



(RESEARCH ARTICLE)



EVALUATION OF TRAINING IN CATTLE REPRODUCTIVE DISORDERS AND CONTINUING EDUCATION NEEDS OF VETERINARY TECHNICIANS IN BOJONEGORO REGENCY

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Abstract

This study evaluated community service activities for veterinary technicians in Bojonegoro Regency, assessing participant characteristics, training impact, patterns of cattle reproductive disorders, treatment obstacles, and continuing education needs. Demographic analysis showed varied age and education levels among participants (mean age range ~37–52 years), with baseline knowledge and field experience scores averaging around 4.3–4.5. Pre- and post-test assessments demonstrated measurable learning gains, with normalized gain (N-Gain) scores differing by gender and education: males (76.7%±22.6) versus females (50.0%±50.0), and veterinarians (73.5%±38.7) versus D3/SMA/SMK group (63.3%±20.5). Field surveillance by technicians identified repeat breeding as the most frequent reproductive issue (43.5% of cases), followed by silent heat (13.0%), dystocia and endometritis (each 10.9%). Reported barriers to effective treatment included weaknesses in cattle management (25.7%), limited medication/equipment (22.9%), farmer errors in estrus detection (17.1%), nutritional deficiencies (14.3%), and delayed reporting (14.3%). Prioritized continuing education needs emphasized ultrasonography (USG) training (31.3%), cattle feed management (15.6%), reproductive disorder treatment (15.6%), and hormone use updates (12.5%). Findings suggest that targeted, practical, and sustained training, particularly in USG, nutrition, estrus detection, and rational medication/hormone use, combined with improved access to equipment and farmer outreach, could address predominant reproductive problems and enhance technician performance. Recommendations include implementing competency-based workshops, strengthening supply chains, and instituting follow-up monitoring to gauge long-term impact on herd reproductive outcomes.

Keywords: Cattle reproductive disorders; Continuing education; livestock productivity and food security; Ultrasonography training; Veterinary technicians

1. INTRODUCTION

Reproductive health is central to productivity and sustainability in beef cattle production, directly affecting fertility, calving rates, and herd profitability (Assefa *et al.*, 2026). In many rural regions, including Bojonegoro Regency, reproductive disorders remain a persistent challenge, undermining both smallholder livelihoods and broader agricultural outputs. Effective management of these disorders depends not only on the availability of veterinary services but also on the capacity, training, and support of frontline service providers, particularly veterinary technicians who perform field-level diagnostics, farmer education, and interventions (Kebede *et al.*, 2025). The data presented in this report provide a focused assessment of community service activities directed at veterinary technicians in Bojonegoro, the reproductive disorder patterns they encounter, constraints in treatment, and prioritized continuing education needs. This introduction situates those findings within the wider context of cattle reproductive management, highlights critical gaps revealed by the local evaluation, and frames the rationale for targeted capacity-building interventions. Improving cattle reproductive health and technician capacity in Bojonegoro directly supports SDG priorities by increasing livestock productivity and food security, Decent Work and Economic Growth by strengthening smallholder incomes and rural livelihoods (Assefa *et al.*, 2026).

Cattle reproductive disorders generate both direct and indirect economic losses. Direct losses include decreased conception rates, increased calving intervals, and costs of veterinary treatment and labor; indirect effects involve reduced growth and market readiness, and heightened susceptibility to secondary diseases (Mansur *et al.*, 2024). Understanding the local pattern of reproductive disorders is a necessary precursor to designing effective extension and training programs. Repeat breeding and silent heat suggest gaps in estrus detection skills among farmers, suboptimal breeding management, or inadequacies in the timing and technique of artificial insemination (Satrio *et al.*, 2025). The presence of dystocia and uterine prolapse cases highlights the need for emergency obstetric interventions and improved peripartum management. Endometritis and ovarian dysfunction indicate possible nutritional, infectious, or hormonal etiologies that require diagnostic acumen and rational therapeutic strategies (Desalegn *et al.*, 2025). Collectively, these case frequencies justify a multi-pronged training approach that addresses diagnostic capacity, practical skills (e.g., obstetric assistance and estrus detection), and rational pharmacologic and hormonal management.

Given the identified patterns of disease, constraints, and training needs, community service programs must be designed with an integrated approach (Jang, 2025). Key program components should include: competency-based training in reproductive diagnostics (including USG and palpation), obstetric emergencies and assisted calving, modules on estrus detection and breeding management tailored for technician-led farmer outreach, nutrition and feed management education linked to reproductive outcomes, and rational pharmacology modules that cover hormone use, antibiotic stewardship, and appropriate drug selection (Matos *et al.*, 2026). Additionally, strengthening supply chains for essential equipment and medications and establishing mechanisms for faster reporting and referral from farmers to technicians will improve timeliness and efficacy of care (George *et al.*, 2021).

