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Review Article

A meta-analysis of the Impact of Endometritis on Reproductive and Productive Performances of Lactating Dairy Herds

By

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ABSTRACT

Endometritis is a major postpartum disease that affects the productive and reproductive performance of dairy cows that is accompanied by heavy economic losses to the farmer. We conduct a meta-analysis to evaluate the effect of Endometritis on daily milk yield (DMY) and some reproductive indices (pregnancy rate, days open (DO), service per conception (S/C), and days to the first insemination) in lactating dairy cows. Data corresponding to 4037 cows was extracted from eleven research papers with sufficient data for analysis. The odds ratio was calculated for binary data (Endometritis incidence and pregnancy rate) by using the multinomial logistic regression, while the summary estimate was calculated for continuous data (DMY, S/C, and DO) by using the Linear mixed model (Multilevel regression). The odds ratio (OR) of Endometritis had a significant difference among different studies and years, paper No.4 recorded an equal number of diseased and healthy cows (OR=1), so we take this paper as a reference category, OR was the highest (1.6) for paper No.10, while it was the lowest (0.2) for paper No. 2. Concerning the pregnancy rate, Endometritis significantly reduced the pregnancy rate by 45% compared with the healthy cow. Regarding the DMY, Endometritis had a significant reduction in DMY by 1.7 kg rather than the healthy one. Concerning the DO, the cow that suffered from Endometritis had a more prolonged DO by 58 days than the healthy one, also S/C had a significant increase by 1.6 compared with healthy cows. Finally, we concluded that Endometritis had an adverse effect on the productive and reproductive performance of dairy herds, and the total Endometritis losses per ten cows were about \$2897.2 yearly. Our recommendation is to apply all preventative measures against Endometritis to maximize the profitability of dairy farms.

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INTRODUCTION

Meta-analysis is a statistical analysis that combines the result of multiple scientific studies. It had many purposes as it can provide a more complex analysis of benefits and harms and also develop a more correct estimate of effect magnitude. In our study, we used it to investigate the impact of Endometritis on milk production and reproductive performance. Endometritis is defined as inflammation of the uterus present more than 3 weeks after calving (Sheldon et al., 2006). Tayebwa et al. (2015)

concluded that the prevalence of Endometritis in dairy cows is widely as low as 3.6 %, while Sheldon et al. (2019) found that there are up to 40% of dairy cattle develop a postpartum uterine disease that causes infertility by compromising the function of the endometrium and ovary. McDougall et al. (2020) recorded a large variation among herds in the prevalence of Endometritis and the reasons for this variation are currently unknown and require further investigation, Endometritis is divided into 4 degrees:

Chronic Catarrhal Endometritis (E1)	Chronic Muco-Purulent Endometritis (E2)
Failure of conception with repeat breeding every 21-25 days. Rectally: there is normal genitalia of an animal. Estrus mucus is slightly increased and turbid.	Rectally: The uterus & cervix are slightly enlarged, flabby, and thickened. Vaginally: Cervix is enlarged and congested (chronic cervicitis) Abnormal discharge was seen on/off estrus. Increased, milky, or cloudy mucous with pus flakes.
Purulent Endometritis (E3)	Pyometra (E4)
The cow is a repeat breeder, and the inflammation is deeper. Rectally: uterus is large, thick, and doughy, Hanged down or on over pelvic pubis. Vaginally: cervix enlarged, congested, indurated, widely opened & contain pus (suppurative cervicitis) Constant mucopurulent or purulent discharge (copious with blood odor).	Collection of large amount of pus in uterus. The animal shows signs of anestrus. According to symptoms, there are: <ol style="list-style-type: none"> 1. Atypical (open- pre coital) pyometra 2. Typical (Closed- Post coital) pyometra Rectally: The uterine wall is thickened & flaccid. The uterine content is doughy. There is no fetal membrane slip.

Some of the possible causes of endometritis

1. Abnormal parturition (Abortion, dystocia, Fetotomy, Retention of placenta, C-section, or twins under unhygienic birth conditions).
2. Ovarian inactivity.
3. Old ages and increase number of previous parturitions.

