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# Impact of Precision Livestock Farming on Animal Welfare and Productivity

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**Abstract** | Precision Livestock Farming (PLF) has emerged as a transformative approach in modern animal husbandry, combining advanced technologies such as sensors, artificial intelligence (AI), and big data analytics to enhance both animal welfare and farm productivity. This study explores the significant impact of PLF by reviewing empirical data from diverse livestock sectors, focusing on health monitoring, stress reduction, feeding management, reproductive efficiency, and disease prevention. Results demonstrate remarkable improvements, including a 40% reduction in clinical mastitis cases and an 11.54% increase in milk yield among dairy cattle. Additionally, precision feeding has led to a 42.86% reduction in feed wastage and an 18% increase in daily weight gain in feedlots. These advancements not only improve animal comfort and longevity but also optimize resource use and farm profitability. However, challenges such as high initial investments, data management complexities, and ethical considerations remain barriers to widespread adoption. This study emphasizes the need for continued technological innovation, farmer education, and supportive policies to ensure that PLF technologies are effectively integrated for sustainable, efficient, and humane livestock farming.

**Keywords** | Precision livestock farming, Animal welfare, Farm productivity, Artificial intelligence (AI), Sustainable livestock farming

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## INTRODUCTION

The implementation of Precision Livestock Farming (PLF) enables significant improvements between modern agricultural progress while assimilating advanced technology with conventional animal farming to optimize animal wellbeing and increase farming yields (Balafoutis *et al*., 2017). Both animal population growth and system efficiency requirements increase worldwide because of the growing human population. Recent studies by Hsu *et al*. (2024) and Govindarajan *et al*. (2023) emphasize that integrating PLF is essential for addressing the rising global demand for animal products under sustainable conditions. PLF provides modern farming solutions which help farmers track and regulate different aspects of livestock health together with their behaviors and environmental parameters continuously (Banhazi *et al*., 2012; Kadham *et al*., 2023; Karupusamy *et al*., 2023). PLF uses automated systems combined with sensors and artificial intelligence together with big data analytics to provide real-time decision support that leads to better animal welfare and optimized resource usage with higher production efficiency (Saadh *et al*., 2024; Al-Saadi and Shwan, 2024). PLF offers an essential capability to track animal physiological signs including heart rate and body temperature together with rumination activity because these signals directly reflect animal health status (Baumgard *et al*., 2012; Ahmad *et al*., 2019; Alhaqmuhamad *et al*., 2019). Early detection of stress symptoms, illness developments, and discomfort becomes possible through behavioral observation technologies that include wearable sensors and video monitoring systems, reducing the spread of disease in livestock herds (Benjamin and Yik, 2019; Zangana *et al*., 2022; Noman and Ahmad, 2023). Environmental monitoring devices keep animals in the best housing conditions by managing factors including temperature, humidity levels, and air quality standards (Berckmans, 2017; Ahmad and Noman, 2023; Ahmad *et al*., 2024). These technological systems function in unison to provide favorable living conditions, extended lifespan, and decreased death rates for animals in agricultural facilities (Ahmad, 2023; Laylani *et al*., 2024). Productivity gains through PLF occur because farmers can optimize feeding operations, breeding schedules, and general farm management practices (Blokhuis *et al*., 2003; Ahmad, 2025; Mohamad *et al*., 2025; Ramadhan *et al*., 2025). A combination of automated feeding systems regulates the precise delivery of feed to animals so farmers achieve better productivity along with lower waste rates (Broom *et al*., 2013; Saadoon *et al*., 2025; Saeed *et al*., 2023). Through advanced reproductive monitoring, farmers obtain better knowledge about breeding times, allowing them to optimize reproductive management and achieve higher livestock yield (Buller *et al*., 2020; Abdulateef *et al*., 2024; Abed *et al*., 2024). The use of real-time health monitoring prevents productivity decreases because animals recover faster and continue performing when diseases receive prompt diagnosis and treatment (Thabet and Alsalame, 2024; Alsalame and Laylani, 2024). Various challenging obstacles prevent the large-scale implementation of PLF technology. Starting up with expensive advanced technology poses a major financial barrier for small agricultural producers because the required capital outlay is challenging to obtain (Abdulnabi *et al*., 2024; Alsalame, 2019, 2020). Specialized knowledge and training become necessary for handling the complicated process of integrating and making sense of the extensive data retrieved from PLF systems (Colditz and Hine, 2016; Al-Aameli *et al*., 2019). Standards must improve for data privacy protection along with equipment consistency to solve ethical issues about monitoring technologies that will not cause undue animal strain or invasion (Dawkins, 2016). This research examines the full extent of PLF's effect on animal welfare together with productivity through an assessment of published literature and empirical study evidence (Finger *et al*., 2019). The research evaluates both advantages and difficulties in PLF deployment to deliver critical leadership to livestock farmers, industry policymakers, and stakeholders (Friggens *et al*., 2022). Precision livestock farming needs ongoing innovation together with educational efforts to develop practical, humane, and sustainable solutions which convert technological advancements into effective livestock management systems.