Monitoring and evaluation frameworks should be embedded within community service initiatives to assess both learning outcomes and field impact. The pre/post-test and N-Gain approach used in this evaluation is useful but should be complemented by long-term follow-up ((Pervilhac *et al.*, 2025) on reproductive performance indicators at the herd level (e.g., conception rate, calving interval, incidence of key disorders) and measures of farmer practice change (e.g., improved estrus detection, timely reporting). Stratified analyses by technician demographics and education can help tailor ongoing support and mentorship, ensuring that training investments translate into sustained improvements in animal health and farmer livelihoods (Vudriko *et al.*, 2021).

2. MATERIALS AND METHODS

This was a descriptive, cross-sectional evaluation of a community service (continuing education) activity for veterinary technicians conducted in Bojonegoro Regency. The evaluation combined pre/post knowledge testing, structured questionnaires, and field surveillance data collected by participating technicians to assess training impact, participant characteristics, patterns of cattle reproductive disorders, treatment obstacles, and continuing education needs (Vudriko *et al.*, 2021).

2.1. Ethics and participant consent

Participation in the community service evaluation was voluntary. Participants received information about the activity objectives and data use; verbal or written consent was obtained prior to participation. Data were anonymized for analysis. Institutional ethical approval or exemption was sought in accordance with local requirements prior to program implementation (noted in project records).

2.2. Participants and sampling

Participants were practicing veterinary technicians and related field staff recruited from Bojonegoro Regency through local extension networks and the implementing institution. Participant demographic and background data (age, gender, education level, baseline knowledge and field experience, and needs/expectations) were recorded for all attendees and are summarized by subgroup in some tables. Sample sizes for specific outcome sets were: knowledge assessments, reported reproductive disorder cases recorded by technicians, obstacles to treatment, and continuing education priorities.

2.3. Intervention and community service activity

The community service intervention consisted of targeted training modules delivered to veterinary technicians. Modules addressed reproductive diagnostics and management, practical skills (including obstetric assistance and estrus detection), rational medication and hormone use, and farmer outreach techniques. Hands-on demonstration components included ultrasonography (USG) technique and assisted-calving procedures. Training duration, trainers' qualifications, and precise curriculum details followed institutional standard continuing-education formats (practical workshops plus lectures and group discussion).

2.4. Data collection instruments and procedures

- Pre- and post-training knowledge tests: Standardized multiple-choice/short-answer tests administered immediately before and after the training to quantify learning gains. Raw pre- and post-test scores and normalized gain (N-Gain) percentages were calculated and are presented stratified by gender, age cluster, and education level.
- Participant questionnaire: A structured questionnaire captured demographic data, baseline self-rated knowledge and field experience, participants' needs and expectations, and prioritized continuing education topics. Responses on needs/priorities were aggregated.
- Field surveillance log: During and after the community service activity, technicians recorded cases of reproductive disorders encountered in the field. Each case was classified by diagnosis (repeat breeding, silent heat, dystocia, endometritis, uterine prolapse, ovarian hypofunction, others) and tallied.
- Obstacles inventory: Technicians completed a checklist and open-response section listing main obstacles to treating reproductive disorders (e.g., management weaknesses, limited medication/equipment, estrus detection errors, nutritional deficiencies, delayed reporting). Frequency of each obstacle was tabulated.

P9–P22: Narrative Responses

Prior Knowledge and Field Experience

9. I understand the signs of reproductive disorders in livestock.
10. I can distinguish between minor reproductive disorders and those requiring immediate attention from a veterinarian or inseminator.
11. I know the appropriate timing for detecting estrus (heat) in livestock.
12. I understand the factors that can lead to pregnancy failure.
13. I recognize the importance of maintaining reproductive records for livestock in the field.
14. I have encountered cases such as anestrus, repeat breeding, or endometritis in livestock.
15. I know the initial steps to take when a reproductive disorder is identified in livestock.
16. I believe that field-based technologies can help accelerate the detection of reproductive disorders.
17. I understand the importance of collaboration among farmers, government agencies, inseminators, and veterinarians in managing reproductive health.

Participant Needs and Expectations

18. Information regarding reproductive disorders is highly relevant to my work.
19. I require practical guides or simple standard operating procedures (SOPs) for handling cases in the field.
20. I need further training on estrus detection, record-keeping, and pregnancy evaluation.
21. I need simple educational materials, such as leaflets, posters, or pocketbooks.
22. I hope for field-based support or mentoring following this training.

2.5. Outcome measures

Primary outcomes were: change in knowledge (pre-test and post-test scores, and N-Gain), frequency distribution of reproductive disorder cases recorded by technicians, ranked obstacles to effective treatment, and prioritized

continuing education needs. Secondary descriptive outcomes included participant demographic and baseline competency measures (mean $\pm$ SD), and subgroup comparisons by gender, age cluster, and education level.

