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Livestock mortality and offtake in sheep and goat flocks of livestock owners making use of services offered by paravets in West Afghanistan

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ABSTRACT

In the present study, we quantified the effect of livestock services provided through paravets (intermediate-level training in veterinary medicine) on mortality and offtake of small ruminants in Western Afghanistan for the years 2010, 2011 and 2013. We compared mortality in adult and in young stock, and offtake of young stock of 120 livestock owners that made use of the paravet services (Users) with 120 livestock owners who did not make use of these services (Non-users). Security issues in the districts under study influenced the choice of villages. Within villages, livestock owners were purposively selected based on their known use of the services, including the provision of biologicals such as anthelmintics and vaccines. In addition, we subdivided both categories into 'partial' and 'full' based on the intensity of use of biologicals. Paravets were not only trained on preventive and curative veterinary medicine, they were also trained in extension and trained on adhering to a cold-chain and applying quality biologicals. For Non-users there was the possibility to buy biologicals through a local market or bazaar. In Afghanistan, local markets have an extensive supply of vaccines, anthelmintics, and medicines from a variety of sources, often not handled appropriately and therefore of varying quality.

The results indicated that livestock owners making partial or full use of the paravet services had statistically significant better animal health and production results. The mortalities in adult stock, expressed as Incidence Rate Ratios (IRRs), for the partial-Users and full-Users categories were estimated to be respectively 0.80 and 0.73 times the mortality observed in the partial Non-users', the reference category. A similar result was observed for young stock mortality with estimated IRRs of 0.81 and 0.77 for partial and full-Users category respectively. The offtake for partial- and full-Users category livestock owners were 1.24 and 1.21 times higher compared with the reference category.

In conclusion, we demonstrated significant improvement of health and production parameters in small ruminants' flocks of owners making use of the services of the DCA-trained paravets, emphasizing the importance of this sustainable and effective system of private veterinary service delivery in Afghanistan.

1. Introduction

In Afghanistan, the livestock sector has always been of major economic importance, providing essential constituents of the daily diet and a source of income for more than 80% of the population. Small ruminants, numbering around 25 million heads of sheep and goats prior to the onset of war in 1979, form the most important group of livestock (Livestock Census, 1969). The Soviet invasion in December 1979 triggered off a decade of war in which most of Afghanistan's infrastructure was destroyed. Rural Afghanistan witnessed a complete disruption of governmental veterinary services, which led to serious threats to the already decimated livestock population: The Agriculture Survey carried out by the Swedish Committee for Afghanistan (SCA) in 1988 indicated that numbers of livestock in Afghanistan were approximately half of figures prior to 1979 (SCA, 1988).

With the establishment in September 1988 of the Veterinary Training and Support Center (VTSC) by the Dutch Committee for Afghanistan (DCA) in Peshawar, Pakistan, an emergency-orientated veterinary program was begun and further developed in the company of several other international Non-Governmental Organizations (NGOs).

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Its aim was to provide basic veterinary care for the remaining Afghan livestock population.

Program activities focused on a six-months' training and deployment of intermediate-level veterinary auxiliary staff ('paravets'). Students were recruited from rural villages in areas of Afghanistan where need for veterinary assistance was identified. Graduated students were deployed in these areas in so-called Veterinary Field Units (VFUs), and with technical backstopping from higher-qualified veterinary personnel provided by the NGO. The tasks of paravets were primarily in preventive veterinary medicine and included 1) vaccinating against major infectious diseases in large and small ruminants and poultry, and 2) administering anthelmintic drugs against nematodes and liver fluke. Vaccinations were done regularly against anthrax, blackleg, enterotoxaemia, hemorrhagic septicemia (HS), and Newcastle disease in target animals. In addition, para-veterinarians were also involved in curative treatments. In those early days, extension activities were not yet an important component of the program. Over the course of the early nineties, the NGO-initiated veterinary program evolved from an emergency program to a program for rehabilitating veterinary infrastructure and services in Afghanistan. This evolvement was supported and in collaboration with international agencies like United Nations Development Programme (UNDP) and the Food and Agriculture Organisation (FAO) (Schreuder and Ward, 2004).

Cost-recovery, at a gradually increasing level, was introduced for the provision and administration of anthelmintics, medicines, and vaccines. In addition, no salaries were paid to the field staff except for a start-up period, rendering the program fully sustainable by the year 2000. All this happened in the absence of an effective government, which left room for developing an innovative system of privatized delivery of clinical veterinary services at field level.

Already after three years into the program, an impact survey was conducted to assess the output of this system built around intermediate-level veterinary personnel and operating at field and community level. This was carried out in the South-Eastern provinces of Afghanistan, being the working area accessible from Peshawar in neighboring Pakistan. The survey focused on livestock mortality differences between districts with and without the veterinary interventions, thus a pair-wise comparison (Schreuder et al., 1996a).