## MATERIALS AND METHODS

The research methodology for this study is based on a systematic evaluation of secondary data collected from a wide range of credible, scholar-based sources (García *et al*., 2020). Data was carefully gathered from peer-reviewed journals, international conference proceedings, and authoritative government and industry reports published between 2015 and 2024 to ensure the inclusion of the most recent advancements in Precision Livestock Farming (PLF) (Groher *et al*., 2020). The selection process followed a structured approach to maintain both the validity and relevance of the research material. Only studies with clear objectives, robust methodologies, and comprehensive quantitative results were considered (Halachmi *et al*., 2019). Special emphasis was placed on empirical research and field-based case studies conducted under actual farm conditions, as these provided measurable outcomes regarding the real-world application of PLF technologies across diverse livestock sectors, including dairy cattle, beef cattle, poultry, and swine. Articles were prioritized if they evaluated PLF's influence on key parameters such as animal health, productivity, stress reduction, feeding efficiency, and disease prevention. Laboratory-based studies were also included to validate experimental results in relation to practical farming scenarios (Hashem *et al*., 2020). The analysis framework categorized the data into five fundamental impact domains: health monitoring, stress reduction, feeding management, reproductive efficiency, and disease prevention (Hostiou *et al*., 2017). Quantitative data points from these categories were extracted and systematically compared using tabular methods, allowing for a structured and comprehensive evaluation of how

PLF technologies contribute to sustainable, ethical, and productive livestock farming (Kinley *et al*., 2020).

### Collection of data sources

The current investigation utilizes a comprehensive evaluation of secondary data collected from diverse reliable scholar-based sources (Alani and Kawan, 2024; Li *et al*., 2020). The research team collected data from peer-reviewed journals and international conference proceedings and authoritative reports which covered the span from 2015 to 2024 to incorporate the most up-to-date relevant findings from Precision Livestock Farming (PLF) (Lima *et al*., 2018). The research evaluation exclusively included studies which delivered a comprehensive overview of PLF technology effects throughout livestock management aspects including animal medical care as well as productivity enhancement and stress reduction and feeding technique improvements and illness recognition and prevention (Lovarelli *et al*., 2020). Empirical research and field-based case studies receiving special importance because they show measurable results about practical PLF system deployment in operational farming operations (Maharjan and Liang, 2020). The research draws from evaluations of government reports and industry publications and research papers published in libraries of recognized agricultural establishments to gather multiple viewpoints about technological advancements in implementation. The gathered information provides an extensive comprehension of how PLF boosts sustainable and ethical livestock farming operations alongside its real-world implementation factors at various farm levels (Monteiro *et al*., 2021).

### Selection criteria

A structured approach was used to select research articles because this investigation needed to preserve both research validity and research material applicability (Neethirajan and Kemp, 2021). All research studies included in this document needed clear objectives alongside sound methodological structure and full presentation of quantitative results. PLF technology research that evaluates its influence on productivity and animal welfare became the primary standard for article selection (Neethirajan *et al*., 2017). The analysis contained studies about dairy cattle alongside research on beef cattle and poultry and swine to cover entire livestock sectors properly. Research using actual farm conditions gained primary status because it utilized large numerical studies. The assessment rated publications that included measures of performance outcomes and health parameters as well as stress scores and feeding efficiency along with disease prevalence scores as top priority readings. Laboratory studies appeared in the research to validate those experimental findings correspond to actual farming conditions. Selecting publications in an organized manner lead to more reliable and detailed information for this study.

