World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

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Early detection and prevention of endometritis in beef cattle through community veterinary extension programs

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World Journal of Advanced Research and Reviews, 2026, 30(03), 053-066

Publication history: Received on 20 April 2026; revised on 29 May 2026; accepted on 01 June 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.30.3.1539

Abstract

Background: Endometritis is one of the major reproductive disorders affecting beef cattle productivity, especially in developing countries with traditional livestock management systems. The disease commonly occurs during the postpartum period and contributes to repeat breeding, prolonged calving interval, decreased conception rate, and significant economic losses. Poor nutrition, inadequate sanitation, improper reproductive management, and delayed diagnosis are important predisposing factors. Limited farmer knowledge regarding reproductive health further increases the incidence of reproductive disorders in rural farming communities.

Objectives: This review aims to discuss the causes, risk factors, diagnosis, and prevention of endometritis in beef cattle, while highlighting the role of community veterinary extension programs in improving farmer awareness and reproductive management practices.

Methods: This study was conducted using a literature review approach by analyzing scientific articles, textbooks, and veterinary reports related to endometritis in beef cattle, reproductive management, and community-based veterinary extension programs. Relevant information regarding etiology, clinical signs, diagnostic techniques, preventive strategies, and educational interventions for farmers was collected and synthesized descriptively.

Results: The review showed that endometritis is closely associated with bacterial infection during the postpartum period, poor nutritional status, inadequate housing and sanitation, and improper reproductive management. Early detection methods such as rectal palpation, vaginoscopy, ultrasonography, and cytobrush examination are effective for identifying both clinical and subclinical endometritis. Preventive measures including nutritional improvement, hygienic calving management, regular reproductive monitoring, and timely treatment significantly reduce disease incidence. Community veterinary extension programs were found to improve farmers' knowledge and awareness regarding reproductive health, estrus detection, postpartum care, and disease prevention. Educational activities and field assistance also strengthened collaboration between veterinarians, academicians, inseminators, and local farmers.

Conclusion: Early detection and preventive management are essential for reducing the incidence of endometritis and improving reproductive efficiency in beef cattle. Community veterinary extension programs play an important role in enhancing farmer knowledge and promoting better reproductive management practices. The integration of veterinary education, farmer participation, and field-based reproductive monitoring can contribute to sustainable beef cattle production and improved rural livestock productivity.

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Keywords: Beef cattle; Endometritis; Reproductive disorders; Veterinary extension; Farmer education; Community service

1. Introduction

Beef cattle production plays an essential role in supporting global food security, improving rural livelihoods, and strengthening the agricultural economy, particularly in developing countries such as Indonesia (Herrero *et al*., 2013). The increasing demand for animal protein has encouraged farmers to improve cattle productivity through better genetic selection, feeding strategies, and reproductive management. Among the various factors influencing beef cattle productivity, reproductive efficiency is considered one of the most important determinants of herd sustainability and economic profitability (Yousif *et al*., 2025). Efficient reproduction directly affects calving rate, calf production, herd replacement, and overall farm income (Shalloo *et al*., 2014). Conversely, reproductive failure contributes to substantial economic losses due to increased breeding costs, prolonged calving intervals, decreased conception rates, and reduced calf output.

Reproductive disorders remain one of the major constraints in beef cattle farming systems worldwide (Arero, 2022). In tropical and developing regions, reproductive inefficiency is frequently associated with poor management practices, nutritional deficiencies, environmental stress, infectious diseases, and limited access to veterinary services. One of the most common postpartum reproductive disorders reported in beef cattle is endometritis. Endometritis is defined as inflammation of the uterine endometrium without systemic illness and generally occurs following bacterial contamination of the uterus during or after parturition. The disease commonly develops during the postpartum period when uterine defense mechanisms are compromised and bacterial invasion occurs (Dahiya *et al*., 2018).

Clinically, endometritis is characterized by mucopurulent or purulent vaginal discharge, repeat breeding, prolonged postpartum anestrus, silent heat, low conception rate, and infertility (Pascottini *et al*., 2023). In severe cases, chronic uterine inflammation may significantly impair reproductive performance and prolong the calving interval (Molina-Coto and Lucy, 2018). Subclinical endometritis is more difficult to identify because affected animals often do not show obvious clinical signs despite the presence of inflammatory cell infiltration within the endometrium. Consequently, many cases remain undiagnosed until reproductive failure becomes apparent. This condition represents a major challenge for farmers and veterinarians because delayed diagnosis reduces treatment success and increases economic losses.

