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Does mastitis cause economic loss in dairy cattle in Nepal?

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ABSTRACT

Mastitis is an economically important disease of dairy cattle worldwide. To assess its economic impact, a study was conducted in 384 households from eight districts namely Jhapa, Morang, Sunsari, Sarlahi, Chitwan, Rupandehi, Makawanpur and Kavre of Nepal having major dairy pockets, higher number of cattle population and higher number artificial insemination records. A semi-structured questionnaire was designed, pretested and asked with the respondents having dairy cattle. A focus group discussion was made with the members of dairy cooperatives, service providers from the government and private sectors including veterinarians, paraprofessionals and development workers. The key informant's interview was performed with livestock experts from veterinary laboratories, veterinarians from Department of Livestock Services (DLS) and Nepal Agricultural Research Council (NARC) to identify and triangulate the economic loss caused by clinical and subclinical mastitis. The survey results showed that an estimated loss of 8320 million Nepalese rupees (around 64 million USD) for sub- clinical mastitis and 4430 million rupees (around 34 million USD) for clinical mastitis. Dairy cattle suffering from mastitis also showed the higher incidence of infertility. The probability of infertility in mastitis affected cattle is 11% higher as compared non affected cattle. It is recommended to initiate the effective mastitis control program immediately which also helps to reduce the incidence of infertility in dairy cattle.

Keywords: Mastitis, economic loss, infertility, technology adoption

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INTRODUCTION

Livestock is the important means of the livelihood of Nepal. It contributes around 5.96 and 38.60 percent to the GDP and AGDP, respectively (DLS 2022). Mastitis in dairy cows is one of the most common diseases causing huge economic impact on the dairy

industry throughout the world (Azooz et al 2020). Mastitis is an inflammation of the mammary gland caused from varieties of infectious organisms, leading to abnormal and decreased milk production in cattle (Cheng and Han 2020). The clear sign of mastitis is inflammation of the udder that turns into a red and hard mass. The swollen mammary gland is hot and the mere touching causes pain and discomfort to the animal (Singh et al 2021). Animals do not allow touching of the udder even kicking to prevent milking. If milked, the milk is usually tainted with blood clots having foul smelling brown discharge. It appears in both clinical and subclinical forms.

Mastitis reduces the milk production and also depreciates the quality of milk (Ogola et al 2007). The prevalence of sub clinical mastitis (SCM) in dairy animals ranges from 13.6 to 60% in different parts of Nepal and high incidence of both Clinical Mastitis (CM) and SCM is associated with poor adoption of good husbandry practices (GHP) (Sah et al 2020). According to Dhakal and Subedi (2002), Dhakal et al (2007), the prevalence of CM is up to 56% in cattle in Nepal. SCM is known as an extensive problem in the dairy industry worldwide and particularly in developing countries (Sah et al 2020, Abrahmsén et al 2014).

Once dairy animals are infected with the mastitis, farmers require waiting for healing from the disease, thus withheld the milking for several days after treatment (Erskine 2022). Economically mastitis is associated with reduced milk production, additional diagnostic and treatment costs (Aghamohammadi et al 2018). Farmers usually resort to treating CM soon after seeing obvious symptoms while the SCM causes huge economic losses due no visible symptoms except in gradual reduction in milk yield and failure to conceive despite numerous inseminations (Birhanu et al 2017). Mastitis compels farmers to discard the milk as it brings changes in the milk composition. Farmers cull the diseased animals and they face financial loss for selling their animals as salvage. In addition to these, mastitis creates additional cost of rearing unproductive animals. It adds some additional cost to the farmers to replace their productive animals and other costs likes labor cost.

Farmers are relatively less aware about the disease as well as the loss caused by mastitis. Generally, milk production starts to decrease with the onset of mastitis. Farmers might have already lost a bulk amount of milk production prior to the diagnosis of disease and immediately after the diagnosis. This study gives an insights to the farmers over the impact of the disease and prevention option to be taken by them. The adoption of GHP and new technology is associated with better milk yield and directly associated with income generation, poverty reduction and food and nutrition security (Herrero et al 2013). A very limited and location specific study has been conducted previously on the economic loss of mastitis and its relation to infertility in cows in Nepal. Therefore, this study aimed to estimate the economic loss caused by mastitis in cattle and the relationship between mastitis and infertility in different geographical location of Nepal. The research questions are: i) Do mastitis in dairy cattle cause huge economic loss? ii) Is there a relationship between mastitis and infertility?.