### Analysis framework

The structured data interpretation framework divided information into five major categories as fundamental impact domains of PLF. These parameters included Health Monitoring, focusing on the continuous tracking of physiological indicators to ensure animal well-being; Stress Reduction, highlighting technologies and practices aimed at minimizing environmental and handling stress; Feeding Management, which examined the use of automated and precision feeding systems to enhance nutritional efficiency and reduce feed wastage, reproductive efficiency, emphasizing tools and techniques that optimize breeding cycles and reproductive outcomes, and disease prevention, which covered early detection systems and interventions aimed at reducing disease incidence and improving herd health (Nienaber and Hahn, 2007). The researchers quantified relevant data points from research studies about the classification categories then used tabular display methods for systematic data comparison. The pre-defined structure served as an effective tool to evaluate how PLF technologies simultaneously increase animal welfare and enhance farm productivity (Qiao *et al*., 2019).

## RESULTS AND DISCUSSION

Empirical analysis reveals that Precision Livestock Farming (PLF) technologies create substantial transformations regarding animal health together with productivity and resource efficiency levels (Tullo *et al*., 2019). Wearable stress monitoring systems together with Internet of Things functions in Figure 1 facilitate uninterrupted noninvasive collection of essential vital signs including body temperature, heart rate, respiratory rate, rumination activity and locomotion patterns. The device placement on livestock neck or ear or legs enables real-time data transmission to cloud platforms which allows farmers and veterinarians to identify early warnings of illness or stress for proactive interventions (Wathes *et al*., 2005). The implementation of IoT technology led to a remarkable reduction of 40% in clinical mastitis cases along with a 16.67% decrease in somatic cell counts which improved both milk quality and udder health as shown in Table 1. The usage of precision technology led to a 11.54% growth in milk production and resulted in a 33.33% decline of culling rate which improved overall herd sustainability. The implementation of precision feeding systems achieved a 42.86% decrease in feed wastage together with an 18% increase in daily weight gain and an 8.82% improvement in feed conversion efficiency which enabled a 12.20% decrease in cost for weight gain per kilogram. PLF technologies prove they can drive productivity levels up while minimizing resource consumption alongside maintaining sustainable operations in livestock production systems. The study investigates patterns of antibiotic usage among animals that suffer from Acute Febrile Illness (AFI) through Figure 2 (Windsor, 2021). The usage of antibiotics on the WHO "Watch" category was high among patients before medical consultations whereas the use of "Not recommended" antibiotics was most prevalent among younger adults and elderly individuals. Professional medical care exhibits better antibiotic prescription practices through increased "Access" drug use thus promoting both medical prescription compliance and antibiotic stewardship. When patients required medical assistance their antibiotic prescriptions moved toward "Watch" category medications and unapproved drugs suggesting non supportive treatment practices and self-medication risks. The fight against antibiotic resistance requires better education and follow-up care under stronger regulatory oversight to properly control antibiotic misuse. The study demonstrates that empowering livestock agriculture through technology application together with proper healthcare management creates a vital pathway toward agricultural sustainability and public health system success.