The pathogenesis of endometritis is strongly associated with bacterial infection involving microorganisms such as *Escherichia coli*, *Trueperella pyogenes*, *Fusobacterium necrophorum*, and *Prevotella* spp. (Liu *et al.*, 2024). These pathogens can colonize the uterus after calving, especially under poor hygienic conditions. Several predisposing factors increase the risk of uterine infection, including retained placenta, dystocia, abortion, metabolic disorders, nutritional imbalance, stress, and inadequate postpartum management (Onyango *et al*., 2014). Nutritional deficiencies, particularly energy, protein, mineral, and vitamin deficiencies, may suppress immune responses and delay uterine involution, thereby increasing susceptibility to infection. Environmental stressors such as high temperature, overcrowding, and poor sanitation further exacerbate reproductive problems in cattle (Khan *et al*., 2023).

In many rural farming systems, reproductive disorders are often exacerbated by limited farmer knowledge regarding animal health and reproductive management (Hashem *et al*., 2021). Traditional livestock practices, lack of regular reproductive examination, poor estrus detection, and delayed veterinary intervention contribute to the persistence of reproductive inefficiency. Smallholder farmers frequently rely on empirical practices and may not recognize the early signs of endometritis or other postpartum disorders. Consequently, reproductive diseases are commonly detected only after repeated breeding failure or infertility occurs. This situation highlights the importance of farmer education and community-based preventive strategies in improving cattle reproductive performance.

Community veterinary extension programs have increasingly gained attention as effective approaches to improve livestock health management in rural areas. Veterinary extension activities aim to transfer practical knowledge and technical skills from veterinarians and academicians to livestock farmers through education, counseling, demonstrations, and field assistance. These programs can improve farmers' understanding of reproductive physiology, estrus detection, postpartum care, nutritional management, and disease prevention strategies. Through participatory educational approaches, farmers become more capable of identifying early clinical signs of reproductive disorders and implementing appropriate preventive measures (Shubeena *et al*., 2018).

In addition, community-based veterinary programs strengthen collaboration between universities, veterinarians, inseminators, local governments, and farming communities. The integration of academic knowledge with practical field applications contributes to sustainable livestock development and improved reproductive efficiency (Dayoub *et al*., 2024). Educational interventions focusing on early detection and prevention of endometritis are particularly important in areas where access to advanced veterinary diagnostic facilities remains limited (Kasimanickam *et al*., 2025). Simple field-based diagnostic approaches, combined with proper management practices, may significantly reduce the incidence of reproductive disorders in beef cattle populations.

Therefore, this review aims to discuss the etiology, risk factors, clinical manifestations, diagnosis, prevention, and management of endometritis in beef cattle while emphasizing the important role of community veterinary extension programs in improving farmer awareness and reproductive health management. The review also highlights how educational and participatory approaches can contribute to sustainable beef cattle production and increased productivity in rural farming systems.

2. Endometritis in Beef Cattle

Endometritis is a postpartum uterine inflammatory disorder characterized by inflammation of the endometrial lining without systemic illness (Dubey and Mehta, 2022). The condition commonly develops after parturition as a consequence of bacterial contamination of the uterus during calving. Under normal physiological conditions, bacterial contamination may be eliminated naturally through uterine immune defense mechanisms and uterine involution. However, failure of uterine clearance due to compromised immunity, poor management, or pathogenic bacterial proliferation may lead to persistent inflammation and reproductive dysfunction (Dahiya *et al*., 2018).

Endometritis is considered one of the most economically important reproductive diseases in beef cattle because it negatively affects fertility and overall herd productivity. The disorder contributes to prolonged postpartum anestrus, reduced conception rates, increased service per conception, repeat breeding, prolonged calving intervals, and infertility (Befekadu *et al*., 2023). These reproductive failures ultimately decrease calf production and increase production costs for farmers.

The postpartum uterus provides a favorable environment for bacterial growth due to tissue damage, fluid accumulation, and temporary suppression of local immune responses following calving. Several pathogenic bacteria have been associated with endometritis, including *Escherichia coli*, *Trueperella pyogenes*, *Fusobacterium necrophorum*, *Prevotella* spp., *Streptococcus* spp., and *Staphylococcus* spp. (Liu *et al.*, 2024). Mixed bacterial infections are commonly observed and may exacerbate the severity of uterine inflammation. The interaction between pathogenic bacteria and the host immune system plays a critical role in disease progression and recovery.

The incidence of endometritis is influenced by various predisposing factors, including dystocia, retained placenta, abortion, metabolic disorders, poor nutrition, stress, unhygienic calving conditions, and inadequate postpartum management (Onyango *et al*., 2014). Nutritional deficiencies, especially deficiencies in energy, protein, minerals, and vitamins, can impair immune competence and delay uterine involution. Environmental stress and poor sanitation also increase bacterial exposure and susceptibility to infection (Inbaraj *et al*., 2023). Based on clinical manifestations, endometritis can be classified into clinical endometritis and subclinical endometritis. Both conditions are associated with impaired reproductive performance, although they differ in clinical presentation and diagnostic approaches.