METHODOLOGY

Study area

A survey was conducted in Jhapa, Morang, Sunsari, Sarlahi, Kavre, Makawanpur, Chitwan and Rupandehi districts Nepal (Figure 1). While selecting the survey districts, the districts having more than average numbers of high yielding cattle population, higher

artificial insemination records and potential dairy pockets were selected for the study. Total number of cattle populations in the selected districts were used as target population.

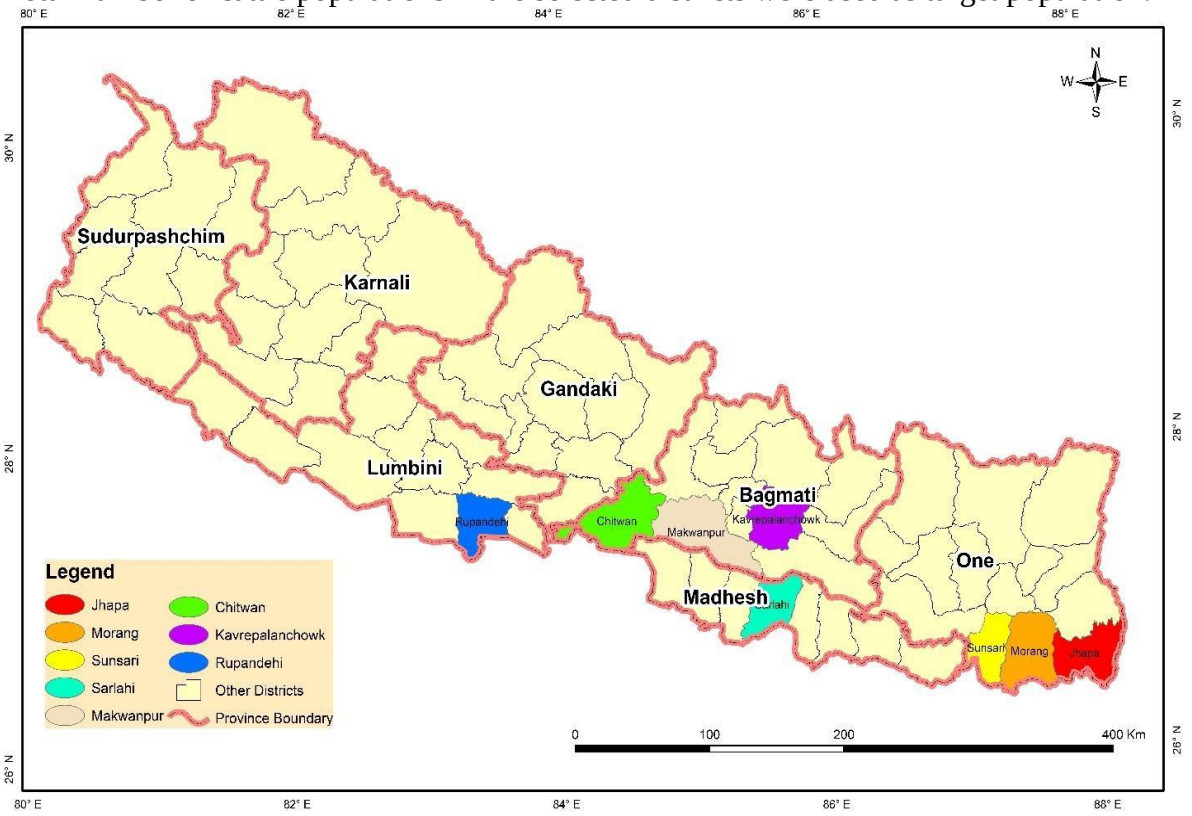

Fig 1. Map showing survey districts 2021/22

Sampling procedure and data collection

The sample size was determined based on proportionate number of cattle populations in each district. After the determination of sample size, pockets in each district with at least 30 samples household rearing cattle in each pocket were selected by round down method. The dairy pockets were listed down in consultation with the respective Veterinary Hospital Livestock Services Experts Center (VHLSEC). Questionnaire was revised and finalized after pre-testing. Altogether 384 samples were selected and surveyed from selected districts. Semi- structured questionnaire survey was conducted and data were collected randomly from the selected pockets of the respective districts. In addition to this, several consultative meetings were conducted with relevant experts and peers before finalizing the questionnaire and conducted a questionnaire pre-testing to check its reliability. In addition to the household questionnaire survey, a parallel focus group discussion (FGD) in each sites was also conducted in each identified dairy pocket. Relevant senior officer from the Department of Livestock Services (DLS), veterinary diagnostic laboratory chiefs from each province, and experts from National Animal Health Research Centre under Nepal Agricultural Research Council (NARC) were identified as members and a Key Informants Interview (KII) was also conducted with them to triangulate and to verify the fact. Secondary information were collected from Centre Bureau of Statistics (CBS), Ministry of Agriculture and Livestock Development (MoALD), DLS, NARC and the information were triangulated with the data collected.