In 1994, DCA could expand its working area into the western parts of Afghanistan, and a Veterinary Training and Support Centre, comparable to the one in Peshawar, was established in Herat. It marked the start of an animal health and production program in the Western region of the country. It is the performance of this program that is covered by the present study.

Several important developments took place over the last two decades: the program became fully sustainable in financial terms (no more subsidies to the field activities); provision of veterinary inputs was arranged for by a commercialized partner; mobility of paravets was guaranteed by the provision of motorcycles; and quality of medicines and vaccines was guaranteed by a complete cold-chain up to VFU-level. But most importantly: the services provided by paravets were no longer limited to provision of curative treatment and preventive measures, but now included extension activities and training of livestock owners on subjects related to animal health, animal nutrition, hygiene and public health.

The objective of the present study was to quantify the effect of recent veterinary services provided through paravets on animal mortality and offtake in Western Afghanistan for the years 2010, 2011 and 2013. The study focused on small ruminants, being the economically most important category of livestock in West Afghanistan.

2. Materials and methods

The initial design was to compare between livestock owners making use of the veterinary services provided through the paravets (in the text referred to as 'Users') with livestock owners that did not use these services (in the text referred to as 'Non-users'). To this end, 240 livestock owners (120 livestock owners in each group) were selected from 20 villages in four districts (Karukh, Kushk Rubat Sangi, Pashton Zargon and Zandajan) of Herat province, Western Afghanistan. Security issues played a role in the selection of the villages. Within villages, livestock owners were purposively selected based on their known use of the services of the paravet services – based on record book of the paravet. Livestock owners not using the paravet services had either no access or had chosen not to use these services. These Non-users were selected through visiting livestock owners of flocks neighbouring the User.

A questionnaire was developed around the objective of this study, with a focus on questions directly related to the outcome variables: mortality and offtake. The questionnaire was extensively pre-tested by the DCA monitoring staff with a selected number of paravets from districts not included in this study. The questionnaires were jointly conducted by one of two regional DCA monitoring staff members and the local paravet. The DCA monitoring staff have gained extensive experience in assessing impact of programme activities and approaches to conduct questionnaires and interviews in a neutral way. The paravet needed to accompany the DCA monitoring staff as a measure of security. It was not possible for a person unknown to the community to travel around freely. The interviews were conducted with the same livestock owners in January 2011, January 2012 and April 2014. In all three years, the questions asked were related to the 12 months' time period counting from the start of the lambing and kidding season of the previous year and thus related to events happening in years 2010, 2011 and 2013, respectively. As lambing/kidding starts in January, the consecutive study periods are congruent with the calendar years.

Originally, this study was part of the activities under project funding that was finishing at the end of 2012. When data collected about 2010 and 2011 was analysed, we encountered the large difference in mortality between these years without having a good explanation. For that reason, we repeated the study in April 2014, thus adding a one-year period (2013). In April 2014, only 118 Non-users and 119 Users were included, as 2 Non-users and 1 User had ceased their involvement with livestock production. The information collected was based on farmer's recollection of events of interest for this study which was unavoidable because the large majority of Afghan agricultural population was illiterate and unfamiliar with keeping written records. The information collected pertained to personal information (name of livestock owner, address, family size), 'flock size' (number of heads of livestock categorized 12 months or younger (young stock) and 13 months or older (adult stock), and 'flock composition' (sheep only, goats only or mixed sheep and goats). The information of primary interest was 'number of livestock died in the previous calendar year, specified by young stock and adult stock; "number of young stock moved off-farm" (including livestock sold, given away or slaughtered); and 'use of veterinary services such as vaccination and anthelmintic treatment' and its origin (through paravet or from local market). In Afghanistan, local markets have an extensive supply of vaccines, anthelmintics and medicines from a variety of sources and of varying quality. Non-users had not made use of veterinary services through the paravet, however, they might have purchased and applied such vaccines and anthelmintics themselves from the local market. Additionally, we were interested whether and to what extent livestock owners' practices about the use of vaccines against various infectious diseases had an impact on the outcome variables of mortality and offtake. For these reasons, an additional categorisation of the use of veterinary services and biologicals (anthelmintics and vaccines for up to 5 different infectious diseases) was created into a variable 'Use of veterinary services':

1) Non-users (NU-0): not using any anthelmintics or vaccines;
2) Non-users but anthelmintics (NU-A): using some anthelmintics bought through the local market;
3) Non-users but vaccinations (NU-AV2): using some anthelmintics and

1–2 vaccine types, bought through the local market;
4) Partial-users (U-AV2): using anthelmintics and 1–2 vaccine types, bought and applied through the paravet;
5) Full-users (U-AV5): using anthelmintics and between 3 and 5 vaccines, bought and applied through the paravet.

Livestock owners indicating to use vaccines but no anthelmintics were very small in number and were grouped into the NU-AV2 category.