4. Pneumovagina or wind suckling.
5. Following coitus (infected semen, infected instruments).
6. Blood & endogenous infection.

But in general, Endometritis is associated with poorer reproductive outcomes. It reduces fertility performance and milk yield, and subsequently, productivity and profitability of

dairy farms. The reduction in performance is associated with considerable economic losses on dairy farms (Nyabinwa et al., 2020b). Nyabinwa et al. (2020a) found that Endometritis reduced DMY by about 1.4 Kg of milk /cow/day. Nakao et al. (1992) showed that Endometritis prolonged days to the 1st insemination in 7 to 12 days, also Hussein et al. (2017) concluded that DO was prolonged by Endometritis. Kasimanickam et al. (2005) showed that postpartum period is often lengthed and the pregnancy rate is reduced due to Endometritis, also, Kasimanickam et al. (2004) reported an increase of 30 to 60 days in the calving to conception interval for cows with Endometritis. Poor reproductive performance is a major factor responsible for the reduction in profitability of dairy farms (Rajala-Schultz and Gröhn, 2001). So, this study aims to determine the effect of Endometritis on the productive and reproductive performance of lactating dairy herds with the resulting economic losses of it.

2. MATERIALS AND METHODS

2.1. Literature search and selection of papers

All English-language papers and abstracts published between 2013 and 2021 that investigated the effect of Endometritis (Independent variable) on milk production and reproductive performance as dependent variables (days to first insemination, Days open (DO), service per conception (S/C), and pregnancy rate) in lactating dairy cows were identified by a computerized literature search (google scholar). A paper was excluded from Meta-analysis if the relationship between Endometritis and dependent variables was not quantified, so we exclude fifteen papers. Eleven papers were finally selected to evaluate the effect of Endometritis on milk production and reproductive performance. The papers were ordered as the following:

Table 1. Coding different studies among different years.

Number	Study (Reference)	Number	Study (Reference)
1	Madoz et al. (2013).	7	Rinaudo et al. (2017).
2	Giuliodori et al. (2013).	8	Lee et al. (2018).
3	Barrio et al. (2015).	9	Sharma et al. (2019).
4	Chaudhari et al. (2015).	10	Nyabinwa et al. (2020a)
5	Nguyen-Kien et al. (2017).	11	Paiano et al. (2021).
6	(Hussein et al., 2017)		
Total cow No: 4037		Healthy No: 2761	Endometritis No: 1276

The total number of records for each parameter was calculated as the sum of a number of its records in each article (healthy and diseased).

2.2. Statistical analysis:

All statistical procedures were performed using the computer programs SPSS/PC⁺ "version 23" (SPSS, 2015). The coefficient of variation in percentage (CV) was calculated from the following equation $(SD/Mean) \times 100$ (de Oliveira et al. 2017).

2.3. Expression of estimate for meta-analysis

For categorical (binary) dependent variables (pregnancy rate), the odds ratio (OR) was calculated between the diseased and healthy cows with 95%CI at a significant level ($P < 0.05$) by using multinomial logistic regression, while

for continuous dependent variables (daily milk yield (DMY), days open (DO), days to first insemination and service per conception (S/C)) the estimate was calculated with 95%CI at a significant level ($P < 0.05$) and intraclass correlation coefficient (ICC) by using Linear mixed model (Multilevel regression).

2.4. Tests of homogeneity of results and evaluating source of heterogeneity

The homogeneity of the results of the studies was tested by calculating Q-Statistic equivalent to a chi-square distribution in order to examine the quality of summary estimates of effects. The null hypothesis was rejected when Q exceeded the bound of chi-distribution with the

number of studies minus one degree of freedom (López-Gatius et al. 2003).

2.5. Economic losses calculation

The economic losses of Endometritis (losses from milk reduction all over the lactation season, costs of extra service per conception number, and costs of treatment) were calculated per ten cows suffered from Endometritis per (\$) = (18.29 EGP) as the following:

Losses from milk reduction per ten diseased cows (\$) = (Reduction in DMY × 305 × Kg milk price × 10) (Abd-El Hamed and Kamel, 2020).