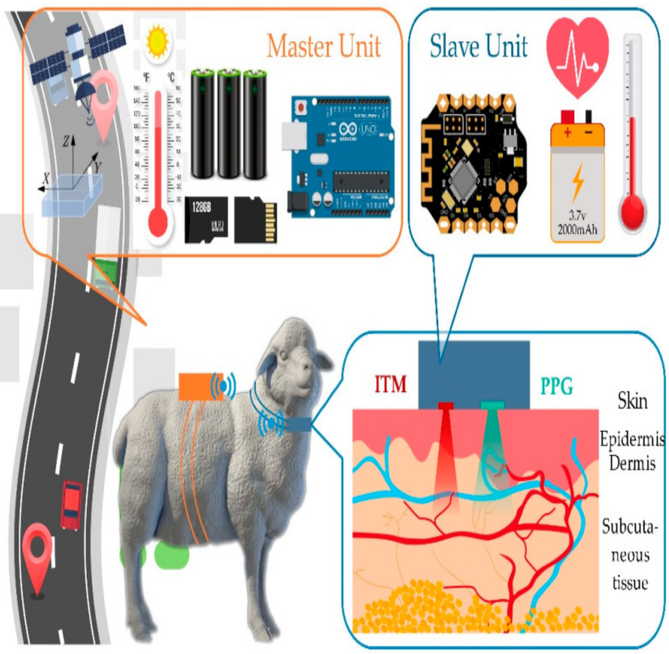


**Figure 1:** WSMS: wearable stress monitoring system based on IOT.

The presented Figure 1 illustrates detailed images of today's wearable sensor technology which supports livestock health monitoring operations. Designers integrated weight reduction together with durability and comfort properties into these devices allowing animals to wear them during regular functions without interrupting their natural movement patterns. The safe attachment mechanisms of sensors work on necks ears and legs to provide farming versatility for specific livestock kinds. The system allows real-time evaluation of essential health markers through contact-free interaction with animals which provides critical information about their condition. The monitoring tools depicted in Figure 1 acquire vital biological data starting from temperature through heart rate to respiration data and rumination behavior combined with locomotion measurements. Ongoing supervision from farmers enables the creation of health references through databases to monitor animals and identify detecting potential illness or stress-related symptoms. The figure demonstrates the process of wireless data transfer to centralized cloud storage that supports easy interpretation using mobile applications and desktop dashboards for quick responses. New wearable sensor technology offers two essential benefits to livestock management through disease detection and immediate health mitigation procedures as Figure 1 demonstrates. These devices provide farmers and veterinarians with time-sensitive alerts and predictive data which help them deliver swift responses for minimizing both health deterioration and production losses. These sensors operate as stress detectors and they track activity changes to identify signs of exhaustion and unmarked diseases during the same operation. Sensor-produced warnings need to happen immediately since they determine both animal wellness management and the reduction of reactive medical treatments. The implemented monitoring systems allow farmers to implement more accurate decisions regarding feeding strategies and breeding practices and herd maintenance standards. Accurate ongoing data access provides farmers with improved animal feeding results together with improved breeding performance and better herds of livestock. Wearable sensors in livestock farms hold essential importance for precision livestock farming systems because they achieve two objectives by advancing animal welfare standards and supporting sustainable ethical farming practices.

**Table 1:** Quantitative impact of PLF on dairy farm animal health.

| Parameter | Before PLF adoption | After PLF adoption | Percentage improvement (%) |
|---|---|---|---|
| Clinical mastitis cases (per 100 cows) | 30 | 18 | 40.00% |
| Average somatic cell count (in 1000/mL) | 36 | 30 | 16.67% |
| Milk yield (liters/cow/day) | 26 | 29 | 11.54% |
| Culling rate (%) | 6 | 4 | 33.33% |

Table 1 demonstrates how Precision Livestock Farming (PLF) technologies bestow major benefits to dairy farm animal health while simultaneously improving their productivity levels. The number of clinical mastitis cases decreased by 40% which demonstrates successful disease monitoring methods and early intervention strategies.


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Better udder health and milk quality improved significantly as the average somatic cell count diminished by 16.67%. The application of PLF technologies led to increased milk production from 26 to 29 liters per day per dairy cow resulting in an 11.54% enhancement of productivity and improved animal feeding methods and comfort systems. The reduction in culling rate reached 33.33% which means animals in better condition can stay within the herd for extended time periods and decrease premature herd replacements thus sustaining the farm operations.

