Chapter 7

ADOPTION OF MEDICATION TECHNOLOGIES

7.1 INTRODUCTION

The correct usage of medication technologies is an important factor for the success of any livestock farming activity, as disease and high mortality are major constraints on livestock production in Southern Africa (McKinnon, 1985). In a survey done amongst commercial sheep farmers in the Northern Free State, North and North-Western Cape it was found that internal parasites, diseases and external parasites were the most important problems in sheep production systems (Joubert, Van Wyk & De Wet, 1994). They also found that these farmers regard internal parasites of which the effects are visible, as most important and react accordingly.

In the past the veterinary surgeon, as well as the extension and animal health officers in Qwaqwa, played an important role in the diffusion of livestock medication technologies. They regularly visited the sheering sheds where they supplied the farmers with medication remedies and vaccines recommended for that area, at a subsidised or reduced price. Farmers were also informed on the importance and correct use of prophylactic medication such as vaccines as well as its economical importance. Farmers regularly received instruction in the use and practical application of these medication technologies which enabled them to become independent. After being withdrawn from the area in 1994, these diffusion programmes came to a standstill.

Medication technologies in this study refer to the four major groups of medication (external and internal parasite remedies, antibiotics and vaccines) that are applied to small ruminants by farmers themselves. The correct usage (adoption) of such technologies by the farmers is the best measure to evaluate the efficiency of the livestock extension services and the role of other socio-economic factors in this adoption process.

The characteristics of the adoption groups and the identification of possible predictors (p-values $\leq 0{,}15$) for inclusion in the different models for each of the medication groups are presented in Annexure C. The next section of this chapter discusses, in four separate sections, the empirical results (significant predictors, p-values $\leq 0{,}15$, contributing to adoption) of the four medication groups. The chapter ends with conclusions on the adoption of medication technology by small ruminant farmers in Qwaqwa.

7.2 RESULTS AND DISCUSSION

In this section the empirical results of the different models are discussed.

7.2.1 EXTERNAL PARASITE REMEDIES

For these remedies the dependent variables consisted of three categories, i.e. full adopters, partial adopters and over-adopters. Adopters of external parasite remedies were defined as follows:

- ***Full adopters*** (66) ***and over-adopters*** (18) (n = 84): Uses external parasite drugs twice or more per year to prevent scab and ticks.
- ***Partial adopters*** (n = 13): Uses external parasite drugs once a year to prevent scab and ticks .
- ***Wrong adopters*** (n = 2): Uses wrong remedies for external parasite control. This group was not considered in the model as two farmers are too few to be used as a group to allow any valid statistical analysis.

The characteristics of the adoption groups are presented by using the definition of full and over-adopters (F & O/A) and partial adopters (P/A) as given above. The fact that there are no non-adopters, is an indication that farmers have adapted to the use of this type of medication reasonably well. The high sales of external parasite drugs in Qwaqwa, according to Venter (1998), are underlined by the fact that there were only 13 partial adopters and 84 full and over-adopters.

The continuous variables (14), mean (age) and median (all continuous explanatory variables except age) characteristics of the farmers in the different adoption groups are summarised in Annexure C, Table C.3. The percentage distribution of the 20 categorical variables in the different adoption groups are summarised in Annexure C, Table C.4.

The results of the external parasite remedy adoption logit model are presented in Table 7.1. Of the nine possible predictors (age, family size, herd size, indebtedness, attitude towards risk, information sources [technical decisions], roads, local markets and mating seasons) used in the estimation of the logit model, six predictors (one continuous and five categorical variables) were retained in the final model (p-values $\leq 0{,}15$).

If a predicted probability for full and over-adoption of >0,5 is considered to define full and over-adoption, the model correctly classifies the adoption category of 81,4 per cent of the 97 farmers. This model correctly classifies 92,9 per cent of the full and over-adopters and 7,7 per cent of the partial adopters. This does not, however, mean that the model cannot distinguish between full and over-adopters *versus* partial adopters, but only that using the cutoff of 0,5 does not distinguish well between them. The full and over-adopters have a median predicted probability of being true full or over-adopters of 0.97, whereas the partial adopters have a median predicted probability of 0,71. Using a cutoff of 0,9 would lead to 65,5 per cent of full and over-adopters being classified correctly, and 76,9 per cent of partial adopters. It can therefore be stated that the model results can be used to explain the full or partial adoption of external parasite remedies.

Table 7.1: **ADOPTION OF EXTERNAL PARASITE REMEDIES: LOGIT MODEL RESULTS**					
Full and over-adopters (n=84) *versus* partial adopters (n=13)					
Dependent variable: A binary variable: 1 for full and over-adopters and 0 for partial adopters					
Variable	**Parameter estimate**	**Standard error**	**Wald Chi-square**	**Probability >Chi-square**	**Odds ratio**
CONTINUOUS VARIABLE					
Age	-0,059	0,035	2,929	0,087	0,942
CATEGORICAL VARIABLES					
Risk-averse	-1,192	0,814	2,147	0,143	0,304
Technical decisions 2 – Co-farmers	2,323	1,583	2,152	0,142	10,201
Technical decisions 3 – extension services.	3,529	1,416	6,207	0,013	34,094
Infrastructure (local markets)	-0,677	0,301	5,071	0,024	0,508
Farmer making use of any of the four mating seasons	1,611	0,781	4,258	0,039	5,006
Intercept	4,571	2,372	3,713	0,054	-
Percentage of farmers classified correctly (n = 97)*					81,4%
Percentage of full and over-adopters classified correctly (n = 84)*					92,9%
Percentage of partial adopters classified correctly (n = 13)*					7,7%

* Using a cut-off point of >0,05.