2.1. Clinical Endometritis

Clinical endometritis is characterized by visible inflammation of the uterus accompanied by abnormal vaginal discharge occurring after 21 days postpartum (Kasimanickam *et al*., 2025). The discharge may appear mucopurulent or purulent and is commonly associated with bacterial infection within the uterine lumen. Affected cows often exhibit repeat breeding, delayed return to estrus, silent heat, and decreased fertility.

The diagnosis of clinical endometritis is generally based on observation of vaginal discharge using vaginoscopy, Metricheck examination, or rectal palpation. Ultrasonography may also be used to evaluate uterine fluid accumulation and uterine wall thickness. Clinical endometritis can significantly reduce reproductive efficiency if not treated promptly (Guiliodori *et al*., 2013).

2.2. Subclinical Endometritis

Subclinical endometritis refers to uterine inflammation without obvious clinical signs of vaginal discharge (Wagener *et al*., 2017). Despite the absence of visible symptoms, inflammatory processes persist within the endometrium and

negatively affect fertility. This condition is more difficult to detect and often remains unnoticed until reproductive failure occurs.

Diagnosis of subclinical endometritis commonly involves cytological examination of endometrial samples obtained using cytobrush or uterine lavage techniques. Increased polymorphonuclear neutrophil (PMN) percentages within the endometrium are considered indicative of subclinical inflammation (Nazhat *et al*., 2018). Research has shown that cows with subclinical endometritis experience lower conception rates and prolonged calving intervals compared with healthy animals.

Subclinical endometritis is particularly important in smallholder farming systems because limited access to reproductive diagnostic tools often delays detection and treatment (Nyabinwa *et al*., 2020). Therefore, farmer education regarding reproductive monitoring and early veterinary consultation is essential to minimize reproductive losses associated with this condition. The economic and reproductive impacts of both clinical and subclinical endometritis highlight the importance of early detection, preventive management, and effective veterinary intervention in beef cattle production systems.

3. Risk Factors Associated with Endometritis

Endometritis in beef cattle is a multifactorial reproductive disorder influenced by the interaction between infectious agents, host immunity, environmental conditions, and management practices. The occurrence and severity of uterine inflammation are strongly associated with several predisposing factors that impair uterine defense mechanisms during the postpartum period. Understanding these risk factors is essential for developing effective prevention and control strategies in cattle farming systems (Bishu *et al*., 2018).

3.1. Nutritional Factors

Nutritional status plays a fundamental role in maintaining reproductive health and immune competence in beef cattle (Wang *et al*., 2026). Poor nutrition is considered one of the major contributing factors to reproductive disorders, including endometritis. During the postpartum period, cows experience increased metabolic demands associated with lactation, uterine involution, and recovery after calving. Inadequate nutrient intake during this period may compromise immune function and delay reproductive recovery.

Deficiencies in energy and protein reduce the ability of immune cells to eliminate bacterial contamination within the uterus. Negative energy balance may suppress leukocyte activity, impair phagocytosis, and reduce resistance to infection. Protein deficiency also affects tissue repair and uterine regeneration following parturition (Herring *et al*., 2018). In addition, deficiencies of essential minerals such as selenium, zinc, calcium, phosphorus, and copper are associated with impaired immune responses and increased susceptibility to uterine infection.

Vitamins, particularly vitamins A and E, are important antioxidants that help maintain epithelial integrity and immune defense mechanisms. Inadequate vitamin supplementation may increase oxidative stress and prolong inflammatory processes within the reproductive tract. Nutritional imbalance also contributes to poor body condition score (BCS), delayed ovarian activity, silent heat, and prolonged postpartum anestrus, which further reduce reproductive efficiency (Diskin and Kennny, 2016). Proper nutritional management involving balanced forage, adequate concentrate supplementation, mineral blocks, and sufficient energy intake is therefore essential for preventing postpartum reproductive disorders and supporting uterine health.

3.2. Environmental Factors

Environmental conditions significantly influence cattle health, welfare, and reproductive performance. Poor environmental sanitation is one of the most important risk factors associated with postpartum uterine infection. Unsanitary housing conditions increase exposure to pathogenic microorganisms during and after calving, facilitating bacterial contamination of the uterus (Sheldon *et al*., 2020).

Wet and dirty flooring contaminated with feces and urine provides an ideal environment for bacterial growth. During parturition, the cervix remains open, allowing opportunistic bacteria to enter the reproductive tract more easily (Adnane and Chapwana, 2022). Inadequate hygiene in calving areas therefore increases the incidence of uterine infection and postpartum inflammation.

Heat stress is another environmental factor contributing to reproductive dysfunction in cattle, especially in tropical regions (Krishnnan *et al*., 2017). High ambient temperature and humidity may increase cortisol secretion, suppress

immune function, and reduce feed intake, resulting in negative energy balance and impaired reproductive performance. Heat stress has also been associated with decreased estrus expression, lower conception rates, and increased embryonic mortality.

Poor ventilation and overcrowded housing conditions further exacerbate stress and facilitate disease transmission among animals (Oke *et al*., 2025). Therefore, maintaining proper housing sanitation, adequate ventilation, dry bedding, and comfortable environmental conditions is important to reduce the risk of endometritis and improve cattle welfare.

