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DEPARTMENT OF BIOMEDICAL SCIENCE,

ASSESSMENT OF FACTORS ASSOCIATED WITH LOW CONCEPTION RATE IN DAIRY CATTLE ARTIFICIAL INSEMINATION SERVICES IN THREE SELECTED DISTRICTS OF EAST WALLAGA ZONE, ETHIOPIA

MSC THESIS

BY

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NEKEMTE, ETHIOPIA

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A THESIS SUBMITTED TO THE GRADUATE STUDIES OF WALLAGA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ANIMAL HEALTH AND PRODUCTION

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APPROVAL SHEET FOR SUBMITTING THESIS

As thesis research advisors, we hereby certify that we have read and evaluated this thesis prepared, under our guidance, by Gemechu Tesfaye, entitled "Assessment of Factors Associated with Low Conception Rate in Dairy Cattle Artificial Insemination Services in Three Selected Districts of East Wallaga Zone, Ethiopia." We recommend that it be submitted as fulfilling the thesis requirement.

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As members of the Board of Examiners of the MSc Thesis Open Defense Examination, We certify that we have read, evaluated the Thesis prepared by Gemechu Tesfaye and examined the candidate, we recommended that the thesis be accepted as fulfilling the thesis requirement for the degree of Master of Science in Animal Health and Production

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DEDICATION

This thesis is dedicated to the Almighty God, the source of all wisdom, knowledge, and strength, who guided me throughout this academic journey. I also dedicate this work to my beloved family for their unconditional love, constant prayers, and encouragement. Your unwavering support has been my pillar throughout this study.

To the hardworking dairy farmers of Guto Gida, Leka Dullacha, and Diga districts your resilience and commitment to livestock improvement inspired this research. May this work contribute in some way to the betterment of your livelihoods.

STATEMENT OF THE AUTHOR

First, I notify that this is my work and that all sources of materials used for this thesis have been duly acknowledged. This thesis is submitted in partial fulfillment of the requirements for MSc. degree at Wallaga University. I solemnly notify that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Brief quotations from this thesis are allowable without special permission provided that accurate acknowledgement of source is made. Request for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of School of Graduate Studies when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

Name: Gemechu Tesfaye, Signature: _____

Place: Wallaga University, Nekemte

Date of Submission: _____

BIOGRAPHICAL SKETCH

The author, Gemechu Tesfaye was born on November, 1998 in Leka Dulacha District Eastern Wallaga Zone. He attended his elementary school education at Waran Gur Primery School and Secondary School education at Getema Secondary School. After completion of Secondary School education in 2006 he joined Bahir Dar University Faculty of Agriculture and graduated with BVSc in Veterinary Science in 2008. After graduation he was employed by Nekemte Semen and Liquid Nitrogen Production and Distribution Center where he worked for 8 years as Semen Production Expert at Semen Production Center laboratory until he re-joined Wallega University in September 2021, to pursue his M.Sc. degree in Animal Health and Production through self-sponsor.

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ACRONYMS AND ABBREVIATIONS

°C	Degree Celsius
AD	After Death
AI	Artificial insemination
AITs	Artificial Insemination Technicians
BSPC	Bahir Dar Semen Production center
CADU	Chilalo Agricultural Development Project
CASA	Computer Assisted Semen Analysis
Cl	Confidence Interval
CSA	Central Statistics Agens
DF	Deep Frozen
HAMI	Hormone Asssisted Mass Insemination
HF	Holstein Friesian
Km	Kilo Meter
LN_2	Liquid Nitrogen
LR χ^2	Likelihood Ratio Chi-square
m.a.s.l.	Meters above Sea Level
mm	Milineter
MS-Excel	Microsoft Excel
MSPC	Mekele Semen Production center
HSPC	Hawasa Semen Production center
NAGII	National Animal Genetics Improvement Institute
NAIC	National Artificial Insemination Center
NSPC	Nekemte Semen Production Center
OR	Odds RAtio
STATA	Statistical Data Analysis
Vs	Versus
VWP	Voluntary waiting period
WADU	Walaita Agricultural Development Project

SUMMARY

Artificial insemination (AI) is one of the most widely applied reproductive biotechnologies in Ethiopia, aimed at improving the genetic potential and productivity of indigenous cattle. However, conception rates remain low, limiting the expected benefits. This study assessed the major factors associated with conception success in dairy cows following AI in three purposively selected districts of East Wallaga Zone: Guto Gida, Leka Dullacha, and Diga. A cross-sectional study was conducted in the selected districts, involving a total of 277 smallholder dairy farmers, nine artificial insemination (AI) technicians, and two semen production experts. Primary data were collected through structured interviews, questionnaires, group discussions, and field observations. Furthermore, a retrospective analysis of 444 insemination records collected between 2017 and 2022 was undertaken using an established statistical model to assess the influence of household, animal, management, and service-related factors on conception outcomes. The overall conception rate was 46%. The models achieved likelihood ratio chi-square values between $\chi^2 = 114.84$ and 128.14 ($p < 0.001$), indicating that the included explanatory variables jointly improved the prediction of conception outcomes compared to the null model. Pseudo R^2 values ranged from 0.19 to 0.21, meaning the models explained about 19–21% of the variability in conception success. Education level, breed type, management system, and season of insemination significantly influenced conception outcomes. Farmers with primary (OR = 3.64, $p < 0.001$) or secondary education (OR = 4.16, $p < 0.001$) achieved higher conception success than illiterate households. Crossbred cows were 3.45 times more likely to conceive than local breeds ($p < 0.001$). Cows managed under semi-intensive systems were 5.25 times more likely to conceive than those in extensive systems ($p < 0.001$). Conception success was highest in winter (OR = 7.09, $p < 0.001$) and spring (OR = 2.52, $p = 0.001$) compared to summer and significantly improved in 2020 (OR = 2.67, $p = 0.006$) and 2021 (OR = 2.50, $p = 0.019$) compared to 2017. The insemination modality was critical, with the HAMI method being 4.07 times more successful than the regular method ($p < 0.001$). Qualitative findings further revealed poor estrus detection skills, inconsistent service delivery, and logistical constraints in semen handling as critical barriers to AI success. The study concludes that improved farmer education, strengthened heat detection practices, better management systems, and seasonal planning are essential to enhance AI outcomes.

Keywords: *Artificial insemination, conception rate, dairy cattle, East Wallaga Zone*

1. INTRODUCTION

Agriculture is the mainstay of the Ethiopian economy, employing approximately 85% of the total population (Sheehy *et al*., 2019). Livestock production is an integral part of Ethiopian agriculture, accounting for about 45% of the total value of agricultural production and supporting the livelihoods of a large share of the population. More than 14 million households, or 70 % of the population, keep livestock, including many poor (Abdi and Seid, 2013).

Ethiopia has a cattle population about 70 million reared under diverse agroclimates. Of these Ethiopian cattle populations, Oromia has about 25.5 million, and East Wallaga has a population of 1,079,293 cattle. However, out of the 70 million Ethiopian cattle population, 97.66% are local breeds, and only 2.34% are considered to be improved (2.0% crossbred and 0.34% exotic breeds) (CSA, 2021).

The cattle population in Ethiopia has slowly expanded over the last decade to help fulfill the growing demand for milk and meat. However, on average, about 1.482 liters per cow per day with an average lactation length of 7 months. The total milk production during the year (2019/20) was 4.962 billion liters (CSA, 2021), which is comparable with the 1.5 liters per cow per day reported a decade ago in 2007/08 (CSA, 2008). On the other hand, the total population of humans who dependably live on animal byproducts has increased by approximately 50% from 2007/08 to 2019/20, as opposed to the nearly stagnant milk yield (Nations, 2019). This shows that AI that should have contributed to dairy genetic improvement contributed an insignificant role in Ethiopian dairy cattle improvement. Therefore, the genetic improvement endeavor during the last years was very weak, indicating the need for immediate action to improve the genetic makeup as well as product and productivity of indigenous cattle.

The human population in Ethiopia is projected to reach 205 million by the year 2050, and the urban population will rise to 74 million. It is, therefore, obvious that animal products and byproducts will be in short supply unless both horizontal and vertical expansions of the dairy industry take place (Nations, 2019).

The current urban distribution of 21.3% will gradually reach 36.3% by the year 2050 (Nations, 2019). Vulnerable age groups (up to 14 years) will account for 34% of the population. Thus, the demand for animal products is expected to increase substantially. Future animal product requirements cannot be met from expansion of cattle numbers alone but will need to be enhanced through both genetics and management improvements. It would be expected that these will be delivered by a wider AI service, the veterinary service, and general farm suppliers.

In Ethiopia, to meet the ever-increasing demand for milk, milk products, and beef and thus contribute to economic growth, genetic improvement of the indigenous cattle has been proposed as one of the options (Abdullah *et al*., 2011; Bedasa *et al*., 2017). In order to improve the low productivity of local cattle, tomeet the ever-increasing demand for animal products, selection of the most promising breeds and crossbreeding of this indigenous breed with highly productive exotic cattle has been considered as a practical solution (Mohammed & Derseh, 2017). Holstein Frisian (HF), Crosses of 75% HF × 25% Borena and 50% HF × 50% Borena, and Jersey, Borena, and Fogera breeds have been used to improve dairy productivity through artificial insemination and nearly a million semen doses are produced annually at the National Animal Genetic Improvement Institute (NAGII) and at four different regional semen-producing centers, such as the Nekemte semen processing center (NSPC), Bahir Dar semen producing center (BSPC), Hawasa semen producing center (HSPC), and Mekele semen producing center (MSPC), for dairy genetic improvement.

AI is the first generation of reproductive biotechnology that has made a profound contribution to genetic improvement, particularly in dairy cattle. The major advantages of AI include genetic improvement, control of venereal diseases, improved record keeping, being more economical than natural when genetic merit is considered, being safe by eliminating injury during natural service, and availing of geographical restrictions (Ndambi *et al.*, 2017). As it was stated by Birhanemeskel and Kide (2018), although there are some encouraging achievements of AI, the success rate was not as expected, and the application of AI has been constrained by a number of factors, including technical, system-related, managerial, and financial problems (Birhanemeskel and Kide, 2018).

Nowadays the Ethiopian government widely gives a special focus to AI technologies as newly established technology in four regional states of Ethiopia, including the Oromia regional state which was instituted in Nekemte town of the East Wallaga Zone. However, the challenges and constraints mentioned above always threaten the region's ability to benefit from these technologies.

1.1. Statements of the Problem

Artificial insemination, the most commonly used and valuable biotechnology (Mohammed, 2018a), has been in operation in Ethiopia for over five decades. Despite the wide application of AI and its success throughout the developed world, the success rate in Ethiopia is still low (GebreMedhin *et al*., 2009). With an average lactation length of 7 months and an average daily milk production of 1.482 liters per cow, the total milk produced during the year 2019/20 was recorded to be 4.962 billion liters (CSA, 2021). This suggests that the total number of crossbred female cattle produced through the crossbreeding work for many decades in the country is quite insignificant, indicating unsuccessful crossbreeding work.

From the previous few studies, the efficiency of AI in the country has remained at a very low level. It is widely believed that the AI service in the country has not been successful in improving the reproductive performance of the dairy industry (GebreMedhin *et al.*, 2009). Despite the fact that the East Wallaga zone has the ownership of the LN_2 and semen processing center, along with favorable conditions and skilled manpower relative to other Oromia regions, the number of crossbreed animals is not as high as in regions such as Showa and Arsi, where artificial insemination services are extensively utilized (CSA, 2021).

Artificial insemination (AI) services in parts of the Oromia Region, including East Wallaga, have historically suffered from low efficiency and conception rates. Previous studies conducted before 2017 have highlighted several factors contributing to this challenge, including inadequate heat detection skills among farmers, inaccurate timing of insemination, limited access to quality semen and liquid nitrogen, and insufficient training of inseminators (Desalegn, 2008).

Objective

General objective

To assess and identify constraints associated with the low conception rate of artificial insemination service in selected districts of the East Wallaga zone.

Specific objective

- To assess and identify the problems associated with artificial insemination services in selected districts in the East Wallaga zone
- To generate information for the better application of the sector and to recommend and give feedback to decision makers to take appropriate measures on it

2. ARTIFICIAL INSEMINATION

2.1. History of Artificial Insemination

Artificial insemination is the oldest and most powerful reproductive biotechnology, defined as a process by which sperm is collected from a genetically superior male animal, processed, deep-frozen, stored at a temperature of minus 196 degrees Centigrade, and artificially introduced into the female reproductive tract for the purpose of conception to improve the productivity of the animals (Temesgen *et al*., 2021; Mann *et al*., 2003). It is easier to perform, more cost-effective, and more successful than other biotechnologies (Vishwanath, 2003).

The first successful insemination was performed by the Italian physiologist and priest Abbe Lazzaro Spallanzani (1780) in a dog, which whelped three pups 62 days later (Foote, 2010). And over 100 years later, in 1890, it was used for horse breeding. According to Vishwanath (2003), the history of AI is interesting in that old Arabian documents dated around 1322 A.D. indicate that an Arab chieftain wanted to mate his prize mare to an outstanding stallion owned by an enemy. He introduced a wand of cotton into the mare's reproductive tract and then used it to sexually excite the stallion, causing him to ejaculate. The semen was introduced into the mare, resulting in conception. In 1899, Ivanoff of Russia pioneered AI research in birds, horses, cattle, and sheep and was apparently the first to successfully inseminate cattle artificially. Mass breeding of cows via AI was first accomplished in Russia, where 19,800 cows were bred in 1931 (Vishwanath, 2003).

A Dane, Sorenson, established the first commercial AI cooperative in 1936 (Foote, 2010). Before the Second World War, farmers in Europe and North America fertilized most cows using natural service. However, since several cows on different farms were mated by the same bull, the spread of genital diseases with decreased fertility outcomes was a constant threat. Moreover, keeping herd bulls was expensive and represented potential danger for the herd manager (Vishwanath, 2003).

