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Factors affecting adoption of dairy cattle milk production technologies in Mosop Sub County, Nandi County, Kenya

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The study was carried out with the specific objective of analyzing the socio-economic factors affecting adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County, Kenya. The study was guided by Innovation Diffusion Theory and descriptive research design was used. Cluster sampling and simple random sampling techniques were used to collect data from a sample of 198 smallholder dairy farmers, 70 large scale dairy farmers and 30 extension staff. To estimate the survey data, multivariate probit regression model was used. Descriptive statistics results revealed that 90% of smallholder dairy farmers were male-headed with 16.8 years of farming experience. Multivariate probit regression results showed that an increase in education level of the household head increased the marginal effect of adopting milking equipment by 7.5 percentage points. Results further revealed that a unit increase in the years of experience in dairy farming by the dairy farmers' household head resulted in a decrease in the marginal effect of adopting the vaccination regime by 24 percentage points, whereas gender of the household head increased the marginal probability of adopting milk equipment technologies by 56 percentage points. Male gender of the household head also increased the marginal effect probability of adopting dairy cattle vaccination regime technologies by 103 percentage points. Therefore, farmer to farmer exchange visits needs to be strengthened, introduction of farmers' mentorship programmes and revamping of extension service are paramount for technology adoption. Consequently, the county and national governments and their agencies should come up with strategies that would enhance the capacities of the dairy farmers so that they can continue appreciating new dairy cattle milk production technologies.

Key words: Dairy cattle milk production technologies, smallholder dairy farmers, multivariate probit regression.

INTRODUCTION

The Kenyan dairy sector is composed of over 625,000 smallholder dairy farmers who are distributed throughout the country. Smallholder dairy farmers produce over 56% of the total milk production produced in Kenya and 25% of the total marketed milk (Muriuki, 2001). Likewise, dairy cattle keeping helps in providing a year-round employment, diversifying production and spreading the risks. Whichever aspect that could increase expenses in the enterprise would be the genesis of risks in the efficiency of the dairy business (Bailey, 2001). The risks that might affect milk production are hired labour, prices of milk, prices of animal feed, crop or production of forage among others.

Kenyan smallholder dairy farmers have always remained in the lead in embracing modern technologies in the region even though they have not reached the desired levels (Mekonnen et al., 2009). These technologies include growing of leguminous crops to supplement dairy cattle dietary requirements, artificial insemination, disease and pest control and commercial feed rations (Ouma et al., 2007). Some of examples of dairy cattle production technologies according to Mekonnen et al. (2009) are deworming, rotational grazing, better animal feed techniques and improved management, use of acaricides, crossbred animals, improved methods of detecting heat, vaccination, baling of hay, silage making and fodder beet.

In Nandi County, dairy milk production is a key foundation of livelihood and it impacts immensely on household income. Production of milk in the County is valued at Ksh. 7.44 Billion per year (County Integrated Development Plan 2018-2023, 2018). It is predicted that approximately 5% of milk produced within the County is consumed by calves, 10% on-farm, 5% spoiled/spillage and 80% is marketed (38.7% to formal and 41.3% to informal markets) (MOALF, 2013). The main dairy breeds that are kept are Friesians, Ayrshires and Crosses. There are a total of 33 milk chilling plants in the County that are owned and managed by New Kenya Cooperative Creameries (NKCC), farmer groups, Co-operatives and farmer companies (Department of Livestock Production Annual report, 2016). Nestlé Kenya, East Africa Dairy Development (EADD) and Kenya Dairy Board (KDB) in conjunction with the County Government of Nandi through the Department of Livestock supported farmers in Mosop Sub County on various dairy cattle milk production technologies which included the type of breeds and breed selection, forage establishment, balanced feeding, silage making, methods of milking, hygiene and health of the dairy cattle (Nestle, 2013).

