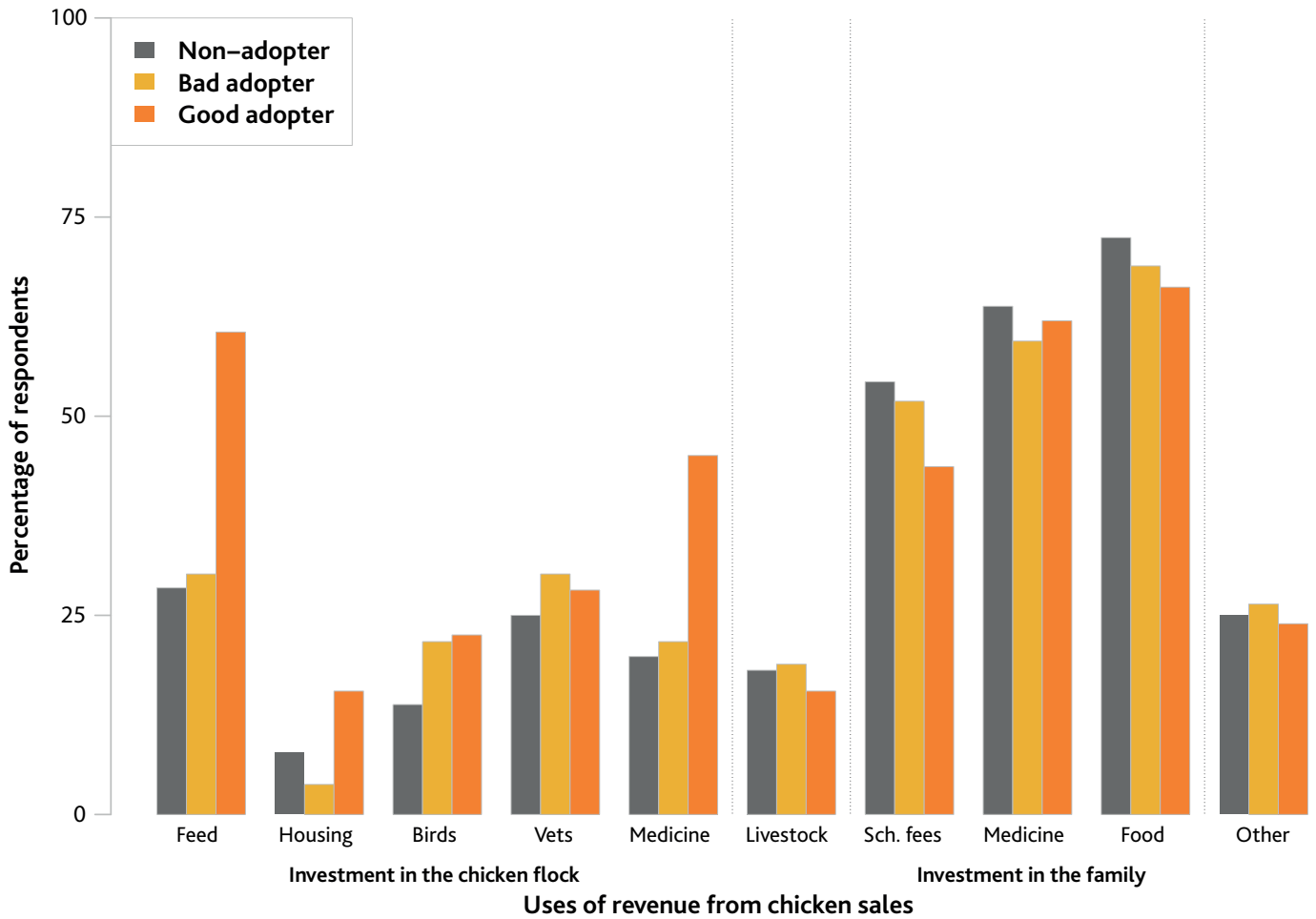
Table 7. Responses to the question “Estimate the value that you expect to receive for selling...”, broken down by adoption of Newcastle disease vaccine.