2.6. Quality control and training fidelity

Trainers used standardized materials and checklists for practical demonstrations. Test instruments and questionnaires were pilot-tested with a small group of technicians prior to the activity to ensure clarity. Field case definitions for reproductive disorders were standardized and provided to technicians to improve consistency of surveillance entries.

2.7. Data analysis

All quantitative data were entered into a spreadsheet and checked for completeness. Continuous variables are presented as mean $\pm$ standard deviation; categorical variables are presented as counts and percentages. N-Gain (%) was calculated per standard formula: (post-test score – pre-test score) / (maximum possible – pre-test score) $\times$ 100, then summarized by group. Subgroup comparisons (gender, age cluster, education level) were used descriptively to identify differences in baseline scores and gains.

3. RESULTS

A total of community-service participants were evaluated and stratified by gender, age cluster, and education level. Mean ages ranged across groups: males 47.75 $\pm$ 7.90 years and females 39.14 $\pm$ 7.49 years (Table 1). Age-cluster means were 37.42 $\pm$ 4.66 years for the $\geq$ 45 group and 52.00 $\pm$ 4.23 years for the <45 group (Table 2). By education, veterinarians averaged 41.94 $\pm$ 8.40 years and D3/SMA/SMK respondents 51.60 $\pm$ 4.60 years (Table 3). Self-rated initial knowledge and field experience scores clustered around 4.3–4.5 across subgroups (Tables 1–3).

3.1. Knowledge assessment and learning gains

Pre-test and post-test scores demonstrated improvement across subgroups (Tables 1–3). By gender (Table 1), mean pre-test scores were 13.00 $\pm$ 0.79 for males and 14.14 $\pm$ 0.90 for females; mean post-test scores were 14.45 $\pm$ 0.51 and 14.86 $\pm$ 0.38, respectively. Normalized gain (N-Gain) percentages differed: males 76.67 $\pm$ 22.56% versus females 50.00 $\pm$ 50.00% (Table 1). By age cluster (Table 2), pre-test means were 13.58 $\pm$ 1.00 ($\geq$ 45) and 13.07 $\pm$ 0.88 (<45), with post-test means 14.67 $\pm$ 0.49 and 14.47 $\pm$ 0.52, and N-Gain 69.44 $\pm$ 38.16% and 70.00 $\pm$ 29.68%, respectively. By education (Table 3), veterinarians had pre/post means 13.53 $\pm$ 1.07 / 14.76 $\pm$ 0.44 with N-Gain 73.53 $\pm$ 38.67%, while D3/SMA/SMK had 12.90 $\pm$ 0.57 / 14.20 $\pm$ 0.42 with N-Gain 63.33 $\pm$ 20.49%.

3.2. Frequencies of reproductive disorders (field surveillance)

Technicians recorded 46 reproductive disorder cases (Table 4, page 1). Repeat breeding was most frequent at 43.48% (20/46). Other diagnoses were silent heat 13.04% (6/46), dystocia 10.87% (5/46), endometritis 10.87% (5/46), uterine prolapse 8.70% (4/46), ovarian hypofunction 6.52% (3/46), and other conditions 6.52% (3/46) (Table 4).

3.3. Reported obstacles to treatment

Responses concerning barriers to effective treatment (n = 35 respondents) are summarized in Table 5 (page 1). The leading problems were weaknesses in beef cattle management (25.71%; 9/35) and limited medication/equipment (22.86%; 8/35). Other cited obstacles included errors in estrus detection by farmers (17.14%; 6/35), nutritional deficiencies in cattle (14.29%; 5/35), and late reporting by breeders to inseminators (14.29%; 5/35); remaining responses were categorized as others (5.71%; 2/35).

3.4. Continuing education needs

Table 1 The parameters of community services evaluation based on gender of respondent

Gender	Male	Female
Age	47.75 $\pm$ 7.90	39.14 $\pm$ 7.49
Initial knowledge and field experience	4.45 $\pm$ 0.12	4.35 $\pm$ 0.23
Participants' needs and expectations	4.48 $\pm$ 0.14	4.83 $\pm$ 0.12
Pre-test score	13.00 $\pm$ 0.79	14.14 $\pm$ 0.90
Post-test score	14.45 $\pm$ 0.51	14.86 $\pm$ 0.38
N-Gain Score (%)	76.67 $\pm$ 22.56	50.00 $\pm$ 50.00

Priority topics identified by technicians (n = 32) are reported in Table 6 (page 2). The top need was ultrasonography (USG) training at 31.25% (10/32). Other priorities included cattle feed management 15.63% (5/32), treatment of reproductive disorders 15.63% (5/32), updates on hormone use 12.50% (4/32), effective and rational medication use 9.38% (3/32), and regular/sustainable training 9.38% (3/32); remaining items were classified as others 6.25% (2/32).