The technologies that have been promoted all along in Mosop Sub County are the feeding regimes which incorporate two major components of feed establishment and feed conservation. Breeding systems of dairy animals are moving away from the use of bulls towards more advanced technologies like Embryo transfer (ET), Artificial Insemination (AI) and Sexed Semen (SS). There are also technologies that are utilized for dairy management, such as record keeping, paddocking, modern milking parlour and feeding areas; mobile platform and computer applications. However, there has been a mismatch between the technologies that have been promoted and the rate of adoption by the recipients (MOALF, 2013). There are 21,604 dairy farmers in Mosop Sub County, out of which 30% have adopted the dairy cattle milk production technologies while 70% have not adopted the technologies despite using the conventional methods of milk production (Nandi County, ASDSP Baseline Report, 2014). However, previous studies have focused on variables which are not specific to dairy cattle milk production technologies, and those studies have only focused on one technology adoption and its impact on production performance of dairy operations (Hisham and Mitchel, 2000). Conversely, as per the secondary review so far carried out by the researcher, there is scanty information in the previous studies on the analysis of factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County. Thus, this current study endeavoured to breach the gap by analysing the factors affecting the adoption of dairy cattle milk production technologies. Therefore, the specific objective of the study was to analyse the socio-economic factors affecting the adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub-County, Nandi County, Kenya.

MATERIALS AND METHODS

Study area

The study was carried out in Mosop Sub County in Nandi County which covers area of 730.9 Km^2 of which 633.53 Km^2 is arable while 104.7 Km^2 is non-arable land. The population of the Sub County was projected to be 187,253 with 31,106 households by 2019 (KNBS, 2009). The Sub County has a cool and moderately wet climate and receives 1,200 to 2000 mm of rainfall per annum. The mean temperature ranges from 18 to 22°C during rainy seasons, while higher temperatures averaging 23°C are recorded during the drier months of December, January and February (Nandi County Development Profile, 2013). Mosop Sub County has a dairy farmer population of 21,604 owning about 67,843 dairy cattle that produce on average 248,208 L of milk per day (Nandi County Strategic Plan, 2018).

Target population

The target population for this study was 21,604 smallholder dairy farmers, out of which 21,534 were smallholder dairy farmers with less than 10 dairy cattle while 70 smallholder dairy farmers were with more than 10 dairy cattle (Nandi County Strategic Plan, 2018).

Sample size

To determine the ‘***n***’ value, this study adopted Smithson (2015) size sampling methodology as shown in Equations 1.

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$$n = Z^2 \frac{P(1-P)}{D^2} \quad (1)$$

Where, *n* is the sample proportion, *P* is the true proportion of factor in the population, or expected frequency value, *D* is the maximum difference between the sample mean and the population mean (or the expected frequency value minus the worst acceptable value, that is: 11 - 7% = 4%, or 7 - 3% = 4%)), *Z* is the standard normal value of 1.96 significant at 5% confidence level,. Therefore, to compute the value of "***n***" (sample size), the values for the parameters were then substituted into Equation 1.

$$n = Z^2 \frac{P(1-P)}{D^2}$$

$$n = 1.96^2 \frac{0.07(1-0.07)}{0.04*0.04}$$

n = 200.9

Therefore, based on the above calculation, the sample size (number of dairy farmers) were calculated proportionately based on the number of dairy farmer households in each of the seven wards of the sub county and as a proportion of the total dairy farmers in the county against the desired sample size of 200.

Sampling procedures

Cluster sampling procedure was used to obtain the sample of smallholder dairy farmers in the seven administrative wards of the Sub County. Thereafter, in each ward, simple random sampling procedure was used to pick on the desired respondents for the study. A list of smallholder dairy farmers was obtained from Mosop Sub County Livestock Production Office and from the two major milk chilling plant companies namely, Kabiyet Dairies Company Limited and Tany Kina Dairies Company Limited respectively. The names of the farmers in the lists were serially numbered and randomly ordered in such a way that it gave each dairy farmer an equal opportunity of being selected. This would therefore, increase the chances of obtaining proportionate and representative sample size for the Sub county. Therefore, based on the aforementioned criteria, the random sample of dairy farmers were 36 from Kebulonik, 21 from Ndalat, 18 from Kabisagat, 31 from Chepterwai, 29 from Kabiyet, 33 from Kipkaren and 32 from Kurgung wards, respectively. After data cleaning, 198 observations remained for analysis.