	Mean value (USD) realised (number of respondents)		
	Non-adopter	Bad adopter	Good adopter
Chicks	1.37 (7)	1.07 (3)	2.22 (1)
Growers	2.25 (21)	2.53 (16)	2.30 (12)
Hens	2.86 (60)	3.19 (53)	3.70 (40)
Cocks	4.85 (98)	5.30 (87)	5.53 (61)

Uses of revenue

Two hundred and ninety-three responses reported using the revenue from chicken sales. Of these, 116 were non-adopters, 106 bad adopters and 71 good adopters. Uses of revenue were similar irrespective of the ND vaccination group, but good adopters were more likely than other respondents to spend revenue on feed and medicines, including vaccines (Figure 18).

Figure 18. Barplot of the percentage of respondents reporting different uses of the revenues from sales. Note that the responses are not mutually exclusive and are only for the 293 respondents that reported sales of chickens.



Secondary results

Other livestock

The good adopters were typically less likely to farm species other than chickens – cattle, goats, sheep and pigs. Out of all 551 respondents, 58.6% farmed cattle, 54.1% goats, 33.9% sheep and 21.8% pigs (Figure 19). Those that were good adopters also kept fewer of each non-chicken species (Figure 20).

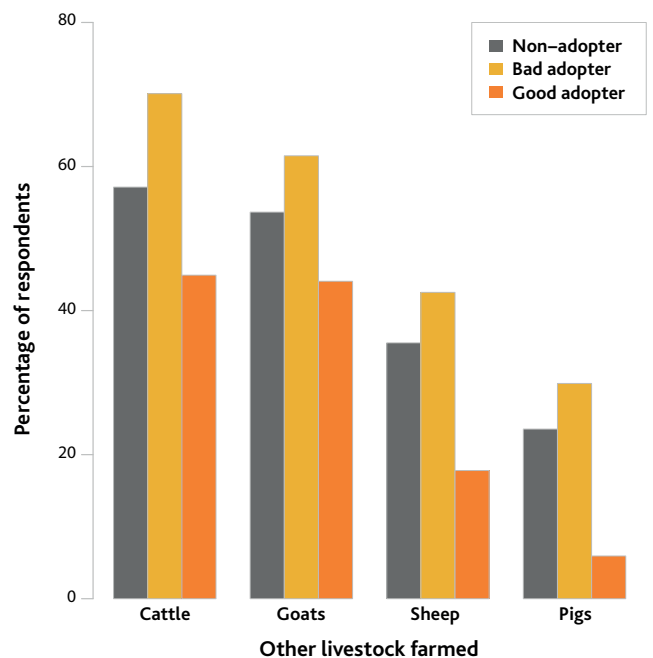
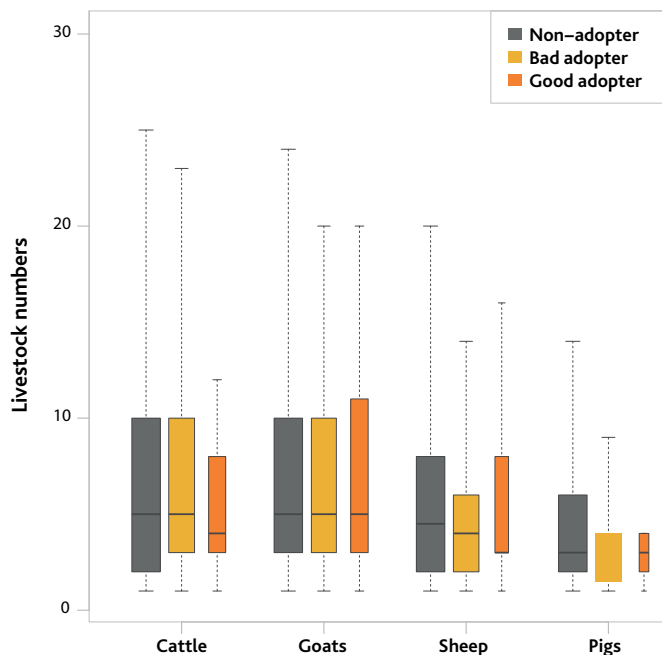


Figure 19. Barplot of the percentage of respondents that farmed species other than chickens.