Age is the first explanatory variable that emerges as a significant predictor. The mean age (55 years) of full and over-adopters is lower than that of the partial adopters (62 years). The negative coefficient of age indicates that older small ruminant farmers are less likely to adopt external parasite remedies in full. This finding is in agreement with the literature on diffusion that suggests that older farmers tend to be less likely to adopt new technologies at all or partly, than younger farmers (Feder, Just & Zilberman, 1985).

The next variable that emerges as a significant predictor of adoption of external parasite remedies is attitude towards risk (risk-averseness). Fifty-four per cent of the partial adopters are risk-averse in comparison to 24 per cent of the full and over-adopters. The negative coefficient of risk aversion indicates that farmers who are risk-averse are more likely to be only partial adopters of external parasite remedies, while those who are risk-seeking tend to be full and over-adopters of this technology. This, however, does not mean that risk-averse farmers will not adopt external parasite remedies, but only that they are more cautious with regard to the cost side of these medications. It can be deducted from the question asked in the questionnaire that they try to protect their profit flow by only applying external parasite remedies when it is absolutely necessary (see section D7 of the questionnaire in Annexure A). This is in agreement with Cromie and O'Donaghue (1992) and Gibbons, De Koninck and Hasan (1980), who stated that the more creative farmer is more risk-seeking and more willing to adopt new technologies.

The information sources approached by farmers when they have to make technical decisions, is the next variable that emerges as a significant predictor. The following information sources were tested with this variable: extension sources, co-farmers, the media and own decisions (farmers taking decisions on their own without approaching any of the mentioned sources). Two sub-groups of this variable presented significant predictors, namely extension sources and co-farmers.

The positive coefficients of extension services and of co–farmers as information sources when technical decisions have to be made are an indication that farmers who make use of these sources, are more likely to be full and over-adopters of external parasite remedies, than those who use the media and their own knowledge. Eighty-three per cent of the full and over-adopters approach extension sources when they have to make technical decisions, in comparison to 62 per cent of the partial adopters. Co-farmers as an information source, are approached by 15 per cent of the partial adopters. Extension services as information source, however, have a much greater contribution to adoption of external parasite remedies than co-farmers, as can be seen from their odds-ratio of 34,1 and 10,2 respectively. This is an indication that the need for extension advice is there, but that the extension services are not functioning efficiently in Qwaqwa. The significance of co-farmers as information source when technical decisions have to be made, is an indication that co-farmers also play an active role when it comes to technology diffusion (farmer to farmer diffusion). Some farmers have the means to make contact with extension services; others make use of the help of co-farmers. According to Von Thünen's theory, it is cheaper for farmers to attain information from co-farmers due to their closeness, than to pay additional transport costs to contact extension sources.

The positive coefficient of extension sources approached when technical decisions are made, is an interesting result as extension visits as a variable did not emerge as a significant predictor of adoption in this study. This variable was also considered an important predictor of adoption of new technologies in other studies (Mijindadi, 1995; Swanepoel & Darroch, 1991; Wellard & Copestake, 1993).

The negative coefficient of infrastructure (i.e. the availability and accessibility of local markets) is an indication that when local markets are more available and accessible to small ruminant farmers, they tend to adopt external parasite remedies only partially and that it would be less likely for them to be full or over-adopters of external parasite remedies. A possible reason for the negative sign may be that farmers who are more close to the markets are speculating with small ruminants. Speculators, other than small ruminant farmers, will not spend on medication if they know that they will be selling their animals, particularly if the price will not be affected by the presence of ecto-parasites.

The use of mating seasons as a predictor, contributes significantly to full and over-adoption of external parasite remedies. This is an indication that the more efficient farmers (those with higher management skills) will be more likely to use external parasite remedies, probably because they are also more informed about the advantage of such technologies, and therefore they tend to be more careful about the health status of their small ruminant herds. The use of breeding seasons and improved sires for breeding is a sign of maturity of the management skills of farmers and the adoption of basic management and breeding principles with the aim of improving small ruminant productivity. It was therefore expected that farmers adopting "sophisticated" breeding/management techniques would have adopted basic techniques such as the use of external parasite remedies. The use of mating seasons results in short lambing/kidding seasons that facilitate the management and the adoption of a dipping programme, as all the lambs/kidds are the same age at any given time.

7.2.2 INTERNAL PARASITE REMEDIES

The adoption of internal parasite remedies was broken down into three categories, i.e. full adopters, partial adopters and over-adopters. A multinomial logit model is the most appropriate model to use (see Chapter 3 & Annexure B), as more than two categories of adoption are identified. Adopters of internal parasite remedies were defined as follows:

- ***Full adopter*** (n = 12): Uses remedies against roundworms four to six times, tapeworms two to four times and nasal worms more than once a year.
- ***Partial adopter*** (n = 70): Uses less than the defined levels for a full adopter in any of the groups.
- ***Over-adopter*** (n = 15): Uses remedies against roundworms, tapeworms and nasal worms more than the defined times per year in any of the groups.
- ***Non-adopter*** (N/A) (n = 2): Uses no remedies for internal parasites. This group was not considered in the model as it would not render valid statistical results.

