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Awareness and adoption level of subclinical mastitis diagnosis among dairy farmers of Punjab, India

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Abstract: Subclinical mastitis (SCM) is a major and silent problem of public health concern. It causes higher economic losses with no initial visible changes in the appearance of milk or udder. Subclinically affected animals always remain a continuous source of infection. Most of the clinical mastitis (CM) cases start as subclinical; hence controlling SCM is the best way to reduce the incidence of diseases. A crosssectional study was carried out during 2018–19 in six districts from different agroclimatic zones of Punjab, India to describe awareness about various technologies and its adoption to diagnose SCM. The multistage random technique was used to select dairy farmers (n = 600). A personal interview technique with the pretested schedule was used to collect information after obtaining participation consent. Around 13% of respondents were aware of SCM diagnosis technologies and very few (6.67%) were implementing the same at their farms. Family size (Odds Ratio – OR 2.44), dairy income (OR 13.67), landholding (OR 2.13), herd size (OR 6.45) and extension contacts are likely to affect the probability of SCM diagnosis adoption. A significant difference ($P < 0.01$) was seen on overall CM incidence at farms level (38.33%), among which 10.00% was on technology adopter farms. Five percent of adopter farms had no incidence of disease. From 600 dairy farms, 3179 dairy animals were exposed and 378 were suffered from CM (12.05%). A significant difference ($P < 0.01$) was found for incidence rate, number of animals affected and exposed to CM among three categories of farms such as 1) technology adopters with no incidence (n = 17), 2) technology adopters with incidence (n = 23), and 3) technology nonadopters with incidence (n = 207). The study confirmed the potential and direct role of SCM diagnosis on reducing CM incidence, however poor awareness coupled with financial status may be the reason limiting adoption, which can be accelerated through comprehensive extension approach for producing clean milk to society.

Key words: Awareness, dairy farmers, Punjab, SCM diagnosis, technology adoption

1. Introduction

Dairying plays a pivotal role in developing countries [1]. It brings socioeconomic transformation of rural poor and makes sustainable rural development through its stable and year-round income [2]. India is a developing tropical country, known as the largest producer as well as the highest consumer of milk in the world [3]. Besides this, it is also herding the world's largest cattle and buffalo population, depicting very poor productivity of the dairy animals [4], which may be due to combined effect of managemental, environmental and social factors.

Mastitis is a global problem as the losses related to culling, decreased production, decreased fecundity, and treatment costs make the country suffer from a huge financial burden [5]. Globally, about $ 53.3 billion losses occur due to mastitis [6] and the annual economic losses due to bovine mastitis are increased 114 folds [7] in about 4 decades from 1962–2001 [8, 9]. Mastitis is considered to be one of the expensive diseases which affect the profitability of rearing animals through production losses [10] and affects the economic returns of the Indian dairy farms heavily [11].

Clinical mastitis (CM), subclinical mastitis (SCM) and chronic mastitis are three types of contagious mastitis [12], among which SCM is a major and silent problem causing higher economic losses to the farmers [13] with no visible changes in the appearance of the milk or the udder, but milk production decreases [14]. As mastitis milk is one of the sources of communicable diseases, it is unsuitable for consumption [15]. Most clinical cases of mastitis start as subclinical; thus, controlling SCM is the best way to reduce the clinical cases [16]. Also, subclinically affected animals always remain a continuous source of infection to other herd mates.

Previous study on SCM reported that the prevalence of subclinical form was found to be more common in

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India (varying from 10%–50% in cows and 5%–20% in buffaloes) when compared to clinical form of mastitis (1%–10%) [17] and it was higher (53.52%) in Punjab [18]. Punjab is an agrarian state of Northern India where 63% of its population reside in rural areas.[1] It is one of the leading states in dairying and milk production in country [19]. Among dairy farmers of Punjab, early mastitis detection is the third constraint followed by the cost of treatment and poor cow and animal housing in controlling mastitis [20].