3.3. Management Factors

Management practices greatly influence reproductive efficiency and postpartum uterine health in beef cattle (Fernandez-Novo *et al*., 2020). Inadequate reproductive management is commonly associated with increased incidence of endometritis, particularly in smallholder farming systems where access to veterinary services may be limited.

Improper calving assistance is one of the major management-related causes of uterine trauma and bacterial contamination. Excessive force during assisted delivery may damage reproductive tissues and delay uterine recovery. Failure to maintain hygiene during obstetrical procedures can also introduce pathogenic bacteria into the uterus.

Poor estrus detection and delayed reproductive examination contribute to prolonged reproductive disorders and reduced conception rates (Merkelytė *et al*., 2025). Farmers with limited knowledge regarding estrus behavior often fail to identify cows requiring reproductive evaluation or treatment. In addition, delayed veterinary intervention may allow mild uterine infection to progress into chronic inflammation.

Inadequate postpartum monitoring is another important management factor. Routine examination during the postpartum period is essential to assess uterine involution, detect abnormal vaginal discharge, and identify early reproductive abnormalities. Failure to monitor postpartum cows may delay diagnosis of endometritis and other reproductive disorders (Kasimanickam *et al*., 2025).

Artificial insemination management also influences reproductive outcomes. Incorrect insemination timing, poor semen handling, and improper insemination techniques may contribute to repeat breeding and uterine irritation (Fontes *et al*., 2020). Therefore, proper reproductive management practices and farmer education are essential to improve fertility and reduce reproductive losses.

3.4. Pathological Factors

Several pathological conditions occurring during or after parturition increase susceptibility to endometritis. Retained placenta is one of the most significant predisposing factors because retained fetal membranes provide an excellent medium for bacterial proliferation within the uterus (Perlman and Carusi, 2019). Delayed expulsion of the placenta prolongs uterine contamination and interferes with normal uterine involution.

Dystocia or difficult calving can cause trauma to the reproductive tract, resulting in tissue damage, hemorrhage, and increased bacterial invasion (Abdela and Ahmed, 2016). Cows experiencing dystocia often show delayed uterine recovery and higher incidence of postpartum infection.

Abortion also contributes to uterine inflammation due to incomplete evacuation of fetal tissues and contamination of the reproductive tract. Similarly, traumatic calving and uterine injury may disrupt the integrity of the endometrial lining, making the uterus more vulnerable to infection (Pascottini *et al*., 2023).

Metabolic disorders such as ketosis, hypocalcemia, and negative energy balance may indirectly increase the risk of endometritis by impairing immune function and reducing uterine contractility. Cows with weakened immune responses are less capable of eliminating pathogenic bacteria during the postpartum period (Gomez *et al*., 2019).

The interaction between pathological conditions and compromised immune defense mechanisms ultimately determines the severity and persistence of uterine inflammation (Vlasofa and Saif, 2021). Therefore, early identification and management of pathological postpartum conditions are important to prevent chronic reproductive disorders and maintain optimal reproductive performance in beef cattle.

4. Early Detection of Endometritis

Early detection of endometritis is essential to prevent chronic reproductive failure and minimize economic losses in beef cattle production systems. Delayed diagnosis may prolonged uterine inflammation, impair ovarian activity, reduce conception rates, and increase repeat breeding incidence (Pohler *et al*., 2020). In many cases, particularly subclinical endometritis, reproductive disorders remain unnoticed until fertility problems become severe. Therefore, accurate and timely diagnosis is important to improve treatment success and reproductive efficiency.

Several diagnostic techniques are commonly used in field and clinical settings to identify uterine inflammation in cattle (Rua *et al*., 2018). These methods range from simple physical examination to more advanced laboratory and imaging procedures. The selection of diagnostic methods generally depends on field conditions, equipment availability, veterinarian expertise, and the severity of the disease.

4.1. Rectal Palpation

Rectal palpation is one of the most widely used reproductive examination techniques in cattle because it is practical, inexpensive, and applicable under field conditions (Bekele *et al.,* 2016). The method allows veterinarians or trained inseminators to evaluate uterine size, uterine tone, symmetry of the uterine horns, cervical condition, and ovarian activity.

In cows affected by endometritis, rectal palpation may reveal delayed uterine involution, enlargement of the uterus, fluid accumulation, or abnormal uterine consistency. Ovarian structures such as follicles and corpus luteum can also be evaluated to determine reproductive status and ovarian cyclicity (Adams and Singh, 2021).

Although rectal palpation is useful for routine reproductive monitoring, its diagnostic accuracy for subclinical uterine inflammation is relatively limited because subtle inflammatory changes may not be detectable through palpation alone. Nevertheless, rectal palpation remains an important first-line diagnostic tool in rural livestock production systems due to its simplicity and low operational cost (Hayat *et al*., 2026).

