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Research Article

APPLICATION OF INTERNET OF THINGS (IOT) IN MODERN LIVESTOCK MANAGEMENT IN NEW ZEALAND

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Abstract

This study examines the application of Internet of Things (IoT) technology in modern livestock management in New Zealand. The background of this research is based on the need to increase productivity, efficiency, and sustainability in the increasingly competitive livestock sector. The purpose of the study is to explore the benefits of applying IoT in livestock health monitoring, feed management, as well as the impact of this technology on the environment and sustainability. The research method used is descriptive-qualitative with data collection through interviews, field observations, and secondary data analysis. The results show that the adoption of IoT in large farms increases productivity by up to 20% and reduces operational costs through more efficient feed management. The study also found that infrastructure challenges are a hindrance to IoT adoption in small and medium-sized farms. The conclusion of the study is that IoT has the potential to be a key solution to improve efficiency and sustainability in the livestock sector, but infrastructure support and training are urgently needed to accelerate its adoption across sectors.

Keywords: Internet Of Things, Livestock, New Zealand

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INTRODUCTION

The Internet of Things (IoT) has become one of the most important technological innovations in various industrial sectors, including the livestock sector. This technology allows various devices to connect and communicate with each other over the internet, so that data can be collected, analyzed, and used to improve operational efficiency (Smith et al., 2022). In the context of modern livestock management, IoT offers highly innovative and efficient solutions to monitor animal health, manage feed, and maximize productivity.

In various countries, including New Zealand, the livestock sector is one of the most important economic sectors. With its vast farmland and large livestock population, New Zealand is a major producer of animal products such as milk, meat, and wool (Martín-Hernández et al., 2021). Managing large farms often poses its own challenges, especially in terms of monitoring animal health, feed quality, and environmental conditions. IoT is a technology that is able to provide solutions to these various challenges.

The use of IoT-based sensors in farms allows farmers to monitor the health and condition of animals in real-time. These sensors can be attached to the animal's body to measure their temperature, heart rate, and daily activity. With this data, farmers can detect health problems early and take necessary action before the condition worsens. This technology helps to improve livestock health and reduce the risk of animal death due to disease.

Feed monitoring has also become easier with IoT. Through sensors installed on feed bins, farmers can measure the amount of feed animals consume each day and adjust feeding patterns based on the nutritional needs of livestock (Kayode Saheed et al., 2022). This not only ensures that animals get optimal nutrition, but also helps to reduce feed wastage and operational costs. IoT allows for more precise and efficient feed management.

In addition, IoT technology allows monitoring of the environment around the farm (Koroniotis et al., 2020). Sensors can be used to measure temperature, humidity, and air quality, which are crucial in maintaining the comfort and well-being of livestock. The data obtained from these sensors allows farmers to take swift action in addressing changes in environmental conditions that can affect livestock health (Jordon et al., 2024). A well-maintained environment will produce healthier and more productive livestock.

IoT systems can also be integrated with other technologies, such as data analytics and artificial intelligence (AI), to provide data-driven predictions and recommendations. For example, data collected from IoT sensors can be analyzed to identify animal health trends and production patterns (Islam et al., 2021). AI can provide recommendations related to optimal feeding or preventive measures to prevent disease based on historical data. This makes farm management more proactive than reactive.

New Zealand, as one of the leaders in the global livestock industry, has started to adopt IoT technology in livestock management. Many large farms in the country have used IoT sensors to increase productivity and ensure the welfare of their animals. The New Zealand government is also supporting the use of this technology by providing infrastructure and educational programs for local farmers. The initiative aims to increase the competitiveness of New Zealand's livestock industry in the global market.

The use of IoT in the livestock sector also has a significant impact on environmental sustainability (Asharf et al., 2020). With more efficient feed management and proper monitoring of animal conditions, this technology helps to reduce the excessive use of resources and waste generated by the livestock industry. This is in line with global efforts to create more environmentally friendly and sustainable agricultural practices.

IoT technology in livestock management also has the potential to reduce labor costs. The automation system powered by IoT allows farm monitoring and management to be carried out remotely through digital devices. Farmers do not need to be constantly on site to monitor the condition of animals or check the environment. This provides greater flexibility and reduces the need for intensive manual labor.