Diagnosis and management of mastitis at the subclinical stage results in an increase in milk production, improvement of milk quality and safety of consumer health [16]. Various methods are used for the diagnosis of SCM, which are based on physical and chemical changes of milk and the cultural isolation of organisms [21]. The International Dairy Federation (IDF) recommended that the microbiological status of the quarter and the somatic cell count (SCC) are the most common tests to detect changes in the milk caused due to an inflammatory process [22]. Over a period of years several direct and indirect tests [23] have been developed for SCM diagnosis. In determining the quality of milk, in the absence of laboratory facilities, indirect tests are useful and suitable for field conditions which include modified California mastitis test (MCMT), modified Whiteside test (MWST), surf field mastitis test (SFMT) [24]. The screening tests like electrical conductivity (EC) and pH test along with methylene blue reduction test (MBRT) as a laboratory test are also some of the indirect tests. Bromothymol blue (BTB) card, sodium lauryl sulphate (SLS) and electrical conductivity (EC) test for diagnosis of subclinical mastitis are simple, economical and easy technologies of SCM diagnosis to use even at farmer level. More than 50.00% of Dutch dairy farmers were willing to use an on–farm SCM diagnostics test [25].

The majority of the farmers considered mastitis as a major constraint to their milk production, but none of the dairy farmers knew about SCM [26], despite the development and availability of technology for SCM diagnosis.

In India, vast research has been carried out and published about prevalence of subclinical mastitis, methods to detect and control it. But information relating to its implementation at farmers end considering awareness and adoption is scant. Such information is important to understand the farmers' perspective about SCM and when designing appropriate strategies that would help to reduce its prevalence and effects. This paper systematically has described the awareness and adoption of various technologies to diagnose SCM. It also focused on the factors affecting adoption and its effect on the incidence of CM.

2. Methodology

The Institutional Ethics Committee, Dayanand Medical College & Hospital, Ludhiana, Punjab, India had approved the necessary ethical permission for the conduct of this study (Ethics approval number: DMCH/ R&D/2018/1008). The study was conducted from June 2018 to May 2019.

2.1. Target and study population

The target population comprised of dairy farmers residing in the rural areas of Punjab rearing cattle or buffaloes or both for milk production with the intention of income generation. The study population was the dairy farmers belonging to 24 selected villages of Punjab.

2.2. Sampling procedure and sample size

The crosssectional analytical study was carried out in 6 different districts representing all agroclimatic zones of Punjab (Barnala, Bhatinda, Hoshiarpur, Ludhiana, SAS Nagar, Tarn Taran). Assuming that 50% of the farmers would have awareness about SCM diagnosis tests, a sample size of 600 farmers were required to estimate the awareness and adoption level at a confidence interval of four with 95% confidence level assuming a response rate of 80% and with 14222 households in the 24 selected villages.[2] The multistage random technique was applied to select 2 blocks from each district, 2 villages from each block and 25 respondents from each village.

The authors visited each village and got an authentic list of dairy farmers from the Veterinary Dispensary. The selection of respondents within each village was based on the age of respondents above 18 years, availability at home, possession of dairy animals at the time of the survey, doing regular milk sale and on farmer's willingness to participate in the study. The participant information statement explaining the purpose of the study was provided to all the participants and written consent was obtained from the participants indicating their willingness to participate in this study.

2.3. Questionnaire design and data collection

A semistructured questionnaire on demographic characteristics, socioeconomic status, awareness, preventive practices, and diagnostic methods followed along with incidence details of mastitis was developed and pretested to allow for improvements. Either open-ended or dichotomous questions were included. The internal consistency of the questionnaire was checked

[1] Census Report (2011). Office of the Registrar General & Census Commissioner, Government of India [online]. Website http://censusindia.gov.in/2011census/dchb/DCHB.html [accessed 12 06 2018].

[2] Dhand NK and Khatkar MS (2014). Stimulator: an online statistical calculator. Sample size calculator for estimating a single proportion [online]. Website http://statulator.com/SampleSize/ss1P.html [accessed 12.06.2018].

by Cronbach's alpha value, which was 0.87, indicating good internal consistency related to the topic covered. All interviews were performed orally in the local language (Punjabi) with a request to participate in the survey during the study period.

2.4. Data analysis

All the data were compiled by Microsoft Excel and descriptive analysis was done by using SPSS Statistic software for Windows, Version 20 developed by IBM Corp. (Armonk, NY, USA).

2.5. Explanatory variable and outcome variable

Demographic, socioeconomic characteristics and communication profile of respondents along with the incidence of disease used as an explanatory variable to study the adoption level as an outcome variable. Descriptive statistics were applied to assess awareness, adoption and household characteristics of dairy farmers in the study area. Characterization was done using contingency tables (crosstabulation) to compare the proportion of adopters and nonadopters of SCM diagnosis in respect of a particular characteristic. A Chi–square test was carried out to assess the association between adoption and socioeconomic variables.