No information was available to what extent livestock owners had received extension services and/or training on animal health and production. It was assumed that all Users were equally exposed to extension and training activities conducted by the paravets whereas Non-users might have been exposed through other sources directly or through paravets indirectly.

Descriptive and statistical analysis

For our assessment of the impact of paravet services, three outcome variables of animal health and production were defined:

- Adult mortality: the number of dead adult stock of sheep and goats recorded in the previous calendar year relative to the total number of adult stock present in the flock at the start of this calendar year. Adult stock was defined as livestock being 13 months of age or above.
- Young stock mortality: the number of lambs or kids that died in the previous calendar year (including the lambing season early on in each year) relative to the total number of young lambs and kids born alive in that same period. Lambing and kidding was strictly seasonal and only took place in the first three months of the year. Stillborn lambs and kids were not included in this parameter.
- Off-take movements: The number of lambs and kids sold, slaughtered or given away in the previous calendar year relative to the total number of lambs and kids born alive in that same period.

For the descriptive analysis, we made use of the variable indicating 'Users' and 'Non-users, whereas for the statistical analysis we used the variable with five categories of "Use of veterinary services". The reason for doing so was to ease the explanation and presentation of the descriptive analysis through graphs such as boxplots.

For the statistical analysis, we used Poisson distributions as the outcome variables were representing 'counts' of animals. We considered three possible levels of clustering between observations:

1) The same livestock owners were interviewed in 2011, 2012 and 2014 (repeated measurements or within-subject clustering);
2) The situation in a village may have an effect on activities of livestock owners from that village. For example, when most livestock owners in a certain village made use of the veterinary services of a paravet, this may have had an effect on the health and production of flocks of livestock owners not making use of these services;
3) Enumerators were a combination of the organization's monitoring staff and the local district paravet. At the level of district, there may have been dependency of observations as the interview was conducted by the same persons.

To account for these possible levels of clustering, a multi-level regression model was applied. The first step was to quantify the extent of clustering through an empty random-effects model accounting for repeated measures (at livestock-owner level) and for clustering of flock-effects within villages (village level). No random effect was included for the district level but instead district was included as independent variable in the model-building process.

However, none of the empty models showed a statistically significant clustering effect for village level which led us to model the outcome variables accounting for within-subject clustering based on the repeated measures of 2010, 2011 and 2013. There are several approaches to model repeated measures and we have chosen for a population-average model using generalised estimating equation (GEE) (Hubbard et al., 2010). The choice for GEE over a random-effects model was based on our interest in an effect across all livestock owners instead of an interest in the individual livestock owners. The GEE method is based on the quasi-likelihood theory and no assumption is made about the distribution of response observations. Pan (2001) proposed a model-selection method for GEE and termed it quasi-likelihood under the independence model criterion. We have used this criterion to select the best-working correlation structure (*qic* command in STATA) (Cui, 2007) and have applied the unstructured correlation for the adult stock mortality and the auto-regressive correlation for the young stock mortality and the offtake.

The model building procedure was straightforward. The variables 'Year' and 'Use veterinary services' were forced into the model as these reflected our primary interest. For the variable 'Use of veterinary services', the category 'NU-AV2' was taken as reference category. This category was representing the partial Non-users and had sufficient numbers of observations over the years. We did not want to choose a reference category that had few or a reducing number of observations such as 'NU-0' and 'NU-A'. An interaction term of 'Year' times 'Use of veterinary services' was included to account for a possible synergetic effect of using the paravet services over time. The effect of vaccination and extension activities of the paravets may have been incremental over time. The variable 'District' was included to account for a possible effect of the enumerator or district-related effects such as geography, climate or vegetation. Other 2-way interaction terms were explored and only retained in the final model if statistically significant and supported by evaluating the QIC statistic for selection of the best subset of predicting variable (Cui, 2007).

The exponential of the estimated coefficients of the final models were taken to calculate the Incidence Rate Ratio (IRR). As the name indicates, it is a ratio, thus comparing one category of a specific variable with the reference category of that variable. For instance, the variable 'Year' represented 'Year 2010' as the reference category and 'Year 2011' and 'Year 2013' as categories of interest. In addition to comparing the QIC statistic between models with different covariates, predicted versus observed counts were evaluated using scatter plots.

To present the results in numbers of livestock rather than in IRRs, we converted the estimates of regression models into estimated numbers (deaths or offtake) per 100 heads of livestock present. To this end, the exponent of the constant of the regression model was taken to acquire a baseline estimate for the reference category. In the next step, we took the exponent of estimated coefficients to present the probability of the event happening and multiplied this probability times 100 to estimate the number of events happening in an assumed population of 100 heads.