Figure 20. Boxplot of the numbers of other livestock reported by respondents by status of Newcastle disease vaccination. The centre line represents the median, and the extremes of the box the 1st and 3rd quartiles. The horizontal lines outside of the boxes represent twice the interquartile range or the most extreme data point; outliers are excluded. Those that did not farm a particular species are excluded from the analysis for that species, and so the baseline is 1.



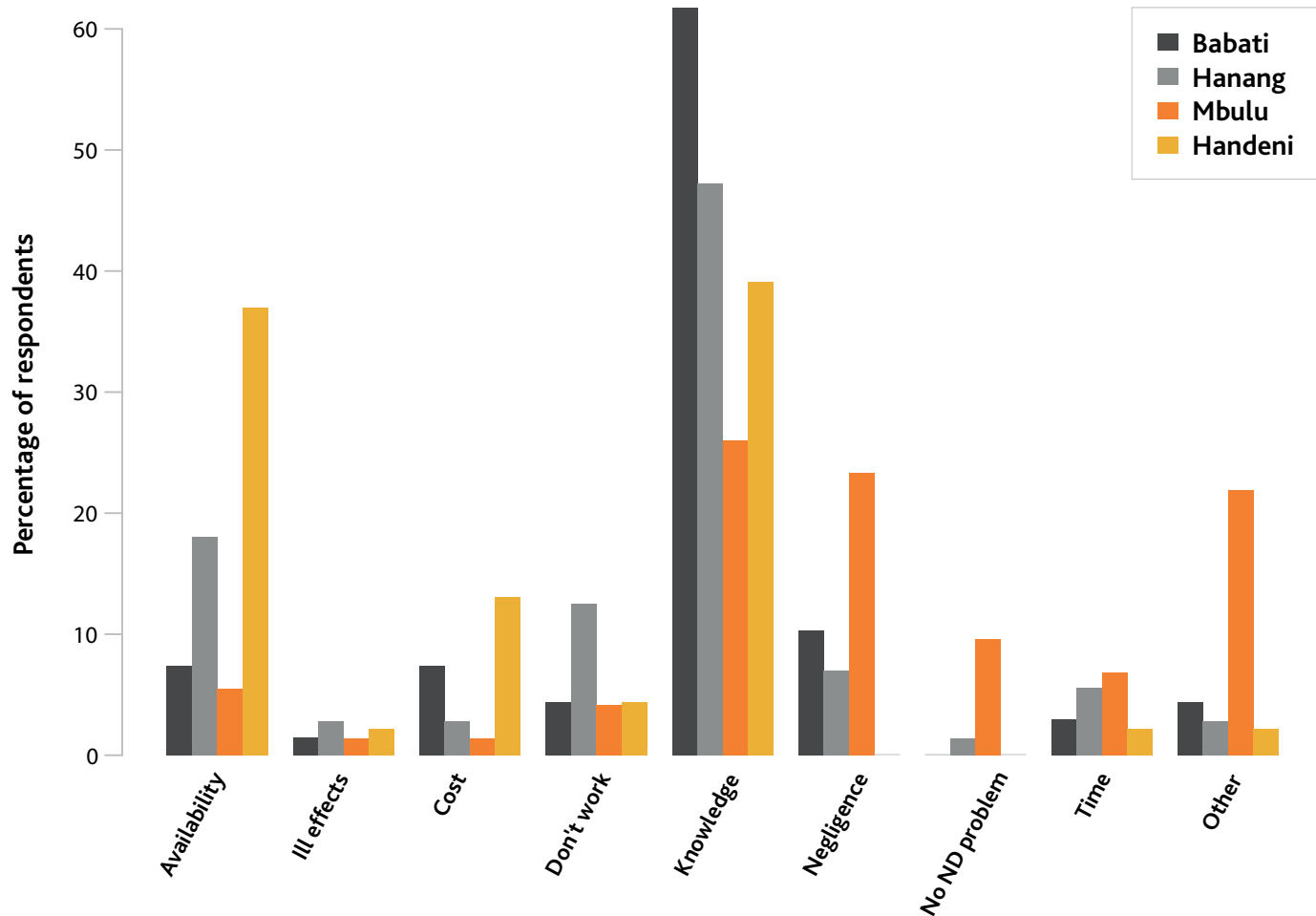
Newcastle disease vaccination practices

The majority of flocks (224; 76.7%) were vaccinated using eye drops, but 61 (20.9%) were vaccinated using drinking water, whilst seven respondents reported vaccinating through injection or feed.