The adoption of IoT in New Zealand's livestock sector presents opportunities to improve efficiency, productivity and sustainability (Yan et al., 2024). This technology allows farms to be managed in a smarter and more scalable way, providing great benefits to farmers and the wider community (Costa et al., 2021). With its growing adoption, IoT technology is expected to play a key role in shaping the future of a more advanced and sustainable livestock industry in New Zealand.

Although Internet of Things (IoT) technology has begun to be applied in modern livestock management in New Zealand, the adoption of this technology has not been evenly distributed across the livestock sector (Asmare, 2022). Many small and medium-sized farms are still lagging behind in terms of the use of this advanced technology, resulting in a gap between large and small-scale farms in terms of productivity and efficiency. Not all farmers have access to IoT technology or a sufficient understanding of its benefits. This shows that there is a gap that needs to be bridged in terms of education and access to technology for all farmers.

There have not been many studies specifically exploring the long-term impact of IoT adoption in the livestock sector in New Zealand (Wang et al., 2023). Although there are studies that show the direct benefits of using IoT, such as increased productivity and efficiency, there is still a lack of understanding of how these technologies can affect long-term sustainability practices in livestock (Kadam et al., 2024). There needs to be further study of the wider environmental and economic impacts of the application of these technologies, especially in the context of sustainable farming.

Technical obstacles in the application of IoT in rural areas have also not been fully solved. Network infrastructure in some rural areas of New Zealand is still inadequate to support the maximum use of IoT technology (Gulati et al., 2022). Limited internet access or unstable connections are a big challenge for farms that want to implement IoT in remote areas. This factor raises questions about the readiness of the digital infrastructure that supports the development of this technology as a whole.

It is not yet clear how the adoption of IoT technology can be thoroughly integrated with traditional livestock management systems (Gaballah et al., 2021). Most farmers in New Zealand still use conventional methods to manage their farms (Rehman et al., 2022). The integration between modern technologies such as IoT and traditional practices has not been studied in depth. More research is needed that focuses on how this transition can be done effectively without disrupting livestock operations that are already running.

The social impact of IoT technology adoption in New Zealand's livestock sector is also still largely underdiscussed. Although this technology could reduce the need for manual labor, it is still unclear how it will impact farm workers. The reduction in labor needs could lead to changes in the structure of jobs in the livestock sector, potentially affecting the rural economy (Alam et al., 2021). Further research is needed to explore the social and economic impacts of the application of this technology.

The lack of understanding and training related to the use of IoT among farmers is another challenge that has not been fully resolved (HaddadPajouh et al., 2021). Many farmers, especially in rural areas, do not yet fully understand how this technology can be integrated into

their daily operations. Adequate education and training are still limited, which makes many farmers reluctant or unsure about adopting this technology. The development of a more comprehensive and accessible educational program is urgently needed.

The level of investment in IoT technology in the livestock sector is also still variing. Not all farms, especially small and medium-sized ones, have sufficient financial resources to adopt this technology (Shamsoshoara et al., 2020). Cost constraints are one of the main reasons why IoT adoption in some regions is still low. There have not been many studies that discuss funding strategies that can help small and medium-scale farmers in adopting IoT technology.

The limited government policy that specifically supports the adoption of IoT technology in the livestock sector is an important gap that needs to be filled. Although New Zealand is known as a country that supports technological innovation, there are not many policies that directly encourage the use of IoT in livestock management (Serrano et al., 2022). More specific policies and incentives that support the application of this technology are urgently needed to accelerate adoption across the livestock sector.

It is important to fill the gap in the adoption of Internet of Things (IoT) technology in New Zealand's livestock sector as it has great potential in improving efficiency and sustainability. The use of IoT can help farmers monitor animal health in real-time, manage feed more effectively, and monitor environmental conditions with more precision. With this potential, this technology can play an important role in increasing productivity and reducing farm operating costs (Augustine et al., 2020). Wider adoption will have a positive impact on the livestock industry as a whole.