Data collection instruments

A structured questionnaire and an interview schedule were utilized as instruments for data collection for this study. The questionnaire was administered to the respondents by the researcher with the assistance from seven trained enumerators through face to face interview. To obtain data from the key informants, an unstructured interview schedule was used. The tool was used to obtain technological information and opinions from experts whose information was crucial for the study.

Data types

The data types that were used in the study included a rrepresentative sample of sample of smallholder dairy farmer households, county extension staff, and extension staff of partner institutions, farm technicians and managers of chilling plants operating within the study area. In order to analyse the responsiveness of dairy farmers to technologies, the farmers were requested to state the level at which different socio-economic factors affect adoption of dairy cattle milk production technologies (Y_j) or otherwise (Y_0). Data collected included dairy farmers socio-economic characteristics (age, gender, and education level, farming experience), dairy cattle milk production technologies and socio-economic factors affecting adoption of dairy cattle milk production technologies.

Operationalization of terms

Continuous, ordinal, dummy and discrete variables for the study were identified and operationalized based on economic theories and econometric studies as follows:

1. Adoption of dairy milk production technologies: Adoption of milk production technologies is a dummy dependent variable that represents the probability of adoption of a dairy milk production technology by the dairy farmer household. The variable takes the value 1= if the farmer adopts the technology or 0 = (otherwise) if the household does not adopt the milk production technology.
2. Age: It is a continuous independent variable that is measured in terms of number of years of the household head. Age of the household head was hypothesized to increase or decrease the probability of adoption of dairy milk production technologies.
3. Gender: Gender is a dummy variable that takes the value 1 if the household head is a male and 0 otherwise. In dairy production, both male and female take part in dairy management.
4. Education level: An ordinal independent variable that is measured in terms of highest academic qualification (1= primary, 2 = secondary, 3=college, 4 = university). A positive relationship was hypothesized between educational level and adoption of dairy milk production technologies. Education plays an important role in adoption of new technologies and it is believed to improve the willingness of the household head to embrace new ideas and innovations.
5. Household size: Household size is a continuous independent variable that is measured in terms of the total number of people (related or not related) living together in the same household. Household size increases household consumption requirements and render the households more risk averse. Therefore, the variable is hypothesized to influence adoption of dairy milk production technologies
6. Farming experience: Continuous variable measured in terms of the number of years in dairy farming. A positive relationship was hypothesized between dairy farming experience of household head and adoption of dairy milk production technologies.

Data analysis and presentation

Parametric estimates of the probit model were used to give direction of the effects of independent variables on the dependent variable. These estimates represent neither the actual magnitude of change nor the probabilities. The coefficients had no direct interpretation. They were simply the values that maximized the likelihood function. The real expected change in probability was measured by use of marginal effects for the specific objective's dependent variable $(\mathbf{Y_j})$ with regard to a unit change in the independent variable from the mean (Green, 2002). Data for the objective was obtained by requesting the respondents to declare the level at which different socio-economic factors affected the adoption of dairy cattle milk production technologies. The data was then subjected to a multivariate probit regression analysis to determine the effect of socio-economic factors on the adoption of

Table 1. Gender of the household head

Sex	Frequency	Percent (%)
Male	178	89.9
Female	20	10.1
Total	**198**	**100.0**

Table 2. Age of dairy farmers' household head.

Parameter	N	Minimum	Maximum	Mean	Std. deviation
HH head's age in years	198	25	90	48.99	11.693

dairy cattle milk production equipment technologies. The analysis used 198 observations. However, two of the observations were with missing information and were therefore dropped from analysis. Descriptive and inferential statistics were analysed and the results presented in frequency tables. Econometric analysis of data used Multivariate probit model as shown in Equation 3 and as adopted from Greene (2012). It is based on the hypothesis that the errors are typically distributed and provides for joint determination and a framework for modelling in two or more common applications.

$$Y_j = \beta_0 + \beta_1 AG_j + \beta_2 GD_j + \beta_3 EL_j + \beta_4 FS_j + \beta_5 EX + \varepsilon_j \quad (2)$$

Where Y_j is the response to positive adoption of technologies by the smallholder dairy farmer n, and 0 otherwise, β_0 is the intercept, β_1-β_1 are the coefficient for the socio-economic variables, *AG, GD, EL, FS* and *EX* are age, gender, education level, family size and years of farming experience respectively. $j_{'s}$ are the indexes for the adoption of dairy technologies, and ε_j is the error term. It was also assumed that $E_{(\varepsilon j)} = 0$, $Var_{(ej)} = \sigma^2$ and $Cov_{(ej)} = 0, \forall \neq j$.