2.2. The Practice of Artificial Insemination in Ethiopia

In Ethiopia, AI was introduced in 1938 in Asmara, then part of Ethiopia, which was interrupted due to the 2nd World War and restarted in 1952 (Foote, 2010). It was again discontinued due to the unaffordable expenses of importing semen, liquid nitrogen, and other related input requirements. The Chilalo Agricultural Development Project (CADU), an integrated project established jointly by the Ethiopian and Swedish governments in the Arsi region, initiated intensive small-scale dairy development in Ethiopia in 1967/68 (Vishwanath, 2003). This was followed by the Walaita Agricultural Development Project (WADU), which was established in 1971 and funded by the World Bank (Haile-Mariam, 1994).

Production of deep-frozen semen started at CADU in 1973. CADU in Assela and WADU in Wolaita continued breeding and distributing crossbred dairy cows to farmers using artificial insemination services (Chebo and Alemayehu, 2012). Until the establishment of the National Artificial Insemination Centre (NAIC) in 1981, the Dairy Development Authority and CADU performed a total of 74,611 inseminations by importing semen and liquid nitrogen.

The current NAIC was established in 1981 to coordinate the overall AI operation at the national level (Gebre Medhin *et al.*, 2007). NAIC is a government AI service provider organization to rural, peri-urban, and urban areas through the regional offices throughout the country so as to achieve an efficient and reliable artificial insemination service. Initially, service was based on the production and use of fresh semen until the liquid nitrogen plant was installed in 1984. Bulls donated by the Cuban Government (25 Holstein and 10 Brahman) and 44,800 doses of Friesian and 2,000 doses of Jersey semen were the source of semen used for frozen semen technology (Chebo and Alemayehu, 2012). Semen collection included exotic breeds such as Friesian, Jersey, and Brahman, as well as indigenous breeds like Boran, Barka, Fogera, Horo, and Sheko. Additionally, there were crosses of 50% and 75% Holstein-Friesian indigenous bulls. The majority of the semen produced comes from Friesian, accounting for 75.3%, while Jersey contributes 10.5%. Nowadays thousands of semen is processed in four regional centers: NSPC (Oromia), HSPC (Sidama), BSPC (Amara), and MSPC (Tigiray), in addition to NAIC.

2.3. Advantages and Disadvantages of Artificial Insemination

Advantages

Increase effectiveness of using bulls

A male will deposit a lot more semen during natural breeding than is necessary to result in a pregnancy. Natural reproduction is also physically taxing (Mohammed, 2018a). The number of matings a male can perform is limited by these two factors. However, a single ejaculate can be extended and diluted to produce hundreds of doses. Additionally, semen is easily transportable and may be kept for extended periods of time, enabling males to continue reproducing long after their natural reproductive lives have ended (Belay, 2016). This enables several females in various geographic regions to be inseminated simultaneously.

Enhance genetic selection potential

Fewer men are required because artificial insemination enables males to produce more children. As a result, the selection intensity can be increased by only using a select few of the top males as parents (Mohammed, 2018a). A progeny testing program can more accurately assess a male's genetic value by evaluating his offspring, which allows males with a greater number of offspring to play a more significant role in the assessment. Finally, small-scale farmers can utilize artificial insemination to broaden the genetic range of prospective mating partners for their animals, potentially reducing the impacts of inbreeding (Afras, 2019).

Lower costs

Male animals frequently mature larger than females and have a higher feed intake. Additionally, male animals need unique housing and handling tools because they are frequently stronger, more powerful, and possibly unruly (Afras, 2019).

Improve security for farmers and animals

Animal males have the potential to grow big and hostile. These reasons suggest that keeping a bull on a farm can be risky. Additionally, natural mating is more likely than artificial insemination to result in accidents and harm to either the cow or the bull because adult males are often larger than females (Legesse and Yohannes, 2014).

Reduce chance of disease transmission

Animal males have the potential to grow big and hostile. These reasons suggest that keeping a bull on a farm can be risky. Additionally, natural mating is more likely than artificial insemination to result in accidents and harm to either the cow or the bull because adult males are often larger than females (Legesse and Yohannes, 2014).

Approving the practice of time-limited insemination

AI technicians should ideally use fixed-time insemination, which controls the female's estrus, ovulation, and insemination

Disadvantages

There are a number of drawbacks to artificial insemination that farmers need to take into account. First, it can require more labor. Male animals naturally identify females that are fertile and ready to mate, but in artificial insemination, the farmer must detect estrus, and poor detection reduces fertility rates. Additionally, increasing the number of offspring per male only benefits selection if farmers can accurately identify the best males; otherwise, this practice merely reduces the population's genetic diversity (Belay, 2016).

The gene pool always shrinks as the number of kids per guy rises. AI requires specially educated operators and specialized equipment, takes longer than natural services, and requires operator understanding of the structure and function of reproduction. Inadequate instrument cleaning and unhygienic environments may also reduce fertility. The transmission of genital illnesses will grow if the bull is not thoroughly tested. To operate an AI program successfully, management skills are required since some males shed viruses in their semen without exhibiting any symptoms of sickness (Legesse and Yohannes, 2014).

2.4. Artificial Insemination Techniques

The technique of inseminating a cow is a skill requiring adequate knowledge, experience, and patience. Farmers must apply proper artificial insemination (AI) techniques to achieve successful conception. To obtain acceptable conception rates, technicians must deposit semen at the optimal location within the cow's reproductive tract and at the correct time (Diskin, 2018). Early AI methods included vaginal deposition, which proved

unsatisfactory; the speculum method; and the recto-vaginal technique—the latter being the most widely used method today (Diskin, 2018). In the recto-vaginal technique of insemination, the necessary steps in the insemination process include the following points (DeJarnette and Nebel, 2016; Diskin, 2018).

- Verify that all necessary supplies and equipment for artificial insemination, such as a semen storage tank, extra LN_2, bull semen, an electronic thawing device or water bath, an insemination rod, arm gloves with plastic sheaths, a thermometer, a timer, lubricant, paper towels, tweezers, a device for cutting straws or scissors, a record-keeping book, etc., are fully available.
- Determine the cow's suitability for artificial insemination (AI) services based on the animal's physical state.
- Restrain the cow to restrict body movements by a crush or a person standing alongside.
- Assess the cow's pregnancy status by measuring the uterus' size and consistency.
- Prepare a water bath for thawing semen and check it with a thermometer that it reaches $35\text{-}37^0$c warm.
- Quickly transfer semen from the tank to the thawing water and thaw for a minimum of 30-45 seconds (Bekana *et al.*, 2007).
- The straw should be wiped dry, cut at right angles, and properly loaded into the insemination gun (pistolette). Prior to loading, the gun should be briskly rubbed with a piece of paper towel to warm it to prevent sudden changes in temperature, which are detrimental to the semen.
- Wear plastic sheaths and lubricate them.
- Locate and manipulate the cow reproductive tract by using the left hand and remove excess manure from the rectum.

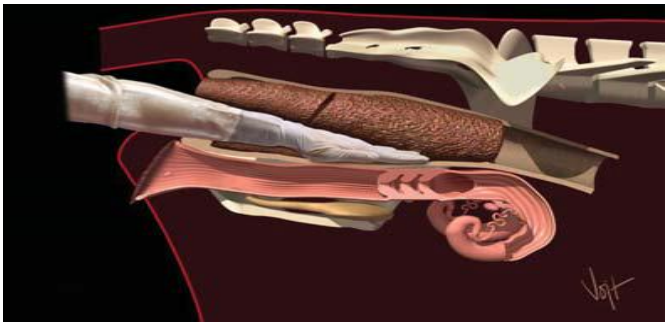


Figure 1: showing how to pass manure over the top of your hand and arm

Source: DeJarnette and Nebel, 2016

- Gently wipe the vulva with a paper towel to remove excess manure and debris. Be careful not to apply excessive pressure, which may smear or push manure into the vulva and vagina. With your left hand make a fist and press down directly on top of the vulva.
- Insert the gun at a 30º upward angle to avoid entering the urethral opening and bladder located on the floor of the vagina. With the gun about 6 to 8 inches inside the vagina, raise the rear of the gun to a somewhat level position and slide it forward until it contacts the external portion of the cervix.
- Grasp the cervix and push it forward to straighten vaginal folds.

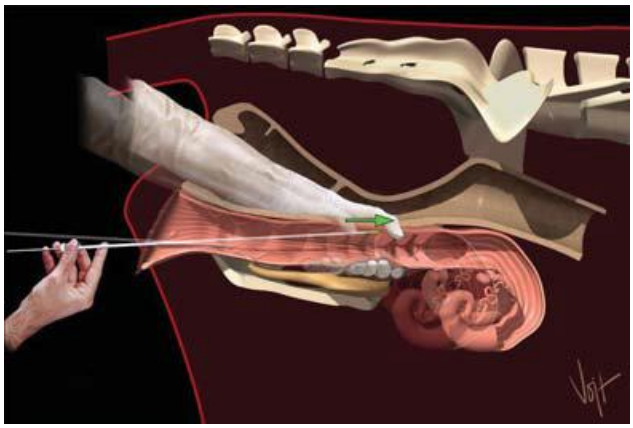


Figure 2: Grasp the cervix and push it forward to straighten vaginal folds
Source: DeJarnette and Nebel, 2016

- Grasp the external opening to the cervix with the thumb on top and the forefingers underneath to close the fornix and guide the gun tip into the cervix.
- Check the AI gun placement by using the index finger before semen deposition.
- As the gun enters the uterine body, push the plunger slowly so that drops of semen fall directly into the uterine body (Mohammed, 2020).

2.5. Timing of Insemination for Maximum Conception

Understanding the voluntary waiting period (VWP), estrus behavior, and the interval from estrus to ovulation is crucial for determining the optimal timing for artificially inseminating cattle (Roelofs *et al*., 2010). A voluntary waiting period (VWP) is the time between parturition and the time at which the cow is first eligible for insemination. It usually lasts about 50 days but may vary a lot from herd to herd according to the breeding strategy in place. A voluntary waiting period allows a cow's uterine tract to recover from

the previous calving, including healing, elimination of uterine debris, overcoming or eliminating bacterial infections, involution, and returning to a state of ovarian cyclicity. Therefore, breeding too soon can impair first-service conception rates; on average, a minimum of 40 days post-calving is therefore often used (Roelofs *et al.*, 2010).

According to Kumar *et al*. (2013), heat detection is basic to reproductive success in artificially bred herds. A frequent question concerning AI is, what time during estrus should cows be bred for the greatest chance of conception? Since estrus may last from 10 to 25 hours, there is considerable latitude in the possible time of insemination. Much research work has been conducted on this subject. Many studies show that conception rate is lower when cows are bred prior to mid-estrus or later than 6 hours after cessation of estrus (standing heat in this case). Maximal conception is obtained when cows are inseminated between mid-estrus and the end of standing estrus, with good results up to 6 hours after estrus (Roelofs *et al.*, 2010).

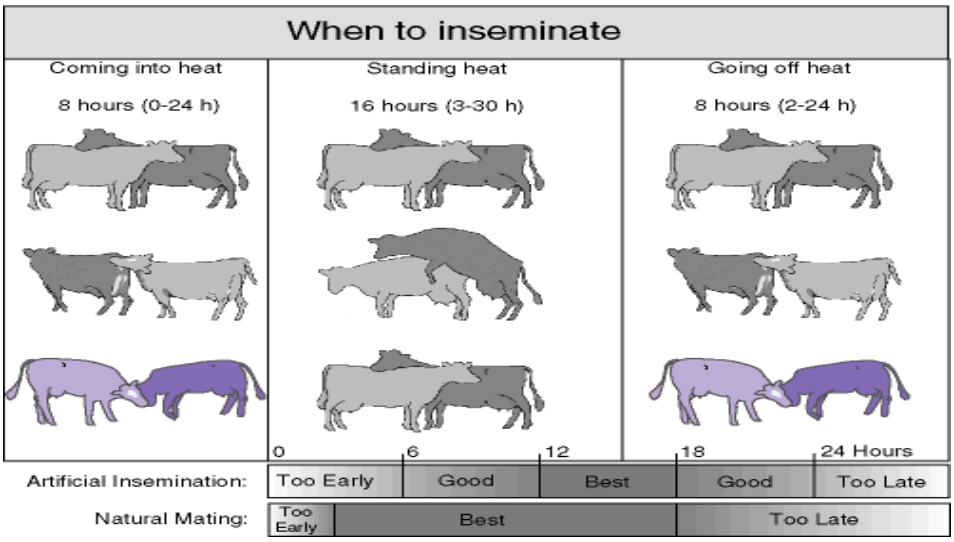


Figure 3: Timing of insemination or natural service for cows in heat

Source: Mohammed, 2018b

According to Jemal and Lemma (2015) and López-Gatius (2000) the site of semen deposition has been an important factor in the success of AI in cattle accurate placement is important for achieving good conception rates. Faulty insemination technique is major factor causing low conception rate in many herds accurate insemination to detail, a clear understanding of reproductive anatomy and the ability to identify the target area and properly position the insemination road (Diskin, 2018; Jemal and Lemma, 2015; López-Gatius, 2000)

2.6. Major Factors Affecting Success of Artificial Insemination Service

Artificial insemination (AI) in cattle depends on a variety of intrinsic and extrinsic variables that have negative effects. For established correction methods, it is crucial to comprehend how these aspects affect the likelihood of success while performing AI (Haugan *et al.*, 2005). In most cattle production systems, reproduction is inefficient; in particular, cows seldom become pregnant due to a variety of management mistakes, dietary deficiencies, postpartum reproductive health issues, poor semen quality, and other problems (Mekonnen *et al*., 2010).