4.2. Vaginal Examination

Vaginal examination is commonly performed to identify abnormal vaginal discharge associated with clinical endometritis (Okawa *et al*., 2017). The examination may be conducted manually or using a vaginal speculum to observe the appearance, consistency, color, and odor of reproductive tract secretions.

Clinical endometritis is generally characterized by mucopurulent or purulent discharge originating from the uterus. The discharge may appear white, yellowish, brownish, or mixed with mucus, depending on the severity of infection and inflammatory response. Foul-smelling secretions often indicate severe bacterial contamination (Pokludová *et al*., 2025).

Vaginal examination is considered a rapid and effective method for detecting clinical uterine infection under field conditions (Ramirez-Garzon *et al*., 2021). However, this technique cannot accurately diagnose subclinical endometritis because cows with subclinical inflammation usually do not exhibit visible vaginal discharge. Proper hygiene during examination is important to avoid introducing additional contamination into the reproductive tract.

4.3. Ultrasonography (USG)

Ultrasonography has become an important diagnostic tool for reproductive evaluation in cattle due to its high sensitivity and non-invasive nature (Lakhanpal *et al*., 2026). Ultrasonographic examination allows visualization of the uterus and ovaries in real time, enabling veterinarians to assess uterine contents, endometrial thickness, ovarian structures, and uterine involution status.

In cases of endometritis, ultrasonography may reveal intrauterine fluid accumulation, echogenic inflammatory material, thickened uterine walls, and delayed uterine involution (Pascottini *et al*., 2023). The technique is particularly useful for identifying subclinical cases that may not present obvious external symptoms.

Ultrasonography also assists in monitoring treatment response and evaluating ovarian activity during reproductive management programs. Compared with rectal palpation alone, ultrasonography provides more accurate and detailed information regarding uterine pathology (Roditis *et al.,* 2023). However, the use of USG may be limited in smallholder farming systems due to equipment costs and limited technical expertise.

4.4. Cytobrush Technique

The cytobrush technique is widely recognized as one of the most reliable methods for diagnosing subclinical endometritis (Buczkowska *et al*., 2014). This method involves collecting endometrial cell samples using a specialized cytobrush inserted through the cervix into the uterus. The collected samples are then examined microscopically to evaluate inflammatory cell infiltration.

Diagnosis of subclinical endometritis is generally based on the percentage of polymorphonuclear neutrophils (PMNs) present in the endometrial cytology sample. Increased PMN percentages indicate ongoing uterine inflammation despite the absence of clinical signs (Katila, 2012). Various PMN threshold values have been proposed depending on postpartum stage and reproductive status.

The cytobrush technique offers high diagnostic sensitivity and specificity for detecting subclinical uterine inflammation (Cengiz *et al*., 2021). Early identification of subclinical cases enables timely therapeutic intervention before reproductive performance is severely affected. Despite its diagnostic advantages, the technique requires laboratory facilities, trained personnel, and appropriate sample handling procedures.

4.5. Vaginoscopy and Metricheck

Vaginoscopy and Metricheck examinations are practical diagnostic methods used to evaluate reproductive tract secretions and identify clinical endometritis in cattle (McDougall, 2014).

Vaginoscopy involves inserting a speculum or endoscope into the vagina to directly visualize the cervix and vaginal walls. This technique enables more accurate observation of abnormal discharge, cervical inflammation, and reproductive tract abnormalities. Vaginoscopy reduces contamination risk and improves visualization compared with manual vaginal examination (Pleticha *et al*., 2009).

Metricheck is a simple field-based diagnostic tool consisting of a rubber cup attached to a rod that is inserted into the vagina to collect secretions from the cranial vagina. The appearance and odor of collected secretions are evaluated to determine the presence of uterine infection (Burfeind *et al*., 2014).

Both vaginoscopy and Metricheck are widely used in field reproductive health programs because they are relatively simple, rapid, and economical. These techniques are particularly useful for screening large numbers of postpartum cows under practical farm conditions.

Early detection of endometritis through appropriate diagnostic methods significantly improves treatment success, reproductive efficiency, and herd productivity (Tobolski *et al*., 2025). Prompt identification and management of uterine inflammation can reduce infertility, shorten calving intervals, decrease repeat breeding incidence, and minimize economic losses in beef cattle farming systems. Furthermore, integrating simple diagnostic approaches into community veterinary extension programs may improve farmer awareness and encourage routine reproductive monitoring in rural livestock communities.

5. Prevention Strategies

Prevention of endometritis in beef cattle requires an integrated management approach involving nutrition, sanitation, reproductive monitoring, postpartum care, and appropriate therapeutic intervention (Hussain *et al*., 2024). Because endometritis is closely associated with postpartum bacterial contamination and impaired uterine defense mechanisms, preventive strategies should focus on improving immune competence, minimizing uterine contamination, and promoting rapid uterine recovery after calving. Effective prevention not only reduces reproductive disorders but also improves fertility, calf production, and overall farm profitability.