One hundred and thirty-seven respondents (46.9%) nominated the community vaccinator to administer the ND vaccines. One hundred and one respondents (34.6%) administered the vaccines themselves, having purchased them from an agro-vet store, and 50 (17.1%) nominated an animal health extension worker.

In Handeni, a district where there has been no market development initiative and in theory no formal route of community vaccination, six respondents (10.7%) reported that community vaccinators vaccinated the chickens. Overall, the principal reason for not vaccinating was cited as a lack of knowledge of ND vaccines; in Handeni a large number of respondents also cited reasons of availability (Figure 21).

Figure 21. Reasons cited by respondents for not vaccinating.



Respondent characteristics

The respondents were 330 females (59.9%) and 220 males (40.1%); for one respondent the gender had not been entered. Similar proportions of both male and female respondents fell into the three categories of response (Table 8).

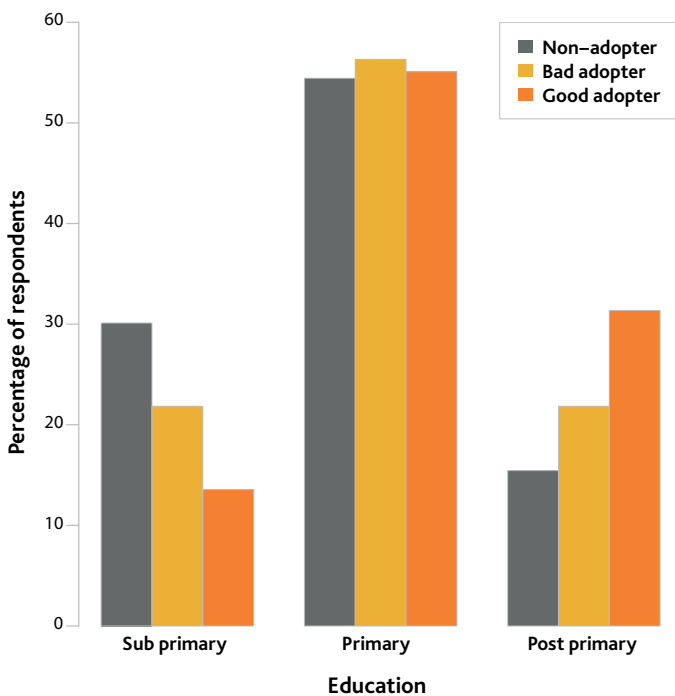
Table 8. Breakdown of the adoption of Newcastle disease vaccination by gender. Percentages relate to the percentage of that gender.

Adoption status	Female	Male
Non-adopter	156 (47.2%)	103 (46.8%)
Bad adopter	102 (30.9%)	71 (32.3%)
Good adopter	72 (21.8%)	46 (20.9%)

In terms of primary sources of household income, 95.6% nominated crops, and 87.8% livestock. Only 15.2% had employment elsewhere and nine respondents named fishing as a primary source of income. Note that respondents could respond with more than one primary income source.

The majority of respondents (304; 55.2%) were educated to primary level. One hundred and thirty-two (24.0%) were educated to below primary level and 115 (20.9%) to above primary level. As the education level increased, the proportion that adopted ND vaccination increased (Figure 22) and this is significant ($X^2_4 = 19.8$; $p < 0.001$).

Figure 22. The education level of the respondents broken down by adoption of Newcastle disease vaccination. One hundred and thirty-two respondents had sub-primary education, 304 had primary and 115 had post primary.