2.6.1. AI delivery system

Lack of a recording system, unclear division of responsibilities among stakeholders, poor integration of AI service with livestock health and feed packages, insufficient support, and a lack of readily available inputs like liquid nitrogen all contribute to the lack of effective collaboration and communication between the NAIC, regional agriculture bureaus and other stakeholders. Due to all of these problems, delivery services are subpar, and some farmers relocate their cow's vast distances in quest of AI treatment. This is taking place all around, and the cause is that AI technicians cannot access transportation options like motorbikes and fuel. However, insemination is a time-consuming task, and during the lengthy journey and waiting times, the heat phase sometimes ends before the treatment is rendered (Lemma, 2010).

2.6.2. Factors related to heat detection

One of the key elements determining the success of artificial insemination (AI), compared to other factors, is the precision of heat detection (estrus detection). Since the period is the shortest interval between two succeeding estrus cycles, heat detection in cows is performed by experienced herd people or inseminators who are able to recognize those animals that would be in heat stand while being mounted or ridden by other female cows or vasectomized bulls (Jemal and Lemma, 2015).

These animals also exhibit various external changes like vulvar edema and absence of wrinkles on vulvar lips, vaginal hyperemia, wetness, and mucus discharge. They also exhibit behavioral symptoms like frequent urination, bellowing, raised tail, restlessness,

and licking of external genitalia. According to Roelofs *et al.* (1010), a variety of factors, including heredity, the number of postpartum days, lactation status, milk supply, and health, might affect the expression of estrus. Environmental elements, including diet, the time of year, housing, herd size, etc. also affect how an estrus is expressed (Jemal and Lemma, 2015*;* Roelofs *et al*., 2010).

The ideal time for insemination to occur in relation to ovulation (the "insemination-ovulation interval") depends mostly on how long spermatozoa can remain fertile and how long an oocyte can remain viable in the female genital tract (Roelofs *et al.*, 2010). Since ova are still viable for 12 to 18 hours after ovulation, insemination must occur at the proper point in the cow's estrus cycle in order for conception to occur (Bekana *et al*., 2005).

2.6.3. Factors related to semen quality

According to Saacke (2008), success must be assessed based on the pregnancy rate of the first AI after taking into account the financial investment in semen and other inputs. Additionally, a positive first-service pregnancy rate response typically denotes favorable second-service circumstances. Semen quality and other crucial variables that affect the pregnancy rate at the initial visit should also be taken into account (primarily dependent on choice of bulls). Semen quality is one of the most important factors in most breeding techniques, whether or not estrous synchronization is used. Male subfertility's nature is proving to be just as complicated as female subfertility (DeJarnette *et al.*, 1992; Saacke, 2008).

2.6.4. Factors related to efficiency of AI technicians

The highly skilled inseminator has made one of the most significant contributions to the successful application of AI in cow breeding. The capacity of the inseminator to deliver the semen to the proper spot in the reproductive canal at the right period of estrus is one of the criteria that determine the effectiveness of cow insemination. Insemination techniques have a tendency to become regular, and aspects connected to the inseminator that can significantly affect fertility are often ignored. Most professional inseminators are not trained to inspect the uterus and ovaries, despite the fact that they regularly palpate the reproductive tracts of several cows. The effectiveness of AI is severely constrained by

this (López-Gatius, 2012). According to Abebe and Alemayehu (2021), animals exhibiting signs of genuine heat should fertilize using frozen semen that has been thawed at 37^0C for 45 seconds (Abebe and Alemayehu, 2021). In order to get pregnant, hygiene, thawing techniques, and temperature control between thawing and insemination have all been important (Milad, 2011).

2.6.5. Breeding season

The insemination season is another source related to the environment determining the rate of conception. In fact, there is deterioration in fertility and consequently conception rates between winter and autumn (Table 1). Inseminations made in winter and spring was more likely to succeed than those of other seasons. This is rather related to the food availability during the seasons considered and its effect on the body condition (BCS) of females, a critical index of fertility. In the summer and autumn, high temperatures reduced the chances of conception through the thermal regulation system (Tadesse *et al.*, 2022).

Table 1: Conception rate with different season of the year

Season of AI	Frequency	Conceived/pregnant N (%)
Winter	1008	606(60.12)
Spring	877	498(56.14)
Summer	867	512(59.10)
Autumn	728	436 (59.89)

Source: Tadesse et al., 2022

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in three purposively selected districts of East Wallaga Zone, Oromia Regional State, western Ethiopia, namely Guto Gida, Leka Dullacha, and Diga. These districts were selected based on their strategic importance in dairy production and artificial insemination (AI) service utilization. First, the areas were identified as milk shed zones, with a relatively dense population of dairy cows and active smallholder dairy systems (Oromia Regional State Agricultural Bureau, 2020). Second, their geographical proximity to Nekemte town, which hosts a liquid nitrogen and semen distribution center, allows a consistent and timely supply of AI inputs, including frozen semen and nitrogen for storage (Aklilu *et al.*, 2018). Third, the districts are found within approximately the same agro-ecological zone, minimizing variability due to climatic and environmental factors and making comparative evaluation across the sites more reliable. Their closeness to Nekemte, the capital of East Wallaga Zone, also ensures better access to veterinary services, infrastructure, and government interventions. The climatic condition of the area was characterized by a unimodal rainfall. Although the region is primarily unimodal, there is significant variation in the amount and timing of rainfall; long rainy season (June to September), a short rainy season (March to May), and a dry winter season (December to March) (wikipedia).

The altitude of the East Wallaga Zone ranged from 1,200 to 2,500 meters above sea level (m.a.s.l.), and the area was classified into three agro-ecological zones: temperate (7.18%), midland (51.08%), and lowland (41.74%). According to the CSA 2021, the livestock population was estimated to be more than 1,079,293 cattle, 274,633 sheep, 171,251 goats, 4,528 mules, 132,271 donkeys, 777,286 chickens, and 220,176 beehives (CSA, 2021).

Guto Gida district, one of the study areas, was geographically bounded by Wayu Tuka to the east, Sassiga and Diga to the west, Gida Ayana and Gudaya Bila to the north, and Leka Dullacha to the south. Nekemte, the largest town in the zone, located 331 km west of Addis Ababa, lies between 8° 40′ and $9^{o}30'$ N latitude and 36° 10′ and 36^{o} 50′ E longitude at an altitude between 1,300m and 3,200 m.a.s.l. The area practiced a mixed farming system and had recently witnessed a rise in market-oriented smallholder dairy

production and fattening activities in urban and peri-urban areas. The mean annual rainfall ranged from 1,500 to 2,200 mm, and average daily temperatures ranged between 15°C and 26°C. The cattle population of Guto Gida was estimated at 94,137, of which 274 were crossbreeds (CSA, 2021).

Leka Dullacha, located southwest of Nekemte along the road to Bedelle, had its district town Gatama situated 27 km from Nekemte. The district covered an estimated land area of 61,745 km² and was bordered by Diga and Guto Gida to the north, Jimma Arjo to the south, and Wayu Tuka to the east. The agro-ecology was similar to Guto Gida due to their geographic proximity. Annual rainfall ranged from 1,600 to 2,000 mm, and temperatures varied between 15°C and 26°C. The altitude ranged between 1,500 and 2,500 m.a.s.l..

Diga district was located southwest of the Abbay Basin at 09°01′29.2″N and 036°27′28″E, about 343 km west of Addis Ababa and 12 km from Nekemte. The altitude varied from 1,200 to 2,342 m.a.s.l., with annual rainfall exceeding 2,000 mm. The district consisted of 60% lowland and 40% midland agro-ecologies (DBOA, 2014). Temperature ranged from 14.6°C to 30.4°C, with an average of 22.5°C. The area had a mixed crop-livestock production system. The cattle population was approximately 95,858 heads (CSA, 2021).

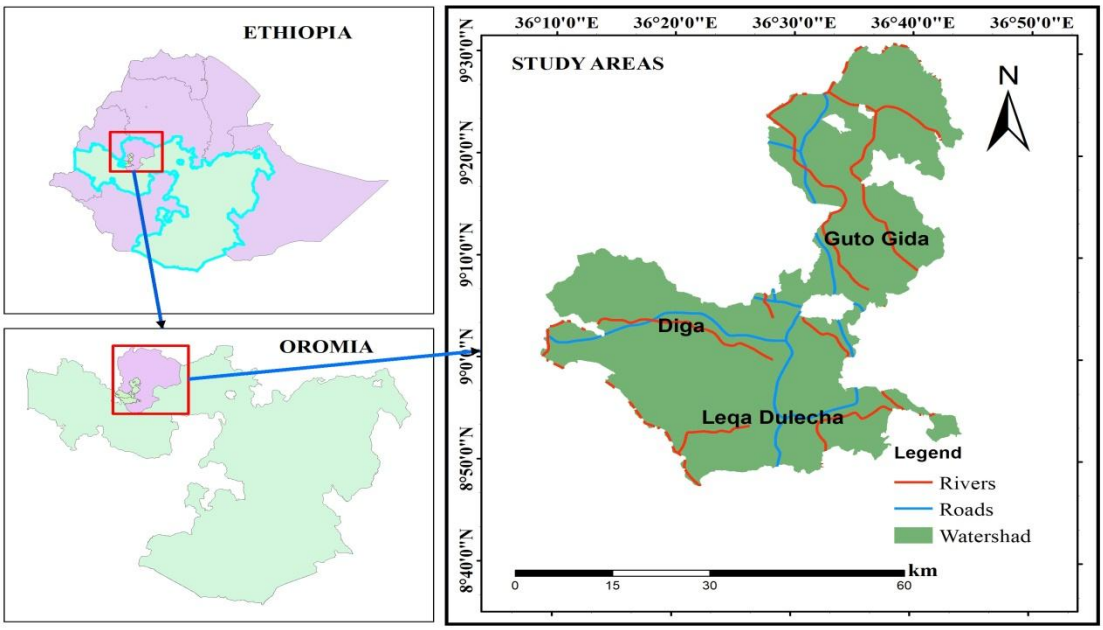


Figure 4: Study area map created by ArcGIS

3.2. Sampling Technique and Sample Size

A purposive sampling method was used to select dairy farmers in the study districts. The inclusion criteria required that farmers must have utilized AI services at least two times during the period between 2017 and 2022. This time frame was chosen due to the government led intensification of AI programs, coinciding with the establishment of a Semen Processing Center in Nekemte town. This center significantly improved the availability and distribution of high-quality semen and liquid nitrogen to western Oromia especially nearby districts, including those selected for the study. By focusing on this period, the research was able to capture data during a time when standardized AI service inputs and improved semen from high-performing bull IDs were disseminated uniformly to these areas. It also ensured consistency in genetic potential, which is a key factor in evaluating reproductive performance.

Farmers were selected based on AI service records obtained from local veterinary and livestock development offices, ensuring that only eligible households with traceable AI history were included.

Dairy cow records were analyzed, derived from farmers meeting the eligibility criteria. The sample included data on conception status, insemination methods, breed, management, timing, seasonality, and inseminator-related factors. This sample size was deemed sufficient for statistical analysis and reflects recommendations in similar livestock studies targeting purposively defined populations (Gebremedhin *et al*., 2018).

3.3. Data Collection Methods

Primary data were collected using a structured questionnaire administered to selected farmers. The questionnaire was pretested and refined before full deployment to ensure clarity and relevance. Secondary data, including AI service records, bull ID usage, and PD (pregnancy diagnosis) results, were retrieved from district-level livestock offices and AI service providers.

3.3.1. Key informants interview

Key informant interviews were conducted with AI technicians, district livestock experts, and laboratory technologists at NSPC through both in-person and telephone conversations. The interviews focused on identifying major challenges affecting AI service success and understanding community perceptions and beliefs.

3.3.2. Questionnaire survey

Structured, pretested questionnaires (both open- and closed-ended) were developed in English and translated into Afaan Oromo. They were used to interview farmers, AI technicians, and semen production experts. Farmer data were collected by local AI technicians under supervision of the researcher, while data from AITs and laboratory experts were gathered directly by the researcher.

Variables assessed for farmers included perception of AI service, consistency and availability of regular, weekend, and mobile AI service, availability of AI inputs and AITs, training and awareness, timing of insemination, knowledge of estrus signs, and overall AI service satisfaction. Variables assessed for AITs included AI service delivery methods, input availability, weekend service provision, on-the-job training, timing of insemination, incentive availability, and technical skill evaluation (estrus signs, record keeping, and motivation). Each respondent received a brief explanation of the study objective before participating, and formal interviews lasted approximately one hour.

3.3.3. Group Discussion and Personal observation

Discussions were conducted with experienced dairy producers, livestock sector agents, and laboratory technologists to validate and triangulate findings from surveys and interviews. The researcher conducted on-site observations to assess semen motility, thawing methods, top-up techniques, and AIT handling practices during insemination.

3.3.4. Semen Sample Straws

Semen straws were collected from district AI technicians and the Nekemte Semen Production Center (NSPC) using a small liquid nitrogen container. These samples were analyzed using a phase contrast microscope to assess differences in handling practices.

3.3.5. Secondary data

Secondary data on AI service records from 2017 to 2022 were obtained from AI centers. These records were utilized to evaluate the coverage of artificial insemination (AI) services and to analyze the record-keeping practices of AI technicians.