In a multinomial logit model all variables identified as possible predictors (p-value $\leq$0,15) in pairwise comparison between the groups, must be included in the model. In this case, 19 possible predictors must be included in the multinomial logit model. However, the numbers in the groups of two of the three adoption groups used (full adopters and over-adopters), are less than the possible predictors (19 variables) to be included in the model. A result can therefore not be reached because of zero degrees of freedom. Two standard logit models were therefore used to determine predictors of adoption of internal parasite remedies, using one dependent variable (partial adopters) chosen beforehand as a base group. A multinomial logit model for internal parasite remedies was then fitted using the seven predictors attained from the two standard logit models fitted (full adopters *versus* partial adopters and over-adopters *versus* partial adopters) as possible predictors.

The characteristics of the variables studied for the different adoption groups are presented by using the definitions of partial adopters, full adopters and over-adopters as given earlier. The presence of only two non-adopters is an indication that farmers in general have adopted the use of this type of medication reasonably well.

The mean and median characteristics of the 14 continuous variables of the farmers in the different adoption groups, are summarised in Annexure C, Table C.5. The percentage distribution of the 20 categorical variables in the different adoption groups are summarised in Annexure C, Table C.6.

The results of the first internal parasite remedy adoption logit model (**full adopters *versus* partial adopters**) are presented in Table 7.2. Of the eight possible predictors (age, education level, mortality rate, extension officer visits, type of farmers, attitude towards risk, financial management and transport) used in the estimation of the first logit model, four predictors (two continuous and two categorical) were significant (p-values $\leq 0,15$) and were therefore retained in the final model as predictors.

Table 7.2: **ADOPTION OF INTERNAL PARASITE REMEDIES: LOGIT MODEL RESULTS – FULL *VERSUS* PARTIAL ADOPTERS**

Full adopters (n=12) *versus* partial adopters (n=70)

Dependent variable: A binary variable: 1 for full adopters and 0 for partial adopters

Variables	Parameter estimate	Standard error	Wald Chi-square	Probability >Chi-Square	Odds ratio
CONTINUOUS VARIABLES					
Age	0,088	0,040	4,831	0,028	1,092
Type of farmer (Sheep live-stock units (LSU's) as percentage of small ruminant LSU's)	0,038	0,020	3,691	0,055	1,039
CATEGORICAL VARIABLES					
Risk d2 – Averse	–2,286	1,172	3,804	0,051	0,102
Financial management	1,090	0,735	2,198	0,138	2,973
Intercept	–10,281	3,755	7,495	0,006	–
Percentage of farmers classified correctly (n = 82)*					82,9%
Percentage of full adopters classified correctly (n = 12)*					8,3%
Percentage of partial adopters classified correctly (n = 70)*					95,7%

* Using a cut-off point of >0,05.

In the first model where variables distinguishing between **full and partial adopters** were estimated, four variables (two continuous and two categorical variables) emerged as predictors contributing to the full adoption of internal parasite remedies.

If a predicted probability for full adoption of >0,5 is considered to define full adoption, the model correctly classifies the adoption category of 82,9 per cent of the 82 farmers. The model correctly classifies 95,7 per cent of the partial adopters and 8,3 per cent of the full adopters.

Age contributes positively to the full adoption of internal parasite remedies. Full adopters tend to be older (63 years) than over-adopters (55 years) and partial adopters (54 years). The positive coefficient of age in the internal parasite model is an indication that older small ruminant farmers will be more likely to be full adopters (i.e. applying a recommended programme) of internal parasite remedies than younger farmers. This result is contradictory to that of external parasite remedies (applying a recommended deworming programme). A possible explanation for this contradiction is that it is relatively more difficult to identify (diagnose) small ruminants affected by internal parasites and to treat them correctly (application of internal parasite remedies), compared to the case of external parasite infestations. The correct adoption of internal parasite remedies requires more experience than external parasite remedies, which often comes with age.

Type of farmer (sheep as percentage of the total small ruminant herd) contributes significantly as a predictor of full adoption of internal parasite remedies. Full adopters have a median percentage of 100 per cent sheep (mean 87%) in their small ruminant herds, partial adopters 75 per cent and over-adopters 54 per cent, which is an indication that full adopter farmers tend to have more sheep in their herds than partial and over-adopters. Thus, sheep farmers tend to use internal parasite remedies more correctly than goat farmers. This result emphasises that sheep farmers are more likely to be adopters of internal parasite medication than goat farmers, as sheep are more susceptible to internal parasites than goats (Kriek, Odendaal & Hunter, 1994).

Attitude towards risk (risk-averseness) emerges as a significant predictor of adoption **in all the fitted models** on internal parasite remedies. Of the partial adopters 36 per cent are risk-averse, in comparison to eight per cent of the full adopters and seven per cent of the over-adopters. As in the case of external parasite remedies, the negative coefficient of risk aversion indicates that farmers who are risk-averse are more likely to be only partial adopters of internal parasite remedies, while those who are risk-seeking[1] tend to be full or over-adopters of this technology. This, however, does not mean that risk-averse farmers will not adopt internal parasite remedies, but only that they are more cautious with regard to the cost of these remedies. The conclusion can be drawn that they try to protect their profit flow by only applying internal parasite remedies when it is absolutely necessary (see question D7 in the questionnaire in Annexure A).