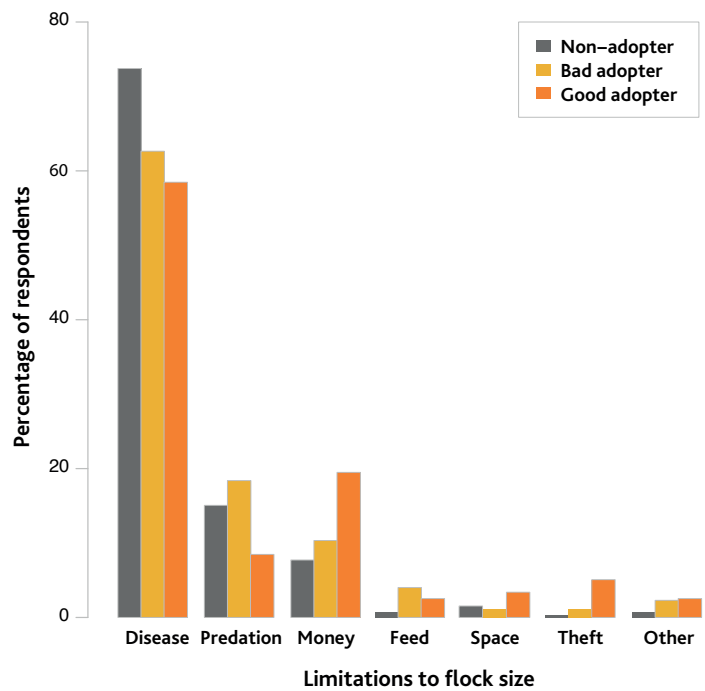


Future ambitions for the flock

In response to the question “What do you plan to do with your flock in the future?”, the majority of respondents (448; 81.3%) responded that they wished to grow their flock; 69 (12.5%) reported that they wished to shrink their flock. No respondents reported that they wished to “Maintain the flock but farm other species”, even though 134 respondents (24.3%) did not farm any non-poultry species. Three respondents reported that they wished to sell their flock.

The principal limitation on the size of respondents’ flocks was disease. However, this was a smaller proportion among ND vaccine adopters, who were more likely than non-adopters to cite a lack of money as the principal limitation to flock size (Figure 23).

Figure 23. Barplot of the limitations on flock size.



Most respondents (92.4%) received no assistance to develop their flock. Thirty-one had received some assistance from a non-governmental organisation (NGO), ten a loan and four some microfinance.

Conclusions

Respondents that vaccinated their chickens against ND have better husbandry practices. Specifically:

- They spend more on medicines and are more likely to use dewormers. This may be because the community vaccinators also sell dewormers.
- They are more likely to use poultry housing and less likely to keep their chickens in their home.
- They spend more on feed, particularly commercial feeds; however, usage of mineral supplements is still poor.
- Although most still keep indigenous breeds, a greater proportion of adopters (21.2%) kept improved breeds compared to non-adopters (2.7%) and bad adopters (8.05%).

It is difficult to ascertain whether improved husbandry is the result of vaccination against ND or whether ND vaccination is practised by farmers that adopt better husbandry (something of a chicken and egg situation, for want of a better expression). There was no evidence that people are farming chickens as a 'stepping stone' to farming larger species. There are some NGO support schemes that promote improved poultry husbandry, but there is no evidence of this in our study: few respondents cited support from an NGO. We can conclude that those that practise both better husbandry and ND vaccination will be more productive.

In addition to employing improved husbandry, respondents that vaccinated:

- Are better educated which most likely influences their decision to use vaccines.
- Have larger flocks.
- Sell and consume more chickens.
- Receive greater prices when they sell chickens.

These findings are consistent with the results from GALVmed's previous field studies.

There are also a number of more general observations regarding ND control:

- Many people will say that they vaccinate their chickens against ND, but adherence to the recommended administration is often poor. The greater proportion of those that stated that they vaccinate was therefore ultimately classed as 'bad adopters'. It was those that were 'good adopters', vaccinating their chickens at least twice during a year, that adopted better husbandry practices.
- Handeni was included as a comparison district in which no market development initiatives for promoting ND vaccination had taken place. It was therefore expected that the practice of ND vaccination would be much poorer in Handeni than in the intervention districts of Hanang and Mbulu and Babati. In fact, Handeni was observed to be an area with a large amount of chicken farming and animal health extension workers that were very active in promoting ND vaccines; vaccine adoption in the district was greater than that in Hanang and Mbulu, but lower than in Babati.

- Those that adopted ND vaccines were less likely to own other species and typically did not have ambitions to own other species. This may be because these households regarded their farming as being just chicken farming and therefore considered chickens as their core focus of investment.
- Those that owned other species paid less attention to treatments for their chickens. This may be because they focused their attention and investments on higher value species, and regarded chickens as something of a 'hobby' or as a 'current account' rather than the 'savings account' that was the other species.