3.4. Data Management and Analysis

Data After being gathered, the data were entered into a 2016 Microsoft Excel spreadsheet and error-checked. STATA (version 17) was used to import and analyze the data. Descriptive statistics, including frequency and percentage distributions, were used to summarize demographic and service-related variables. To assess the factors associated with conception rate following artificial insemination (AI), a generalized linear model was fitted. The dependent variable was the pregnancy diagnosis (PD) status of cows (0 = not conceived, 1 = conceived). The independent variables included household sex and education, cow breed, year of insemination, breeding season, management system, AI technician, educational level of AI technician, work experiences of AI technician, and location. The fitted model was expressed as:

$$\boldsymbol{Y_{ijklmnopqrst}} = \mu + \boldsymbol{H_i} + \boldsymbol{E_j} + \boldsymbol{B_k} + \boldsymbol{Y_l} + \boldsymbol{S_m} + \boldsymbol{M_n} + \boldsymbol{T_0} + \boldsymbol{L_p} + \boldsymbol{X_q} + \boldsymbol{A_r} + \boldsymbol{P_s} + \boldsymbol{I_t} + \boldsymbol{e_{ijklmnopqrst}}$$

Where:

μ = overall mean,

H_i = the i_{th} effect of household effect (1 = male household, 2 = female household),

E_j = the j_{th}effect of education level of households (1 = not attended formal schooling, 2 = attended primary school, 3 = attended secondary school, 4 = diploma and above)

B_k = *the* k_{th} *effect of breed (*$1 = local\ and\ 2 = crossbred$)

Y_l = *the* l_{th} *effect of year of insemination (*$1 = 2017, 2 = 2018,\ 3 = 2019, 4 = 2020, 5 = 2021$ & $6 = 2022$*)*

S_m *= the* m_{th} *effect of season (1 = summer, 2 = winter, 3 = spring & 4 = autumn)*

M_n *= the* n_{th} *effect of management (1 = Extensive, 2 = Semi-Intensive)*

T_o *= the* o_{th} *effect of AI tech (1 = AIT 1, 2 = AIT 2, 3 = AIT 3, 4 = AIT 4, 5 = AIT 5, 6 = AIT 6, 7 = AIT 7, 8 = AIT 8, & 9 = AIT 9)*

L_p *= the* p_{th} *effect of location (1 = Diga, 2 = Leqa Dullacha & 3 = Guto Gidda)*

X_q *= the* q_{th} *effect of AI tech experience (1 = 5-10 yrs & 2 = >10 yrs)*

A_r *= the* r_{th} *effect of the education level of AI tech (1 = diploma, 2 = degree and above)*

P_s *= the* s_{th} *effect of cow parity (*1 = 1st parity, 2 = 2nd parity, 3 = 3rd parity & 4 = 4th & above parities*)*

I_t *= the* I_{th} *effect of insemination modality (*1 = regular & 2 = HAMI*)*

$e_{ijklmnopqrst} = Error\ residual\ effect$

This model was chosen because it allows simultaneous assessment of multiple household, animal, management, and service delivery factors, thereby identifying which predictors significantly influenced conception outcomes. Compared to simple chi-square tests, the model provides a more robust estimation of the relative effects of each independent variable while accounting for potential confounding.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

A total of 277 smallholder dairy farmers participated in this study from the three districts. The gender distribution of respondents showed that 76.2% were male and 23.8% were female (figure 5). Majorities (69.7%) of the farmers completed primary education and above, and 30.3% did not attend formal school. Most farmers (92.4%) practiced mixed crop-livestock farming (Table 3). The majority (92.4%) of respondents use both natural mating and artificial insemination (AI); 60.3% have participated in HAMI, have used AI between 5 and 9 years (50.5%), and check cows once (38.6%) or twice (37.5%) per day, while 15.2% check three times for heat (Figure 5; Table 2).

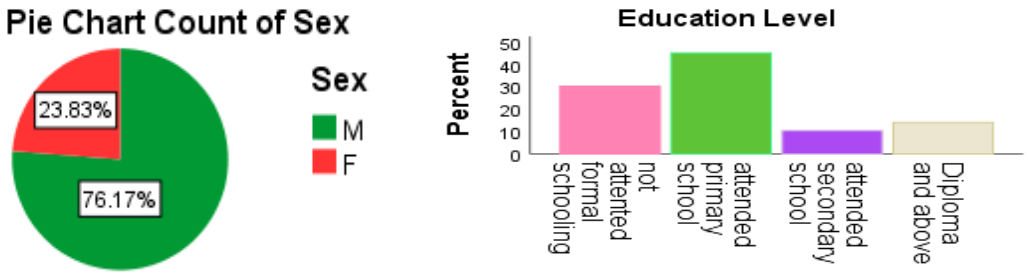


Figure 5: Gender distribution and education level of household respondents

Table 2: Cattle management system of the study area

	Management System				
		Frequency	Percent	Valid Percent	Cumulative Percent
Predictors	Extensive	256	92.4	92.4	92.4
	Semi-Intensive	21	7.6	7.6	100.0
	Total	277	100.0	100.0	

A total of 9 AI Technicians (AITs) participated in the study from the Guto Gida, Leka Dullacha, and Diga districts. As shown in Figure 6, the majority of AITs were male (88.9%), while only one was female (11.1%). They had attained diploma and degree levels of education and have 6 to 14 years of work experience in AI service.

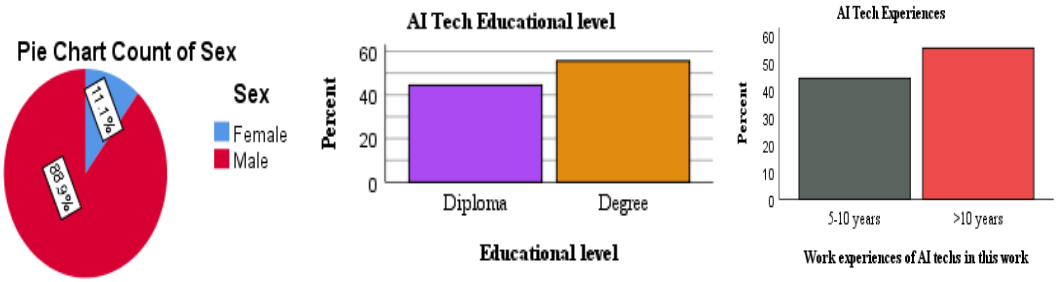


Figure 6: Gender distribution, Education Level, and Experiences of AITs

4.2. Univariable Analysis

In the univariable models, several variables showed significant associations with conception, including education level of household head, cow breed type, management system, year of insemination, season of insemination, and method of insemination. Their Likelihood Ratio Chi-square (LR χ^2) and P-values for education level (31.93, $p < 0.001$), breed type (30.74, $p < 0.001$), management system (33.02, $p < 0.001$), season of insemination (LR $\chi^2 = 56.30$, $p < 0.001$), and method of insemination (LR $\chi^2 = 38.67$, $p < 0.001$) indicated that these predictors individually explained a substantial portion of the variation in conception. In contrast, other factors such as sex of the household head (LR $\chi^2 = 0.38$, $p = 0.536$), district (LR $\chi^2 = 0.10$, $p = 0.950$), parity of the cow (LR $\chi^2 = 0.54$, $p = 0.909$), technician identity (LR $\chi^2 = 8.08$, $p = 0.425$), technician education level (LR $\chi^2 = 0.32$, $p = 0.573$), and technician work experience (LR $\chi^2 = 1.13$, $p = 0.287$) did not show statistically significant associations with conception rate. These findings suggest that while cow- and environment-related factors play a crucial role in determining conception outcomes, technician-related characteristics, at least as measured in this study, had no significant independent effect. Overall, the model fit was statistically significant and sufficient to proceed with interpretation of individual predictors (Table 3).

Table 3: Univariable analysis of predictors of conception following artificial insemination in dairy cattle and the model fit

Predictors	N	LR χ^2	p-value	Pseudo R^2	Log Likelihood
Sex of Household Head	444	0.38	0.537	0.0006	-307.02
District	444	0.10	0.950	0.0002	-307.16
Education Level	444	31.93	0.000	0.0520	-291.25
Breed Type	444	30.74	0.000	0.0500	-291.84
Management System	444	33.02	0.000	0.0537	-290.70
Year	444	10.86	0.054	0.0177	-301.78
Technician	444	8.08	0.425	0.0132	-303.17
AI Tech Education Level	444	0.32	0.573	0.0005	-307.05
Experience	444	1.13	0.287	0.0018	-306.65
Parity	444	0.54	0.909	0.0009	-306.94
Season	444	56.30	0.000	0.0916	-279.06
Method of Insemination	444	38.67	0.000	0.0629	-287.88

N-no of observation, LR χ^2- Likelihood Ratio Chi-square

4.3. Multivariable Analysis of Predictors of Cow Conception

The multivariable models achieved likelihood ratio chi-square values between $\chi^2 = 114.84$ and 128.14 ($p < 0.001$), indicating that the included explanatory variables jointly improved the prediction of conception outcomes compared to the null model. Pseudo R^2 values ranged from 0.19 to 0.21, meaning the models explained about 19–21% of the variability in conception success. Odds ratios with 95% confidence intervals were reported to quantify the strength and direction of associations. Key predictors retained in the multivariable analysis included the education level of the household head, crossbred cattle, semi-intensive/intensive management system, rainy season, and notably the years 2019 and 2020 significantly improved odds of conception (Table 4). Thus, the model fit was statistically significant and sufficient to proceed with interpretation of individual predictors.

Table 4: Multivariable analysis of predictors of conception following artificial insemination in dairy cattle

Predictor	Odds Ratio (OR)	Std. Err.	Z	p-value	95% CI (Lower–Upper)
Education level					
Secondary school	3.27	1.38	2.81	0.005	1.43 – 7.48
Diploma and above	3.01	1.09	3.03	0.002	1.47 – 6.13
Breed type					
Crossbred	1.98	0.70	1.94	0.052	0.99 – 3.95
Management system					
Semi-intensive	3.68	1.37	3.51	0.000	1.78 – 7.62
Year of insemination					
2018	2.93	1.18	2.66	0.008	1.33 – 6.47
2019	2.92	1.29	2.42	0.015	1.23 – 6.96
2020	2.39	1.00	2.07	0.038	1.05 – 5.42
Season					
Summer	2.39	0.99	2.12	0.034	1.07 – 5.36
Autumn	6.83	2.80	4.69	0.000	3.06 – 15.24
Model Fit					
Number of observation		444			
LR χ^2		114.84–128.14			
Chi^2		$p < 0.001$			
Log Likelihood		–249.79 to –243.14			
Pseudo R^2		0.19–0.21			

LR χ^2 Likelihood Ratio Chi-square, Chi^2 – P-value, Std. Err. – Standard error

4.4. Model Fit

The analysis model fit was evaluated using the likelihood ratio chi-square (LR χ^2), log likelihood, and pseudo R^2 statistics. These measures provided evidence on how well the predictors explained variation in conception outcomes following artificial insemination. In the univariable models (Table 4), several predictors showed strong individual associations with conception rate. Education level of household head (LR $\chi^2 = 31.93$, $p < 0.001$), cow breed type (LR $\chi^2 = 30.74$, $p < 0.001$), management system (LR $\chi^2 = 33.02$, $p < 0.001$), season of insemination (LR $\chi^2 = 56.30$, $p < 0.001$), and method of insemination (LR $\chi^2 = 38.67$, $p < 0.001$) each contributed significantly to model improvement. These predictors had pseudo R^2 values between 0.05 and 0.09, indicating that individually they explained 5–9% of the variation in conception outcomes. Conversely, predictors such as

sex of household head, district, parity, and technician-related characteristics (education, identity, and work experience) did not significantly improve the model, as reflected by low LR χ^2 values ($p > 0.05$) and negligible pseudo R^2 values (< 0.002) (Table 4).

In the multivariable analysis (Table 4), where significant predictors were considered jointly, the overall model fit improved substantially. The LR χ^2 ranged from 114.84 to 128.14 ($p < 0.001$), showing that the explanatory variables collectively provided a significantly better fit compared to the null model. The log likelihood values (–249.79 to –243.14) further supported model adequacy, while pseudo R^2 values of 0.19–0.21 indicated that the model explained about 19–21% of the total variation in conception success. This explanatory power is consistent with other studies in Ethiopia and similar settings, where logistic regression models have explained between 15 and 25% of the variability in cattle conception outcomes (Gizaw *et al*., 2021; Shiferaw *et al.,* 2020).

The findings demonstrate that conception outcomes were more strongly influenced by cow and environment-related factors (breed type, management system, season, year of insemination) and household-level characteristics (education of the household head) than by technician-related attributes. This aligns with the observation by Mekonnen and Leul (2020) that biological and management variables tend to outweigh technician-related characteristics in explaining conception outcomes in Ethiopian dairy systems (Mekonnen and Leul, 2020). Overall, the model fit statistics confirm that the multivariable analysis adequately captured the main drivers of conception success, and the model can be reliably used to interpret the effects of key predictors.

The overall conception rate observed in this study 46% is within the broad range reported in Ethiopia but lower than several high-performing reports and higher than some low-performing ones, illustrating substantial regional and program-level variability in AI outcomes. A retrospective analyses and field studies in Ethiopia have reported conception rates of ~54–60% in some settings (Tadesse *et al*., 2022; Hamid *et al.,* 2021), while other studies have documented overall conception rates near 40–45% or even much lower (Ali *et al*., 2013; Mekonnen and Meseret, 2023). These differences likely reflect variation in breed composition (crossbreds usually show higher conception), management intensity, seasonality, technician practices, and semen cold-chain integrity. Cross-study comparisons indicate that sites with higher proportions of crossbred cows, semi-intensive management, better farmer awareness of estrus detection, and reliable semen handling

tend to report higher conception rates (Tadesse *et al*., 2022; Hamid *et al*., 2021), whereas programs with poor heat detection, weak cold-chain and infrastructure, and low adoption of good management report lower rates (Ali *et al*., 2013; Mekonnen and Meseret, 2023).

4.5. Household and Socio-economic Factors

4.5.1. ***Sex of household head***

The effect of household head sex was first tested using a simple logistic regression (Model 1 and Model 2 in the output). Results showed that being in a female-headed household was associated with slightly lower odds of conception (OR = 0.87, 95% CI: 0.57–1.35, p = 0.537) compared to male-headed households. Conversely, when female was used as the reference category, the odds ratio for male-headed households was OR = 1.15 (95% CI: 0.74–1.77, p = 0.537) (Table 5).