In smallholder farming systems, preventive management is particularly important because limited access to veterinary services often delays diagnosis and treatment (Nyabinwa *et al*., 2020). Therefore, practical and affordable preventive measures that can be implemented at the farm level are essential for improving reproductive performance in beef cattle populations.

5.1. Nutritional Improvement

Proper nutritional management is one of the most important components in preventing reproductive disorders, including endometritis (Ciebiera *et al*., 2021). Adequate nutrition supports immune function, tissue repair, uterine

involution, and ovarian activity during the postpartum period. Nutritional deficiencies may weaken the animal's defense mechanisms and increase susceptibility to uterine infection.

Balanced feeding containing sufficient energy, protein, vitamins, and minerals is necessary to maintain reproductive health and physiological recovery after calving. Energy deficiency during the postpartum period may lead to negative energy balance, reduced immune response, delayed ovarian cyclicity, and prolonged uterine involution (Nigussie, 2018). Protein deficiency also interferes with tissue regeneration and immune cell function.

Minerals such as selenium, zinc, copper, calcium, and phosphorus play important roles in maintaining immune competence and reproductive performance. Selenium and vitamin E act as antioxidants that protect reproductive tissues from oxidative stress and inflammatory damage (Żarczyńska *et al*., 2026). Supplementation with mineral blocks, mineral premixes, and quality forage may improve reproductive health and reduce postpartum disorders.

High-quality forage combined with adequate concentrate supplementation helps maintain optimal body condition score (BCS), which is closely associated with fertility and uterine recovery (Diskin and Kenny, 2016). In tropical farming systems, nutritional management should also consider seasonal feed availability and forage quality fluctuations that may affect cattle productivity.

5.2. Hygienic Reproductive Management

Maintaining hygiene during and after parturition is essential to minimize bacterial contamination of the reproductive tract (Campbell *et al*., 2015). The postpartum uterus is highly susceptible to infection because the cervix remains partially open and the uterine environment contains lochia and tissue debris that support bacterial growth.

Clean calving environments significantly reduce exposure to pathogenic microorganisms. Calving pens should be dry, well ventilated, and regularly cleaned to prevent accumulation of feces, urine, and contaminated bedding materials. Proper sanitation decreases the risk of bacterial invasion during delivery and postpartum recovery (Appiah *et al*., 2020).

Hygienic handling during obstetrical assistance and reproductive examination is equally important. Veterinary instruments and examination gloves should be properly sterilized to avoid introducing contaminants into the uterus (Dahiya *et al*., 2018). Excessive or traumatic manipulation during calving should also be avoided because tissue injury may facilitate bacterial colonization and inflammation (Dubey and Mehta, 2022).

In addition, maintaining overall farm biosecurity and environmental sanitation contributes to improved herd health and reduced incidence of infectious reproductive diseases (Gomez *et al*., 2019).

5.3. Regular Reproductive Monitoring

Routine reproductive monitoring is essential for early detection of postpartum abnormalities and prevention of chronic uterine disorders (Pohler *et al*., 2020). Regular examination allows veterinarians, inseminators, or trained farmers to identify reproductive problems before severe infection or infertility develops.

Postpartum reproductive evaluation commonly includes rectal palpation, vaginal examination, ultrasonography, and observation of estrus behavior (Roditis *et al*., 2023). Monitoring uterine involution, vaginal discharge, and ovarian activity enables early recognition of abnormal reproductive conditions such as retained placenta, metritis, silent heat, and endometritis (Okawa *et al*., 2017).

Early diagnosis improves treatment success and reduces reproductive losses associated with repeat breeding and prolonged calving intervals. In addition, routine monitoring supports more accurate estrus detection and improves timing of artificial insemination programs (Diskin and Kenny, 2016).

In rural farming systems, farmer participation in reproductive monitoring is highly important. Educational programs that train farmers to recognize abnormal postpartum signs, estrus behavior, and reproductive disorders can substantially improve herd reproductive efficiency (Yousif *et al*., 2025).

5.4. Proper Postpartum Care

Appropriate postpartum management is crucial for preventing uterine infection and supporting rapid reproductive recovery after calving. The postpartum period represents a critical phase during which the uterus undergoes involution and restoration of normal reproductive function (Pascottini *et al*., 2023).

Monitoring cows during the postpartum period allows early identification of complications such as retained placenta, metritis, dystocia-related injury, and delayed uterine involution (Abdela and Ahmed, 2016). Prompt management of these conditions can prevent progression into chronic endometritis and infertility (Dubey and Mehta, 2022).

Adequate postpartum nutrition, hydration, and environmental comfort are important to support immune function and tissue repair. Stress reduction through proper housing and minimizing overcrowding also contributes to better reproductive recovery (Fernandez-Novo *et al*., 2020).