Methods and techniques of data analysis

Collected primary data were examined and cleaned to ease the econometric estimation and relevant analysis. Scrutinized data were entered into MS excel sheet and analyzed for

descriptive and inferential statistics. Frequency, percentages, were analyzed through descriptive analysis and probit regression was used to identify the drivers of infertility incattle.

Economic loss due to mastitis

Economic loss can be assessed in terms of milk production loss, treatment and medication cost, veterinary service cost, value of discarded milk, additional labor needed for care of diseased animals, depreciation of animal value, replacement cost and miscellaneous cost. These individual costs incurred make the total loss of mastitis. Economic loss caused due to mastitis was estimated according to the method described by Singh et al (2021). The economic loss for subclinical and clinical mastitis was estimated separately. Parameters usedto establish the total economic loss is given below in Table 1.

Table 1. Total economic loss estimation of mastitis

Losses due to sub- clinical mastitis	Losses due to clinical mastitis
Total milk production losses can be calculated as follows	Loss due to reduced milk production
Average lactation yield (lts)= A	Reduced milk production per animal= Average milk losses due to clinical mastitis (%) x Average daily milk yield of animal x Average price ofmilk x Average duration of mastitis affection=P
Average production loss (%)= B	Reduced milk production per animal (Rs)= P* Average price of milk = I
Average milk price (Rs)= C	Cost of milk discarded due to clinical mastitis per animal (Rs)=0.50 x Average daily milk yield of animal x average price of milk x Number of days milk isdiscarded =J
Milk loss per animal per lactation	Loss due to replacement of mastitic animal = Average price of lactating animal - price received for culled animal= K
Quantity = axb (lts)= D	Replacement value of new animal = Average price of lactating animal + loss incurred inculling a mastitic animal =L
Value= axbxc (Rs)= E	Number of animals culled due to mastitis = percent culling rate (1%) x milch animal population = M
Average incidence (%)= F	Total loss due to culling mastitic animal along with their replacement = replacement value of new animal (L) x no. of animals culled due to mastitis (M) = N
Milch animal population (millions)= G	Total losses incurred on one animal= I+ J + vets fee +cost of treatment=O
Number of animals affected (million)= Fx G = H	Total loss due to clinical mastitis = [O x number ofanimals affected] + N
Milk production losses Quantity (Million tons)= D x H	

Adapted from Singh et al (2021)

Factors affecting infertility in cattle

Probit model was used to analyze the factors affecting infertility in cattle in the study area. In this study either affected (or not affected) to infertility are two outcomes or decision (1= infertility and 0 = none).

The probit model specified in this study to analyze the factors affecting infertility in cattle.

Pr (Animal affected to infertility =1) = f (a_0+ a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7 + a_8X_8 + a_9X_9 +$a_{10}X_{10}$)

Where, Pr = Probability score of animal affected with infertility X_1= Incidence of mastitis (Dummy)

X_2= Cattle reared (Dummy)

X_3= Agro-ecological (Dummy)X_4= Gender (Dummy)

X_5= Experience in dairy farming (Continuous) X_6= Membership in organization (Dummy)

X_7= Credit Access (Dummy)

X_8= Distance to Vet office (Continuous) X_9=Veterinary service taken (Dummy) X_{10}= Education (Years of schooling)

a_1, a_2…. a_{10} = Probit coefficient,a_0 = Regression coefficient

RESULTS

Socio-economic profile

Livestock farming is found as the major source of income for the farmers in the study area. Around 62% of the total households' incomes come from livestock resources in these districts (Table 2). The present study has found that around 46% of farmers are rearing improved breed of cattle, 34% are keeping local breeds and 20 % of the farmers keep both improved and local cattle breeds. On an average, each household is found to rear two cattle and around 59% of the farmers are members either in the farmers' groups or dairy cooperatives. Most of the dairy farmers have reportedly acquired lower secondary education but their average experience in dairy farming is found 23 years (Table 2). In the meantime, it is observed that 60% of the family decision in matters related to livestock farming is taken by men. Livestock extension and veterinary service seems to be inadequate in these sites, only 20% of those farmers have access to veterinary service and only 20% of farmers have access to credit facility. Similarly, there is inadequate coverage of livestock insurance service, only 27% of farmers have taken livestock insurance service in these districts (Table 2).