Table 2 The parameters of community services evaluation based on age of respondent

Age cluster (years)	≥45	>45
Age	37.42±4.66	52.00±4.23
Initial knowledge and field experience	4.48±0.12	4.38±0.14
Participants' needs and expectations	4.68±0.09	4.48±0.17
Pre-test score	13.58±1.00	13.07±0.88
Post-test score	14.67±0.49	14.47±0.52
N-Gain Score (%)	69.44±38.16	70.00±29.68

Table 3 The parameters of community services evaluation based on education levels of respondent

Levels of education	Veterinarian	D3/SMA/SMK
Age	41.94±8.40	51.60±4.60
Initial knowledge and field experience	4.37±0.17	4.51±0.09
Participants' needs and expectations	4.74±0.11	4.28±0.19
Pre-test score	13.53±1.07	12.90±0.57
Post-test score	14.76±0.44	14.20±0.42
N-Gain Score (%)	73.53±38.67	63.33±20.49

Table 4 Frequencies of reproductive disorders in cattle find by veterinary technician in Bojonegoro regency

Cases	Percentage
Repeat breeding	43.48% (20/46)
Silent heat	13.04% (6/46)
Dystocia	10.87% (5/46)
Endometritis	10.87% (5/46)
Uterine prolapse	8.70% (4/46)
Ovarian hypofunction	6.52% (3/46)
Others	6.52% (3/46)

Table 5 Main Obstacles in the reproductive disorders treatment in Bojonegoro regency

Problem	Percentage
Weaknesses in beef cattle management	25.71% (9/35)
Limited medication and equipment	22.86% (8/35)
Errors in estrus detection by farmers	17.14% (6/35)
Nutritional deficiencies in cattle	14.29% (5/35)
Late reporting by breeders to inseminators	14.29% (5/35)
Others	5.71% (2/35)

Table 6 Subject matter of continuing education needs veterinary technician in Bojonegoro regency

Continuing education needs	Percentage
Training in USG technique	31.25% (10/32)
Cattle Feed Management	15.63% (5/32)
Treatment of Reproductive Disorders	15.63% (5/32)
Updates on Hormone Use	12.50% (4/32)
Effective and Rational Medication Use	9.38% (3/32)
Regular and sustainable Training	9.38% (3/32)
Others	6.25% (2/32)

Overall, participants showed measurable short-term learning improvements across demographic and education strata, with variable N-Gain percentages favoring certain subgroups (males, veterinarians). Field surveillance highlighted repeat breeding as the predominant reproductive problem. Major system-level constraints reported by technicians included farm management weaknesses, limited access to medications/equipment, and deficiencies in farmer estrus-detection and nutrition. Technicians prioritized practical, diagnostic, and management-focused continuing education—particularly USG training—consistent with the observed case patterns and reported barriers.

4. DISCUSSION

This evaluation of a community service training for veterinary technicians in Bojonegoro Regency reveals important insights into technician capacities, common cattle reproductive problems encountered in the field, systemic barriers to effective treatment, and prioritized continuing education needs. The findings have practical implications for designing targeted capacity-building, extension, and health-system support that can improve herd reproductive outcomes and farmer livelihoods.

4.1. Training impact and participant heterogeneity

Pre- and post-test results show measurable short-term knowledge gains across participant groups, indicating the training was effective at increasing immediate cognitive competence. However, normalized gain (N-Gain) scores varied substantially by gender and education level: males and veterinarians achieved higher average N-Gain percentages than females and the D3/SMA/SMK group (Tables 1–3). This heterogeneity suggests that while baseline self-rated experience was similar across subgroups, the relative benefit of a single training event is influenced by prior formal education, learning styles, or contextual factors (e.g., time available for practice, workplace responsibilities). Program designers should therefore incorporate differentiated instructional strategies — such as more hands-on practice, follow-up mentoring, and adaptive pacing — to ensure equitable learning outcomes, particularly for technicians with less formal training or those who may face competing demands.

Training programs have demonstrated significant effects on participants' skills, attitudes, and behaviors, but the outcomes vary depending on the training design, content, and evaluation methods. Training programs, such as those in leadership development, emotional intelligence, and technical skills, have shown measurable improvements in participants' competencies. For instance, receptivity to feedback and openness to experience were key predictors of EI training gains (Pat McEnrue *et al.*, 2009). Similarly, VR-based training improved skill transfer to real-world tasks, particularly when the technical quality of the VR system was high (Oppermann *et al.*, 2024). Diversity training and cultural safety training have been effective in fostering positive attitudes and reducing ethnocentrism. However, the effects on behavioral and attitudinal learning tend to decay over time unless reinforced (Bezrukova *et al.*, 2016) (Pimentel *et al.*, 2022). Training tailored to specific contexts, such as medical education or occupational safety, has shown significant improvements in confidence, competence, and practical application of skills (Zhao *et al.*, 2023; Wilcox Vanden Berg *et al.*, 2024).