2.6. Determinants of adoption

Binary logistic regression model, an econometric model was applied and best fitted to identify factors affecting the adoption of technology [27]. Correlation analysis was used to check the multicollinearity between the explanatory variable [1]. Logit model specified by Pindyck and Rubinfeld [28] is as follows:

$$\text{In}\left\{\frac{P_i}{1 - P_i}\right\} = \beta_0 + \beta_1 X_1 + \text{..........}\beta_i X_i$$

where Pi indicates the probability of adopting the technology for ith respondent which ranges from 0 to 1 (the qualitative variable adopt is 1 if adopt and 0 if not adopt), β_0 denotes the intercept and βi represents the slope parameter in the model and Xi are used for explanatory/independent variables affecting the adoption of the technology.

2.7. Effect of adoption

Percentage analysis was performed for the incidence of CM among the dairy farms categorized as adopters and nonadopters of SCM diagnosis. One–way analysis of variance (ANOVA) was applied to assess the effect of adoption on the incidence of CM. The parameters viz. incidence rate, number of animals affected and exposed to CM on selected farms were considered for the study. The test was applied between 3 categories of farms based on the adoption of diagnosis technology and incidence of disease such as 1) technology adopters with no incidence (n = 17), 2) technology adopters with incidence (n = 23), and 3) technology nonadopters with incidence (n = 207).

3. Results

3.1. Characteristics of respondents and adoption of SCM diagnosis

For collecting information from 600 consented livestock farmers to participate in the survey, 660 livestock farmers were contacted from 24 selected villages of Punjab. The response rate was 90.90%; the remaining 9.10% farmers were excluded because of not fulfilling the selection criteria of the study. The detailed demographic and socioeconomic profile of the participants have been presented in association with the application of SCM diagnosis in Table 1. Most of the respondents (85.00%) were male, belonged to a joint type family (66.67%). The majority of respondents (44.00%) were 36–50 years of age, had a high school level of education (32.17%) and a medium–sized family (52.33%). About 30.83% of farmers were small landholders followed by marginal (21.83%), semimedium (21.33%), medium (12.17%), landless (11.00%), and large farmers (2.83%). Dairy farming was the primary source of income for 45.67% of households. The majority of farmers were having high dairy farming experience (> 10 years), medium herd size (between 6–15 animals), and both species at their farms. Proportionately, the majority of respondents had medium extension contacts and mass media exposure. Very few respondents attended training. About 37.00% of respondents had social participation and only 8.00% belonged to a project beneficiary category[3*].

Very few dairy farmers (6.67%) performed the diagnosis of SCM at their farms. Chi–square statistics indicated that all the socioeconomic characteristics of dairy farmers were significantly associated ($P < 0.01$, $P < 0.05$) with the adoption of technology except dairy farming experience.

3.2. Awareness and adoption level of SCM diagnosis tests

The survey data for awareness of respondents about various SCM diagnosis tests and its adoption at farm level is presented in Table 2, indicated that around 13.00% of respondents were aware about the sodium lauryl sulphate (SLS) Paddle test followed by the bromothymol blue (BTB) card test (11.67%). Around 7.00% of dairy farmers were using these tests to prevent and control the occurrence of disease. The awareness and use regarding modified California mastitis test (MCMT) was merely observed (0.17%).

3.3. Determinants of adoption

Lower values of correlation coefficients ranging between 0.002 and 0.372 for all the independent variables indicated no existence of any multicollinearity between independent variables (Supplementary Table 1).

Around 57.20% (R^2) of the variability in the dependent variable has been explained by the fitted logistic regression

[3] Project beneficiary indicates the enrollment of the respondent as a beneficiary of the project implemented by any institute including central and state governments focusing on dairy farming.

Table 1. Socioeconomic characteristics based on SCM diagnosis adoption.