Costs of extra S/C number (\$) = Extra S/C no. × Insemination cost × 10

Costs of treatment (\$) = Costs of treatment per cow × 10

3. RESULT

Table 2. Coefficient of variation (CV) for dependent variables.

Pregnancy rate						
Animal category	Articles	Records	Units	Mean	SD	CV%
Healthy	3(1,5,8)	688	%	35.5	9.5	26.8%
Endometritis	3(1,5,8)	425	%	25.43	4.07	16.0%
Days Open						
Healthy	5(2,3,4,6,7)	1775	Days	107.9	10.2	9.50%
Endometritis	5(2,3,4,6,7)	564	Days	166.2	17.75	10.70%
Days to First Insemination						
Healthy	5(3,4,6,7,11)	531	Days	82.17	9.07135	11.00%
Endometritis	5(3,4,6,7,11)	208	Days	69.25	9.85	14.20%
Service per Conception						
Healthy	4(3,4,6,7)	384		2.09	0.1	0.5%
Endometritis	4(3,4,6,7)	147		3.7	0.5	13.8%
Daily Milk yield						
Healthy	3(9,10,11)	298	Kg	14.70	11.30	76.80%
Endometritis	3(9,10,11)	287	Kg	13.01	11.60	89.00%

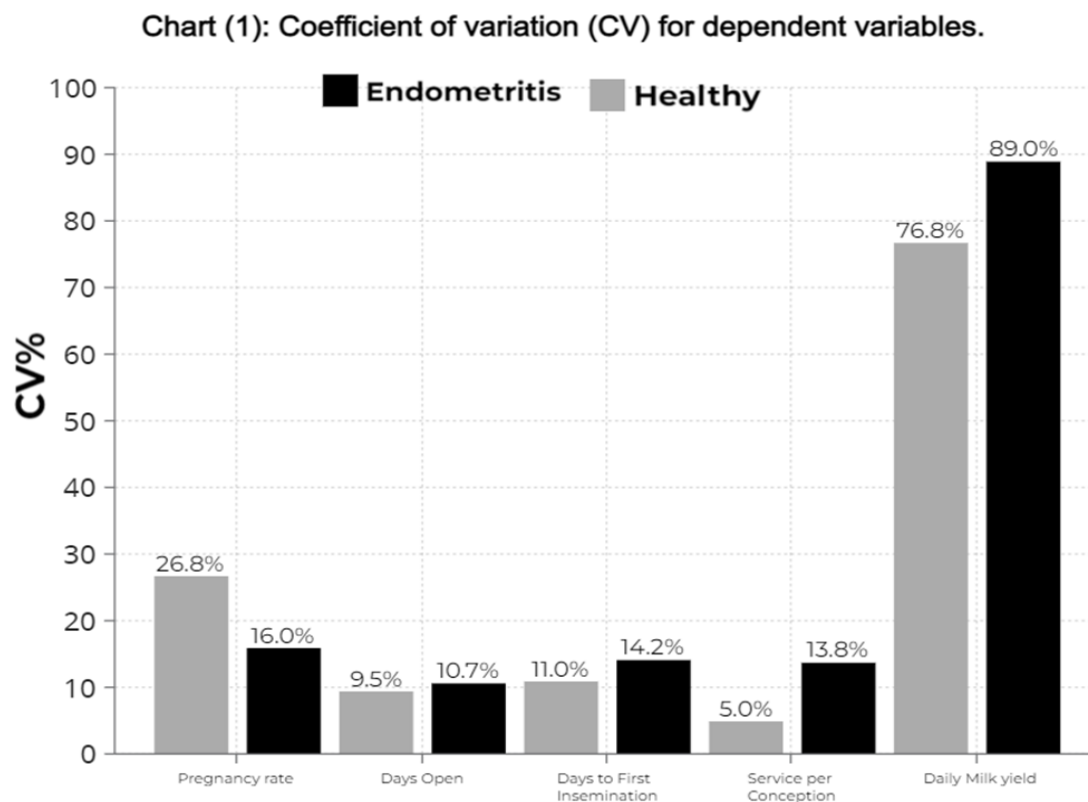


Table 3. Odds ratio for endometritis among different studies and years. 4 (2017) is a reference category (OR=1)