Table 2. Socio-economic profile of cattle rearing farmers

Variable	Mean	SD	Min	Max
Education (years of formal education)	6.41	4.14	0	18
Experience of farmers (No. of years)	22.66	14.65	0	70
Cow shed (Improved=1)	0.38	0.48	0	1
Total owned cattle (No.)	2.17	3.10	0	42
Access to veterinary service (nearness of the service center in Kilometer)	3.86	3.75	0.1	41
Member of farmers dairy group/cooperatives (Yes=1)	0.59	0.49	0	1
Access to extension service (Yes=1)	0.18	0.39	0	1
Access to credit (Yes=1)	0.20	0.40	0	1
Gender of the cattle attendant (Male=1)	0.60	0.49	0	1
Livestock main source of income	0.62	0.48	0	1
Cattle breed (Improved breed=1)	0.46	0.49	0	1
Livestock insurance (Yes=1)	0.27	0.44	0	1

Economic loss due to mastitis

From the socioeconomic field survey, the average prevalence of clinical mastitis in dairy cattle was 19%; and it is reported that the prevalence could be even higher including SCM. During FGD, veterinary laboratory chief from each province and filed practicing veterinarians claimed that the prevalence of SCM is around 32%. The KII with laboratory veterinarians supported the claim during the FGD discussion and published literatures

about the mastitis.

There are around 1.2 million cattle producing 1.06 million metric ton of milk throughout the country (DLS 2022). Total loss was calculated by considering the average prevalence of clinical and subclinical mastitis, total number of milking cattle and average selling price of milk Rs. 55.17 per liter. The total loss due to subclinical is found to be Rs. 8320 million which is almost double the value of clinical mastitis i.e. Rs. 4430 million as shown in Figure 2.

Antibiotics and therapeutics were found to be used for the treatment of mastitis. These antibiotics have different withdrawal period. If the waiting periods of antibiotics and therapeutics drugs is included in the cost, then the overall cost of mastitis become even more than that of the estimated figure.

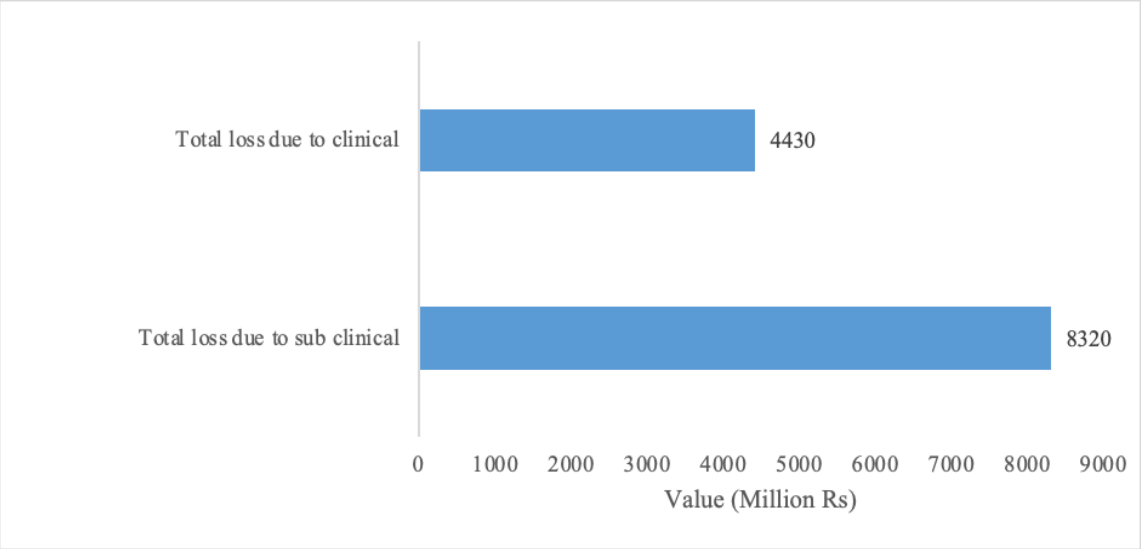

Fig 2. Total value of losses (in terms of Nepal currency) due to mastitis

Mastitis at lactation stage

Mastitis was seen in the initial lactation stage i.e. around 10 weeks followed by peak (11-18 weeks) and last (18+ weeks) in the study sites (Figure 3).