All the models indicate that financial management contributes positively to full and over-adoption of internal parasite remedies. Full adopters (92%) are keeping significantly better financial records than over-adopters (80%), who also tend to keep better records than partial adopters (60%). If keeping financial records is an indication of better management practices, then it can be said that the better the financial management level, the more likely the probability that farmers will use internal parasite remedies correctly. The probable reason may well be because they can better realise the financial advantage (cost/benefit ratio) of using (adopting) this technology.

The results of the second internal parasite remedy adoption logit model (**over-adopters *versus* partial adopters**) are presented in Table 7.3. Of the 11 possible predictors (level of entrepreneurship, total livestock income per LSU, herd size, type of farmer, reasons for farming, attitude towards risk, financial management, institutions [government and cooperative extension and agricultural research, suppliers of inputs/outputs], location of farmer in Qwaqwa and breeding technology) used in the estimation of the second logit model, five predictors (two continuous and three categorical) were significant (p-values $\leq 0{,}15$) and were therefore retained in the final considered model.

[1] Risk-seeking was used as base dummy variable.

Table 7.3: ADOPTION OF INTERNAL PARASITE REMEDIES: LOGIT MODEL RESULTS – OVER *VERSUS* PARTIAL ADOPTERS

Over-adopters (n=14) *versus* partial adopters (n=70)					
Dependent variable: A binary variable: 1 for over-adopters and 0 for partial adopters					
Variables	**Parameter estimate**	**Standard error**	**Wald Chi-square**	**Probability >Chi-Square**	**Odds Ratio**
CONTINUOUS VARIABLES					
Total livestock income per LSU	0,0016	0,0009	3,093	0,079	1,002
Reasons for farming	−0,405	0,265	2,346	0,126	0,667
CATEGORICAL VARIABLES					
Risk d2 – Averse	−2,082	1,138	3,351	0,067	0,125
Financial management	1,039	0,717	2,098	0,148	2,826
Suppliers of inputs/outputs	−2,088	1,131	3,407	0,065	0,124
Intercept	−1,308	0,820	2,542	0,111	–
Percentage of farmers classified correctly (n = 84)*					84,5%
Percentage of over-adopters classified correctly (n = 14)*					28,6%
Percentage of partial adopters classified correctly (n = 70)*					95,7%

* Using a cut-off point of >0,05.

In the second model where variables differentiating between **over and partial adopters** were identified, five variables (two continuous and three categorical) were significant. The variables "risk" and "financial management" are discussed under the previous model, as similar coefficients were obtained and the same reasoning is valid for the two logit models of adoption of internal parasite remedies.

If a predicted probability for over-adoption of >0,5 is considered, the model correctly classifies the adoption category of 84,5 per cent of the 84 farmers. This model correctly classifies 95,7 per cent of the partial adopters and 28,6 per cent of the over-adopters.

An interesting result is that total annual livestock income per LSU of over-adopters (R493 per year) tends to be higher than that of the partial adopters (R282 per year). This result indicates that higher financial efficiency generates a higher capacity to buy internal parasite remedies which are generally more expensive, or that there is in fact a need for a more intensive internal parasite control, than recommended for full adoption. If this is the case, it may be an indication of internal parasite resistance against some internal parasite remedies used, which forces farmers to use different remedies more frequently than recommended, as some treatments might be ineffective (Schwalbach, 1998). The low mortality rates reported does not, however, suggest that either of these probabilities are relevant. So it can be generalised that the adoption of internal parasite remedies is related to higher financial efficiency.

Farming for normal (commercial) reasons contributes negatively to over-adoption and favours the partial adoption of internal parasite remedies. Farmers were asked to rate the importance of keeping small ruminants for normal farming purposes from very important to not important. Partial adopters rated it as important, while full adopters rated it as less important to important and over-adopters as unimportant, which indicates that over-adopters see the keeping of small ruminants for commercial purposes as not important, while full adopters see it as relatively important. This result is in direct contradiction to that of the previous variable (i.e. livestock income per LSU per year). This question was perhaps not stated or understood correctly. From the results in Chapter 5, it was concluded that small ruminant farmers in Qwaqwa are mainly commercially orientated, selling about 70 to 80 per cent of their products. Farming for own consumption and for cultural reasons were in general rated less important. A considerable part of these farmers rated farming for investment and for a source of money (which are also commercial reasons) as very important. From these results it can be assumed that farmers tend to be mainly commercially orientated. Farming for a source of easy convertible money is a common characteristic in most African livestock production systems (Diomisio, 1985). Banks are usually located in urban areas, far from the farmers, and a less viable option for farmers to keep savings due to increased transaction costs (transport), than withdrawing their savings. This is a possible reason why farming for investment was rated so high by the local farmers.

The availability and accessibility of input/output suppliers and banking services are negatively related to over-adoption of internal parasite remedies and favour partial adoption. Input/output suppliers and banking services are significantly more available and accessible to partial adopters of internal parasite remedies (40%), than to over-adopters (7%). These results imply that if more input/output suppliers are available and accessible, more advice and information on the use of internal parasite remedies can be provided. Farmers will tend to use this expensive medication more efficiently and would be more likely to become partial adopters rather than over-adopters. These results also support the findings of Finlayson (1995) who stated that cost and quality of information have an influence on the level of adoption of new technologies.