3. Results

Of the 720 initial observations, a total of 703 (representing a minimum of 113 Non-users and 118 Users in any one year) were eligible for further analysis. For four observations, the number of livestock was missing, for 14 observations the use of veterinary services was not recorded or livestock owners had ceased livestock production.

Based on year 2010, most flocks (131 or 56%) kept both sheep and goats, while 61 (26%) of flocks have sheep only and 41 (18%) of flocks have goats only. The number of sheep kept was higher than the number of goats, both in mixed herds as well as in herds with only one species. There were no statistical differences between Users and Non-users (Proportion test, P-value = 0.55) for having a mixed flock. The average flock size for small ruminants was not statistically-significant different between Users and Non-users (51 for Users, 48 for the Non-users, Ranksum test, P-value = 0.20).

For Users, in addition to using anthelmintics, the majority (80 livestock owners, 70%) applied vaccination for 3–5 different infectious

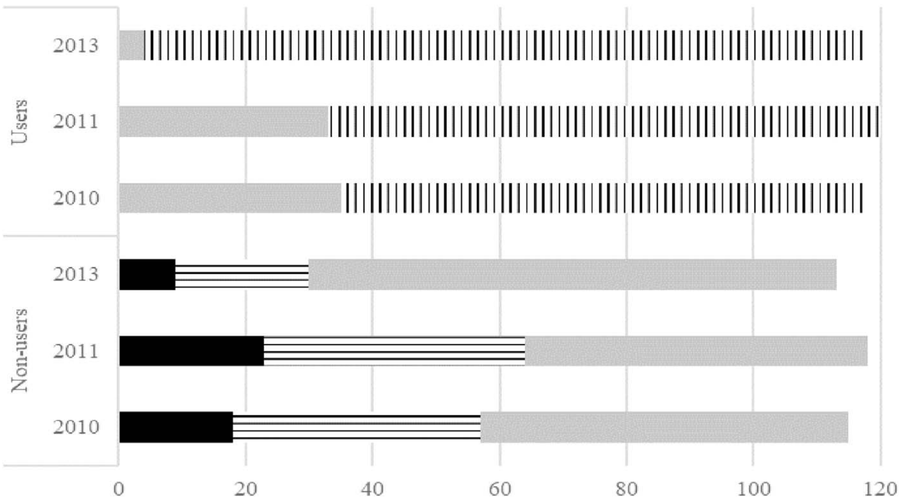

Fig. 1. Stacked bar graph of frequency of livestock owners and their use of veterinary services in 2010, 2011 and 2013 by categories of Non-users and Users of paravet services, in Herat province in Afghanistan. Black bars represent 'No use of anthelmintics or vaccines', horizontal-striped bars represents 'Use of anthelmintics only', grey bars represents 'Use of anthelmintics and vaccines against a maximum of 2 infections' and vertical-striped bars represent 'Use of Anthelmintics and vaccines against 3–5 infections'.

diseases, all obtained through the paravets (Fig. 1). For Non-users, 18 out of 115 (16%) did not apply anthelmintics or vaccination in 2010. However, this number reduced to 9 in 2013 while the number of farmers using anthelmintics and 1–2 vaccines acquired through the local market (category NU-AV2) increased from 58 in 2010 to 83 in 2013.

The mean mortality in adult stock in 2010 in Non-users (0.126) was almost 30% higher compared with the years 2011 and 2013 (0.088 and 0.086 respectively) (Fig. 2). The same trend was seen in Users. However, adult mortality in the User group across the years was 25–30% lower compared with Non-users (Fig. 2). A similar trend was seen for young stock mortality (Fig. 3) while off-take proportions between years and user groups mirrored these mortality findings (Fig. 4).

The results of the GEE regression models further elaborated the effect of different levels of use of veterinary services: Livestock owners making use of the paravet services had statistically significant better animal health and production results. The mortalities in adult stock for the partial Users (U-AV2) and full Users (U-AV5) categories were estimated to be 0.80 (IRR 95% CI: 0.73–0.87) and 0.73 (IRR 95% CI: 0.66–0.77) times the mortality observed in the partial Non-users (NU-AV2) category respectively (Table 1). Thus, reflecting a reduced adult stock mortality of 20% and 27% respectively. A similar result was observed for young stock mortality with estimated IRRs of 0.81 (95% CI: 0.75–0.86) and 0.77 (95% CI: 0.74–0.80) for partial Users and full Users respectively (Table 2). The offtake for partial Users and full Users were 1.24 (95%CI: 1.09–1.41) and 1.21 (95% CI: 1.06–1.37) times higher compared with the partial Non-users (Table 3).