Table 5: Effect of household gender

Predictor (Household Head Gender)	Odds Ratio (OR)	95% CI [Lower, Upper]	p-value	Log Likelihood
Female vs. Male (ref)	0.87	0.57 -1.35	0.537	-307.02
Male vs. Female (ref)	1.15	0.74 - 1.77	0.537	-307.02

CI – Confidence Interval

This finding suggests that in the study area, access to AI services and conception success may not be systematically limited by the sex of the household head. This may reflect relatively equitable AI extension efforts or effective gender-inclusive practices in local livestock services. This aligns with several studies in East Africa that similarly report no association between the gender of the household head and AI use/adoption. Mugisha *et al*. (2014) in central Uganda found no link between AI use and household head gender (P = 0.56), and a Woliso District study reported no significant adopter difference by head-of-household gender (Mugisha *et al.*, 2014; Tadese, 2020). This finding contrasts with Gebremedhin *et al*.'s (2018) finding that female-headed households may face resource limitations, affecting livestock productivity (Gebremedhin *et al.*, 2018).

4.5.2. ***Household education level***

The model analysis for education level of household head was statistically significant (LR $\chi^2(3) = 31.93$, $p < 0.001$; Pseudo $R^2 = 0.052$; Log likelihood = –291.25). This indicates that education significantly influenced conception outcomes. Using households not attended formal school education as a reference category, households attended primary education was associated with 23% higher odds of conception (OR = 1.23, 95% CI: 0.79–1.92), though not statistically significant (p = 0.362). Those who attended secondary education increased the odds of conception by over threefold (OR = 3.64, 95% CI: 1.77–7.47, p < 0.001). Households that attended diploma-level and above education further increased the odds by over fourfold (OR = 4.16, 95% CI: 2.24–7.74, p < 0.001) (Table 6).

Table 6: Effect of education level of household head on conception outcome

predictor (education level)	OR	[95% conf. interval]	p-value	log likelihood
not attended formal school	1.00	–	–	–
primary education	1.23	0.79, 1.92	0.362	-291.25
secondary education	3.64	1.77, 7.47	0.000	-291.25
diploma and above	4.16	2.24, 7.74	0.000	-291.25

Note: OR- Odds Ratio

The findings demonstrate that the education level of the household head is a critical determinant of conception outcomes. Higher education was linked with significantly greater odds of successful AI conception, reflecting better knowledge of heat detection, timing, and animal management practices.

This pattern is consistent with several studies showing that higher farmer education or awareness improves adoption of good breeding practices such as timely heat detection, correct timing of AI, and improved record keeping, which in turn increase conception success. Gizaw and Dima (2016) reported that education improves awareness and application of reproductive technologies, including proper heat detection, timely insemination, and basic reproductive health monitoring (Gizaw and Dima, 2016). Teferal (2013) also highlighted that farmers' understanding of AI procedures and cooperation with technicians are critical for AI success. Educated farmers are more likely to follow guidelines for cow management before and after AI, improving chances of conception (Teferal, 2013). On a broader level, Mekonnen and Gebremariam (2024) have

emphasized the importance of farmer education in improving livestock productivity, noting that access to knowledge and extension services greatly enhances adoption and proper use of AI technologies (Mekonnen and Gebremariam, 2024).

Overall, the collective effect of education level was significant ($p < 0.001$), reinforcing that increased literacy and formal education enhance farmers' ability to detect estrus, timely insemination, and cow management practices, thereby positively influencing conception success.

Out of the total respondents (277), only 47.3% reported having knowledge of heat detection, while 52.7% admitted having no such knowledge (Figure 7; Appendix 2). Farmers with knowledge of heat detection were generally more successful in identifying estrus signs, which is a critical step for timely AI service delivery. According to data from AITs, significant signs of estrus include clean mucus discharge, mounting other animals, bellowing frequently, restlessness, and standing to be mounted. Out of these stands to be mounted is the most obvious and practically important estrus sign (Appendix 5). Farmers' knowledge of heat detection is a critical factor influencing success with AI services**.** When farmers are able to identify the signs of estrus in their cows, they are more likely to time insemination correctly, leading to higher conception rates, better productivity, and ultimately greater success with the AI program. On the other hand, lack of knowledge about heat signs often results in delayed or poorly timed insemination, leading to failed conception attempts, repeated inseminations, economic losses, and disillusionment with AI services.

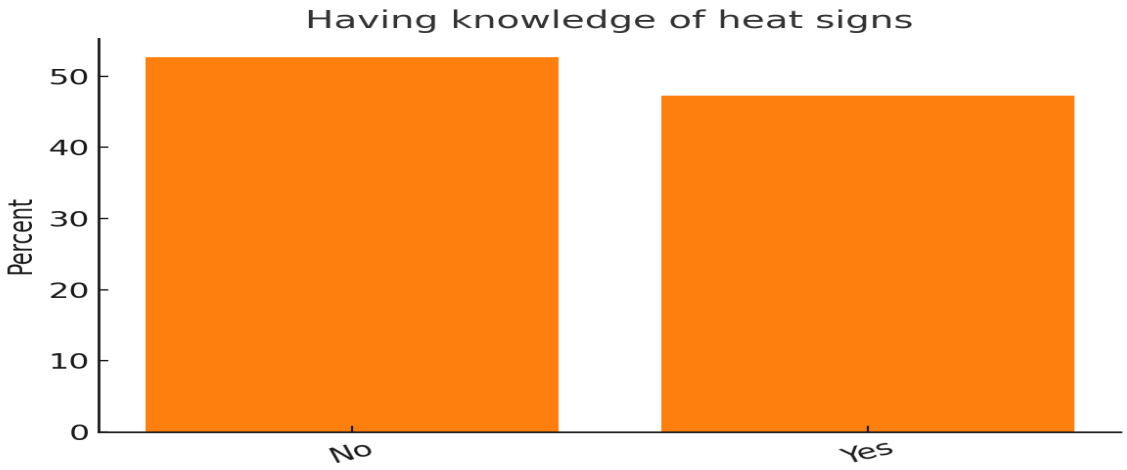


Figure 7: knowledge of Households on heat signs

Kebebew and Bekele (2020), in a study from Adama town, reported that more than 60% of AI failure cases were attributed to poor heat detection skills among farmers. They concluded that training in heat detection substantially improved conception and satisfaction outcomes (Kebebew and Bekele, 2018). Tesema *et al.* (2020), in their study on dairy cattle in central Ethiopia, found that poor heat detection was one of the most significant constraints to successful AI use. They emphasized that most inseminations were done at the wrong time due to farmers' limited knowledge, resulting in low conception rates (Tesema *et al*., 2020).

Similarly, the frequency of checking cows for heat per day varied considerably: 38.6% of respondents checked once, 37.5% checked twice, 15.2% checked three times, and 8.7% reported no particular time (Figure 8; Appendix 3). Since estrus signs are often short and can be easily missed, households checking two or more times per day were in a better position to detect heat accurately, thereby increasing the chance of conception. Desalegn *et al*. (2008) found that insufficient frequency of heat detection was a major cause of AI failure in Ethiopian dairy farms. Farmers checking their cows more frequently had better conception outcomes (Desalegn *et al.*, 2008). Gedefa *et al*. (2021) reported that farmers who checked cows only once or irregularly per day often missed heat signs, resulting in poor AI success and low satisfaction (Gedefa *et al*., 2025). Globally, Ball and Peters (2004) recommend monitoring cows at least twice daily during suspected estrus periods, reinforcing that more frequent checks correlate with better AI results and farmer confidence (Ball and Peters, 2004)**.**

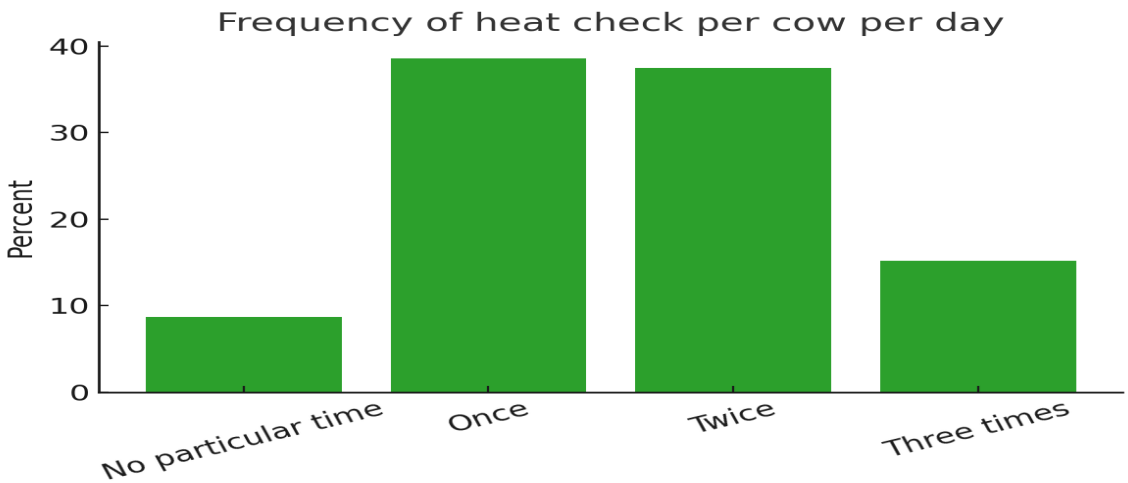


Figure 8: Frequency of Checking Cows for Heat Signs per day

Regarding the knowledge of the correct time of insemination after heat, 41.9% of households answered correctly, while 58.1% lacked this knowledge (Figure 9; Appendix 4). This knowledge gap directly reduces conception rates, since inseminating too early or too late can result in fertilization failure. Desalegn *et al*. (2008) found that insufficient frequency of heat detection was a major cause of AI failure in Ethiopian dairy farms. Farmers checking their cows more frequently had better conception outcomes (Desalegn *et al.*, 2008). Gedefa *et al*. (2021) reported that farmers who checked cows only once or irregularly per day often missed heat signs, resulting in poor AI success and low satisfaction (Gedefa *et al*., 2025). Globally, Ball and Peters (2004) recommend monitoring cows at least twice daily during suspected estrus periods, reinforcing that more frequent checks correlate with better AI results and farmer confidence (Ball and Peters, 2004)**.**

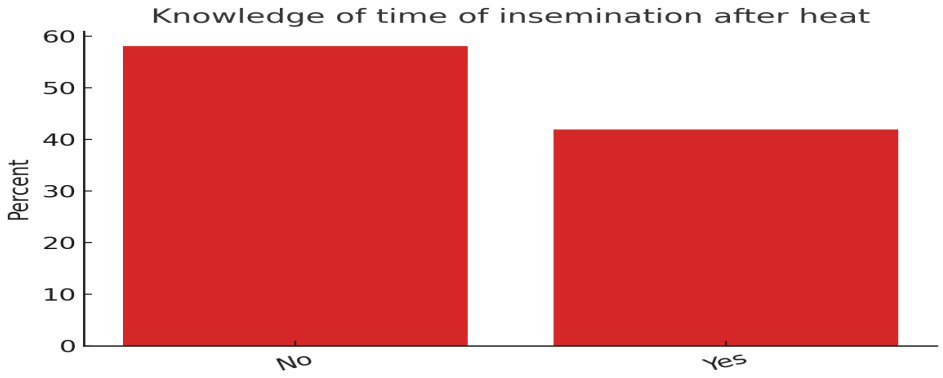


Figure 9: Households knowledge of time of insemination after heat signs

4.6. Cow Related Factors

Breed type

A univariable analysis examining the relationship between cow breed type and conception status showed a strong and statistically significant association (LR $\chi^2(1) = 30.74$, $p < 0.001$; Pseudo $R^2 = 0.0500$; Log likelihood = −291.84316; N = 444). Crossbred cows had substantially higher odds of conception compared with local/native cows: OR = 3.45 (95% CI = 2.19 – 5.44, $p < 0.001$). When breed type was included together with other covariates, the estimated effect was reduced and became borderline or non-significant depending on the model specification (Table 7).

Full multivariable model (many covariates included): LR $\chi^2(24) = 128.14$, $p < 0.001$; Pseudo $R^2 = 0.2086$; Log likelihood = −243.14088; N = 444. Adjusted odds ratio for crossbred vs local = OR = 1.98 (95% CI = 0.99 – 3.95, p = 0.052). After adjusting for education, management system, year, AI technician, experience, season, and other covariates, crossbred cows had roughly double the odds of conception, but this association was marginal ($p \approx 0.05$) (Table 7).

Table 7 : Univariable and multivariable analysis of effect of cow breed type

Predictor Rf=local	LR χ^2	p-value	Pseudo R^2	Log Likelihood	Odds Ratio (OR)	95% CI (Lower –Upper)	p-value (breed)
				Univariable (breed only)			
	30.74	< 0.001	0.0500	−291.84316	3.45	2.19 – 5.44	< 0.001
Cow				Multivariable Full model (many covariates)			
breed	128.14	< 0.001	0.2086	−243.14088	1.98	0.99 – 3.95	0.052
type							

Note: No of Observation = 444, Rf- Reference group, CI – Confidence Interval

The univariable analysis indicates a large and statistically significant advantage for crossbred cows approximately 3.5 times higher odds in conception probability following AI service. This is biologically plausible; crossbred animals may combine desirable genetic traits of higher fertility potential, better body condition, or greater responsiveness to management, or they may be managed differently, i.e., better nutrition, housed in higher-input systems, which improves conception success (Kebede *et al*., 2024).

However, the effect of breed is attenuated after adjusting for managerial, seasonal, and farmer/household characteristics. In the full multivariable model the adjusted OR (≈1.98) was borderline significant (p = 0.052). This attenuation suggests that part of the unadjusted breed advantage is explained by confounding with other factors. For example, crossbred cows may be more common in households with higher education, in better-managed systems, or in particular seasons/years when conception probability is higher. In short, breed remains associated with higher conception in unadjusted analysis, but after controlling for key covariates, its independent effect is marginal.