Special attention should be given to cows with dystocia, retained placenta, twins, or difficult calving because these animals have higher risk of postpartum uterine infection (Perlman and Carusi, 2019). Veterinary intervention should be provided promptly when abnormal clinical signs are observed.

Proper postpartum care also includes observation of feed intake, body condition, milk production, and general health status because systemic illness may indirectly impair reproductive recovery (Herring *et al*., 2018).

5.5. Therapeutic Management

Therapeutic management may be necessary in cows showing clinical signs of uterine infection or persistent reproductive abnormalities. Treatment aims to eliminate pathogenic bacteria, reduce inflammation, and restore normal uterine function (Pascottini *et al*., 2023).

Several intrauterine therapeutic agents have been used in the management of endometritis under veterinary supervision. Common treatments include povidone iodine, cephapirin, and oxytetracycline administered intrauterinely to reduce bacterial contamination within the uterus (Kasmanickam *et al*., 2025). Antibiotic selection should consider bacterial sensitivity, severity of infection, withdrawal periods, and prudent antimicrobial use (Liu *et al*., 2024).

Hormonal therapy may also be utilized to improve uterine clearance and stimulate ovarian cyclicity. Prostaglandin F2α (PGF2α) is commonly used to induce luteolysis and enhance uterine contractility, thereby facilitating expulsion of inflammatory exudates (Yousif *et al*., 2025).

Supportive therapy involving nutritional supplementation and immune support may improve treatment outcomes and reproductive recovery. However, therapeutic intervention should always be accompanied by correction of underlying management and environmental risk factors to prevent recurrence (Hussain *et al*., 2024).

Preventive management combined with early therapeutic intervention is considered the most effective strategy for reducing the incidence and economic impact of endometritis in beef cattle production systems. Furthermore, integrating preventive education into community veterinary extension programs can improve farmer awareness and encourage adoption of better reproductive management practices in rural livestock communities (Shubeena *et al*., 2018).

6. Role of Community Veterinary Extension Programs

Community veterinary extension programs play an important role in improving livestock health management, reproductive efficiency, and farmer knowledge in rural cattle production systems (Herrero *et al*., 2013). In many developing countries, including Indonesia, smallholder farmers often rely on traditional livestock practices and have limited access to veterinary services, reproductive technologies, and scientific information. Consequently, reproductive disorders such as endometritis frequently remain undetected until severe fertility problems occur. Community-based veterinary extension programs therefore serve as essential educational platforms to bridge the gap between scientific knowledge and practical field application.

Veterinary extension activities are designed to improve farmers' understanding of reproductive physiology, animal health management, disease prevention, and proper livestock husbandry practices (Shubeena *et al*., 2018). Educational interventions help farmers recognize early clinical signs of reproductive disorders and encourage prompt veterinary consultation before reproductive failure becomes chronic (Kasimanickam *et al*., 2025). Increasing farmer awareness regarding reproductive health is particularly important because successful prevention and early treatment of endometritis depend heavily on timely identification and management.

One of the major components of veterinary extension programs is farmer counseling regarding reproductive health management. Counseling activities provide information about postpartum uterine disorders, estrus cycles, breeding management, calving intervals, and factors affecting fertility (Adams and Singh, 2021). Through interactive educational

sessions, farmers gain better understanding of how nutrition, sanitation, stress, and reproductive monitoring influence cattle productivity (Fernandez-Novo *et al*., 2020). Counseling also encourages farmers to adopt evidence-based management practices that support reproductive efficiency and herd sustainability.

Training on estrus detection and postpartum monitoring is another important aspect of extension programs. In many rural farming systems, poor estrus detection remains a major cause of reproductive inefficiency and repeat breeding (Befekadu *et al.,* 2023). Farmers are often unable to recognize behavioral and physical signs of estrus, leading to improper breeding timing and delayed reproductive intervention. Training programs help farmers identify signs such as vulvar swelling, mucus discharge, mounting behavior, restlessness, and decreased feed intake associated with estrus. In addition, postpartum monitoring education enables farmers to recognize abnormal vaginal discharge, delayed uterine recovery, retained placenta, and other reproductive abnormalities that may indicate endometritis (Wagener *et al*., 2017).

Demonstration of simple reproductive examination techniques is also highly beneficial for improving field-level reproductive management. Practical demonstrations conducted by veterinarians, inseminators, or academicians help farmers understand basic reproductive evaluation procedures such as observation of vaginal discharge, body condition scoring, and recognition of abnormal postpartum conditions (McDougall, 2014). Although advanced diagnostic methods such as ultrasonography and cytobrush examination may not always be available in rural areas, simple observational techniques can still provide valuable information for early disease detection (Buckowska *et al*., 2014).