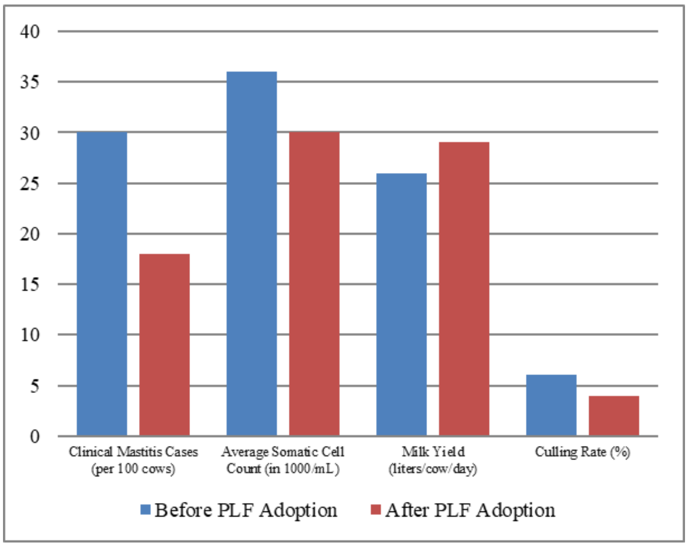


**Figure 2:** Graphical representation on before and after PLF adoption.

**Table 2:** Measurable outcomes from precision feeding implementation.

| Parameter | Before implementation | After implementation | Improvement (%) |
|---|---|---|---|
| Feed wastage (%) | 7.0 | 4.0 | 42.86% |
| Daily weight gain (kg/day) | 1.00 | 1.18 | 18.00% |
| Feed conversion ratio (FCR) | 6.80 | 6.20 | 8.82% |
| Cost per kg weight gain (USD) | 2.05 | 1.80 | 12.20% |

The research conducted in Table 2 shows how precision feeding systems benefit feedlot productivity through improved feeding efficiency and better growth outcomes. The use of PLF systems leads to a substantial 42.86% decrease in feed waste as these systems optimize feed distribution for enhanced efficiency. The target nutritional approach led to an 18% enhancement in animal weight gains for each day. The improvement of feed conversion ratio reached 8.82% while the cost per kilogram of weight gain reduced by 12.20% which resulted in increased operational efficiency and reduced expenses. The combined data shows that PLF implementation enables improved animal welfare with simultaneous advantages for economic performance and sustainability and stock production in agricultural facilities.