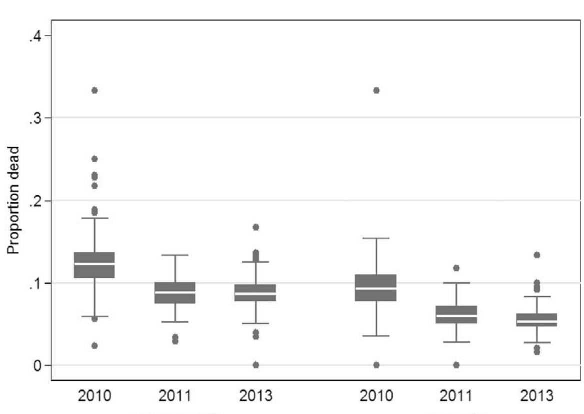

Fig. 2. Boxplot graph of the proportional adult stock (13 months and above) mortality of 230 small ruminant flocks during years 2010, 2011 and 2013 in Herat province, Afghanistan.

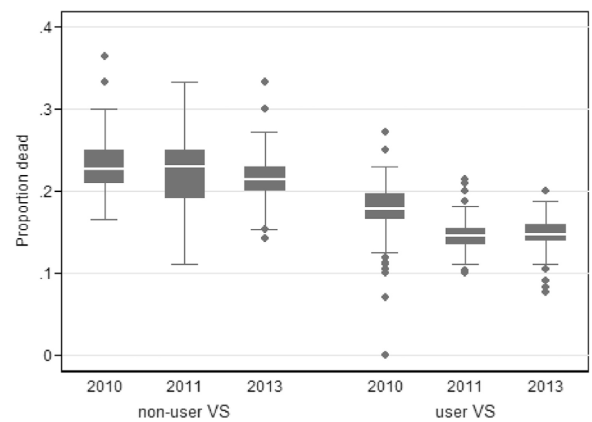

Fig. 3. Boxplot graph of the proportional young stock (0–12 months of age) mortality of 230 small ruminant flocks during years 2010, 2011 and 2013 in Herat province, Afghanistan.

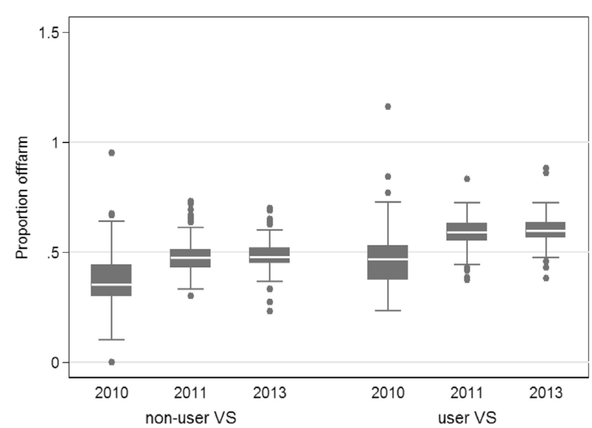

Fig. 4. Boxplot graph of the proportional off take of young stock (0–12 months of age) in 230 small ruminant flocks during years 2010, 2011 and 2013 Herat province, Afghanistan.

Additionally, the results showed significant effects for 'Year' and this was true for all three models. Mortality rates for adult and young stock were reduced in 2011 (IRR 0.65 (95%CI: 0.59–0.71) and 0.93 (95%CI: 0.88–0.98) respectively) and 2013 (IRR 0.68 (95%CI: 0.64–0.73) and 0.95 (95%CI: 0.92–0.97) respectively) compared with 2010, while offtake significantly increased (IRR 1.24 (95%CI: 1.09–1.41) and 1.21 (95%CI: 1.06–1.37) compared with 2010.

The interaction terms of 'Year' times 'Use of veterinary services'

Table 1
Regression results (estimate, standard error of estimate, P-value based on Wald statistic, IRR and 95% confidence interval of IRR) for deaths amongst adult sheep and goats in smallholdings in 4 districts of Herat province, Afghanistan and under 5 different categories of the use of veterinary services and biological, in years 2010, 2011 and 2013.

Variable	Category	Estimate	Standard error	P-value	IRR	95%CI IRR
Constant		−2.070	0.030	0.000		
Year	2010	Reference				
	2011	−0.433	0.045	0.000	0.65	0.59 − 0.71
	2013	−0.384	0.035	0.000	0.68	0.64 − 0.73
Use of veterinary services	Non-users (NU-0)	0.039	0.064	0.546	1.04	0.91 − 1.18
	Non-users (NU-A)	0.006	0.048	0.908	1.01	0.92 − 1.10
	Non-users (NU-AV2)	Reference				
	Partial-users (U-AV2)	−0.225	0.046	0.000	0.80	0.73 − 0.87
	Full-users (U-AV5)	−0.321	0.039	0.000	0.73	0.66 − 0.77
Interaction 'year' times 'use of veterinary services'	NU-0 * 2011	0.052	0.077	0.499	1.05	0.91 − 1.23
	NU-0 * 2013	0.047	0.065	0.475	1.05	0.92 − 1.20
	NU-A * 2011	0.019	0.080	0.817	1.01	0.87 − 1.19
	NU-A * 2013	−0.018	0.079	0.821	1.00	0.87 − 1.19
	U-AV2 * 2011	−0.157	0.069	0.066	0.89	0.78 − 1.00
	U-AV2 * 2013	−0.167	0.099	0.094	0.87	0.70 − 1.03
	U-AV5 * 2011	0.021	0.055	0.708	1.02	0.92 − 1.14
	U-AV5 * 2013	−0.127	0.051	0.014	0.87	0.79 − 0.97