RESULTS AND DISCUSSION

Household socio-economic factors

As shown in Table 1, about 90% of the smallholder dairy farmer households were male headed while 10% were female headed. According to the findings by Oni et al. (2010), male and female-headed households have almost equal chance of participating in smallholder farming, which is in contrast and divergent with the current findings. Research findings by Ward et al. (2008) on factors affecting adoption of livestock production practices revealed that 89% of the respondents were males, which is in convergence with the current study findings. Therefore, these current study findings imply that male-headed households have greater chances of participating in up take of dairy cattle milk production technologies as compared to female-headed households.

Table 2 shows the age of the dairy farmer household head. The youngest and the oldest small-holder dairy farmer were aged 25 and 90 years, respectively. The mean age of the majority of smallholder dairy farmers in the study area was 49 years. Age of a dairy farmer household head is an important factor in the adoption of dairy cow milk production technologies. According to the study findings by He and CAO (2007) and Sidibe (2005), the probability of young household heads to adopt new technologies were high as compared to older household heads. These previuos study findings on age of household head are in convergence with the current study findings on age and adoption of agricultural technologies.

Results in Table 3 show that a large number of the smallholder dairy farmers in the study area had attained the pre-primary and primary levels of education which represented about 43% of the total respondents. About 31, 3 and 11% of the respondents had attained secondary, vocational training and post-secondary/college levels of education, respectively. Only two of the respondents had attained a university level of education. These results show that most of the smallholder dairy farmer household heads were fairly educated which could enable them to fairly adopt dairy cattle milk production technologies. Mishra (2010) found out in his study that higher education level leads to ease of access to knowledge and information on agricultural undertakings. This would lead to higher up take of technologies in agriculture. A study by Knowler and Bradshaw (2007) revealed that education level has a positive influence on dairy cattle milk production technology adoption because there is a correlation between education and knowledge. The findings of the two previous studies were in agreement with the current study findings. This means that dairy farmers with better education levels would easily adopt dairy cattle milk production technologies.

Table 4 of results shows the mean years of dairy farming experience of the dairy farmer household heads. From the results, dairy farmer household heads had on average 16.8 years of dairy farming experience. Farmers experience as put across by Ingabire et al. (2018) on the agricultural technology adoption found out that majority of none technology adopters had farm experience of

Table 3. Highest education level

Education level	Frequency	Percent (%)
No formal education	10	5.1
Less than Primary	13	6.6
Pre-primary/Primary	85	42.9
Secondary	61	30.8
Vocational training	5	2.5
Post-sec/College	22	11.1
University	2	1.0
Total	**198**	**100.0**

Table 4. Years of farming experience of the household head.

Parameter	N	Mean	Standard deviation
Years of dairy farming experience	198	16.7677	11.55022

Table 5. Multicollinearity test.

Variable	VIF	1/VIF
Gender	3.91	0.255637
Household head	3.57	0.280337
Age	2.55	0.391419
Farming years (experience)	2.24	0.447239
Education level	1.20	0.830199
Family size	1.02	0.980780
Mean VIF	**2.42**	

between 1 and 4 years while adopters had experience of above 10 years, which is in convergence with the current study results.

Diagnostic test

Table 5 presents the results of multicollinearity test. Multicollinearity was measured by use of the variance inflation factor (VIF) and contingency coefficient factor (CCF) among continuous and discrete variables for the analysed specific objective. Multicollinearity arises once two or more predictors in the model are correlated and provide redundant information about the response. According to Ringle et al. (2015) and Mile (2014), the maximum VIF values should be less than 5 and 10, respectively. Preliminary test results for the diagnostic test revealed that the output coefficient or collinearity statistics as shown by the VIF values ranged from 1.02 to 3.91. This shows that there were no potential multicollinearity symptoms among the predictors and hence found to have no potential influence on the estimates from the model. The small VIF values as shown in the table indicate that there was low correlation among the variables under consideration.