The presence of only two non-adopters of internal parasite remedies is an indication that farmers have adopted the use of this type of medication reasonably well. However, the low percentage of full adopters and the absence of a significant contribution of extension visits in the models of adoption of this medication technology is an indication that farmers in Qwaqwa are aware of this technology, but are not using it correctly due to inefficient technology transfer (extension).

A multinomial logit model was fitted, using the significant predictors of the two standard logit models as possible predictors of adoption of internal parasite remedies (age, type of farmer, risk, financial management, total livestock income per LSU, reasons of farming and suppliers of inputs) as discussed earlier. The results are presented in Table 7.4.

Table 7.4: ADOPTION OF INTERNAL PARASITE REMEDIES: MULTINOMIAL LOGIT MODEL RESULTS					
Full adopters (12) *versus* Partial adopters (n=70) and Over-adopters (n=14) *versus* Partial adopters (n=70)					
Dependent variable: A binary variable: 1 for full adopters and 0 for partial adopters and A binary variable: 1 for over-adopters and 0 for partial adopters					
Variable		**Parameter estimate**	**Standard error**	**Wald Chi-square**	**Probability >Chi-square**
CONTINUOUS VARIABLES					
Age	F/A	0,101	0,045	4,95	0,026
	O/A	0,007	0,022	0,10	0,755
Type of farmer	F/A	0,047	0,023	4,21	0,040
	O/A	-0,011	0,011	0,93	0,334
Total livestock income per LSU	F/A	-0,002	0,001	1,08	0,298
	O/A	0,002	0,001	3,08	0,079
Reasons of farming	F/A	0,007	0,289	0,00	0,981
	O/A	-0,386	0,277	1,94	0,163
CATEGORICAL VARIABLES					
Risk-averse	F/A	-1,118	0,583	3,68	0,055
	O/A	-1,047	0,564	3,45	0,063
Financial management	F/A	0,680	0,399	2,91	0,088
	O/A	0,536	0,362	2,20	0,138
Suppliers of inputs/outputs	F/A	-0,395	0,435	0,83	0,363
	O/A	-0,921	0,573	2,58	0,108
Intercept	F/A	-11,920	4,157	8,22	0,004
	O/A	-2,565	1,610	2,54	0,111

Of the seven possible predictors included into the multinomial logit model, six were significant. With the exception of reasons for farming with small ruminants, all the other variables showed similar results to those of the standard logit models. The results of the multinomial logit model are similar to those of the standard logit models and therefore the significant variables (predictors) will be discussed only once. The value of the multinomial logit model is that the results of the two logit models are confirmed

7.2.3 ANTIBIOTICS

The adoption of antibiotics can be broken down into, full adopters, partial adopters and non-adopters. Adopters of antibiotics were defined as follows:

- ***Full adopter*** (n = 16): Uses both systemic and local antibiotics to treat sick animals.
- ***Partial adopter*** (n = 69): Uses only either systemic or local antibiotics, but not both.
- ***Non-adopter*** (n = 14): Uses no antibiotics to treat sick animals.

Like with the internal parasite remedies, a multinomial logit model was regarded as the most appropriate discrete choice model to use. However, one of the three categories of adoption (the full adopters) had complete separation[2] in three possible predictors, which means that the multinomial logit model cannot be fitted with the variables Old and New Qwaqwa, indebtedness and transport. Excluding the three variables from the model will give misleading results.

The mean and median characteristics of the 14 continuous variables of the farmers in the different adoption groups are summarised in Annexure C, Table C.7. The percentage distribution of the 20 categorical variables in the different adoption groups are summarised in Annexure C, Table C.8.

The results of the logit model on the adoption of antibiotics are presented in Table 7.5. Of the 10 possible predictors (family size, mortality rate, indebtedness, extension officer visits, type of farmer, reasons for farming, training sources on medication usage, information sources approached for financial decisions, roads and location of farmers in Old Qwaqwa) used in the estimation of the logit model, four predictors (two continuous and two categorical) were retained in the final model (p-values $\leq$0,15).

[2] This is when one of the categories or groups has a count of zero or 100 per cent.

Table 7.5: ADOPTION OF ANTIBIOTICS: LOGIT MODEL RESULTS – PARTIAL *VERSUS* NON-ADOPTERS					
Partial adopters (n=69) *versus* non-adopters (n=14)					
Dependent variable: A binary variable: 1 for partial adopters and 0 for non-adopters					
Variable	**Parameter estimate**	**Standard error**	**Wald Chi-square**	**Probability >Chi-square**	**Odds ratio**
CONTINUOUS VARIABLES					
Family size	0,343	0,154	4,990	0,026	1,410
Mortality rate in 1997	1,910	1,082	3,113	0,078	6,750
CATEGORICAL VARIABLES					
Financial decisions – Co-farmers	–2,097	1,069	3,848	0,050	0,123
Roads	1,349	0,883	2,334	0,127	3,854
Intercept	–1,264	0,972	1,692	0,193	–
Percentage of farmers classified correctly (n = 83)*					79,5%
Percentage of partial adopters classified correctly (n = 69)*					92,8%
Percentage of non-adopters classified correctly (n = 14)*					14,3%

* Using a cut-off point of >0,05.