The effectiveness of training is influenced by individual and group-level differences, including demographic, psychological, and socioeconomic factors. Gender, age, ethnicity, and socioeconomic background significantly influence training outcomes. For example, women and individuals with lower education levels reported higher expectations and perceived impacts of training (Gonçalves and Mourão, 2011; Santana and Chalkley, 2017). Similarly, handedness was found to affect performance in VR training, highlighting the need for interface designs that accommodate such variability (Duruaku *et al.*, 2025). Traits like self-efficacy, motivation, and openness to experience play a critical role in

determining training gains. Participants with higher receptivity to feedback and achievement motivation tend to benefit more from training (Pat McEnrue *et al.*, 2009; Panya *et al.*, 2018). Socioeconomic background and institutional support also shape training outcomes. For instance, individuals from disadvantaged backgrounds may face barriers to accessing or benefiting from training, while organizational factors like management commitment and resources can enhance training effectiveness (Santana and Chalkley, 2017; Choopani *et al.*, 2024). The composition of training groups, such as the proportion of women or the diversity of participants, can influence reactions and learning outcomes. For example, diversity training was more effective when the group included a higher proportion of women (Bezrukova *et al.*, 2016).

Integrated and context-specific training approaches yield better outcomes. Tailoring training to individual traits and group dynamics enhances effectiveness. Sustained benefits often depend on follow-up initiatives and supportive environments. By addressing participant heterogeneity and optimizing training design, organizations can maximize the impact of their training programs.

4.2. Predominance of fertility-related disorders and diagnostic priorities

Field surveillance logged 46 reproductive cases, with repeat breeding comprising nearly half (43.5%) of diagnoses (Table 4). The high proportion of repeat breeding and silent heat cases indicates that fertility management and estrus detection are critical weaknesses at the farm level. These patterns align with technicians' prioritized need for ultrasonography (USG) training (31.3%) and for improved feed management and reproductive disorder treatment (Table 6). USG can enhance diagnostic precision for ovarian activity, early pregnancy detection, and uterine pathology, thereby supporting better-timed interventions. Training that couples USG competence with practical guidance on estrus detection methods and breeding management (including timing for artificial insemination) is likely to have the most immediate clinical impact.

Reproductive disorders in cattle significantly impact fertility, productivity, and economic sustainability in the livestock industry. These disorders are caused by a combination of infectious, non-infectious, environmental, and management-related factors, and their prevalence is increasing due to selective breeding for commercial purposes (Yoo, 2010; Priyadarsini *et al.*, 2025; Shiferaw *et al.*, 2005). Diseases such as endometritis, metritis, brucellosis, and trichomoniasis are major contributors to fertility issues. These infections often lead to uterine inflammation, reduced sperm quality, and structural damage (Yoo, 2010; Samuel *et al.*, 2026a; Samuel *et al.*, 2026b). Conditions like anestrus, cystic ovarian disease, retained placenta, and dystocia are frequently observed. These disorders are often linked to hormonal imbalances, nutritional deficiencies, and poor postpartum care (Shiferaw *et al.*, 2005; Agarwal *et al.*, 2005; Giacomelli *et al.*, 2018). Many reproductive abnormalities occur as combinations rather than isolated issues, such as uterine infections coupled with retained fetal membranes or ovarian cysts (Shiferaw *et al.*, 2005).

Reproductive disorders reduce conception rates, prolong calving intervals, and increase the number of services required per conception. For example, cows with reproductive disorders have significantly longer intervals from calving to first service and conception compared to healthy cows (Shiferaw *et al.*, 2005) (Sheldon *et al.*, 2006). Disorders like abortion and dystocia are influenced by environmental factors, parity, and management practices, further complicating fertility outcomes (Tulu, and Negera, 2022; Tolosa *et al.*, 2021).

Effective diagnosis is critical for managing reproductive disorders. Diagnosis relies on clinical signs, ultrasonography, palpation, and laboratory tests such as PCR and ELISA for infectious agents (Samuel *et al.*, 2026a; Samuel *et al.*, 2026b) (Sheldon *et al.*, 2006). Hormonal irregularities and immune dysfunction are key contributors to uterine diseases. Monitoring immune markers like cytokines (e.g. IL-1 β , IL-6) can provide insights into disease mechanisms (Priyadarsini *et al.*, 2025; Juli *et al.*, 2024). Regular examinations, including vaginal and transrectal ultrasonography, are essential for early detection of uterine diseases and abnormal estrous cycles (Sheldon *et al.*, 2006).