Determinants of adoption of dairy cattle milk production technologies

A detailed econometric result of the multivariate probit regression model for socio-economic determinants of adoption of dairy cattle milk production technologies is presented here. The results of the analysis are as shown in Table 6. Results reveal that the likelihood chi-square ratio test of 43.63 with a p-value of 0.0000 means that the model as a whole was statistically significant, that is, it fits significantly better than a model with no predictors. Three predictor variables namely age, gender and education level are statistically significant. The probit regression coefficients give the change in the z-score or probit index for a one-unit change in the predictor. For a one-unit increase in age, the z-score increases by 0.039 and the z-score increases by 0.27 with a one-unit increase in the level of education.

Table 7 shows the results of the average marginal effects for the multivariate probit model estimates.

Table 6. Probit regression estimates of adoption of milk equipment and socio-economic factors.

Milk equipment	dy/dx	Std. Err.	Z	P>z	[95% Conf.	Interval]
Age	0.0388243	0.0136529	2.84	0.004*	0.0120651	0.065583
Gender	2.046087	0.4823852	4.24	0.000*	1.100629	2.991544
Education level	0.2729715	0.1106942	2.47	0.014**	0.0560149	0.489928
Family size	-0.0165469	0.0198834	-0.83	0.405	-0.0555175	0.022424
Farming years	-0.2550132	0.1312307	-1.94	0.052	-0.5122207	0.002194
Constant	-3.426247	0.976716	-3.51	0	-5.340575	-1.511919
Number of Obs	197					
LR ch² (5)	43.63					
Prob > ch²	0.0000					
Log likelihood =	96.693637		Pseudo R² =		0.1841	

*,** and ***= 1, 5 and 10% levels of significance.

Table 7. Marginal effects for socio-economic factors on the adoption of milk equipment.

Parameter	dy/dx	Std. error	z	P>z	[95% Conf.	Interval
Age	0.010631	0.0035388	3.00	0.003*	0.0036951	0.0175668
Gender	0.5602664	0.1135051	4.94	0.000*	0.3378004	0.7827323
Family size	-0.0045309	0.0054283	-0.83	0.404	-0.0151702	0.0061084
Highest education	0.074746	0.0291629	2.56	0.010**	0.0175877	0.1319042
Farming experience	-0.0698286	0.03509	-1.99	0.047**	-0.1386038	0.0010533

Average marginal effects: Number of obs = 197; Model VCE: OIM; Expression: Pr (Milk equipment), predict; dy/dx with respect to age, gender, family size, education level and farming experience; *,** and ***= 1, 5 and 10% levels of significance.

Results show that the signs of marginal effects variable are in line with the signs obtained from parameter estimates in Table 9. Output results reveal that the predicted probability for socio-economic factors on adoption of milk equipment technologies by dairy farmer household was significant with the following factors; level of education, age, years of farming experience and gender.

Results revealed that the age of the household head had a positive and significant marginal effect at 1% level of significance on the adoption of milk equipment technologies. For a unit increase in the age of the dairy farmer, the marginal probability of adopting milk equipment technology (z-score) increased by 1.1 percentage points, which means that as farmer's age increases, the adoption of the milk equipment increases or their willingness to adopt would be positive. This would be attributed to the generalized increase in experience. This finding could be in contrast with the finding of Tesfaw (2013), who reported that the age of the household head negatively influenced market participation decision since as the head gets older and older, they shift to production of lesser labour-intensive farming alternatives. But the current result is in convergence with the findings by Kafle and Shah (2012) who found out that the up take of potato superior varieties was popular amongst the adult farmers.

Gender of the dairy farmer household head had positive marginal effect and significantly related to the adoption of milk equipment at 1% level of significance. Results shows that when the gender of household head was male, the marginal effect of adopting dairy cattle milk equipment increased by 56 percentage points. The outcomes on the gender of head of the household as per the current study was in convergence with findings by Doss and Morris (2001) who found out that if the gender of head of the household was a male, then they would adopt new agricultural technologies easily compared to households headed by female. This is attributed to the easy access to resources by the male gender as compared to the female gender.