Figure 10 : Local and Crossbreds Cows

The univariable finding is in line with findings from Fikru *et al*. (2019) and Mesele and Hadgu (2020), who reported that crossbreds generally exhibit improved fertility performance. The better reproductive outcomes of crossbred cows may be attributed to their superior genetic potential, better estrus expression, and stronger physiological response to improved management and feeding practices (Fikru *et al*., 2017; Mesele and Hadgu, 2024). Moreover, Beneberu and Wodajo (2024) highlighted that crossbred cattle not only yield higher amounts of milk but also exhibit improved reproductive efficiency, making them particularly compatible with AI-based genetic improvement programs in Ethiopia (Beneberu and Wodajo, 2024).

Cow Parity

A univariable logistic regression with parity (reference = first parity) showed no statistically significant association between parity and conception outcome. The likelihood-ratio test for parity was small (LR $\chi^2(3) = 0.54$, $p = 0.9092$) and the model log-likelihood = −306.9403. Odds ratios for parity categories 2, 3, and 4 vs. first parity were close to 1, and their 95% CIs all contained 1, indicating no evidence of effect (Table 8).

Table 8: Univariable Analysis of Cow parity

Predictor	Category	Odds Ratio	95% CI	Z	p-value	LR χ^2 (df)	Log-likelihood
Parity	2nd parity	1.1478	0.7080 – 1.8606	0.56	0.576	LR $\chi^2(3) = 0.54$	−306.9403
(1st parity =	3rd parity	1.1917	0.7211 – 1.9695	0.68	0.494	LR $\chi^2(3) = 0.54$	−306.9403
reference)	4th parity	1.1500	0.6161 – 2.1466	0.44	0.661	LR $\chi^2(3) = 0.54$	−306.9403

CI – Confidence Interval

The lack of association aligns with findings by Kebede *et al*. (2019) and Tadesse *et al.* (2022), who reported that parity alone does not significantly affect conception rates, especially when cows are kept under uniform management, nutrition, and health care systems (Kebede *et al.*, 2019; Tadesse *et al*., 2022). According to Senbeta *et al.* (2024), parity becomes a significant factor only when it is associated with increasing age or poor reproductive health, such as uterine infections or metabolic issues more common in high-parity cows (Senbeta *et al*., 2024). These studies disagree with Getahun *et al.* (2019), who found that moderate parities 2nd and 3rd had slightly higher conception rates (Getahun *et al.*, 2019).

4.7. Environmental Related Factors

District (Location)

The model testing the effect of district on conception outcomes showed no statistically significant associations (LR $\chi^2(2) = 0.10$, $p = 0.950$; Pseudo $R^2 = 0.0002$; Log likelihood = –307.16). Compared to the reference district Leka Dullacha, Diga district had an odds ratio (OR) of 1.07 (95% CI: 0.67–1.69, p = 0.778), and Guto Gida had an OR of 1.06 (95% CI: 0.68–1.66, p = 0.788). The odds ratios were close to 1.0, and the wide confidence intervals overlapping unity indicate no meaningful differences in conception outcomes across districts (Table 9).

Table 9: Effect of district of household head on conception outcome

Predictor (District)	Odds Ratio (OR)	95% CI (Lower, Upper)	p-value	Log Likelihood
Leka Dullacha (Ref)	1.00	–	–	–
Diga vs. Leka Dullacha	1.07	0.67, 1.69	0.778	-307.16
G/Gida vs. Leka Dullacha	1.06	0.68, 1.66	0.788	-307.16

CI – Confidence Interval

In the present study, the district of the household head (Leka Dullacha, Diga, and Guto Gida) was not significantly associated with conception outcome. This finding indicates that AI service delivery, technician performance, and management practices may be relatively uniform in the study area, resulting in homogeneous reproductive outcomes. Comparable observations have been made in large-scale synchronization and mass AI programs. For instance, in the East Shewa and West Arsi zones of Oromia, a

synchronized mass AI program achieved an overall conception rate of 68.9%, and conception outcomes did not significantly differ between districts (Arega *et al*., 2024). This supports the interpretation that when AI services are implemented with standardized protocols and extension support, regional district effects can be minimized.

Conversely, other Ethiopian studies have documented clear district-level variation. Ali et al. (2013) reported a first service conception rate (FSCR) of 40.9%, with statistically significant differences across the four districts studied in southern and northwestern Ethiopia. Likewise, in the Lemo and Misha districts of Southern Ethiopia, the conception rate following estrus synchronization varied markedly: in the Misha district, local breed cows achieved only 27.3% conception, whereas in the Lemo district, crossbred cows attained up to 56.3% conception (Darbalo and Iyasu, 2018). These disparities highlight that differences in agro-ecological conditions, breed composition, nutrition, and technician skill can lead to significant district effects.

The contrast between the present findings and those of earlier reports underscores two possibilities. First, the uniform odds ratios across districts in the current study may reflect genuinely homogenous service quality, environment, and herd structure, similar to the East Shewa and West Arsi results. Alternatively, the absence of district differences could partly be due to limited sample size or restricted variation in agro-ecological conditions across the three districts compared here, as opposed to the broader contrasts in environment and management documented in Ali *et al*. (2013) and Darbalo and Iyasu (2018) (Ali et al., 2013; Darbalo and Iyasu, 2018).

Season of insemination

Season of insemination was highly significant (LR $\chi^2(3) = 56.30$, $p < 0.001$), with model log-likelihood = −279.0634. Using winter as the reference season, spring (OR = 1.24, 95% CI: 0.54–2.87, p = 0.616) showed no difference, summer (OR = 2.52, 95% CI: 1.19–5.33, p = 0.015) significantly increased conception odds, and autumn (OR = 7.09, 95% CI: 3.37–14.95, $p < 0.001$) showed the strongest effect. The season effect remained significant after adjustment in the reduced model (education, management system, year, season; log-likelihood = −249.7921); summer (OR = 2.39, p = 0.034) and autumn (OR = 6.83, $p < 0.001$) had higher odds compared to winter. Spring remained non-significant. In the full model (education, breed type, management system, year, experience, season; log-

likelihood = −248.4833), summer (OR = 2.47, p = 0.029) and autumn (OR = 6.98, p < 0.001) were again significant (Table 10).

These findings align with the general understanding of environmental and nutritional influences on fertility, where milder temperatures and better feed availability in autumn improve reproductive performance. These results corroborate the findings of Tadesse *et al. (*2022), Mouffok *et al*. (2019), and Temesgen *et al*. (2022), who reported significantly higher conception rates during autumn and summer in Ethiopia (Mouffok *et al*., 2019; Temesgen *et al.*, 2022; Tadesse *et al.*, 2022). Furthermore, the improved conception outcomes during autumn and summer may be due to better thermal comfort and optimal pasture quality, all of which contribute to improved estrous expression and hormonal balance (Mekonnen and Meseret, 2023).

Table 10: Univariable and multivariable results for season

Predictor	Category	OR	95% CI	Z	p-value	LR χ^2 (df)	Log-likelihood
			Univariable logistic				
	Spring	1.24	0.54 – 2.87	0.50	0.616	56.30 (3)	−279.0634
	Summer	2.52	1.19 – 5.33	2.42	0.015		
	Autumn	7.09	3.37 – 14.95	5.15	<0.001		
Season			**Multivariable (reduced model)**				
(winter =	Spring	1.08	0.43 – 2.67	0.16	0.870	114.84 (14)	−249.7921
Reference)	Summer	2.39	1.07 – 5.36	2.12	0.029		
	Autumn	6.83	3.06 – 15.24	4.69	<0.001		
			Multivariable (full model)				
	Spring	1.09	0.43 – 2.68	0.18	0.858	117.46 (16)	−248.4833
	Summer	2.47	1.10 – 5.58	2.18	0.019		
	Autumn	6.98	3.11 – 15.65	4.71	<0.001		

CI – Confidence Interval

4.8. Service-Related Factors

Management system

The univariable analysis showed that the management system had a strong and statistically significant effect on conception outcome (LR $\chi^2(1) = 33.02$, $p < 0.001$). The model log-likelihood was −290.7018, OR = 5.247, 95% CI: 2.813 – 9.788, and $p < 0.001$ (Table 12). The management system remained significant in both the reduced and full

multivariable models. In the reduced final model, there are higher odds of conception (OR = 3.681, 95% CI: 1.778–7.621, p < 0.001) with log-likelihood = −249.7921. In the full model, OR = 2.441, 95% CI: 1.012–5.887, and p = 0.047 with log-likelihood = −248.4833 (Table 11).

Table 11: Univariable and multivariable results for management system

Predictor	Category	OR	95% CI	Z	p-value	LR χ^2 (df)	Log-likelihood
Management System (reference = Extensive)	Semi-Intensive /Intensive	**Univariable logistic (Management system only)**					
		5.247	2.813 – 9.788	5.21	<0.001	33.02 (1)	−290.7018
		Multivariable (reduced final model)					
		3.681	1.778 – 7.621	3.51	<0.001	114.84 (14)	−249.7921
		Multivariable (full model)					
		2.441	1.012 – 5.887	1.99	0.047	117.46 (16)	−248.4833

CI – Confidence Interval

The anagement system was one of the strongest predictors of conception. The univariable OR of 5.25 shows cows in a semi-extensive management system were nearly five (5) times more likely to conceive compared to those in an extensive management system. The likelihood-ratio test confirmed a highly significant improvement in model fit (p < 0.001). Even after accounting for education, breed type, year, season, and experience, the effect remained significant. In the reduced multivariable model, the odds of conception were 3.68 times higher under the system. In the full model, the effect decreased slightly (OR = 2.44, p = 0.047) but remained statistically significant. This indicates that the management system independently influences conception, beyond the effects of education, breed, year, or season. Semi-intensive management systems likely provide better nutrition, heat detection, insemination timing, or general herd management practices, all of which enhance fertility.

This aligns with a longitudinal study of intensive dairy farms around Addis Ababa, which reported a 66.1% AI conception rate in environments characterized by improved housing, controlled feeding, and better heat detection practices (Tschopp *et al*., 2021). Beneberu et al. (2021) also observed that semi-intensive and intensive systems offer more controlled feeding, housing, and health care, which collectively improve estrus detection, body condition, and timing of AI, key factors for successful conception (Tesfaye et al., 2015; Beneberu *et al.*, 2021). In contrast, extensive systems, characterized by free grazing and

minimal supervision, often limit timely estrus detection and proper nutrition, thereby reducing AI success (Assefa *et al*., 2024).

AI technician

A univariable model results with inseminator technician (reference = AIT 1) (LR $\chi^2(8)$ = 8.08, p = 0.425), model log-likelihood was −303.1700, and odds ratios for individual technicians (AIT 2: OR = 1, 95% CI: 0.510–1.98 p = 1.0; AIT 3: OR = 0.39, 95% CI: 0.14–1.06, p = 0.064; AIT 4: OR = 1.29, 95% CI: 0.64–2.66, p = 0.488; AIT 5: OR = 0.8, 95% CI: 0.37–1.72, p = 0.568; AIT 6: OR = 0.67, 95% CI: 0.23–1.54, p = 0.341; AIT 7: OR = 0.84, 95% CI: 0.42–1.71, p = 0.639; AIT 8: OR = 1.19, 95% CI: 0.56–2.54, p = 0.653; AIT 9: OR = 0.81, 95% CI: 0.38–1.72, p = 0.580;)(Table 13).

In the full multivariable model, log-likelihood = −248.4833, and the inseminator technician was included, but none of the categories reached statistical significance. Odds ratios varied widely (e.g., AIT 4 OR = 18.92, 95% CI: 0.92–389.5, p = 0.057; AIT 7 OR = 17.95, 95% CI: 0.88–366.0, p = 0.060), but the very wide confidence intervals and borderline p-values indicate instability and lack of reliable evidence (Table 12).



Figure 11 : Picture Shows When AITs Inseminating the Cow

The univariable model showed no significant differences between technicians. Although Technician 3 had a lower odds ratio (0.39, p = 0.064), this was not statistically significant. After adjusting for other predictors (education, breed type, management, year, experience, and season), the inseminator technician remained non-significant. The lack of clear statistical effect suggests that conception outcomes were not systematically influenced by inseminator identity. Variation seen in multivariable models is likely due to sparse data for some technicians, producing unstable estimates (Table 12).

Table 12: Univariable and multivariable results for inseminator technician

Predictor (ref = Tech 1)	Category	OR	95% CI	Z	p-value	LR χ^2 (df)	Log-likelihood
			Univariable logistic				
	2	1.00	0.51 – 1.98	0.00	1.000	8.08 (8)	−303.1700
	3	0.39	0.14 – 1.06	−1.85	0.064		
	4	1.29	0.63 – 2.66	0.69	0.488		
	5	0.80	0.37 – 1.72	−0.57	0.568		
	6	0.67	0.29 – 1.54	−0.95	0.341		
	7	0.84	0.42 – 1.71	−0.47	0.639		
	8	1.19	0.56 – 2.54	0.45	0.653		
	9	0.81	0.38 – 1.72	−0.55	0.580		
Inseminator			**Multivariable (full model)**				
Technician	2	0.73	0.32 – 1.64	−0.76	0.447	128.14 (24)	-243.1409
	3	5.66	0.37 – 85.88	1.25	0.211		
	4	18.92	0.92 – 389.5	1.91	0.057		
	5	0.65	0.25 – 1.65	−0.91	0.364		
	6	10.68	0.49 – 230.6	1.51	0.131		
	7	17.95	0.88 – 366.0	1.88	0.060		
	8	1.61	0.67 – 3.90	1.06	0.288		
	9	15.00	0.73 – 306.4	1.76	0.079		

CI – Confidence Interval

Although this study did not find a statistically significant overall effect of inseminator identity on AI conception, the responses of AI technicians highlight several practical challenges that plausibly influence AI success. As shown in Table 13, all technicians (100%) reported that they perform other duties beyond insemination and that they do not receive the necessary support from the Agricultural Office. Transportation was also a major constraint, with most technicians (77.8%) relying on walking to reach farmers, while only a few (22.2%) used motorbikes (Table 13). This suggests that delayed arrival to farms may affect the timing of insemination relative to estrus, which is critical for conception (Gizaw *et al*., 2021; Shiferaw *et al.,* 2020). Furthermore, none of the technicians indicated that farmers report cows for insemination on time, and all (100%) rated the overall availability of inputs as poor. Previous research in the Oromia and Amhara regions similarly highlighted that timely reporting of cows and a reliable supply of inputs are essential for achieving acceptable conception rates (Tadesse *et al.,* 2020; Kebede *et al*., 2019). Limited weekend and holiday service provision (only 33.3%

provided services) and the complete absences of job-related incentives or training opportunities (100% reported no incentives) further indicate systemic service delivery gaps. Studies from both Ethiopia and Kenya emphasize that technician competence, motivation, and continuous refresher training are key determinants of AI service effectiveness (Kassa and Wuletaw, 2018; Shiferaw *et al.*, 2020).