Nutritional management education is another essential component of veterinary extension activities. Many reproductive disorders in beef cattle are closely associated with poor nutrition, negative energy balance, and mineral deficiencies (Ciebiera *et al*., 2021). Extension programs commonly educate farmers regarding balanced feeding strategies, forage quality, concentrate supplementation, mineral block utilization, and seasonal feed management. Farmers are also informed about the relationship between nutritional status, immune function, ovarian activity, and uterine recovery after calving (Vlasova and Saif, 2021). Improved nutritional awareness contributes to better body condition score (BCS), enhanced fertility, and reduced incidence of postpartum uterine infection.

Assistance and mentoring from veterinarians and inseminators further strengthen the effectiveness of community veterinary programs. Direct field assistance allows farmers to receive practical guidance regarding reproductive examination, artificial insemination management, treatment procedures, and disease prevention strategies (Yousif *et al*., 2025). Continuous mentoring also helps build trust between farmers and animal health professionals, encouraging farmers to seek veterinary consultation more frequently when reproductive problems arise.

In addition to improving technical knowledge, veterinary extension programs strengthen communication and collaboration between universities, veterinarians, local governments, inseminators, and rural communities. Academic institutions play an important role in transferring scientific knowledge to farming communities through community service activities, field education programs, and participatory research. This collaborative approach promotes sustainable livestock development and enhances the implementation of practical reproductive health interventions at the farm level (Dayoub *et al*., 2024).

Participatory educational approaches are particularly effective because they actively involve farmers in problem identification, discussion, and decision-making processes. Farmers become more motivated to adopt preventive measures when educational activities are adapted to local farming conditions and cultural practices. Interactive methods such as field demonstrations, group discussions, practical workshops, and reproductive health campaigns improve learning outcomes and increase farmer participation(Shubeena *et al*., 2018).

Community-based education is especially important in remote or underserved areas where veterinary infrastructure and diagnostic facilities remain limited. In such regions, preventive education may become the most practical and cost-effective strategy for reducing reproductive disorders. Early awareness regarding postpartum management, hygiene, and nutritional improvement can substantially decrease the incidence of endometritis and improve overall herd productivity (Pascottini *et al*., 2023).

Continuous extension activities and practical mentoring programs have been shown to improve farmers' confidence and competence in reproductive management. As farmers become more knowledgeable about reproductive health, they are better able to monitor cattle conditions, identify abnormalities earlier, and implement preventive management strategies. Ultimately, strengthening community veterinary extension programs contributes not only to improved reproductive performance and cattle productivity but also to rural economic development and sustainable livestock production systems (Herrero *et al*., 2013).

7. Impact on Beef Cattle Productivity

Improved reproductive management plays a significant role in enhancing beef cattle productivity and overall farm profitability (Diskin and Kenny, 2016). Proper reproductive health monitoring and timely intervention can reduce the incidence of repeat breeding, which is one of the major causes of reproductive inefficiency in cattle (Befekadu *et al*., 2023). In addition, effective management practices help shorten calving intervals, allowing cows to produce calves more regularly and efficiently.

Better reproductive performance also increases conception rates, leading to improved pregnancy success and higher calf production. As a result, farmers can achieve greater herd productivity and better livestock quality. Furthermore, healthy and productive cattle provide higher economic returns through increased calf sales and reduced treatment costs associated with reproductive disorders (Shaloo *et al*., 2014).

Overall, optimal reproductive performance is essential for maintaining the sustainability and efficiency of beef cattle production systems, particularly in rural farming communities where livestock serves as an important source of income and food security.

8. Conclusion

Endometritis remains one of the major reproductive disorders that negatively affects fertility and productivity in beef cattle. The condition can lead to decreased conception rates, prolonged calving intervals, and significant economic losses for farmers. Therefore, early detection, proper treatment, and preventive reproductive management are essential to reduce reproductive failures and improve herd performance.

Community veterinary extension programs play an important role in increasing farmers' knowledge and awareness regarding reproductive health, nutritional management, hygiene practices, and disease prevention. Educational support and continuous assistance help farmers recognize clinical signs earlier and apply better management strategies in their livestock systems.

Furthermore, strong collaboration among veterinarians, universities, inseminators, and farmers is necessary to improve reproductive efficiency and strengthen sustainable livestock development, especially in rural communities. Through integrated efforts in education, health services, and reproductive management, beef cattle productivity and farmer welfare can be improved sustainably.

Compliance with ethical standards

Acknowledgments

We would like to express our sincere gratitude to the Department of Animal Husbandry and Fisheries of Bojonegoro; the village officials of Palembon, Bojonegoro; and all lecturers of the Faculty of Veterinary Medicine, Universitas Airlangga. The contents of this paper were presented at the Community Service Program with Sustainable and Impactful Outcomes organized by the Faculty of Veterinary Medicine, Universitas Airlangga, entitled: "Community Empowerment in Palembon Village through the Improvement of Livestock Health, Nutritional Management, Reproductive Technology Innovation, and Processing of Livestock Products" in the Assisted Village of the Faculty of Veterinary Medicine, Universitas Airlangga.

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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