Author, Year	OR	95% CI
1(2013)	0.25	(0.1-0.6)
2(2013)	0.20	(0.09-0.45)
3(2015)	0.27	(0.1-0.7)
5(2017)	1.15	(0.5-2.6)
6(2017)	0.69	(0.2-1.6)
7(2017)	1.46	(0.6-3.4)
8(2018)	0.49	(0.2-1.1)
9(2019)	0.42	(0.1-1.5)
10(2020)	1.6	(0.7-3.6)
11(2021)	0.41	(0.17-0.97)

Forest plot (1): Odds ratio for endometritis among different studies and years.

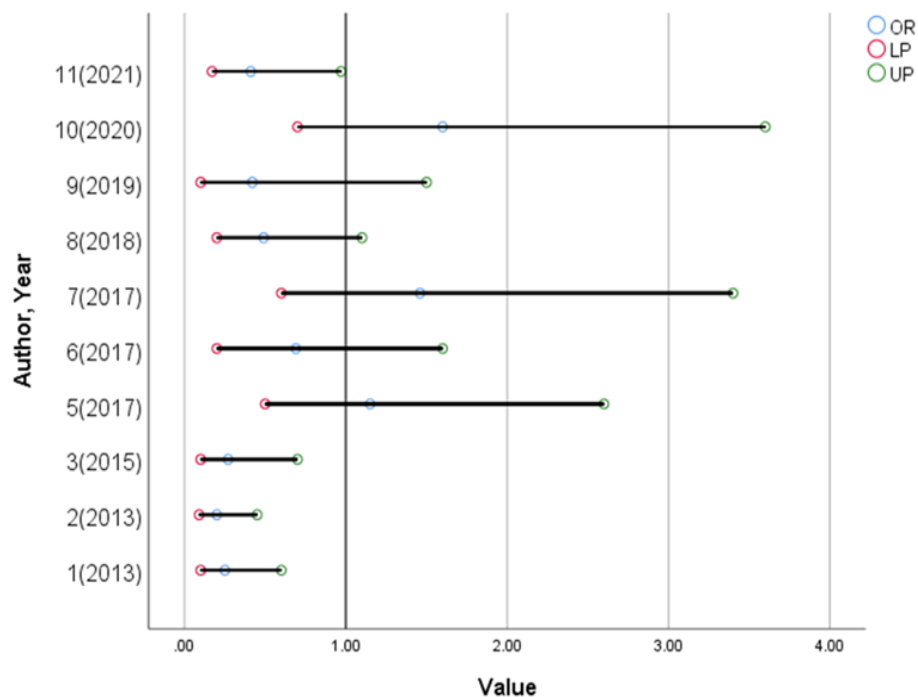


Table 4. Effect of Endometritis on the pregnancy rate.

Variable	Odd ratio of conception	95% CI	Reference	Cow No.	Inter study homogeneity
Healthy Cows	Reference category		1,5,8	688	
Endometritis	0.557*	(0.42-0.73)	1,5,8	425	No

Q=7.6

d.f. =2

X²=2.2

Table 5. Effect of Endometritis on daily milk yield and some reproductive performance indices of dairy herds

Items	Article	Records	Intercept	95%CI	Summery Estimate	95%CI	ICC
Days open							
Healthy	5(2,3,4,6,7)	1775	Reference group				
Endometritis	5(2,3,4,6,7)	564	107.9***	(92.5-123.3)	58.24**	(38.9-77.6)	0.53
Days to first insemination							
Healthy	5(3,4,6,7,11)	531	Reference group				
Endometritis	5(3,4,6,7,11)	208	69.25***	(58.8-79.6)	12.93*	(2.4-23.4)	0.82
Service per conception							
Healthy	4 (3, 4, 6, 7)	384	Reference group				
Endometritis	4 (3, 4, 6, 7)	147	2.09***	(1.6-2.5)	1.6**	(0.98-2.2)	0.50
Daily Milk Yield							
Healthy	3(9,10,11)	298	Reference group				
Endometritis	3(9,10,11)	287	14.7	(-13.6-43.1)	-1.70*	(-3.40- (-.030))	0.99

Table 6. Economic losses of Endometritis per ten cows during the whole lactation season.