1) Non-users (NU-0): not using any anthelmintics or vaccines.
2) Non-users but anthelmintics (NU-A): using some anthelmintics bought through the local market.
3) Non-users but vaccinations (NU-AV2): using some anthelmintics and 1–2 vaccine types, bought through the local market.
4) Partial-users (U-AV2): using anthelmintics and 1–2 vaccine types, bought and applied through the paravet.
5) Full-users (U-AV5): using anthelmintics and between 3 and 5 vaccines, bought and applied through the paravet.

were in few situations statistically significant. There was incremental reduction in adult stock mortality for full Users in 2013 (IRR 0.87, 95% CI: 0.79–0.97). The mortality in young stock was additionally reduced for both User categories in 2011 and 2013, increasing the overall effect of using paravet services. No interaction terms were statistically significant for the offtake model. During the model-building process, there were no statistically significant effects of the variables 'Flock-size', 'Flock composition' and 'District' and therefore these factors were not retained in the final models.

For the offtake regression model, there was one outlier. It was representing a large (203 heads) sheep-only farm in 2010 that moved 156 heads off-farm between 2010 and 2011, including some stock from the previous year whereas the model predicted off-farm movement of 98 heads. Exclusion of this one outlier did not alter the estimates of the regression model significantly and for that reason the observation was kept in the analysis.

When converted to counts per 100 heads of livestock present (Table 4), livestock owners making partial or full use of paravet services incurred on average 5 fewer deaths per 100 lambs and kids present in 2010 while this number increased to 7 fewer lambs and kids dying in 2011 and 2013 compared to the reference group. A similar beneficial effect was seen for the offtake of offspring. Livestock owners making use of paravet services sold or traded on average 9 more young stock in 2010, a number that increased to 12 for the years 2011 and 2013.

4. Discussion

The results of this study showed consistent beneficial effects on mortality and offtake in flocks of which owners made use of the paravet services. Mortality with livestock owners making use of paravet services was between 20 and 25 per cent lower compared with mortality in flocks where livestock owners were not making use of the paravet services, while the offtake of livestock increased by around 24 per cent.

Interestingly, the results showed that there was little effect of the number of vaccines applied by the livestock owner or the paravet. There was an increased application of vaccines in both groups between 2010 and 2013. One explanation could be that farmers requested more vaccinations at the time of a health problem in their flock. Whereas another explanation could be that both groups of livestock owners might have gained an attitude towards preventive measures and

Table 2
Regression results (estimate, standard error of estimate, P-value based on Wald statistic, incidence rate ratio (IRR) and 95% confidence interval of IRR) for deaths amongst lambs and kids in smallholdings in 4 districts of Herat province, Afghanistan and under 5 different categories of the use of veterinary services and biological, in years 2010, 2011 and 2013.

Variable	Category	Estimate	Standard error	P-value	IRR	95%CI IRR
Constant		−1.481	0.012	0.000		
Year	2010	Reference				
	2011	−0.071	0.027	0.008	0.93	0.88 − 0.98
	2013	−0.052	0.014	0.000	0.95	0.92 − 0.97
Use of veterinary services	Non-users (NU-0)	0.077	0.041	0.061	1.08	0.99 − 1.17
	Non-users (NU-A)	−0.016	0.024	0.506	0.98	0.94 − 1.03
	Non-users (NU-AV2)	Reference				
	Partial-users (U-AV2)	−0.213	0.029	0.000	0.81	0.75 − 0.86
	Full-users (U-AV5)	−0.262	0.022	0.000	0.77	0.74 − 0.80
Interaction 'year' times 'use of veterinary services'	NU-0 * 2011	0.004	0.052	0.941	1.01	0.91 − 1.11
	NU-0 * 2013	−0.073	0.047	0.123	0.93	0.85 − 1.02
	NU-A * 2011	0.078	0.047	0.096	1.08	0.99 − 1.18
	NU-A * 2013	0.015	0.032	0.644	1.01	0.95 − 1.08
	U-AV2 * 2011	−0.137	0.041	0.001	0.87	0.80 − 0.95
	U-AV2 * 2013	−0.171	0.059	0.004	0.82	0.75 − 0.95
	U-AV5* 2011	−0.103	0.034	0.003	0.90	0.84 − 0.96
	U-AV5* 2013	−0.100	0.025	0.000	0.91	0.86 − 0.95

Table 3
Regression results (estimate, standard error of estimate, P-value based on Wald statistic, IRR and 95% confidence interval of IRR) for offtake of lambs and kids in smallholdings in 4 districts of Herat province, Afghanistan and under 5 different categories of the use of veterinary services and biological, in years 2010, 2011 and 2013.