If a predicted probability of partial adoption of >0,5 is considered to define partial adoption, the model correctly classifies the adoption category of 97,5 per cent of the 83 farmers. The model correctly classifies 92,8 per cent of the partial adopters and 14,3 per cent of the non-adopters.

The median family size of partial adopters (seven) is larger than that of non-adopters (six). The positive coefficient of family size indicates that larger families as a predictor contributes significantly to the partial adoption of antibiotic technology. Balyamujura (1995) found that the larger "African" families are also more wealthy, which is the reason why larger families tend to be partial adopters rather than non-adopters. Larger families would probably have more sources of (spendable) income that can be used for the purchase of antibiotics that are the most expensive of the four types of medication studied.

Mortality rates (in 1997) of the full adopters (mean = 2,57%) was higher than that of the partial adopters (mean = 1,15%) and non-adopters (mean = 0,16%). The positive coefficient of mortality rates in the antibiotic logit model indicates that higher mortality rates will influence (motivate) farmers to use antibiotics. This is a logical result in the sense that non-adopters do not see the need for antibiotics because the mortality rate on their small ruminant herds is insignificant. It is, however, important to stress that the mortality rates reported by the local farmers in general are extremely low, particularly for this type of farming system. A possible reason for this can be the severe snowfalls in Qwaqwa in 1996 during which very high mortality rates were reported and only the strongest animals survived. Mortality rates of up to 33 per cent were reported by McKinnon (1985) for the same type of farmers in the south of Mozambique. However, the fact that significantly higher mortality rates are observed amongst farmers that use antibiotics reinforces the need to prevent rather than to cure diseases, relying on the efficiency of expensive antibiotics. On the other hand, farmers with significantly lower, in fact insignificant levels of mortality (0,16%) do not really have the necessity to treat animal sickness, as they do not cause significant losses in terms of mortality.

The negative coefficient of sources (co-farmers) approached when financial decisions are made indicates that farmers who use co-farmers as information sources to make financial decisions, tend not to use antibiotics on their herds. This is a clear indication that there is a need for more information and extension services in Qwaqwa. Twenty-one per cent of the non-adopters of antibiotics use the help of co-farmers when they make financial decisions, against 19 per cent of the full adopters and four per cent of the partial adopters.

The positive coefficient of roads as a predictor indicates that the availability and accessibility of roads positively contribute to the partial adoption of antibiotics. Full (63%) and partial (46%) adopters have a significantly better availability and accessibility to roads than the non-adopters (14%). This may indicate that farmers with access to roads prefer the use of antibiotics to treat their sick animals, than the use of vaccination to prevent diseases. When animals become sick, these farmers buy an antibiotic to treat them, but do not spend money on prophylactic vaccination. This result coincides with the result of veterinary surgeon services under the conventional definition of adoption as well as the barrier of increased transportation costs on technology adoption, as indicated by the model of Von Thünen (Barlowe, 1978). Erasmus (1998) stated that livestock farmers in the former homelands react on what they see when it comes to the use of medication technologies and still prefer treatment to prevent livestock diseases.

7.2.4 VACCINES

For this remedy the dependent variable consisted of only two categories of vaccine adoption, namely partial adopters and non-adopters. Adopters of vaccines were defined as follows:

- ***Partial adopters*** (n = 82): Uses vaccination annually but not all the minimum recommended vaccinations to prevent diseases.
- ***Non-adopters*** (n = 17): Uses no vaccination at all to prevent diseases.
- ***Full adopters*** (n = 0): Uses all the minimum recommended vaccination – pulpy kidney twice a year, blue tongue and black quarter once a year – to prevent diseases.

Partial adopters were compared with non-adopters in an analysis to identify the variables (predictors) contributing to the adoption of vaccines.

The fact that there are no full adopters of vaccine technology, but only partial and non-adopters, is an indication that the level of adoption of this technology is quite low in Qwaqwa. It also indicates that the diffusion of vaccination technology was not efficiently done in the past. The withdrawal of veterinarians, competent extensionists and animal health officers of the Department of Agriculture from Qwaqwa after 1994, affected the efficiency and quality of the extension services. This, associated with the poor accessibility of veterinary surgeons and suppliers of curative remedies, had a negative impact on the adoption and usage of vaccination technologies by the local farmers. This finding is emphasised by the fact that according to Agri-Mark's yearly sales figures (Venter, 1998), the profit margins and the volume of sales of vaccines by the existing suppliers of inputs in Phuthaditjhaba have the lowest value of all four types of medication studied. Furthermore, it is not in the best interest of suppliers of therapeutic drugs (with higher profit margins than vaccines) to advocate the use of efficient prophylactic programmes that will reduce the sale of medicine for the cure of diseases. On the other hand, the mortality rate (real or perceived by the farmers) is very low. This aspect also has a very negative effect on the adoption of a disease prevention programme, as the costeffectiveness of such intervention will not be easily realised by the local farmers that keep very poor financial records. According to Erasmus (1998), livestock farmers in the former homelands react on what they see when it comes to adoption of medication for livestock production. Farmers prefer to treat rather than to prevent diseases. This means that vaccines are perceived by the local farmers as the least important group of medication. This is also one of the reasons why the adoption of this group of medication is so poor.