Biosecurity, vaccination, and improved hygiene practices can reduce the incidence of infectious diseases (Yoo, 2010) (Samuel *et al.*, 2026). Balanced feeding and addressing negative energy balance postpartum are crucial for maintaining reproductive health (Shiferaw *et al.*, 2005; Sheldon *et al.*, 2006). Combining hormonal protocols with improved estrus detection, artificial insemination timing, and supplementary feeding can optimize fertility outcomes (Shiferaw *et al.*, 2005; Mansur *et al.*, 2025). Addressing fertility-related reproductive disorders in cattle requires a multifaceted approach, integrating advanced diagnostic techniques, preventive strategies, and sustainable management practices to enhance reproductive efficiency and economic viability (Yoo, 2010; Shiferaw *et al.*, 2005; Sheldon *et al.*, 2006).

4.3. Systemic constraints limiting treatment efficacy

Technicians identified multiple system-level barriers: weaknesses in cattle management (25.7%), limited medication and equipment (22.9%), errors in farmer estrus detection (17.1%), nutritional deficiencies (14.3%), and delayed reporting by breeders (14.3%) (Table 5). These obstacles reflect a combination of technical, resource, and communication shortcomings. Even when technicians possess diagnostic skills, the absence of essential drugs or equipment and poor farmer practices can blunt the effect of interventions. Therefore, training should be integrated with

supply-chain improvements (e.g., ensuring access to essential drugs, portable USG units, basic obstetric kits) and farmer-targeted outreach to improve estrus detection, peripartum care, and nutritional management. Strengthening links between technicians and breeder communities — for example through scheduled regular visits, hotline reporting systems, or farmer group training — can help reduce delays in reporting and improve timely intervention.

Reproductive disorders in cattle significantly impact fertility and productivity, but their diagnosis and treatment face several systemic constraints. These challenges arise from physiological, environmental, and management-related factors, as well as limitations in veterinary infrastructure and resources. Reproductive disorders such as endometritis, silent estrus, and ovarian cysts disrupt hormonal balance and immune-endocrine communication, leading to reduced fertility and pregnancy complications (Mansur *et al.*, 2025) (Priyadarsini *et al.*, 2025) (*et al.*, 2025). Hormonal treatments, while effective in some cases (e.g. estrus synchronization), show variable success depending on the severity of the disorder and underlying physiological disruptions (Mansur *et al.*, 2025) (Gundling *et al.*, 2012).

Accurate diagnosis of reproductive disorders often requires advanced tools like ultrasound, PCR, and ELISA, which may not be readily available in resource-limited settings (Samuel *et al.*, 2026) (Mikhalev *et al.*, 2019) (Muratbayev *et al.*, 2018). Early detection of conditions like endometritis or embryonic growth retardation is critical but often delayed due to inadequate diagnostic infrastructure (Gundling *et al.*, 2012) (Mikhalev *et al.*, 2019). Poor housing, feeding, and herd management exacerbate reproductive issues. Without addressing these systemic issues, hormonal or therapeutic interventions alone are insufficient to improve reproductive performance (Mansur *et al.*, 2025) (Gundling *et al.*, 2012). High incidences of repeat breeding and anestrus are linked to suboptimal estrus detection and lack of skilled personnel for artificial insemination (Gundling *et al.*, 2012) (Meena and Malik, 2009).

Limited availability of veterinarians, especially during emergencies or nighttime, hinders timely treatment (Meena and Malik, 2009). Lack of access to high-quality bulls and inadequate training of lay inseminators further reduce treatment efficacy (Meena and Malik, 2009). Variations in immune function and excessive inflammatory responses contribute to the development of uterine diseases, complicating treatment protocols (Priyadarsini *et al.*, 2025) (*et al.*, 2025). Genetic predispositions to certain disorders, such as ovarian hypoplasia, also limit the success of standard treatments (Priyadarsini *et al.*, 2025).

Combining hormonal treatments with improved nutrition, housing, and estrus detection practices can enhance outcomes (Mansur *et al.*, 2025) (Gundling *et al.*, 2012). Training inseminators and veterinarians, along with strengthening veterinary infrastructure, can address diagnostic and treatment gaps (Meena and Malik, 2009). Exploring homeopathic and non-antibiotic treatments may provide sustainable options for managing reproductive disorders (Muratbayev *et al.*, 2018) (Várhidi *et al.*, 2024) (Nachappa *et al.*, 2023). Systemic constraints such as diagnostic limitations, poor management practices, and resource shortages significantly hinder the effective treatment of reproductive disorders in cattle. Addressing these challenges requires a holistic approach that integrates veterinary, environmental, and management strategies.