Lessons learned

- Data collection using the ODK Collect app was successful. It resulted in a clean dataset that was georeferenced and had a number of checks on data quality. Furthermore, the app gave the project manager the ability to monitor the study as it progressed. It also minimised data loss at the stage of data entry.
- Improvements could be made to the use of the ODK Collect app, and more validation steps could be included. Furthermore, these were some issues in the use of GPS in the field. These problems were eventually overcome, but the process would have been made easier if each phone had its own SIM card. However, sourcing and maintaining such SIM cards would create administrative overheads.
- There are clearly issues surrounding ND vaccination programmes as some of districts adhered very poorly to their usage. Adherence to ND vaccination was better in Handeni than in Mbulu and Hanang.
- It was unfortunate that the analysis required dividing the respondents into three categories, rather than two categories of adopter and non-adopter. However, this was necessary given the challenges of identifying smallholders that vaccinate their chickens. The sampling strategy could have been altered to actively seek out 'good adopters' but this may have weakened the quality of data. Furthermore, the final sample size was adequate for providing significant results; this may not have been the case otherwise.

Acknowledgements

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The study was managed on behalf of GALVmed by Paul Bessel of EPI Interventions, prbessel@gmail.com. Data collection in Tanzania was undertaken by Dr Jaribu Sultan, jaribusultan@gmail.com and his team of field workers.

Reference

Bessell, P.B., Kushwaha, P., Moshia, R., Woolley R., Al-Riyami, L., Gammon, N., 2017. Assessing the impact of a novel strategy for delivering animal health interventions to smallholder farmers. *Preventative Veterinary Medicine*, 147, 108–116.

Appendix 1

Questionnaire

Respondent details

Respondent last name	
Respondent first name	
Respondent gender	<input type="radio"/> Female <input type="radio"/> Male
District	<input type="radio"/> Babati <input type="radio"/> Hanang <input type="radio"/> Mbulu <input type="radio"/> Handeni
Village	
Address	
Respondent education	Select ONE: <input type="radio"/> Illiterate <input type="radio"/> Literate without formal schooling <input type="radio"/> Literate below primary school <input type="radio"/> Primary school <input type="radio"/> Middle or secondary school <input type="radio"/> High school <input type="radio"/> Diploma or certificate course <input type="radio"/> Graduate <input type="radio"/> Postgraduate or above
Is the respondent responsible for looking after the chickens?	<input type="radio"/> Yes <input type="radio"/> No
Who takes care of the poultry?	Select ALL that apply: <input type="checkbox"/> Adult female(s) <input type="checkbox"/> Adult male(s) <input type="checkbox"/> Young boys in the house <input type="checkbox"/> Young girls in the house
What are the primary occupations / sources of income for the household?	Select ALL that apply: <input type="checkbox"/> Farming own crops <input type="checkbox"/> Farming own livestock <input type="checkbox"/> Fishing <input type="checkbox"/> Employed elsewhere

This section is about meat and egg consumption

Approximately how frequently do you eat chicken meat?	Select ONE: <input type="radio"/> More than twice per week <input type="radio"/> Twice per week <input type="radio"/> Once per week <input type="radio"/> Twice per month <input type="radio"/> Once per month <input type="radio"/> Less than once per month <input type="radio"/> Never
Approximately how frequently do you eat eggs?	Select ONE: <input type="radio"/> More than twice per week <input type="radio"/> Twice per week <input type="radio"/> Once per week <input type="radio"/> Twice per month <input type="radio"/> Once per month <input type="radio"/> Less than once per month <input type="radio"/> Never
Approximately how frequently do you eat other meat?	Select ONE: <input type="radio"/> More than twice per week <input type="radio"/> Twice per week <input type="radio"/> Once per week <input type="radio"/> Twice per month <input type="radio"/> Once per month <input type="radio"/> Less than once per month <input type="radio"/> Never