Table 13: General responses of AI technicians on AI service (N = 9)

Variable	Category	Frequency	Percent (%)
Perform other duties	Yes	9	100.0
Support from Agricultural Office	No	9	100.0
Transportation system	Stationed & on foot	7	77.8
	Stationed & motorbike	2	22.2
Farmers report on time for insemination	No	9	100.0
Overall availability of inputs	Poor	9	100.0
Provide services on weekends/holidays	No	6	66.7
	Yes	3	33.3
Incentives and training opportunities	No	9	100.0

See Appendix 7 for details.

Education level of AI technicians

A univariable analysis was conducted to evaluate the effect of artificial insemination technicians' (AITs) education level on conception outcome. The model showed no statistically significant association between technician education level and conception outcome (LR $\chi^2(1) = 0.32$, $p = .573$). The odds of conception for cows inseminated by higher-educated (BSc degree) technicians were slightly lower (OR = 0.90, 95% CI [0.62, 1.31]) compared to the reference group (Diploma), but the effect was not significant. The model explained very little variation in conception outcome (Pseudo $R^2 = 0.0005$), and the log-likelihood (−307.05) indicated poor explanatory power (Table 14).

Table 14: Univariable results for education level of AI technicians

Predictor (ref = diploma)	Category	OR	95% CI	Z	p-value	LR χ^2 (df)	Log-likelihood
Education level	**Univariable logistic**						
	Degree	0.90	0.62 – 1.31	-0.56	0.573	0.32 (1)	−307.0528

These findings align with the study by Gizaw *et al*. (2016) and Ybanez *et al.* (2017), which reported that practical experience and continuous skill upgrading were more influential in determining AI success than formal education level (Gizaw *et al.*, 2016; Ybanez *et al.*, 2017). In contrast, Mekonnen and Leul (2019) observed a moderate positive relationship between higher education levels and AI success rates in regions with limited access to refresher training (Mekonnen and Leul, 2020).

Experience of AI technician

Experience of AI technicians was not a significant predictor of conception outcome in univariable analysis (LR $\chi^2(1) = 0.01$, $p = 0.918$). The model log-likelihood was −309.7063. The odds ratio was close to 1 (OR = 1.03, 95% CI: 0.60–1.78, p = 0.918), indicating no meaningful difference in conception odds between more and less experienced technicians. Experience was included in the full multivariable model (household education level, breed type, management system, year, experience, season; log-likelihood = −248.4833). Again, it was not significant (OR = 1.15, 95% CI: 0.60–2.20, p = 0.668). The reduced model (excluding non-significant predictors like experience) had a nearly identical fit, suggesting experience did not improve model explanatory power (Table 15).

Table 15: Univariable and multivariable results for experience of AI technicians

Predictor (ref = 5-10 experience)	Category	OR	95% CI	Z	p-value	LR χ^2 (df)	Log-likelihood
			Univariable model				
Experience	>10	1.03	0.60 – 1.78	0.10	0.918	0.01 (1)	−309.7063
			Multivariable (full model)				
Experience	>10	1.15	0.60 – 2.20	0.43	0.668	117.46 (16)	−248.4833

CI – Confidence Interval

Experience level of technicians showed no association with conception in univariable findings. The odds ratio was very close to 1 with wide confidence intervals, indicating no effect. Even after controlling for education, management system, breed, year, and season, experience remained non-significant. Removing experience did not worsen model fit, confirming its negligible contribution. This suggests that formal education and training quality may be more influential than years of practice alone. In some contexts, experience

is beneficial, but if technicians are already standardized in their training, additional years may not strongly affect conception outcomes. A study conducted around Haramaya town involving 221 inseminated cows found an overall conception rate of 60.2%, but the experience of the inseminator did not significantly influence conception outcomes ($p > 0.05$) (Hamid *et al*., 2021).

Year of insemination

Year had a borderline overall effect on conception (LR $\chi^2(5) = 10.86$, $p = 0.054$). The univariable model log-likelihood was −301.7816. Compared to the reference year (year 2017), conception odds were significantly higher in year 2020 (OR = 2.67, 95% CI: 1.32–5.37, $p = 0.006$) and year 2021 (OR = 2.50, 95% CI: 1.16–5.37, $p = 0.019$). The year 2022 showed a marginal effect (OR = 2.01, 95% CI: 0.97–4.16, $p = 0.061$). Years 2018 and 2019 did not differ significantly from Year 2017. Year remained an important predictor after adjusting for other variables in the reduced multivariable model (education, management system, year, season; log-likelihood = −249.7921); higher odds were observed in Year 4 (OR = 2.93, $p = 0.008$), Year 5 (OR = 2.92, $p = 0.015$), and Year 6 (OR = 2.39, $p = 0.038$) compared to Year 2017 (Table 16). In the full model (log-likelihood = −248.4833), Year 2020 (OR = 2.89, $p = 0.009$), Year 2021 (OR = 2.77, $p = 0.022$), and Year 2022 (OR = 2.30, $p = 0.049$) remained significant. The years 2018 and 2019 continued to show no difference (Table 16).

Univariable results show that conception odds improved significantly in the years 2020 and 2021 compared to the year 2017, with the year 2022 showing a near-significant increase. This suggests a possible upward trend in conception success over time. Even after controlling for other predictors (management system, education, season, etc.), the years 2020–2022 consistently showed 2018–2019 times higher odds of conception compared to the year 2017 (Table 16).

Table 16: Univariable and multivariable results for year

Predictor (ref = 2017	Category	OR	95% CI	Z	p-value	LR χ^2 (df)	Log-likelihood
			Univariable logistic				
	2018	1.61	0.77 – 3.37	1.25	0.210	10.86 (5)	−301.7816
	2019	1.46	0.70 – 3.06	1.02	0.310		
	2020	2.67	1.32 – 5.37	2.75	0.006		
	2021	2.50	1.16 – 5.37	2.35	0.019		
Year	2022	2.01	0.97 – 4.16	1.88	0.061		
			Multivariable (reduced model)				
	2018	1.69	0.74 – 3.89	1.24	0.213	114.84 (14)	−249.7921
	2019	1.61	0.71 – 3.64	1.15	0.250		
	2020	2.93	1.33 – 6.47	2.66	0.008		
	2021	2.92	1.23 – 6.96	2.42	0.015		
Year	2022	2.39	1.05 – 5.42	2.07	0.038		
			Multivariable (full model)				
	2018	1.73	0.75 – 3.98	1.28	0.200	117.46 (16)	−248.4833
	2019	1.58	0.70 – 3.58	1.10	0.269		
	2020	2.89	1.30 – 6.41	2.60	0.009		
	2021	2.77	1.16 – 6.63	2.29	0.022		
Year	2022	2.30	1.00 – 5.25	1.97	0.049		

OR-Odds Ratio, CI Confidence interval

This indicates that the year effect is not fully explained by management or seasonal variables. Improvements in farmer experience, better insemination techniques, or gradual adoption of improved management practices over the study period may explain higher conception rates in later years. Environmental conditions (rainfall, feed availability) that varied by year may also contribute.

These findings are comparable with other Ethiopian evidence. For example, Tadesse et al. (2022), in a 10-year retrospective cohort study, observed a gradual improvement in AI success rate over time, though they did not always report odds ratios by individual year (Tadesse *et al*., 2022). In contrast, Mekonnen & Berhe (2023) reported a low overall calving rate of 20.5% and a first-service conception rate of 20.4% during 2013-2018 and found no significant difference across those years (Mekonnen and Berhe, 2023). The West Wallaga study (2019-2022) also showed some year-to-year variation in reproductive

performance traits such as number of services per conception and conception rates, which suggests that improvements are possible but may depend heavily on management, feeding, service timing, and record completeness (Kefelegn *et al.*, 2024). The absence of year effects in this study may reflect challenges such as inconsistent feed availability, variable technician performance, or fluctuations in management practices that offset potential service improvements.

Method of Insemination

The logistic regression analysis revealed that the method of insemination had a highly significant effect on conception outcome ($LR\ \chi^2(1) = 38.67$). The model achieved a log-likelihood value of −287.8787 and a pseudo R^2 of 0.0629, indicating that about 6.3% of the variation in conception rate was explained by the insemination method. Compared with the reference category (regular insemination), cows inseminated using the HAMI method were 4.07 times more likely to conceive (OR = 4.07; 95% CI = 2.56 – 6.48; z = 5.93; $p < 0.001$) (Table 17).

Table 17: Univariable results for method of insemination

Predictor (ref = Regular)	Category	OR	95% CI	z	p-value	LR χ^2 (df)	Log-likelihood
Method of insemination	HAMI	4.07	2.56– 6.48	5.39	0.000	38.67 (1)	−287.8787

OR = odds ratio, CI = confidence interval.

The present finding shows that the HAMI method significantly improved conception outcomes compared to the regular insemination technique. The odds ratio of 4.07 suggests that, holding other conditions constant, use of the HAMI protocol increased the likelihood of conception by more than fourfold.

This substantial effect may be attributed to the more precise semen deposition and timing procedures used in the HAMI method, which ensure that insemination occurs closer to ovulation and that sperm cells are optimally placed in the uterine body for fertilization. This result aligns with Hamid *et al.* (2021), who reported that correctly timed insemination relative to estrus onset improved conception rates by up to 20 percentage points in crossbred dairy cows (Hamid *et al.*, 2021). Likewise, Tadesse *et al.* (2022) found that adherence to optimal insemination protocols significantly enhanced conception rates in smallholder herds (Tadesse *et al.*, 2022).

In summary, the significant effect observed in this study suggests that adopting improved and standardized insemination methods such as HAMI could markedly enhance conception rates in smallholder dairy systems. Efforts should therefore prioritize technician training in HAMI protocols, improving estrus detection accuracy, and ensuring timely insemination to maximize reproductive performance.

Semen Quality Assessment

The proportion of all sperm cells in semen samples that are actively moving forward is known as individual semen motility. The Bull ID (ET-000022689) semen used in this study had 81.4% morphology, a 7.2 pH reading, and 3 graded (highest) libido. At the time of collection and processing at NSPC, the individual fresh motility of the bull (ET-000022689) semen used in this study was 82%. However, after freezing was completed, it dropped to 65%, which is an average loss of 17% owing to freezing. The average motility of frozen semen at the date of distribution was 60%, which lost 5%. The present study revealed that semen samples collected from AI technicians showed a considerable reduction in motility of 5 to 20% compared to semen from the storage room of the Nekemte Semen Processing Center (Table 18).

The average motility of sampled semen from AI technicians in Leka Dullacha district was 17.5%, in Guto Gida was 15%, and in Diga district was 11.7%. However, the sample taken from NSPC semen storage did not show any significant motility difference (60%) with the motility of the semen at the time of distribution (Table 18). This clearly suggests that improper handling and storage of semen at the field level significantly compromises semen quality, which in turn affects conception rates. Factors such as inadequate liquid nitrogen supply, poor maintenance of storage containers, and delays in replenishing nitrogen are likely contributors to this decline.



Figure 12 : Semen sample collection and laboratory assessment at NSPC.

These findings are consistent with earlier studies conducted in Ethiopia. Abebe and Alemayehu (2021) underscores how poor handling, absent AI inputs, and inadequate training can degrade semen quality in smallholder systems (Abebe and Alemayehu, 2021). Similarly, Birhanemeskel and Kide (2016) documented lower motility and live sperm percentages in field-level AI centers compared to a regional hub, reflecting tangible degradation during transport or storage consistent with the significant motility drop (Birhanemeskel and Kide, 2018).

Table 18: Result of semen sampled from AI technician and NSPC storage room.

Bull ID	District	AI Tech code	Production date	Batch Number	Conc	PH	Morphology	Fresh Mass Motility	Motility Fresh Indiv	Motility Frozen	Motility Motility at the date of	Motility of sampled
ET-00002689	Nspc	Store	1/16/2025	016/25	1	7.2	81.40%	4	82%	65%	60%	60%
	Leka	T1	1/16/2025	016/25	1	7.2	81.40%	4	82%	65%	60%	45%
	Dulacha	T2	1/16/2025	016/25	1	7.2	81.40%	4	82%	65%	60%	40%
	Guto Gida	T1	1/16/2025	016/25	1	7.2	81.40%	4	82%	65%	60%	40%
		T2	1/16/2025	016/25	1	7.2	81.40%	4	82%	65%	60%	50%
		T3	1/16/2025	016/25	1	7.2	81.40%	4	82%	65%	60%	45%
	Diga	T1	1/16/2025	016/25	1	7.2	81.40%	4	82%	65%	60%	50%
		T2	1/16/2025	016/25	1	7.2	81.40%	4	82%	65%	60%	40%
		T3	1/16/2025	016/25	1	7.2	81.40%	4	82%	65%	60%	55%

T1- Code for Technician, Conc- Concentration, PH- measure of acidity or basicity of aqueous

Overall, the observed motility drop in this study underscores the importance of strengthening semen storage facilities, ensuring a regular supply of liquid nitrogen, and providing refresher training to AI technicians on semen handling.

4.9. Thematic Analysis

To complement the quantitative data, a group discussion was conducted with laboratory technologists, AI service input distributor experts, AI technicians (AITs), and livestock experts from the study areas of Guto Gida, Leka Dullacha, and Diga districts. The purpose of the discussion was to explore practical challenges and perceptions regarding the low conception rate of artificial insemination (AI) services and to identify areas for future improvement. The findings are presented thematically below.