Results on the education level of the dairy farmer household head had positive marginal effect on the adoption of dairy cattle milk equipment and statistically significant at 5% level. From the results, a unit increase in the level of education of the dairy farmer household head increases the marginal effect of using the milk equipment by 7.5 percentage points. The findings of the household head on education were in convergence with the study findings by Caswell (2001) who found out that education facilitated a positive attitude to appreciating new technologies.

Table 8. Average marginal effect estimates for the adoption of AI technology.

AI	dy/dx	Std. error	Z	P>z	[95% Conf.	Interval]
Age	-0.0316774	0.0113199	-2.80	0.005*	-0.053864	-0.009491
Gender	-0.2288996	0.348659	-0.66	0.511	-0.9122588	0.45446
Education level	-0.0261317	0.0789844	-0.33	0.741	-0.1809384	0.128675
Family size	0.0083315	0.018395	0.45	0.651	-0.0277219	0.044385
Farming experience	-0.006034	0.1089846	-0.06	0.956	-0.2196399	0.207572
_cons	2.077987	0.7061331	2.94	0.003	0.6939913	3.461982
Probit regression						
Log likelihood =	125.80161					
Number of obs=	198					
LR chi² (5) =	13.91					
Prob> chi² =	0.0162					
Pseudo R²	0.0524					

Further, results of the study revealed that farming experience of the dairy farmer household was statistically significant at 5% level with a negative marginal effect on the adoption of dairy cattle milk equipment. A one year increase in the farming experience of the dairy farmer household head reduces the adoption of dairy cattle milk equipment by 6.5 percentage points. The current study findings were in divergence with the one by Makokha et al. (2007), who found out that farmers with experience utilized their long term acquired knowledge and skills to reduce risks related with dairying and management of diseases. Further, a study was done by Kinambuga, (2010) revealed that experience assists in making decisions and allocation of resources which meant that the more experience one has, the wiser decisions are being made in terms of allocating resources to new technologies. Komolafe et al. (2014) confirmed that as the dairy farmers grow old, their level of output decline while Osanyinlusi and Adenegan (2016) found out that experience in farming was negatively related to production per unit area. Studies by Komolafe et al. (2014) and that of Osanyinlusi and Adenegan (2016) were in convergence with the current study which revealed that the adoption of milk equipments reduces as the household head's farming experiences increases by year.

Table 8 shows the results of the multivariate probit regression analysis to determine the effect of socio-economic factors on the adoption of AI technology. From the average marginal effect estimates for the adoption of AI technology results table, the likelihood ratio chi-square test of 13.91 with a *p*-value of 0.0162 shows that the model that was used as a whole was statistically significant and it fitted significantly better than a model with no predictors. Results shows that only age of the dairy farmer household head was statistically significant at 1% level even though with a negative marginal effect on the adoption of dairy cattle milk production technologies. The rest of the variables in the model namely gender, education level, farming experience and family size were not statistically significant.

The coefficient for age of the dairy farmer household head is -0.032 with a *p*-value of 0.005. This result shows that as the age of the dairy farmer household head increases by a year, the marginal probability of adopting AI technology decreased by 3.2 percentage points. This means that young dairy farmers as opposed to older farmers can easily adopt new AI technologies. They can also easily change to other technologies as compared to older dairy farmers who are reluctant to abandon old technologies for ones that are new. This result is in divergent with the study finding by Kaaya et al. (2005) who found out that age was positively connected to embracing and utilization of AI technology. The result is also in divergence with the study findings by Nzomoi et al. (2007) who found out that the age of the household head played an important role in the adoption of dairy technologies. Quddus (2013) found out that young farmers within the productive age are able to take up new technologies easily as compared to farmers who are old, which is in convergence with the current study findings. As a dairy farmer gets older, their experience notwithstanding, they tend to relax, lack long term planning and become a risk-averse and therefore adopting new technologies would be a challenge.

Table 9 presents the results of the analysed socio-economic factors that influenced the adoption of vaccination regime technologies by the dairy farmer households. Probit analysis was performed because the outcome of the predicted variables was binary. Results revealed that the likelihood ratio chi-square is 35.17 with a *p*-value of 0.0000. This shows that the model was statistically significant and it fitted significantly better than a model with no predictors. The *p*-values for years of farming experience and gender were statistically significance at 5% level with positive marginal effects on adoption of vaccination regime technologies. The rest of the socio-economic factors were insignificant to the

Table 9. Marginal effects estimate on use of vaccination regime technologies.