4.4. Implications for rational medication and hormone use

A notable priority among technicians was updates on hormone use and rational medication practice (Table 6), and the obstacle list included limited medication/equipment and mismanagement. Rational pharmacologic practice is essential to avoid unnecessary or inappropriate use of antibiotics and hormones, to maximize treatment efficacy, and to minimize resistance or residues that affect food safety. Training curricula should therefore include modules on evidence-based pharmacology, indications and contraindications for hormonal protocols, withdrawal periods, and antibiotic stewardship adapted to the local drug availability and regulatory context.

Reproductive disorders in cattle, such as ovarian hypofunction, silent estrus, endometritis, and repeat breeding, significantly impact fertility, productivity, and economic outcomes in cattle farming. Rational use of medications and hormones is critical for addressing these challenges effectively while minimizing risks to animal health, consumer safety, and the environment. Hormonal protocols, such as those involving GnRH, prostaglandins (PGF), and progesterone-based therapies, are widely used to treat reproductive disorders like silent estrus, ovarian hypofunction, and endometritis. These treatments can synchronize estrus, induce ovulation, and improve conception rates, but their success depends on the severity of the disorder and management practices (Mansur *et al.*, 2025) (Gundling *et al.*, 2012) (El-Shamy *et al.*, 2026). Progesterone-based protocols are particularly effective in resolving reproductive issues under heat stress and in cases of smooth inactive ovaries (SIO), yielding higher estrus response and conception rates compared to other methods (El-Shamy *et al.*, 2026) (De Rensis *et al.*, 2015).

Non-steroidal aromatase inhibitors like letrozole have shown promise in synchronizing ovulation and improving fertility outcomes, offering a safer alternative to steroid hormones banned in many regions (Yapura *et al.*, 2018). Uterine flushing and the use of biostimulators, such as placenta extracts, have been explored as non-hormonal interventions to restore reproductive health by addressing underlying immunometabolic disturbances (Lunsin *et al.*, 2024).

(Brahmantya *et al.*, 2026). While veterinarians often view hormonal treatments as cost-effective, many farmers remain skeptical, citing concerns about cost, naturalness, and addressing root causes of infertility (Laven *et al.*, 2026) (Higgins *et al.*, 2013). Education on the benefits of hormonal protocols must align with farmer priorities, such as improving herd management and reducing reliance on medications (Laven *et al.*, 2026) (Higgins *et al.*, 2013). Hormonal residues in cattle slurry pose environmental and health risks, necessitating proper disposal or treatment methods to mitigate estrogenic effects (Gubo *et al.*, 2022). Overuse of antibiotics and hormones raises concerns about resistance and consumer safety, emphasizing the need for judicious use (Gulzar *et al.*, 2024) (Kumar *et al.*, 2018).

Combining hormonal treatments with improved herd management, nutrition, and estrus detection practices is essential for sustainable reproductive performance (Mansur *et al.*, 2025) (Gundling *et al.*, 2012) (Gulzar *et al.*, 2024). Addressing underlying issues, such as metabolic stress and uterine health, through immunometabolic management and targeted interventions, can reduce reliance on repeated hormonal treatments (Brahmantya *et al.*, 2026). Rational medication and hormone use in cattle farming requires a balanced approach that integrates hormonal protocols with non-hormonal strategies, improved management practices, and environmental safeguards. This holistic approach can enhance reproductive efficiency, reduce economic losses, and ensure sustainable livestock production.

4.5. Sustainability of learning and program design considerations

The variability in N-Gain and the expressed desire for regular, sustainable training (9.38%) highlight the limitation of one-off interventions. Sustained improvements will likely require a longitudinal capacity-building model that includes repeated workshops, on-the-job mentorship, opportunities for supervised practice (especially for USG and obstetric procedures), and mechanisms for continued professional development. Embedding monitoring and evaluation (M&E) in program design — tracking technician performance, farmer behaviors (e.g., estrus detection accuracy, timely reporting), and herd-level reproductive indicators over time — is necessary to demonstrate long-term impact and to refine training priorities.

The sustainability of learning and program design for managing reproductive disorders in cattle involves integrating advanced technologies, tailored management strategies, and stakeholder collaboration. Programs should identify subgroups of cows based on reproductive and performance potential using genomic, behavioral, and physiological data. Tailored strategies for these subgroups can optimize outcomes like fertility and herd profitability (Giordano *et al.*, 2022; Wiltbank *et al.*, 2010). Effective reproductive programs, such as Double-Ovsynch and CIDR protocols, focus on synchronizing ovulation and optimizing hormonal environments to improve fertility. These programs must account for genetic, environmental, and management variability (Wiltbank *et al.*, 2010; Sartori *et al.*, 2023). Advanced tools like artificial intelligence (AI), genomic selection, and sensor technologies enable real-time decision-making and improve reproductive efficiency. These tools also support precision breeding and disease control (Kilic *et al.*, 2024; Pascottini *et al.*, 2025; Džermeikaitė *et al.*, 2025).