Items	Endometritis
Milk losses (\$)	\$ 2536.4
Costs of extra S/C No. (\$)	\$ 87.5
Treatment cost (\$)	\$ 273.4
Total losses/10 cows (\$)	\$ 2897.2

4. DISCUSSION

Endometritis is a major postpartum disease that affects the productive and reproductive performance of dairy cows which is accompanied by heavy economic losses to the farmer. The coefficient of variation (CV) for all dependent variables is presented in table (2), the lowest CV was for DO, it was (9.5 and 10.70%) for healthy and diseased cows respectively, which indicated that their variation from the mean is limited, while it was the highest for DMY, it was (76.8 and 89.0%) for healthy and diseased cows respectively, that referred a larger variation in DMY values from their means than other parameters. The odds ratio of Endometritis among different studies and years are presented in Table (3) and Chart (1): paper No.4 recorded an equal number of diseased and healthy cows (OR=1), so we take this paper as a reference category. The OR had a non-significant increase for papers No. 5, 7, and 10, they were (1.15, 1.46 & 1.6, respectively) in compared with the reference group, while it had a significant decrease for papers No. 1, 2, 3, and 11, they were (0.25, 0.20, 0.27 & 0.41, respectively). Concerning papers No. 6, 8, and 9 they had a non-significant decrease in their Odds ratio compared to the reference group, they were (0.69, 0.49 & 0.42, respectively). Effect of Endometritis on the pregnancy rate is presented in table (4), we found that the odds ratio (OR) for the diseased cows was (0.55) with 95%CI (0.42-0.73), this result indicated that Endometritis significantly reduced the pregnancy rate by 45% in compared with the healthy cow. Regarding the analysis of heterogeneity, there is heterogeneity among different studies. This might be due to a low number of animals and the type of study. Effect of Endometritis on DMY and reproductive performance of dairy herds are presented in Table

(5). The summery estimate of DMY is (-1.7Kg) with 95%CI (-3.4-(-0.3)), this result indicated that Endometritis had a significant reduction in DMY by (1.7kg) rather than the healthy one. Intraclass correlation (ICC) =0.99, that means the proportion of variation in DMY that lies among different studies is approximately 99%. In responding to the days open, the cow that suffered from Endometritis had a prolonged days open by (58 days) than the healthy one with 95%CI (38.9-77.6) which represented a significant increase in DO of diseased cows. ICC = 0.53, that means the proportion of variation in DO that lies among different studies is approximately 53%. Concerning the days to first insemination, it had a significant increase by 13 days with 95% CI (2.4-23.4) than the healthy one (69 day). ICC= 0.82, that means the proportion of variation in the number of days to the first insemination that lies among different studies is approximately 82%. Regarding service per conception (S/C), it had a significant increase by 1.6 with 95%CI (0.98-2.2) than the healthy cow that was 2. ICC= 0.5, that means the proportion of variation in S/C that lies among different studies is approximately 50%. Economic losses of Endometritis per ten cows during the whole lactation season are presented in Table (6). Regarding the milk reduction losses, it is about \$ 2536.4, while the costs from extra S/C number is about \$ 87.5, and the treatment cost is about \$ 273.4, so the total losses from Endometritis per ten cows are estimated \$ 2897.2 yearly.

5. CONCLUSION & RECOMMENDATION

Endometritis had an adverse effect on the reproductive performance, milk yield, and profitability of lactating dairy herds. Endometritis significantly reduced the preg-

nancy rate by 45% compared with the healthy cow with prolonged days to the 1st insemination and DO by (13 & 58 days, respectively) compared with the healthy one, also it increased S/C by 1.6 higher than the healthy cow. Endometritis had a significant reduction in DMY by 1.7kg rather than the healthy one. The total losses of Endometritis per ten cows were about \$2897.2 yearly.

Recommendation: From the economic point, all preventative measures against Endometritis should be followed to maximize the profitability of dairy herds as prevention is better than treatment.

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