Characteristics/categories	Nonadopters (%)	Adopters (%)	Total (%)	x^2 value	P value
Age (years)					
Middle (36–50)	248	13	261 (43.50)	9.086	0.011
Old (> 50)	157	7	164 (27.33)		
Young (< 36)	155	20	175 (19.33)		
Education level					
Illiterate (no education)	63	2	65 (10.83)	13.251	0.021
Primary (up to 4th)	72	3	75 (12.50)		
Middle (between 5th–8th)	89	4	93 (15.50)		
High school (between 9th–10th)	182	11	193 (32.17)		
Higher sec (between 11th–12th)	107	17	124 (20.67)		
Graduate (above 12th)	47	3	50 (8.33)		
Family size (no. of family members)					
Large (more than 8)	67	16	83 (13.83)	33.868	0.000
Medium (between 5–8)	292	23	314 (52.33)		
Small (up to 4)	201	1	202 (33.84)		
Agricultural land holding (hectors)					
Landless (no land)	66	0	66 (11.00)	22.566	0.000
Marginal (up to 1)	127	4	131 (21.83)		
Small (between 1–2)	177	8	185 (30.83)		
Semimedium (between 2–4)	111	17	128 (21.33)		
Medium (between 4–10)	64	9	73 (12.17)		
Large (more than 10)	15	2	17 (2.83)		
Dairy as a primary source of income					
No	318	8	326 (54.33)	20.361	0.000
Yes	242	32	274 (45.67)		
Dairy farming experience (years)					
High (more than 10)	415	25	440 (73.33)	3.773	0.152
Low (up to 5)	46	3	49 (8.17)		
Medium (between 5–10)	99	12	111 (18.50)		
Species reared					
Cattle & buffalo (both)	287	30	317 (52.83)	9.206	0.010
Buffalo	185	5	190 (31.67)		
Cattle	88	5	93 (15.50)		
Herd size					
Large (more than 15)	39	27	66 (11.00)	142.011	0.000
Medium (between 6–15)	306	12	318 (53.00)		
Small (up to 5)	215	1	216 (36.00)		
Extension contacts (mean score)					
High (up to 4)	89	26	115 (19.17)	59.027	0.000
Low (more than 9)	60	0	60 (10.0)		
Medium (between 4–9)	411	14	425 (70.83)		

Table 1. (Continued).

Mass media exposure (mean score)					
High (more than 12)	92	28	120 (20.00)	67.943	0.000
Low (up to 4)	81	0	81 (13.50)		
Medium (between 4–12)	387	12	399 (66.50)		
Social participation					
No	364	16	380 (63.33)	10.048	0.002
Yes	196	24	220 (36.67)		
Training attended					
No	506	21	527 (87.83)	50.068	0.000
Yes	54	19	73 (12.17)		
Project beneficiary					
No	521	29	550 (91.67)	20.610	0.000
Yes	39	11	50 (8.33)		
Adoption of SCM diagnosis	560 (93.33)	40 (6.67)	600 (100.00)		

Table 2. Awareness and knowledge level about on field SCM diagnosis tests.

(n = 600)

SCM diagnosis test	Awareness		Adoption	
	Yes (%)	No (%)	Yes (%)	No (%)
Bromothymol blue (BTB) card	70 (11.67)	530 (88.33)	40 (6.67)	560 (93.33)
Sodium lauryl sulphate (SLS) paddle test	77 (12.83)	523 (87.17)	40 (6.67)	560 (93.33)
Modified California mastitis test (MCMT)	01 (0.17)	599 (99.83)	1 (0.17)	599 (99.83)

model. The results in Table 3 revealed that demographic factor like family size (Odds Ratio - OR 2.436) was likely to affect the probability of adoption along with factors of economic importance like dairy income (OR 13.667), landholding (OR 2.130), herd size (OR 6.445), and incidence of clinical mastitis. Factors related to the communication profile such as extension contacts, training attended, and project beneficiary significantly affected the probability of SCM diagnosis adoption. However, there was no statistical evidence to conclude variability in age, education, and social participation affecting the adoption of the technology.

3.4. Effect of adoption of SCM diagnosis technology on incidence of clinical mastitis

The data were analyzed to study the association and effect of SCM diagnosis test adoption on the incidence of clinical mastitis (CM). Chi–square analysis indicated ($P < 0.01$) significant difference was seen in the incidence of CM on SCM diagnosis adopter and nonadopter farms (Table 4). About 230 dairy farms were having CM in their herds, representing a 38.33% incidence at the farm level, out of which only 10% was on technology adopter farms, and rest is on nonadopter farms (Figure). There were about 4.60% of adopter farms where no incidence was observed. (Supplementary Table 2)

From the 600 dairy farms, 3179 dairy animals were exposed, out of which 378 were suffered with CM (12.05%). Result of analysis of variance (Table 4) indicated a significant difference ($P < 0.01$) among all the 3 categories of farms for the number of animals affected, exposed and incidence rate of CM.