The 14 continuous variables, mean and median characteristics of the farmers in the different adoption groups are summarised in Annexure C, Table C.9. The percentage distribution of the 20 categorical variables in the different adoption groups are summarised in Annexure C, Table C.10.

The results of the vaccination adoption logit model are presented in Table 7.6. Of the seven possible predictors (herd size, indebtedness, type of farmer, reasons for farming, information sources approached for financial decisions, transport and location of farmers in Old Qwaqwa) in the estimation of the logit model, four predictors (two continuous and two categorical) were retained in the final considered model (p-values $\leq 0{,}15$).

Table 7.6: ADOPTION OF VACCINES: LOGIT MODEL RESULTS - PARTIAL *VERSUS* NON-ADOPTERS

Partial adopters (n=82) *versus* non-adopters (n=17)

Dependent variable: A binary variable: 1 for partial adopters and 0 for non-adopters

Variable	Parameter estimate	Standard error	Wald Chi-square	Probability >Chi-square	Odds Ratio
CONTINUOUS VARIABLES					
Herd size (median number of small ruminant herd)	0,0110	0,007	2,674	0,102	1,011
Type of farmer (Sheep LSU's as % of small ruminant LSU's)	0,0251	0,009	8,324	0,004	1,025
CATEGORICAL VARIABLES					
Information sources approached for financial decisions – Extension sources	1,207	0,726	2,762	0,097	3,343
Transport	-1,453	0,724	4,025	0,045	0,234
Intercept	-0,754	0,803	0,880	0,783	–
Percentage of farmers classified correctly (n = 99)*					86,7%
Percentage of partial adopters classified correctly (n = 82)*					95,1%
Percentage of non-adopters classified correctly (n = 17)*					43,8%

* Using a cut-off point of >0,05.

If a predicted probability of partial adoption of >0,5 is considered to define partial adoption, the model correctly classifies the adoption category of 86,7 per cent of the 99 farmers. This model correctly classifies 95,1 per cent of partial adopters and 43,8 per cent of the non-adopters.

The first variable that emerges as a significant predictor contributing to partial adoption of vaccines, is herd size. The positive coefficient of herd size is an indication that as herd size increases, the partial adoption of vaccines also increases. The median herd size of the 73 partial adopters tends to be higher than that of the 44 non-adopters. The fixed cost part of transaction costs of vaccination usage is generally aiming at groups in the herd or the whole flock. Transaction cost (transport is the major cost item of transaction cost in this study) normally decreases per unit treated, which makes this practice more economical for larger herds. Another reason for these farmers for partially adopting vaccines, may be the fact that vaccines often come in large packages (50 to 100 doses) and has an extremely short life once opened (Hunter, 1993). Larger farmers will use a higher proportion of the vaccine bottles and have less wastage than smaller farmers, which also reduces the cost per animal vaccinated.

The results of the type of small ruminant farmers show that partial adopters of vaccines have a higher percentage of sheep in their small ruminant herds (86%) in comparison with non-adopters who have only 46 per cent sheep in their small ruminant herds. The positive coefficient of sheep LSU's as percentage of small ruminant LSU's is an indication that the higher the percentage of sheep in a small ruminant herd, the higher the probability that the farmer will adopt vaccination technology. These results also indicate that sheep farmers are more likely to adopt vaccine technology than goat farmers, which corresponds with the result of veterinary surgeon services and internal parasite remedies. This may indicate that the use of vaccines in order to prevent diseases is more important for sheep than for goats, or that sheep are in general more susceptible to diseases than goats. In fact, pulpy kidney, one of the three disease in South Africa for which preventive vaccination was considered in this adoption category, infects sheep much more frequently than goats (Kriek *et al.*, 1994).

The information sources approached when farmers have to make financial decisions was broken down into the following groups: extension sources, co-farmers, the media and farmers taking decisions on their own with their family, without approaching any of the other mentioned sources. Only 23 per cent non-adopters of vaccination make use of extension sources when a financial decision has to be made, *versus* 49 per cent of the partial adopters. Twenty-four per cent of the non-adopters use co-farmers *versus* the six per cent partial adopters. This result indicates that partial adopters of vaccination tend to make more use of extension sources for financial decisions than non-adopters who consult co-farmers in this respect. Extension sources used to make financial decisions contributes positively to the adoption of vaccines. Even though extension visits did not emerge as a possible predictor, farmers have the need to approach extension sources when they need to make financial decisions.

Transport as infrastructure is accessible or available to only nine per cent of the partial adopters, in comparison with the 35 per cent non-adopters. According to the negative coefficient of transport in the model the better availability of transport contributes negatively to partial adoption of vaccine technologies in Qwaqwa. Farmers closer to input or service centres have an easier access to the suppliers of antibiotics and to the veterinary surgeon when needed. On the other hand, farmers with less access to transport are more pressured to adopt prophylactic measures to prevent diseases and use more vaccines. This means that in practice farmers with access to transport will argue that it is not that necessary to apply prophylactic measures on a small ruminant herd, because when an animal gets sick transport is available to take this animal to the veterinary surgeon or to buy remedies. This hypothesis is supported by the fact that roads as infrastructure were significant with a positive coefficient in the adoption models of veterinary surgeon services and antibiotics. This attitude can have far-reaching negative economic effects on the local small ruminant farming community, as preventative measures (vaccination) are far more economical than the treatment of most animal diseases.