Variable	Category	Estimate	Standard error	P-value	IRR	95%CI IRR
Constant		−0.940	0.050	0.000		
Year	2010	Reference				
	2011	0.219	0.061	0.000	1.24	1.10 − 1.40
	2013	0.209	0.053	0.000	1.23	1.11 − 1.37
Use of veterinary services	Non-users (NU-0)	−0.098	0.078	0.210	0.91	0.78 − 1.06
	Non-user (NU-A)	0.028	0.072	0.691	1.03	0.89 − 1.18
	Non-users (NU-AV2)	Reference				
	Partial-users (U-AV2)	0.215	0.067	0.001	1.24	1.09 − 1.41
	Full-users (U-AV5)	0.187	0.065	0.004	1.21	1.06 − 1.37
Interaction 'year' times 'use of veterinary services'	NU-0 * 2011	0.111	0.083	0.181	1.12	0.95 − 1.32
	NU-0 * 2013	0.049	0.085	0.569	1.05	0.89 − 1.24
	NU-A * 2011	−0.074	0.084	0.372	0.93	0.79 − 1.09
	NU-A * 2013	0.014	0.079	0.849	1.02	0.86 − 1.20
	U-AV2 * 2011	−0.036	0.070	0.644	0.96	0.83 − 1.13
	U-AV2 * 2013	0.007	0.074	0.921	1.00	0.88 − 1.16
	U-AV5*2011	0.025	0.067	0.734	1.03	0.89 − 1.19
	U-AV5*2013	0.038	0.051	0.570	1.04	0.91 − 1.19

applied multiple vaccines, consequently incurring fewer losses. However, the difference between Users and Non-users remained similar between years and we concluded that this could be attributed to the combination of actual paravet services, his/her understanding to use high quality biologicals and store these under correct conditions and his/her extension skills. This supported the case for the initial objective of establishing animal health services through intermediate-level para-veterinarians as an approach to deliver preventive and curative services combined with increasing levels of extension on relevant aspects of animal health and production such as nutrition, housing and welfare.

There were large differences in mortality between 2010 and 2011 for which we could not find a good explanation and therefore an extra one-year period was added. As indicated, the time period under investigation was the previous calendar year 2013. For April 2014, this required farmers to think further back in time compared with years 2011 and 2012. That may have been reason for additional recall bias, but given the consistency of results between 2011 and 2013, we considered that bias minimal.

This study faced a number of challenges in conducting the questionnaires. Firstly, for reasons of security, data collection was only possible with the local paravet accompanying the enumerator. In Herat province, no professional enumerators other than the DCA monitoring staff were available. However, we believed in the professional ability of the monitoring staff to assess impact of the paravet services and their approaches to conduct questionnaires and interviews in such a way that interviewees were addressed in a neutral way. Based on the statistical approaches used with regard to the variable 'District', there was no support that bias related to one or more enumerators was being present: The empty random model did not show significant variation by district, nor was 'District' as variable in the regression analyses acting as a significant explanatory variable. The authors are aware that this does not rule out the possibility that there could still have been similar biases at work across all districts.

Secondly, livestock owners were asked to recall events of mortality and offtake. As the majority of the Afghan agricultural population is illiterate and not used to keep written records, this was the only option. These challenges may have introduced some bias in favour of farmers making use of the services offered by the paravets. For this reason, the study focused on what we would like to call robust outcome variables. Livestock owners in general remember well any deaths of livestock, while offtake such as sales and livestock being given away are other major events in a livestock production system. Offtake of adult sheep and goats was not included because for the livestock production system for small ruminants in Herat province, Afghanistan, it was the young-stock that were the main livestock being sold, slaughtered or given away. Sales wass to traders that fatten the young stock for some more months and these traders were based near major cities. The proportion of adult stock being sold, slaughtered of given away was less than 10% of the total off-farm movements.

In a previous impact study on livestock mortality in Afghanistan, Schreuder et al. (1996a) concluded that annual mortality in cattle, sheep and goats was substantially lower in districts that received veterinary services through the paravets compared with districts that had no veterinary services at all for the previous 10 years. Their results indicated that annual mortality rates between districts with and without veterinary services differed by 30% and 22% in lambs and kids respectively. By contrast, estimates on adult mortality indicated a 40% and 60% decrease in sheep and goat mortality, substantially higher than the estimated mortality reduction in our study. However, different districts could well have provided different levels of disease challenge,

Table 4
Estimated numbers of adult stock deaths, young stock deaths and offtake given a population of 100 livestock present, variables included were 'year', 'use of veterinary services and the interaction term of 'year' times 'use of veterinary services'.