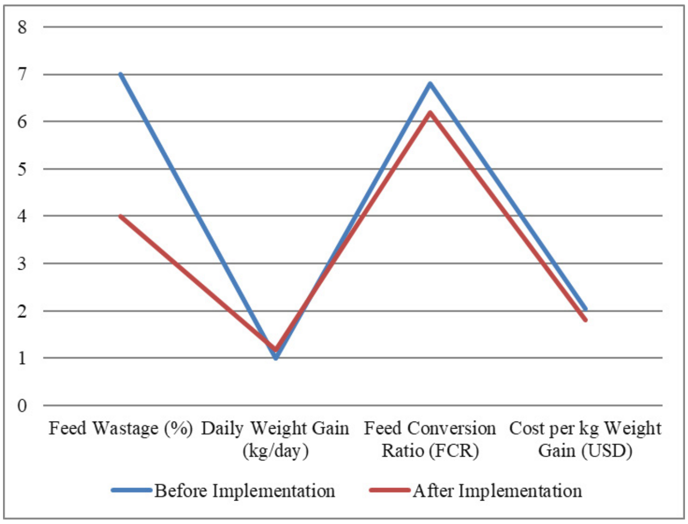


**Figure 3:** Graphical representation on before and after implementation.

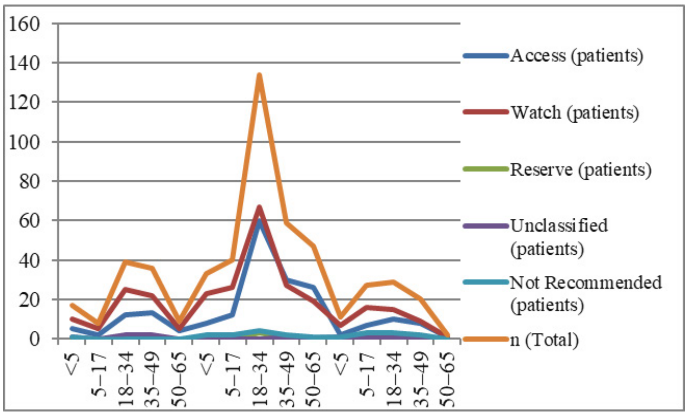


**Figure 4:** Antibiotic use before and after seeking care for acute febrile illness.

The provided image (Figure 2) visualizes antibiotic therapy use throughout different age groups before AFI onset and during and following the need for medical care for acute febrile illness. The antibiotic encounter data shown in the bar chart divides medications into five categories from the WHO's AWaRe system including access (green), watch (yellow), reserve (red), unclassified (black) and not recommended (gray). Before seeking care antibiotic consumption mainly uses the "Watch" category (yellow) throughout all age groups according to the data while "Watch" stays most prominent within the 5–17, 18–34 and 35–49 age categories. The "Access" antibiotics (green) account for a smaller proportion, generally between 20–40%. When patients seek care from professionals the age groups under five years old and fifty-five through sixty-five receive non-recommended gray antibiotics. Medical treatment introduces changes in prescription patterns at the "During" phase. The percentage of "Watch" antibiotics diminishes while "Access" antibiotics increase in prescriptions which indicates better antibiotic prescription practices across age groups including those younger than five years old and five-year-old to seventeen-year-old groups and thirty-five-year-old to forty-nine-year-old groups. The use of "Reserve" (red) antibiotics occurs sparingly in cases of medical treatment among the 18–34 and 35–49 age groups. Accumulations of both medical categories named "Unclassified" (black) and "Not recommended" (gray) antibiotics remain quite limited because healthcare professionals follow prescription guidelines.

During the "After" care-seeking stage the antibiotic prescriptions mostly involve drugs classified as "Watch" antibiotics. Among the "Access" antibiotic group there remains a stable use pattern within the smaller patient demographics of ages under 5 years old and between 5 and 17 years old. The use of "Unclassified" (black) antibiotics grows slightly in the 18–34 and 35–49 years age groups possibly due to antibiotic usage that does not comply with WHO clear guidelines. After patients sought care no antibiotics classified under the Reserve category were prescribed thus indicating caution during treatment recovery. The illustration shows major differences between antibiotic prescriptions across different ages and time periods. Post-care results point toward unfinished antibiotic stewardship efforts because the usage of Access antibiotics and minimal improper prescriptions during care diminishes while patients resume at least some watch-group and unclassified antibiotic use. The need exists for well-structured patient education and comprehensive follow-up because it helps prevent antibiotic misuse and development of antibiotic resistance.

## CONCLUSIONS AND RECOMMENDATIONS

The research shows that Precision Livestock Farming technology demonstrates positive impacts on animal welfare together with increased productivity achievements by measuring lower disease prevalence and feed conservation and improved survival rates. Smallholder farmers need to adopt Precision Livestock Farming by receiving training in the technology and using systems that are easy to operate for sustainable success.

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## NOVELTY STATEMENT

The originality of this research is in its systematic and data-intensive analysis of Precision Livestock Farming (PLF) systems and their quantifiable effects on farm production and overall farm success. Although PLF technologies have been debated at length in terms of their potential effects, few studies have utilized such a systematic, large-scale examination based on comprehensive quantitative data taken from a broad variety of empirical studies and real-farm case reports. This paper fills that gap by not only tabulating but systematically evaluating performance measures like animal health outcomes, stress, feeding efficiency, reproductive success, and disease prevention measures across various livestock industries. By concentrating on measurable outcomes from field-based uses instead of theoretical hypotheses, the study offers tangible proof of how PLF technologies affect the fundamental operational and economic features of livestock production, emphasizing their ability to enhance both animal welfare and productivity in real-world, quantifiable terms.

This research contributes to the existing body of knowledge by providing an inclusive assessment of the contribution of PLF toward farm prosperity a facet that is largely unexplored in the current body of literature. While existing research has emphasized standalone aspects such as monitoring animal health or feeding accuracy, this paper specifically evaluates the comprehensive contribution of PLF systems towards long-term farm profitability and sustainability. The organized structure of the paper enables cross-comparison among various technological interventions and their compounded impacts on farm efficiency and economic performance. This holistic approach not only offers a new angle of vision but also offers actionable insights to farmers, policymakers, and agri-tech developers. It underlines that PLF is not just a technology trend but a force of change that can promote economic resilience, resource optimization, and ethical livestock management at scale.

## AUTHOR'S CONTRIBUTION

All of the trials were designed by OAH, OMK. HBF, AAH and WMD conducted all of the tests, gathered the data, and composed the manuscript draft. YAI and HAA-AA helped with the data analysis that was done to prepare the work for submission to the journal. The final draft of the work was reviewed and approved by all authors for publication in the Journal of Animal and Health Production.

### Ethical consideration

Not applicable.

### Generative AI or AI-assisted Technology Statement

The author(s) declare that no Genrative AI was used in the creation of this manuscript.

## Conflict of interest

The authors have declared no conflict of notice.

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