Details of chickens owned

Total cocks	
Total hens	
Total growers	
Total chicks	
Total chickens (all ages)	
What breeds of chicken do you keep?	<p>Select All that apply:</p> <input type="checkbox"/> Indigenous <input type="checkbox"/> Cross breed <input type="checkbox"/> Pure exotic <input type="checkbox"/> Don't know
What is the principal cause of loss in your flock?	<p>Select ONE:</p> <input checked="" type="radio"/> Disease <input checked="" type="radio"/> Predation <input checked="" type="radio"/> Theft <input checked="" type="radio"/> Other (Specify):
What do you plan to do with your flock in the future?	<p>Select ONE:</p> <input checked="" type="radio"/> Grow the flock <input checked="" type="radio"/> Keep the flock the same size <input checked="" type="radio"/> Maintain the flock but farm other species <input checked="" type="radio"/> Shrink the flock size <input checked="" type="radio"/> Sell the flock <input checked="" type="radio"/> Not considered <input checked="" type="radio"/> Don't know
What is the main reason for not growing your flock?	<p>Select ONE:</p> <input checked="" type="radio"/> Lack of availability of feed <input checked="" type="radio"/> Disease <input checked="" type="radio"/> Predation <input checked="" type="radio"/> Theft <input checked="" type="radio"/> Lack of money to invest in the flock <input checked="" type="radio"/> Lack of space <input checked="" type="radio"/> Do not wish to grow flock <input checked="" type="radio"/> Other (Specify):

Other species farmed

Does the smallholder own any other species?	<input type="radio"/> Yes <input type="radio"/> No
---	---

If 'Yes' then list all that are farmed:

Number of cattle	
Number of goats	
Number of sheep	
Number of pigs	
Number of turkeys	
Number of ducks	
Number of Guinea fowl	
Number of horses	
Number of donkeys	

If 'No' then:

Why do you not own any other species?	Select ALL that apply: <input type="checkbox"/> Lack of space <input type="checkbox"/> Lack of grazing <input type="checkbox"/> Lack of money <input type="checkbox"/> Disease <input type="checkbox"/> I do not wish to own other species
---------------------------------------	---

History of Newcastle disease in the flock

Has the respondent heard of Newcastle disease?	<input type="radio"/> Yes <input type="radio"/> No
--	---

If 'Yes' then:

Estimate the number of Newcastle disease outbreaks in your flock during the past year	
Estimate the number of deaths due to Newcastle disease during the past year	
Have you ever vaccinated your chickens against Newcastle disease?	<input type="radio"/> Yes <input type="radio"/> No

If 'Yes' then:

How many months since you last vaccinated against Newcastle disease?	
For how long have you been vaccinating against Newcastle disease?	Select ONE: <input type="radio"/> Less than 1 year <input type="radio"/> Between 1 and 2 years <input type="radio"/> More than 2 years
During 2016, how many times did you vaccinate your chickens against Newcastle disease?	Select ONE: <input type="radio"/> Not at all <input type="radio"/> Once <input type="radio"/> Twice <input type="radio"/> Three times <input type="radio"/> Four times
How is the Newcastle disease vaccine administered?	Select ONE: <input type="radio"/> Eye drop <input type="radio"/> Injection <input type="radio"/> Drinking water <input type="radio"/> Feed
Who normally vaccinates your chickens?	Select ONE: <input type="radio"/> Farmer themselves <input type="radio"/> Community vaccinator <input type="radio"/> Government extension officer <input type="radio"/> CBO / NGO <input type="radio"/> Other (specify):
What is the cost (in Tshs) of a dose of Newcastle disease vaccine?	

If 'No' then:

Why do you not vaccinate against Newcastle disease?	Select ONE: <input type="radio"/> I do not know about vaccines <input type="radio"/> Newcastle disease is not a problem <input type="radio"/> Vaccines are too expensive <input type="radio"/> Vaccines are not easily available <input type="radio"/> Vaccines do not work <input type="radio"/> Vaccines have bad effects
---	---

Other treatments that you use for your animals

Over the past 3 months estimate, what was your total expenditure (in Tshs) on medicines, vaccines and dewormers for your chickens?	
What other vaccines do you use?	Select ALL that apply: <input type="checkbox"/> Fowl pox <input type="checkbox"/> Fowl coryza <input type="checkbox"/> Gumboro
Have you used dewormers on your chickens during the past year?	<input checked="" type="radio"/> Yes <input type="radio"/> No
Have you used dewormers on any other animals during the past year?	<input checked="" type="radio"/> Yes <input type="radio"/> No