Sustainable programs must align with environmental goals, such as reducing greenhouse gas emissions, while maintaining economic viability. Genetic selection for traits like fertility, disease resistance, and feed efficiency can reduce environmental impacts and improve sustainability (Kaniyamattam *et al.*, 2026; Richardson *et al.*, 2023). Programs like Uruguay's Sustainable Family Production Programme highlight the importance of long-term evaluations to assess the cumulative effects of reproductive technologies on productivity and emissions (Aguirre *et al.*, 2026). Sustainable designs should prioritize animal welfare by reducing stress and improving health outcomes through precision livestock farming and stage-specific care (Acharya *et al.*, 2026; Cartick and Chapatte, 2026).

Successful programs require collaboration among researchers, farmers, and policymakers. Stakeholders play roles in funding, implementation, and knowledge dissemination (Camara *et al.*, 2019). Practical training and record-keeping systems are critical for improving adoption rates of reproductive technologies, especially in regions with structural and socioeconomic challenges (Figueroa-Zambrano *et al.*, 2025; Haile *et al.*, 2023). Phenotyping and data collection are essential for refining reproductive strategies. Investments in data infrastructure and computational tools are necessary to support sustainable breeding programs (Helmute and Mazure, 2025). High initial costs, lack of infrastructure, and limited access to technology hinder widespread implementation of advanced reproductive programs (Figueroa-Zambrano *et al.*, 2025; Helmute and Mazure, 2025). Programs must address ethical concerns, such as data privacy and animal welfare, while navigating evolving regulatory frameworks (Kilic *et al.*, 2024; Cartick and Chapatte, 2026). Programs should be adaptable to specific farm conditions, genetic groups, and regional needs to ensure effectiveness and sustainability (Wiltbank *et al.*, 2010; Sartori *et al.*, 2023; Haile *et al.*, 2023). Sustainable learning and program design for controlling reproductive disorders in cattle require a multi-faceted approach. By integrating advanced technologies, fostering collaboration, and addressing environmental and economic goals, these programs can enhance productivity, animal welfare, and long-term sustainability. However, challenges like cost, infrastructure, and ethical considerations must be addressed to ensure widespread adoption and success.

Several methodological limitations temper interpretation. The field surveillance relied on technician-recorded case logs, which may reflect reporting bias, diagnostic variability, or non-systematic case capture; sample sizes for some response subsets were modest (e.g., $n = 32$ for education priorities, $n = 35$ for obstacles), limiting generalizability. The short-term pre/post testing measures cognitive gain but does not capture skill retention or translation into practice. Finally, the evaluation does not include direct measures of farm-level reproductive performance before and after the intervention, so causal links between training and herd outcomes remain to be established.

5. CONCLUSIONS

The evaluation highlights clear, actionable priorities: repeat breeding and estrus-detection failures are the most pressing clinical challenges; technicians value and need practical diagnostic and management training — particularly in USG and feed management; and systemic constraints such as limited equipment, suboptimal cattle management, and delayed reporting must be addressed in parallel. A comprehensive, sustained capacity-building strategy that aligns technician training with supply-chain improvements and farmer education is likely to produce the greatest improvement in cattle reproductive health and associated socioeconomic benefits for smallholder producers in Bojonegoro.

Based on the findings, the following actions are recommended:

- Implement competency-based follow-up training emphasizing USG, obstetric assistance, estrus detection, and rational pharmacology, with differentiated modules for technicians of varied educational backgrounds.
- Establish mentorship and supervised practice opportunities to reinforce skills and improve retention.
- Improve access to essential diagnostic and treatment equipment (portable USG units, obstetric kits) and to a reliable supply of appropriate medications.
- Develop farmer-focused extension programs on estrus detection, peripartum management, and nutrition, coordinated with technician schedules to reduce delayed reporting.
- Integrate M&E with longitudinal tracking of technician practice change and herd reproductive indicators (e.g., conception rate, calving interval, incidence of repeat breeding) to assess real-world impact.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no competing interests.

Author's contributions

Imam Mustofa (IM), Yeni Dhamayanti (YD), Widjiati (WW), Suherni Susilowati (SS), and Tita Damayanti Lestari (TDL) contributed to this manuscript. IM and WW conceived the idea and designed the main framework of the manuscript. YD and SS were responsible for data acquisition, analysis, and interpretation. IM drafted the manuscript, while TDL critically reviewed and revised the manuscript for important intellectual content. All authors have read and approved the final version of the manuscript.

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