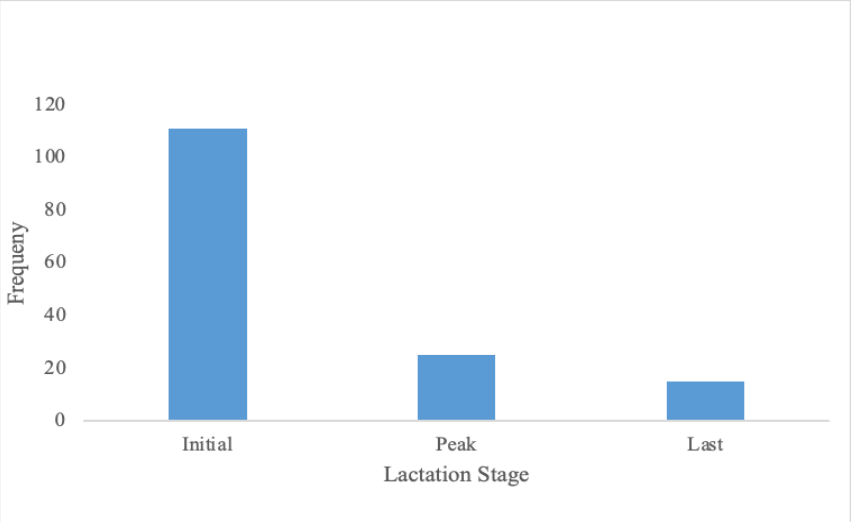

Fig 3. The frequency of mastitis during the different lactation stages (10 to 18+ weeks duration)

Association of Mastitis with infertility

To identify the factors affecting infertility in cattle, a probit regression model was used. The probit model estimated a pseudo R^2 of 0.09 indicates that independent variables' ability to explain the dependent variable is equal to 9% (Table 3). The measure of goodness of fit here is non-significant and concluded that the probit model employed is robust and appropriate.

Out of the 10 factors used as shown in Table 3, incidence of mastitis, improved breed of cattle and access to veterinary service (nearness of the veterinary service) center were found positively associated with the incidence of infertility in cattle. It showed that a cow suffering from mastitis is more prone to infertility (Table 3). In addition to this, improved breed of cattle is found more prone to infertility rather to the local breed (Table 3). The probability of acquiring infertility is more by 11% in mastitis affected cattle than non-affected cattle. Improved breeds of cattle have 9% more chance to get infertility than that of the local breeds of cattle (Table 3). Access to veterinary office is also positively associated with the infertility of the cattle. It means nearness to the veterinary office has lower incidence of infertility (Table 3). It can be interpreted that farmers who can easily access veterinary service can reduce the chance of infertility in their cattle.

Table 3. A relationship between infertility and various other associated factors in cattle

Variables	dy/dx	Std. Err.
Incidence of mastitis (Yes=1)	.0114***	0.042
Cattle breed (Improved breed=1)	0.095***	0.040
Agro-ecological Region (Terai=1)	0.052	0.041
Gender of the cattle attendant (Male=1)	-0.015	0.033
Experience of farmers (No. of years)	0.000	0.001
Member of farmers dairy group/cooperatives (Yes=1)	0.018	0.038
Access to Credit (Yes=1)	0.055	0.046
Access to veterinary service (nearness of the service center Kilometer)	0.010***	0.004
Veterinary service (Yes=1)	0.062	0.048
Education (years of formal education)	-0.003	0.004
Number of observations	384	
LR chi^2 (10)	30.15*** (Prob > chi2=0.0008)	
Log-likelihood	-149.65369	
Pseudo R^2	0.0915	
Goodness of fit test	Pearson chi2 (367) = 371.36 .Prob> chi^2 =0.4267	

***, ** and * indicates Significance at 1, 5 and 10% level respectively

DISCUSSION

Farmers are gradually upgraded to commercial cattle farming in certain dairy pockets due to the improved access to road, electricity and the market. They are adopting semi-intensive to intensive system of husbandry and using artificial insemination technology for breed improvement. However, the incidences of mastitis is not declining but exist almost in similar pattern. Mastitis has been recognized as one of the most important economic disease of Nepal (Dhakal 2000). It causes colossal losses as a result of reduced milk production, discarded milk, and treatment and replacement costs. Malinowski and Gajewski (2010) also stated that mastitis causes changes in many active constituents in milk and blood. It not only impairs the milk quality but also requires sufficient time for milk withholding after treatment.

Philpot and Nickerson (1991) reported that National Mastitis Council (NMC) has confirmed that 70-80% of all losses are associated with subclinical mastitis while 20-30% is due to clinical mastitis. Similarly the report of National Animal Health Research Centre (Joshi 2003) has also mentioned that the incidence of sub clinical mastitis and clinical mastitis was 35-55% and 20-30%, respectively. Considering the incidence of sub clinical and clinical mastitis was 32 and 19%, it is approximately estimated that the value of around 8320 million and 4420 million Nepalese rupees is losing by the farmers annually by sub clinical and clinical mastitis, respectively. The monetary loss due to SCM is enormous in comparison to that of CM. Singh et al (2021) has also estimated more loss in subclinical mastitis ascompared to clinical mastitis.