4.9.1. Farmer Awareness and Attitude

Participants reported that one of the major challenges affecting the success of AI services is the limited awareness and negative attitudes among farmers. Many farmers were unaware of the critical importance of timely heat detection and proper animal management before and after insemination. It was noted that some farmers lacked basic knowledge of the signs of estrus and relied on guesswork or anecdotal advice when deciding to call AITs. Others expressed skepticism about the effectiveness of AI, especially if they had previous unsuccessful experiences. As a result, some preferred to return to traditional natural mating, which compromises genetic improvement efforts. The group agreed that continuous community education is needed to address misconceptions and increase AI acceptance.

4.9.2. Infrastructure and Logistics

Infrastructure was a recurring theme during the discussion. AITs and livestock experts emphasized that poor road conditions and lack of transportation severely limit service coverage. Many kebeles are located in remote or hard-to-reach areas, where AITs struggle to deliver timely services. The absence of AI delivery stations at the kebele level, coupled with the lack of motorbikes or fuel for movement, results in delayed insemination, especially when cows come into heat during weekends or off-hours. This delay significantly reduces conception success. The group strongly recommended the expansion of kebele-level AI delivery points and equipping AITs with reliable transportation.

4.9.3. Technician-Related Factors

The group also discussed issues related to the technicians themselves. It was noted that there is a shortage of well-trained AITs, especially in densely populated or geographically scattered areas. In some kebeles, a single technician serves multiple locations without adequate logistical support. This affects both the timeliness and quality of service. Furthermore, some participants expressed concerns about the lack of ongoing professional development, indicating that many AITs have not received refresher training since their initial certification. These factors contribute to inconsistent handling practices and poor service delivery.

4.9.4. Estrus Detection by Farmers

Incorrect or delayed heat detection by farmers was consistently identified as a leading cause of AI failure. Several AITs shared experiences where they were called after the cow was already past the optimal insemination window. In other cases, farmers mistook unrelated behaviors such as bellowing or tail rising for heat signs. These errors result in poor timing of insemination, which drastically reduces conception rates. The participants stressed the urgent need to provide basic estrus detection training for farmers and encourage them to observe cows closely, especially during early morning and evening hours when signs are most visible.

4.9.5. Semen Handling Challenges

The discussion revealed notable issues in semen storage, thawing, and handling. In some areas, AI technicians operate without access to functional liquid nitrogen (LN_2) containers or proper thawing equipment. Semen doses are sometimes transported long distances under suboptimal conditions, and delays during service delivery further reduce sperm viability. Some AITs admitted to practices such as multiple thawing and refreezing, which compromise semen quality. In addition to the group feedback, personal observations confirmed poor semen handling practices at several district offices. These included long distances between the semen thawing location and the cow's insemination site**,** irregular LN_2 topping schedules**,** and the lack of standard AI equipment (such as thermometers and thawing devices) for many technicians. These observations reinforced the need for better training, equipment, and support systems to maintain semen viability and improve conception outcomes.

5. CONCLUSION AND RECOMMENDATION

This study examined the determinants of the low conception rate of AI in the Guto Gida, Leka Dullacha, and Diga districts of the East Wallaga zone, which is attributed to a combination of household, cow-related, and service-related factors. Despite the availability of AI centers and trained personnel, systemic inefficiencies, including input shortages, poor semen handling, and low farmer knowledge, have limited the success of AI services. Addressing these factors through targeted training, improved logistics, regular input supply, and incentive schemes for AITs is essential for improving AI outcomes and boosting dairy productivity in East Wallaga.

The findings demonstrate that the conception rate of AI services in the study area remains suboptimal at 46%, influenced by cow-level factors (breed), environmental factors (season), household-level factors (education, awareness), and service-related factors (management system, semen quality, and method of insemination). Crossbred cows, semi-intensive management, higher household education, and insemination during favorable seasons significantly improved conception success. However, persistent challenges related to semen handling, cold chain management, and farmer awareness of estrus detection contributed to low overall performance.

The absence of significant technician-level differences suggests that formal qualification and experience alone may not determine AI success; instead, continuous refresher training, proper supervision, and logistical support are key. These results highlight that AI service effectiveness is not only a technical procedure but also an integrated system involving farmer knowledge, technician competence, infrastructure, and semen handling practices. Overall, the findings highlight that AI conception is not determined by a single factor but by the combined effects of farmer knowledge, cow genetics, seasonal conditions, management practices, and service quality**.**

While this study provides useful insights into factors affecting low conception rates in dairy cattle AI services in East Wallaga Zone, the findings should be viewed with caution. The cross-sectional design and reliance on retrospective data may limit causal interpretation. Unmeasured factors such as nutrition, body condition, and disease status could also influence outcomes. Hence, the conclusions are open to amendment as future

studies with larger samples, longitudinal designs, and broader geographic coverage provide additional evidence.

Recommendations

For Farmers

- Improve heat detection: Check cows at least twice daily and inseminate at the correct time after estrus onset.
- Adopt semi-intensive systems: Provide better feeding, housing, and veterinary care to enhance reproductive performance.
- Favor crossbred cows when resources allow, as they show higher conception rates than local breeds.
- Plan inseminations in winter**,** when feed and body conditions are more favorable.

For Policymakers

- Strengthen farmer training programs on heat detection, reproductive management, and AI timing.
- Promote semi-intensive and feed-improving interventions to reduce seasonal effects on AI outcomes.
- Support genetic improvement programs by facilitating access to crossbred semen and improving AI service coverage.
- Monitor and standardize AI services to reduce technician-related variability.

For AI Technicians

- Deliver continuous awareness training for farmers on heat signs and the correct time of insemination.
- Ensure adequate logistics, including liquid nitrogen, insemination tools, and transport facilities, to avoid service delays.
- Address technician work overload and minimize service interruptions on weekends and holidays through proper staffing and scheduling.

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7. APPENDICES

Appendix 1 : Availability of AI service on weekends and Holidays

Do you provide services on weekends and on holidays					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	6	66.7	66.7	66.7
	Yes	3	33.3	33.3	100.0
	Total	9	100.0	100.0	

Appendix 2 : Having knowledge of Heat Signs

Having knowledge of heat					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	146	52.7	52.7	52.7
	Yes	131	47.3	47.3	100.0
	Total	277	100.0	100.0	

Appendix 3 : Frequency of heat check per cow per day

How many times would you check your cow for heat per day					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no particular time	24	8.7	8.7	8.7
	Once	107	38.6	38.6	47.3
	twice	104	37.5	37.5	84.8
	three times	42	15.2	15.2	100.0
	Total	277	100.0	100.0	

Appendix 4 : Knowledge of time of insemination after heat

Knowledge of time of insemination after heat					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	161	58.1	58.1	58.1
	Yes	116	41.9	41.9	100.0
	Total	277	100.0	100.0	

Appendix 5: Most obvious and practical impotant Estrus sign

Which sign is the most obvious and of practical importance?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Mounting other Animals	2	22.2	22.2	22.2
	stand to be mounted	7	77.8	77.8	100.0
	Total	9	100.0	100.0	

Appendix 6 : Major problems associated with the AI service in study area

Major problems associated with the AI service in study area?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	lack of Station in Kebeles				
	late farmer reporting				
	poor AI service input				
	availability				
	Poor Delivery Logistic				
	other responsibilities				
	inconvenient distance				
	transport issues				
	lack of motivation				
	All of the above	9	100.0	100.0	100.0

Appendix 7: General Response of AI Technicians on AI Service

General Response of AI Technicians on AI Service					
	Do you perform other duties/responsibilities?				
		Frequency	Percent	Valid Percent	Cumulative Percent
	Yes	9	100.0	100.0	100.0
	Get the necessary support by the Agricultural Office				
	No	9	100.0	100.0	100.0
	Transportation system				
	stationed & On Foot	7	77.8	77.8	77.8
	stationed & motor bike	2	22.2	22.2	100.0
	Do farmers report on time for inseminations				
	No	9	100.0	100.0	100.0
N = 9	Overall availability of inputs				
	Poor	9	100.0	100.0	100.0
	Do you provide services on weekends and on holidays				
	No	6	66.7	66.7	66.7
	Yes	3	33.3	33.3	100.0
	Incentives on job and trainings				
	No	9	100.0	100.0	100.0

N- Number of AI Technicians

Appendix 8 : Images of Semen Collection Time, Laboratory Examination, Cow Insemination, and Born Calves in the Study Area



Appendix 9: Questionnaire developed to collect data on Assessment of Factors Associated with Low Conception Rate to Artificial Insemination Services

School of Veterinary Medicine

Wallaga University

Questionnaire developed to collect data on Assessment of Factors Associated with Low Conception Rate to Artificial Insemination Services in Guto Gida, Leka Dullacha, and Diga Districts of East Wallaga Zone

2025

I. **Questionnaire to be used to collect information from cow owners**

Address: Region_____, Zone ___, District ___, Kebele ___ Farmer ID _____

a. Specific location 8° 40′ and 9°30′ N latitude and 36° 10′ and 36° 50′ E

Socio-economic characteristics

b. Age of Household _____

c. Sex of Household head _____

d. Family size _____

e. Education level _____

f. Landholding per household _____

1. How many cattle do you have?

A. 1-5 B. 6-10 C. 11-15 D. ≥ 16

B. Breeds of cattle he has?

2. What type of breeding method do you use to breed your cow?

A. NM B. AI C. both of them

B. If you use natural mating, the source of breeding bulls? I. from my own herd, II. From neighborhood at grazing area III)……

3. For how long do you use AI service?

A. <5 years B. 5-9 years C. >10 years

What was the main reason for using AI?

_____

4. Where did you get AI Service?

_____

_____

Do you get the AI service regularly without interruptions?

A. Yes B. No

5. If your answer to the above question is no, what is the reason? Because

A. Unavailability due to distance

B. No knowledge of AI services

C. Other,

specify_____

_____

6. Do you get AI service on weekends and holidays?

A. Yes B. No

7. If your answer to the above question is no, then how do you breed your cow?

A. Pass the date without breeding the cow B. Use NM

8. If your cows didn't conceive with repeated inseminations, then what did you do?

A. Use AI again and again B. Use NM C. Sell (cull out) the cow

9. Are you satisfied with the overall AI service provision? A. Yes B. No

10. If your answer to the above question is no, reason it out.

_____

Can you identify breeding animals in heat? A. Yes B. No

A. If yes, what types of symptoms do they show?

_____

B. If not, how did you identify whether the animal is in heat or not?

_____

11. How many times do you check your cow for heat per day?

A. Once B. twice C. three times D. no particular time

12. When does the cow that showed heat signs in the afternoon, be inseminated?

_____

13. When does the cow that showed heat signs in the morning, be inseminated?

_____

14. In relation to the above answer, what do you do if the AI technician comes too late for insemination?

A. Get the service any way B. Reject the service and wait for another 21 days

C. Use NM D. Do not know

Have you been involved in Hormone assisted mass Insemination?

Was it good?

II. **Questionnaire used to collect information from AITs**

Address: Region_____, Zone_____, Woreda_____,Kebele____, AIT ID ____

Please answer the following questions precisely:

Sex of the AI tech _____

Age of the AI tech _____

Education level _____

Q1. When did you start your career as AIT?

A. 1968-1978 B.1979-1989 C. 1990-2000 D. 2001-2014

Q2. Where did you attend your training as AIT?

A. Assela B. NAIC C. NSPC D. Region

Q3. For how long did you attend your training as AIT?

A. 6 months B. 3 months C. 9 months D. 2 months

Q4. How do you evaluate the quality of training?

A. Very good B. good C. poor

Q5. What is the method of AI service delivery?

A. stationed B. daily runs C. on call basis

Q6. How long did you inseminate the cow?

A. 1-5yrs B. 6-10yrs C. 11-15yrs D. 16-20yrs E. >20yrs

Q7. Do you get on- the- job training and other incentives?

A. Yes B. No

Q8. Where do you get semen?

A. regional BoARD B. District BoARD C. NAIC D.NSPC

Q9. Do you face any problem while obtaining semen?

A. Yes 2. No

Q10. In relation to the above question, list out those problems.

_____

Q11. Do you provide services on weekends and on holidays?

A. Yes B. No

Q12. If your answer to the above question is no, why did you not provide?

Q13. How do you judge the overall availability of inputs including liquid nitrogen and other consumables? A. Good B. Poor

Q14. Do farmers report on time for inseminations?

A. Yes B. No

Q15. Do you perform other duties/responsibilities?

A. Yes B. No

Q16. If your answer to the above question is yes, then does this type of work affect your work in AI? A. Yes B. No

Q17. Do you get the necessary support by the BoARD and District agricultural office to the AI service? A. Yes B. No

Q18. What is the average number of cows you are covering per day?

A. 1-5 B. 6-10 C. 10-15 D. 15-20 E. ≥ 20

Q19. Is the distance being covered convenient for application of the service? A. Yes B. No

Q20. Which transportation system do you use?

A. stationed B. on foot C. motorbike D. car

Q21. What are the major problems associated with the AI service in your area?

Q22. What are the major signs of estrus?

Q23. Which sign is the most obvious and of practical importance?

Q24. When do you inseminate a cow, which came in heat early in the morning?

Q25. How do you thaw semen for insemination?

_____

Q26. At what temperature of water do you thaw the semen for insemination?

_____

Q27. How do you check the temperature of the water during thawing?

Q28. For how long do you thaw semen?

A. For 15 seconds B. for 25 seconds C. for 35 seconds D. for 45 seconds

Q29. Do you keep records?

I. Do you provide service takers with the breed of sire (semen) and blood level with which you inseminate his/her cows?

II. Do you top up your semen?

If yes, A) once every day B) once every other day c) once every three days?

Q30. Do you have any idea on how to improve the AI service in the future?

_____