Categories of Use of veterinary services	Estimated number of adult stock dying per 100 heads present in flock			Estimated number of young stock dying per 100 offspring present in flock			Estimated number offspring taken off farm per 100 offspring present in flock		
	2010	2011	2013	2010	2011	2013	2010	2011	2013
Baseline deaths in reference group Partial non-users (NU-AV2): livestock owners using anthelmintics and up to 2 vaccinations from the local market	12.6	8.2	8.6	22.7	21.2	21.6	39.1	48.6	48.1
Non-users (NU-0)	13.1	9.0	9.4	24.6	23.0	21.7	35.4	49.3	45.8
Non-user (NU-A)	12.7	8.4	8.5	22.4	22.5	21.6	40.2	46.4	50.2
Partial-users (U-AV2)	10.1	5.6	5.8	18.4	14.9	14.7	48.4	58.2	60.1
Full-users (U-AV5)	9.2	6.1	5.5	17.5	14.7	15.0	47.1	60.1	60.3

possibly contributing to different mortality rates. We believe that our current study has been able to circumvent this potential bias by comparing between Users and Non-users in the same locations, thus comparing situations facing similar disease challenge. Using these results, the same authors (Schreuder et al., 1996b) conducted a benefit-cost analysis and estimated that the benefit-cost ratio was between 1.8 and 4.8. They concluded that this high benefit-cost ratio partly resulted from low programme costs because it was implemented by a volunteer-run, non-governmental organization. Additionally, due to the special circumstances prevailing in the country, any input in combatting disease was bound to have a relatively high impact.

Comparison between then and now requires caution as not only the study design but also the selection of subjects and statistical analyses were different. Additionally, and maybe more importantly, the background against which the effect of interventions was measured differed. In the previous study, the control group had not received any veterinary care for at least 10 years, which may have accounted for higher adult mortality rates in that period. Nonetheless, the direction and magnitude of results underscored the improvement of livestock health and production for those livestock owners that made use of the paravet services. The results of both studies, with a time-interval of almost 20 years emphasize the importance of a sustainable and effective system of private veterinary service delivery to improve animal health and production in Afghanistan.

There have been several studies conducted on the impact of Community Animal Health Workers (CAHWs) (Catley et al., 2004). These were primarily situated in Africa and related to large-scale disease control programs such as the Pan-African Rinderpest Campaign and the Tse-tse control programs. Often, evidence of impact of CAHW activities was derived from cross-sectional studies with a broad range of outcome variables being used: Change in mortality, milk production, flock size. Statistical analyses were based on qualitative and semi-quantitative records collected using participatory data collection approaches such as proportional piling and ranking. These approaches were used because objective assessments of project impact in terms of disease and mortality occurrence were rarely possible in areas where basic diagnostic facilities were absent and conventional epidemiological surveys were considered not feasible (Catley and Leyland, 2001). For example, in an evaluation of CAHWs in the Horn of Africa, the livelihoods impact of cattle, small ruminant and camel diseases were all significantly reduced for diseases handled by CAHWs compared with diseases not handled by CAHWs (Leyland et al., 2014). In Tanzania, it was concluded that with the presence of CAHWs, livestock owners perceived decreased calf mortality due to East Coast Fever, increased milk availability and improved knowledge on the treatment of mange and on animal husbandry (Nanitolela and Allport, 2002). In addition, a study in Ethiopia (Admassu et al., 2005) saw significant reductions in disease impact for diseases handled by CAHWs compared with diseases not handled by CAHWs. The studies referred to here, assessed the impact of CAHWs, a level considered lower-trained veterinary auxiliary personnel. However, we were not able to find studies assessing the impact of intermediate-level veterinary auxiliary staff, other than the one described in the introduction and conducted in Afghanistan (Schreuder et al., 1996a).

Results from this study may serve as input for a benefit-cost analysis on the veterinary interventions similar to what Schreuder et al. (1996b) had conducted previously. Additional data collection on market prices and expenses on treatment, housing, nutrition and preventive measures is planned to be collected. For facilitating the dissemination of the results to stakeholders, we already converted the regression estimates into number of deaths and offtake based on a 100-head flock population.

5. Conclusions

The current study focused on animal health and production parameters that can be considered robust as livestock owners in general remember deaths and sales well. It clearly demonstrated that the combined animal health and extension services as provided by paravets, substantially reduced mortality in adult and young stock, while enhancing the off-farm sales.

In the study area, the North-western region of Afghanistan, over 95% of the veterinary field personnel were paravets providing private veterinary and extension services. The remainder consisted of higher qualified veterinary staff. The results of the present study are supportive for the choices made in the early stages of the program as to focus on intermediate level of veterinary auxiliary personnel (para-professionals) with additional skills like extension activities trained for over time.

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