A total annual loss due to mastitis in USA was nearly 2 billion US dollars, i.e. 181US dollars/cow/year (NMC 1987). In Indian context, milk loss was reported to 106.80 Indian rupees and the total loss on an average for each affected cow was found 325.64 Indian rupees which includes the cost of treatment and loss of milk (Sashidhar et al 2002). Similarly, Dhakal and Thapa (2003) reported a total cost associated with milk production loss was about 63 US dollars in a study in Chitwan district. Grohn et al (2004) mentioned that the reduction in milk production starts one or two weeks before diagnosis and the maximum loss occurred just following disease diagnosis. The affected cows often never recover their potential yield. It is associated with yield loss at the time of diagnosis, and, more importantly, yield loss often persists throughout lactation (Rajala-Schultz et al 1999). Reduced milk yield is the major component of the cost associated with both CM and SCM (Huijps et al 2008, Hortet and Seegers 1998, Degraves and Fetrow 1993). The extent of yield loss depends on severity, causative pathogen, parity of cow, and the stage of lactation at which mastitis develops. Similarly, the first lactation stage cow was more prone to mastitis in the study sites.

According to Large animal 2016, mastitis can affect long-term cow productivity by impairing their ability to conceive. The SCM induces infertility by causing premature activation of primordial follicles, injury to developing oocytes due to oxidative stress, and disruption of communication between oocytes and cumulus cells (Waseem 2019). Wolfenson et al (2016), mentioned that acute clinical form of mastitis has a time-dependent disruptive effect on conception rate that include depression of steroid production in the preovulatory follicle associated with low and delayed preovulatory luteinizing hormone surge, resulting in delayed ovulation in one-third of subclinical cows. In addition, mastitis impairs oocyte competence, reflected in low production of blastocysts and causes severe pain which ultimately affects appetite of cow and results increased negative energy balance. This negative energy balance can damage the oocytes.

The corpus luteum provides the uterine environment that helps in implementation and pregnancy (Oliver and Pillarisetty 2022). According to Large animal 2016, if an active corpus luteum is in place, that could induce early luteolysis, impairs embryo implantation or causes resorption due to a decline in progesterone levels and increased contractility of the uterine smooth muscle. When mastitis is first diagnosed the *corpus luteum* seems to be insensitive to mastitis, possibly due to the use of non-steroidal anti-inflammatory drugs (Malinowski and Gajewski 2010). McDougall et al (2009) showed that by adding the non-steroidal anti- inflammatory drug (NSAID) meloxicam to an antibiotic mastitis treatment, fewer treated cows were culled when compared with a control group.

The teat dipping technology developed and recommended by Nepal Agricultural Research Council is the mixture of 0.5% povidone iodine and glycerine in the ratio of 9:1. This

technology is used to prevent from infection and reduce the incidence of the disease. Teat should be dipped on the solution for 30 seconds after each milking every day after cleaning the teats which helps to prevent mastitis (Dhungana 2018). About 3.8 % of the farmers in these areas were found adopting this technology. The research conducted by Dhungana (2010), claimed that prevalence of Bovine Mastitis can be reduced by 75% from the initial infection level by regular teat dipping. Similarly, Joshi (2002) reported that the incidence of SCM can be reduced by 70% in first year and 68.5% in the second year from the initial infection level. The focus on management plays the important role in prevention from the new infections on the teat end. So the hygiene milking is essential and the most important management for the sub clinical mastitis is the use of effective germicide as a post milking teat dip (Erskine 2022).

CONCLUSION

Mastitis causes most extensive milk yield loss in every episode. It is estimated that around 8320 million and 4420 million Nepalese rupees is lost from sub-clinical and clinical mastitis, respectively. It is also observed that incidence of infertility is also correlated with the incidence of mastitis. The study inferred that mastitis predisposes lactating cows to infertility by 11 percent more. Access to prevailing veterinary services are inadequate especially to dairy cattle farmers, therefore, more veterinarians need to be deputed in dairy pockets either by the provincial government or by the municipalities. There is a good scope of private veterinarians or clinicians in the dairy pockets from the perspective of disease incidence and prevalence. Awareness to economic loss due to mastitis, early detection and preparedness using recent technologies is essential for dairy farmers to prevent the potential economic loss as well as mastitis prevention and control. A nationwide mastitis control program should be initiated immediately to prevent further economic loss. It is likely that the mastitis infection is not only related to technical treatment of infected cattle, but its prevalence is related to hygiene, cleanliness, hand washing activities. Therefore, more campaigning for cleanness of the cow housing, hygiene and proper washing could be advocated and practiced to avoid the mastitis pathogen from the host.