4. Discussion

Awareness of livestock owners about SCM diagnosis tests in Punjab state of India was assessed during the study. The results of the study indicated that the awareness level (< 13%) was very low. This might be due to the reason that the farmers were less aware of the prevalence of SCM in dairy animals and had poor knowledge about the prevention and control of the disease. Recently, Gangil [29] reported that only 5.00% of the dairy farmers in Punjab had correct knowledge about the mastitis diagnosis kit. Present findings were in support with Mdegela [30],

Table 3. Determinants adoption of SCM diagnosis test.

Variable	β	P value	OR (95% CI)
Age	–0.505	0.159	0.604
Education	–0.005	0.983	0.995
Dairy as a main source of income	2.615***	0.000	13.667
Family size	0.890**	0.028	2.436
Social Participation	0.130	0.786	1.139
Land holding	0.756***	0.007	2.130
Training Attended	0.874*	0.094	2.396
Dairy herd size	1.863***	0.000	6.445
Clinical mastitis incidence	–1.673***	0.004	0.188
Extension contacts	1.398***	0.003	4.047
Project beneficiary	1.391**	0.018	4.019
Constant	–14.303	0.000	0.000

n = 600; *** = Statistically significant at 1%; ** = Statistically significant at 5%; * = Statistically significant at 10%; Goodness of fit = 57.20% (Naglekerke R^2).

Table 4. Effect of adoption of SCM diagnosis technology on incidence of clinical mastitis.

Particulars	Technology adopters with no incidence	Technology adopters with incidence	Technology nonadopters with incidence	F value	P value
No. of animals affected	0 ± 0.00	2.00^a ± 0.33	1.60^a ± 0.11	9.178	0.000
No. of animals exposed	8.82^a ± 1.15	17.65^b ± 2.16	6.49^a ± 0.41	32.230	0.000
Incidence rate	0.00^a ± 0.00	13.37^b ± 2.34	31.23^c ± 1.36	30.493	0.000

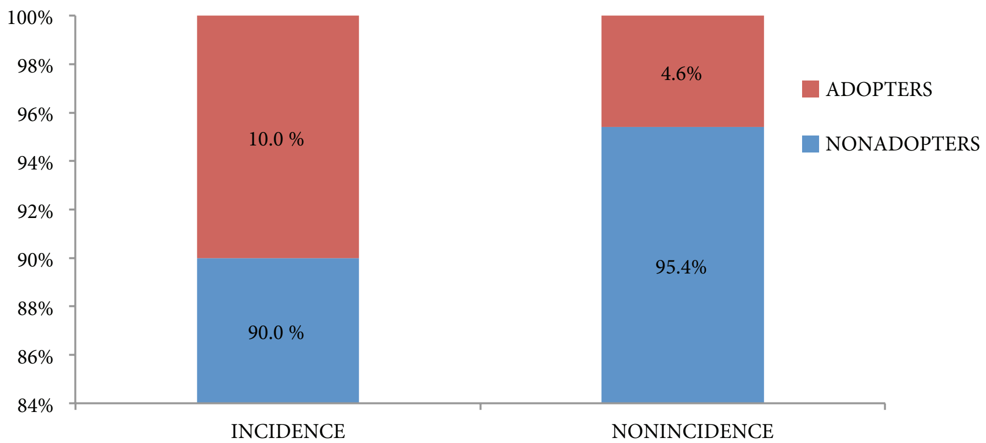

Figure. Adoption of SCM diagnosis technology and incidence of clinical mastitis at dairy farms of Punjab.

Mathialagan [31], Rathod [32], who reported that none of the farmers was aware of SCM and practices to control it. The awareness and use about SLS paddle and BTB card tests were observed more than the CMT test. This might be due to the efforts of the veterinary university in Punjab, which is trying its level best to disseminate the scientific technologies at field level by all possible means.

Lack of awareness about SCM and its prevention may lead to very less adoption of SCM diagnosis tests by livestock farmers reported Mpatswenumugabo [33].

Rathod et al. [32] also observed that unawareness of the SCM detection test and lack of awareness on mastitis prevention methods were the first and third constraints respectively in the prevention and control of mastitis. As awareness is the first stage of the adoption decision process, vigorous efforts must be put forth for widespread information on SCM diagnosis, prevention, and treatment.