Vaccination regime	dy/dx	Std. Err.	Z	P>z	[95% Conf.	Interval]
Age	-0.0100701	0.0121704	-0.83	0.408	-0.0339236	0.013783
Gender	1.029128	0.4144704	2.48	0.013**	0.2167806	1.841475
Highest education	0.0356271	0.082599	0.43	0.666	-0.1262639	0.197518
Family size	0.0113402	0.0191948	0.59	0.555	-0.026281	0.048961
Farming experience	-0.2429342	0.1165877	-2.08	0.037**	-0.4714418	-0.014427
_cons	0.2435127	0.8036385	0.30	0.762	-1.33159	1.818615
Probit regression						
Number of obs =	196					
LR chi² (5) =	35.17					
Prob> chi² =	0.0000					
Pseudo R² =	0.1370					
Log likelihood =	110.73812					

*,** and ***= 1, 5 and 10% levels of significance.

adoption vaccination regime technologies by the dairy farmer households. Since gender was a dummy variable with values 1 for male respondents and 0 for non-male respondents, the coefficient of gender indicates that when the respondent was male, the z-score increased or the marginal probability of adopting vaccination regime by dairy farmer household increased by 103 percentage points. Similarly, a unit increase in the years of experience in dairy farming by the dairy farmers' household head results in a decrease in the marginal effect of adopting the vaccination regime by 24 percentage points. Experience in any venture cannot be overemphasized. In the dairy sector, experience is very important especially in improving the breeds and breeding. Farmers with fast experience are better placed to address the challenges related to dairy cow milk production. According to findings by Idrisa et al. (2012), farmers with more experience have enhanced skills, access to information and exposed to better technologies. The findings by Idrisa et al. (2012) are in convergence with current study finding.

The result for gender shows a positive marginal effect with a significant effect on the adoption of vaccination regime at 5% level. This shows that as gender of household head was male, the marginal effect of adopting dairy cattle vaccination regime technologies increased by 102 percentage points. According to study results by Adebiyi and Okulola (2013), households headed by females were less experienced in terms of dairy cow milk technologies as compared to male-headed households because the female was too engaged with home chores and family management as compared to male counterparts. Adesina and Chianu (2002) found out that the female head is less likely to adopt new technologies while according to findings by Baiyegunhi (2015), male farmers tend to accept new technologies as equated to female counterparts.

CONCLUSION AND RECOMMENDATIONS

This article analysed the socio-economic factors affecting adoption of dairy cattle milk production technologies by smallholder dairy farmers in Mosop Sub County, Nandi County, Kenya using a multivariate probit regression model. Descriptive statistics results revealed that 90% of smallholder dairy farmers were male-headed with 16.8 years of farming experience. Results of the multivariate probit regression model revealed that age of the household head had a positive marginal effect on the adoption of dairy cattle milk equipment technologies. A unit increase in age of the dairy farmer household head increased the marginal probability of adopting milk equipment technology by 1.1 percentage points. A unit increase in the level of education of the household head increases the marginal effect of using the milk equipment by 7.5 percentage points. Gender of the head of household also had a positive marginal effect and increased the marginal probability of adopting milk equipment by 56 percentage points. Further, results shows that the gender of the household head had a significant positive marginal effect on the adoption of vaccination regime. As gender of household head was male, the marginal effect of adopting dairy cattle vaccination regime technologies increased by 103 percentage points. Similarly, a unit increase in the years of experience in dairy farming by the dairy farmers' household head resulted in a decrease in the marginal effect of adopting the vaccination regime by 24 percentage points. In conclusion, the present study contributes to our theoretical understanding by showing that the socio-economic factors, particularly age, gender, farming experience and education level affects positively the adoption of dairy cattle milk equipment technologies whereas, gender plays an important role in the adopting of vaccination regime by the dairy farmer household.

Therefore, the National and County governments should come up with helpful strategies and policies to reach out to the dairy farmer households at the various farming categories. The two levels of government should also come up with new extension approaches that would go towards enhancing the adoption of dairy cattle milk production technologies.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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