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Authors' Contributions

MK, KPT and SPA were involved in designing the research plan. MK and SPA collected data. MK analyzed the data and drafted the manuscript. DRK and TPP involved in site selection, questionnaire design and revision of the paper. KPT and CD guided in research design, interpretation and critical revision of the manuscript for the finalization of the paper. All authors listed have made a substantial, direct and intellectual contribution to the study, and approved it for publication.

Conflicts of Interest

The authors have no relevant financial or non-financial interests to disclose.

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REFERENCES

Abrahmsén M, Y Persson, BM Kanyima and R Båge. 2014. Prevalence of subclinical mastitis in dairy farms in urban and peri-urban areas of Kampala, Uganda. Trop. Anim. Health Prod. **46**: 99–105. Doi: https://doi.org/10.1007/s11250-013-0455-7.

Aghamohammadi M, Haine D, DF Kelton, HW Barkema, H Hogeveen, GP Keefe and S Dufour. 2018. Herd-Level Mastitis-Associated Costs on Canadian Dairy Farms. Frontiers in Veterinary Science **5.** https://doi.org/10.3389/fvets.2018.00100

Azooz MF, SA El-Wakeel and HM Yousef. 2020. Financial and economic analyses of the impact of cattle mastitis on the profitability of Egyptian dairy farms. Vet World **13**(9):1750-1759. doi: https://doi.org/10.14202/vetworld.2020.1750-1759

Birhanu M, S Leta, G Mamo and S Tesfaye. 2017. Prevalence of bovine subclinical mastitis and isolation of its major causes in Bishoftu Town, Ethiopia. BMC Res Notes. doi: https://doi.org/10.1186/s13104-017-3100-0.

Cheng WN and SG Han .2020. Bovine mastitis: risk factors, therapeutic strategies, and alternative treatments - A review. Asian-Australas J Anim Sci. **33**(11):1699-1713. doi: https://doi.org/10.5713/ajas.20.0156.

Degraves FJ and J Fetrow. 1993. Economics of Mastitis and Mastitis Control. Veterinary Clinics of North America-Food Animal Practice **9**(3): 421-434. Department of Animal Breeding and Genetics Uppsala.

Dhakal IP. 2000. Occurrence of subclinical mastitis in buffaloes in different management systems in Chitwan. IAAS Research Reports (1995-200): 13-18.

Dhakal, IP and BB Thapa. 2003. Economic impact of clinical mastitis in buffaloes during lactation. Nepalese Veterinary Journal. **Pp** 24-31.

Dhungana KP, RP Shah, YK Shreshtha, MK Shah, BR Acharya, SP Devkota and S Aryal. 2010. Study on Epidemiology and Preventive Strategy in Bovine Mastitis in Syangja District. RARS, Lumle.

Dhungana KP. 2018. Gaai bhaisi ma laagne thunelo rog ra yesko byawasthapan. Lumle Krishi Darpan 5Regional Agriculture Research Station (RARS) (in Nepali language).

DLS. 2022. Livestock Statistics of Nepal (2020/21), Department of livestock Services, Ministry of Agriculture and Livestock Development, Government of Nepal.

Erskine R J. 2022. Mastitis in Cattle. Reproductive System. MSD Veterinary Manual. https://www.msdvetmanual.com/reproductive-system/mastitis-in-largeanimals/mastitis-in-cattle

Ghani MW, L Bin, MW Birmani, A Nawab, LG Cun, L Ye and X Mei. 2019. Impact of Subclinical Mastitis on Reproductive Performance of Dairy Animals. International Journal of Veterinary Sciences Research **5**(2): 48–57.https://doi.org/10.18488/journal.110.2019.52.48.57.

Gröhn YT, DJ Wilson , RN González , JA Hertl , H Schulte, G Bennett and YH Schukken. 2004. Effect of pathogen-specific clinical mastitis on milk yield in dairy cows. Journal of Dairy Science **87**(10): 3358-74. doi: 10.3168/jds.S0022-0302(04)73472-4.

Hagnestam-Nielsen C and S Ostergaard. 2009. Economic impact of clinical mastitis in a dairy herd assessed by stochastic simulation using different methods to model yield losses. Animal **3**(2): 315-328.