This section relates to poultry housing

Do you have poultry housing for your chickens during the night time?	<input checked="" type="radio"/> Yes <input type="radio"/> No
--	--

If 'Yes' then:

What types of housing do you use?	Select ALL that apply: <input type="checkbox"/> Single house <input type="checkbox"/> Separated hen and chick houses <input type="checkbox"/> Cage for chicks <input type="checkbox"/> In the main house with people
-----------------------------------	--

If 'No' then:

Where do your chickens pass the night time?	Select ALL that apply: <input type="checkbox"/> Nesting on the ground <input type="checkbox"/> Roost in a tree <input type="checkbox"/> In the main house with people <input type="checkbox"/> Other <input type="checkbox"/> Don't know
---	---

This section relates to feeding the chickens

How are your chickens fed?	Select ONE: <input checked="" type="radio"/> Poultry feed only <input type="radio"/> Scavenging & poultry feed <input checked="" type="radio"/> Scavenging only
----------------------------	--

If poultry feed is given then:

What feed do you give your chickens?	Select ALL that apply: <input type="checkbox"/> Commercial feed (purchased) <input type="checkbox"/> Crops and seeds (non-purchased) <input type="checkbox"/> Leftover food <input type="checkbox"/> Mineral and vitamin supplements <input type="checkbox"/> Other – specify:
During which season are your chickens fed?	Select ONE: <input checked="" type="radio"/> All year <input type="radio"/> Dry season only <input type="radio"/> Wet season only
Over the past 3 months estimate your total expenditure (in Tshs) on chicken feed	

This section relates to how you use your chickens

<i>To the best of your memory, estimate for the past <u>3 months</u>:</i>	
The number of your own chickens that were consumed	
Were any chicks sold?	<input type="radio"/> Yes <input type="radio"/> No
<i>If yes then</i> Number of indigenous chicks sold Number of exotic/crossbreed chicks sold	
Were any growers sold?	<input type="radio"/> Yes <input type="radio"/> No
<i>If yes then</i> Number of indigenous growers sold Number of exotic/crossbreed growers sold	
Were any hens sold?	<input type="radio"/> Yes <input type="radio"/> No
<i>If yes then</i> Number of indigenous hens sold Number of exotic/crossbreed hens sold	
Were any cocks sold?	<input type="radio"/> Yes <input type="radio"/> No
<i>If yes then</i> Number of indigenous cocks sold Number of exotic/crossbreed cocks sold	
Estimate the number of chickens that were gifted	
<i>To the best of your memory, estimate for the past <u>2 weeks</u>:</i>	
Estimate the number of your own eggs that were consumed	
Estimate the number of eggs that were sold	

This section relates to financial aspects of farming

<i>Estimate the value (Tshs) that you expect to receive for selling:</i>	
1 Indigenous chick 1 Exotic / crossbred chick	
1 Indigenous grower 1 Exotic / crossbred grower	
1 Indigenous hen 1 Exotic / crossbred hen	
1 Indigenous cock 1 Exotic / crossbred cock	
1 Egg	
Where are your chickens sold?	Select ALL that apply: <input type="checkbox"/> Market <input type="checkbox"/> Locally in the village <input type="checkbox"/> Other (Specify):
Estimate the travel distance (in km) to the nearest market	
Have you received any support to help build your flock?	Select ALL that apply: <input type="checkbox"/> NGO <input type="checkbox"/> Microfinance <input type="checkbox"/> Other loan – non-microfinance <input type="checkbox"/> Other (Specify):
How do you spend the income from sales?	Select ALL that apply: <input type="checkbox"/> Poultry feed <input type="checkbox"/> Purchasing poultry housing <input type="checkbox"/> Purchasing chickens <input type="checkbox"/> Veterinary services <input type="checkbox"/> Medicines for livestock <input type="checkbox"/> Purchasing other livestock <input type="checkbox"/> School fees <input type="checkbox"/> Medical fees for family <input type="checkbox"/> Food <input type="checkbox"/> Other (Specify):



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