Almost all the technology adopters were males of the young age group with education up to the higher secondary level. All women respondents were unaware of SCM diagnosis and prevention. The findings are corroborated with the study conducted by Mathialagan [31] who found that only 2% of dairy women were aware of the detection of subclinical mastitis in the study area.

Most of the adopters had dairy farming as a primary source of income which focuses more on management as it is the main source of income. Economic factors such as landholding and herd size are likely to affect adoption positively as these variables are related to wealth of the household having moderate to high livelihood status and voluntary initiative to buy and use the improved technologies. The core finding of the study also suggested that frequent extension visits, and training affects the adoption decision positively, supporting the innovation diffusion model [34]. The increase of change in knowledge, skill, and attitude increases the inclination of the farmers to use the technology. The finding corroborates with the study conducted by Kaaya et al. [35] and Dehinenet et al. [36]. Vigorous extension at the grassroots level is desired for changing and building farmers' awareness, understanding and perception regarding SCM diagnosis and prevention through mass media publicity, training, demonstration, field visits, experience sharing, etc. as suggested by Chelkeba et al. [27]. The incidence of mastitis is likely to have an inverse relation with SCM diagnosis.

The results from this study generally confirmed the potential direct role of the technology in reducing the incidence of clinical mastitis and improving rural household productivity as well as welfare. It confirms the statement of Swami et al. [5]; SCM results in clinical mastitis when left untreated and becomes difficult to cure and permanently affects the udder, resulting in stable loss of production trend. Similar findings were reported by Rathod et al. [32] that after imparting knowledge and skills on the mastitis detection and control techniques with the improved keeping quality of milk, a reduction in the occurrence of mastitis cases were recorded in the study area. Awareness of the importance and adoption of the SCM diagnosis by the dairy farmers as a preventive measure is the need for time to reduce the losses due to mastitis and protect consumer welfare. As SCM affects the milk quality as well as production, a comparative study is desired at the field level considering various diagnostic and preventive methods adopted for mastitis control, which was lacking in this study.

We suggest extensive and repetitive awareness campaigns and capacity building programs on clean milk production covering SCM and mastitis prevention at the village level. To achieve this, all stakeholders in the dairy industry (state veterinary varsity, animal husbandry and dairy department, milk cooperatives, and nongovernment organizations) can converge and work collectively. This will lower a farmer's expenditure on treatment and enhance the productivity thereby economic viability of the farm on one hand, while on the other hand, keeping consumer safety at the center.

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Conflict of interest
The authors declare no conflict of interest.

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Supplementary Table 1. Correlation analysis to check the multicollinearity between the explanatory variable.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1 - Age	1										
X_2 - Education	-.351**	1									
X_3 - Dairy income	-.089*	.011	1								
X_4 - Family size	.134**	-.007	-.062	1							
X_5 - Social participation	.083*	.248**	-.017	.147**	1						
X_6 - Land holding	-.010	.203**	-.392**	.278**	.249**	1					
X_7 - Training attended	-.025	.164**	.150**	.136**	.151**	.086*	1				
X_8 - Dairy herd size	-.030	.129**	.223**	.367**	.244**	.405**	.242**	1			
X_9 - CM incidence	-.063	.175**	.241**	.130**	.161**	.187**	.231**	.379**	1		
X_{10} - Extension contacts	-.121**	.203**	.125**	.090*	.194**	.312**	.357**	.372**	.257**	1	
X_{11} -Project beneficiary	-.089*	-.013	-.046	.027	.046	.147**	-.002	.165**	-.002	.107**	1

** = Statistically significant at 1%;
* = Statistically significant at 5%

Supplementary Table 2. Adoption of SCM diagnosis technology and incidence of clinical mastitis at dairy farms of Punjab.

Particulars	Adopters	Affected animals (Exposed animals)	Nonadopters	Affected animals (Exposed animals)	Overall	Affected animals (Exposed animals)	Chi-square x^2
Incidence of CM	23 10.00%	46 (406)	207 90.00%	332 (1343)	230 38.33%	378 (1749)	94.477**
Nonincidence	17 4.60%	00 (150)	353 95.40%	00 (1237)	370 61.67%	00 (1387)	
Overall	40	46 (556)	560	332 (2580)	600 100.00%	378 (3136)	

** = Statistically significant at 1%;