Herrero M, D Grace, J Njuki, N Johnson, D Enahoro, S Silvestri and MC Rufino. 2013. The roles of livestock in developing countries. Animal **7**(1): 3-18.

Hortet P and H Seegers .1998. Loss in milk yield and related composition changes

resulting from clinical mastitis in dairy cows. Preventive veterinary medicine **37**(1-4): 1-20.. doi: https://doi.org/10.1016/s0167-5877(98)00104-4.

Huijps K, TJ Lam and H Hogeveen. 2008. Costs of mastitis: facts and perception. Journal of Dairy Research **75**(1):113-120.

Joshi BR.2002. Response of teat dipping on incidence of mastitis in high yielding dairy cow, Lumle seminar Paper No. 2002/13 Agriculture research station, Lumle.

Lamsal P. 2018. Cattle hygiene status and its relation with subclinical mastitis: A study in commercial farms in Rampur Nepal. Int. J. Appl. Sci. Biotechnol. **6**:252–254. Doi: https://doi.org/10.3126/ijasbt.v6i3.21180

Large Animal.2016. Mastitis and the link to infertility. Veterinary Ireland Journal **6**(2): 95100. https://www.veterinaryirelandjournal.com/images/pdf/large/la_feb_2016.pdf

Malinowski E and Z Gajewski. 2010. Mastitis and fertility disorders in cows. Pol J Vet Sci.**13**(3):555-60. PMID: 21033574.

McDougall S, MA Bryan and RM Tiddy. 2009. Effect of treatment with the nonsteroidal antiinflammatory meloxicam on milk production, somatic cell count, probability of re-treatment, and culling of dairy cows with mild clinical mastitis. Journal of Dairy Science **92**(9): 4421-4431. Doi: https://doi.org/10.3168/jds.2009-2284.

Joshi BR. 2003. Pasuma laagne thunelo rog ra yeska rokthaamka upaayeharu. Pamphlet by National Animal Health Research Centre, Khumaltar, Lalitpur, Nepal

National Mastitis Council (NMC). 1987. Current concepts of bovine mastitis. 3rd ed. Arlington, V.A. 22201. Ogola H, Shitandi A and Nanua J. 2007. Effect of mastitis on raw milk compositional quality. J Vet Sci. **8**(3): 237-42. doi: 10.4142/jvs.2007.8.3.237.

Oliver R and Pillarisetty LS.2022. Anatomy, Abdomen and Pelvis, Ovary Corpus Luteum. [Updated 2022 Oct 24]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022. https://www.ncbi.nlm.nih.gov/books/NBK539704/

Philpot WN and SC Nickerson. 1991. Mastitis: Counter Attack, Babson Bros. Company (publisher) https://books.google.com.np/books?id=OSHpGAAACAAJ.

Rajala-Schultz PJ, YT Gröhn, CE McCulloch and CL Guard. 1999. Effects of Clinical Mastitis on Milk Yield in Dairy Cows. Journal of Dairy Science **82**(6): 1213- 1220.

Sah K, Karki P, Shrestha R D, Sigdel A, Adesogan A T and Dahl G E. 2020. MILK Symposium review: Improving control of mastitis in dairy animals in Nepal. Journal of Dairy Science **103**(11): 9740-9747, https://doi.org/10.3168/jds.2020-18314.

Sashidhar PVK, YR Reddy and BS Rao. 2002. Economics of Mastitis. Indian Journal of Animal Science **72**: 439-440.

Singh SV, JP Singh, Ramakant, D Niyogi, DK Yadav, R Gupta, and SK Maurya. 2021. Analysis of Economic Losses due to Mastitis in Cattle of Uttar Pradesh, India. Int. J. Curr. Microbiol. App. Sci. **10**(03): 1571-1576. doi: https://doi.org/10.20546/ijcmas.2021.1003.196.

Singh VP, BV Singh, RK Singh and AK Singh. 2021. Mastitis: A most significant diseases of dairy animals. Agriblossom, A monthly peer reviewed e-magazine for Agriculture & allied Sciences **1**(11): 3-6.

Wani SA, RI Ul Haq, OR Parray , Q Ul A Nazir, M Mushtaq, RA Bhat, JU Parrah, S Chakraborty, K Dhama and M I Yatoo. 2022. A Brief Analysis of Economic Losses Due to Mastitis in Dairy Cattle. The Indian veterinary journal **90**: 27-31.

Wolfenson D, G Leitner and Yaniv Lavon (2016). The Disruptive Effects of Mastitis on Reproduction and Fertility in Dairy Cows, Italian Journal of Animal Science **14**(4):4421-4431. https://doi.org/10.4081/ijas.2015.4125.