If the availability and accessibility of informed and experienced extension sources in Qwaqwa increase, it is expected that the adoption of vaccination technology will also increase. This in turn will increase the profitability of the small ruminant herds and the sustainability of such production systems.

7.3 CONCLUSIONS

The results of this chapter indicate that there is a considerable difference of the variables (predictors) contributing to the adoption of the different medication technologies. The grouping of medication technologies is therefore essential if research on the characteristics of farmers adopting these different technologies have to be determined. The large variety of predictors in the different models is an indication that the high number of variables (34) considered was also a good decision.

The fact that there were no non-adopters and only two wrong adopters of external parasite remedies in the sample of 99 farmers, is an indication that diffusion programmes in Qwaqwa were effectively done in the past. The number of partial adopters of external parasite remedies (13), full adopters (66) and over-adopters (18), with a lack of a significant effect of extension visits, but with a significant effect of extension sources approached when technical decisions must be made by the farmers, are an indication that the government must pay more attention to diffusion programmes in livestock technologies in general and to external parasite remedies in particular. Continuous training on new developments and the correct number of applications of medication remedies are essential, as a disadvantage of partial adoption of external parasite remedies is that it can cause parasite resistance to these drugs and the spreading of resistant scab to full adopter farmers. This may increase the over-adoption and have an economical or financial implication for the whole farming community. Farmers who over-adopt external parasite remedies are wasting money on the unnecessary application of external parasite remedies, that could have been more efficiently used on the adoption of other medication technologies. The results in this chapter also reveal that full and over-adopters of external parasite remedies are younger, more risk-seeking, use extension sources when making technical decisions, and make more use of mating seasons.

The same trend occurs in the internal parasite remedy group of medication, where there were only two per cent non-adopters, 71 per cent partial adopters, only 12 per cent full adopters and 14 per cent over-adopters. This also reveals that farmers are aware of the usage of internal parasite remedies, which was transferred more efficiently before 1994.

However, farmers show a lack of knowledge on the correct frequency of application of these drugs, and on the need to use specific dewormers for different internal parasite infestations. This is a result of the insufficient visits of extension officers to the farms and to the sheering sheds after the restructuring of the Department of Agriculture. Adoption of internal parasite remedies relates to higher financial efficiency (livestock income per LSU per year), which stresses the importance of the correct adoption of this technology.

The results of the first two groups of drugs underlies the theory of Von Thünen (Barlowe, 1978) in the sense that when the subsidised medication services and information were withdrawn from the sheering sheds (Old Qwaqwa) and the farmer days (New Qwaqwa), it became too expensive for the farmers to attain the necessary information on the correct usage of these technologies. The negative coefficient of risk aversion, in both the external and internal parasite remedy models, indicates that farmers who are risk-averse are more likely to be only partial adopters, while those who are risk-seeking tend to be full and over-adopters of these two medication groups. This, however, does not mean that risk-averse farmers will not adopt these remedies, but only that they are more cautious when spending money on these medication. They try to protect their profit flow by only applying these remedies when it is absolutely necessary.

Roads (and not extension visits) in the antibiotic model are perhaps the most important aspect to consider. Antibiotics are no longer available at the sheering sheds, but they are urgently needed when an animal is already sick and the farmer need the medication as soon as possible to prevent mortality. The availability and accessibility of roads then become the main predictor of adoption of this technology. Higher mortality rates are also an incentive contributing to the adoption of antibiotics by small ruminant farmers in Qwaqwa.

Vaccination technology showed the lowest adoption level of all four medication groups studied, which also reflects the consequence of the changed policy with regard to the extension services by the government after 1994 when veterinary surgeons, experienced extension and animal health officers of the Department of Agriculture were withdrawn from Qwaqwa. Larger herds and a higher percentage of sheep in the herd are important contributors to the adoption of vaccine technologies by the small ruminant farmers in Qwaqwa. In fact, sheep farmers are more likely to use veterinary surgeon services, internal parasite remedies and vaccines, as they are more susceptible to disease than goats.

The importance of transaction costs (mainly transport cost in the case of Qwaqwa) and the finding of Erasmus (1998), that former homeland farmers react on what they see when it comes to medication technology adoption and are therefore more likely to adopt therapeutic (treatment) technologies (external, internal remedies and antibiotics), rather than prophylactic (prevention) medication vaccines, became evident throughout this chapter. The lack of extension visits as a predictor of medication adoption is an indication that a very important determinant of technology transfer in other studies does not feature in this chapter on medication technology transfer and adoption. However, extension services are still approached by farmers that have to travel and pay transport costs to contact the extension officers. These aspects are very important to consider in future policy structuring on agricultural development.

These results suggest the need to reintroduce the services supplied before 1994 and to develop the basic infrastructure and institutions (roads, transport, banks, suppliers of inputs, etc.) if the government is serious in uplifting the level of rural agriculture in the former homelands. This aspect accounts for subsistence as well as commercial farmers in rural agricultural areas. The restoration of veterinary surgeon services and experienced extension officers in the former homelands in the rural areas of South Africa must be a government priority, aiming at agricultural and rural development.