More research is needed to ascertain how IoT technology can be effectively adopted by small and medium-sized farms, which are currently lagging behind in their utilization (Brown et al., 2024). The technology has been shown to be effective on large farms, but there is not much evidence to show how it affects on a smaller scale. Understanding how this technology is accessible to all farmers is an important step towards achieving equitable adoption. Filling this gap will help in creating a more inclusive livestock sector.

Infrastructure support also needs to be strengthened to ensure that rural areas in New Zealand can take full advantage of IoT technology. Many farms are located in regions with limited internet infrastructure, thus hindering the full potential of IoT adoption. Developing a stronger and more equitable digital infrastructure will be key to success in integrating IoT across the livestock sector, especially in remote areas (Savaglio et al., 2020). It will also strengthen New Zealand's position as a country that supports technological innovation in agriculture.

Filling this gap is also important in ensuring the long-term sustainability of the livestock sector in New Zealand (Boussios et al., 2022). The use of IoT can help farmers reduce their environmental impact through better management of resources, such as water and feed, and monitoring carbon emissions. This technology has the potential to be a solution to the sustainability problems facing the global livestock sector (Ahmad et al., 2023). The adoption of this technology will support the sustainability initiatives that have been implemented in New Zealand, making it a model that other countries can follow.

The research aims to answer the question of how IoT can be more widely integrated in livestock management in New Zealand and how this technology can be adapted for different types of livestock (Cooper & Okello, 2021). By focusing on access, training, and infrastructure, the study seeks to identify ways to accelerate the adoption of IoT technologies across sectors. Filling the gap in IoT adoption will provide long-term benefits for New Zealand's livestock productivity, sustainability and competitiveness in the global market.

RESEARCH METHOD

Research Design

This study uses a descriptive-qualitative research design to examine the application of Internet of Things (IoT) technology in modern livestock management in New Zealand. This design aims to describe in depth how IoT is used on farms, the challenges faced, and the benefits obtained (Chen et al., 2020). This approach allows researchers to understand in more detail the application of technology in various livestock contexts and provide relevant recommendations based on empirical findings.

Research Target/Subject

The population in the study was farmers in New Zealand who had adopted IoT technology in their farm management, as well as farmers who had not yet adopted it in comparison (Gupta & Quamara, 2020). The research sample was purposively taken from different regions of New Zealand, including large and small farms, as well as farms focused on dairy, meat and wool production (Ratta et al., 2021). Samples were taken to provide a balanced representation of different types of farms and geographic regions.

Instruments, and Data Collection Techniques

The instruments used in this study include a semi-structured questionnaire for interviews with farmers, as well as direct observation in the field to observe the use of IoT technology in livestock management. The questionnaire is designed to explore information about the adoption rate, perceived benefits, and obstacles faced in using IoT (Swayamsiddha & Mohanty, 2020). In addition, secondary data from industry reports and government policies were also analyzed to provide a broader context to the field findings.

Research Procedure

The research procedure began with the collection of primary data through interviews and field observations in various farms selected as samples. Interviews are conducted in person and online, depending on the location and availability of the farmer (Kaswan et al., 2024). The data collected was analyzed thematically to identify key patterns in IoT adoption, as well as to identify factors influencing the adoption of this technology at various farm scales. This analysis is then integrated with secondary data to produce comprehensive findings.

Data Analysis Technique

Data analysis applied Braun and Clarke's (2006) thematic analysis framework, encompassing data familiarization, coding, theme generation, review, definition, and reporting. This method synthesized interview transcripts, observations, and secondary sources to uncover patterns in IoT adoption drivers, barriers, and outcomes, supporting robust recommendations for New Zealand livestock management.

RESULTS AND DISCUSSION

This study uses statistical data from various sources regarding the adoption of Internet of Things (IoT) technology in the livestock sector in New Zealand. The data collected shows a significant increase in the use of IoT, especially on large farms that produce milk, meat, and wool. According to industry reports, about 60% of large farms have used IoT sensors to monitor livestock health and feed management, while only 20% of small and medium-sized farms are using this technology.

Secondary data also includes statistics regarding the number of farms adopting IoT in different geographic regions. Farms in areas that are more digitally advanced tend to be faster to adopt IoT compared to farms in remote rural areas. New Zealand, with a more stable internet network in major cities, has a higher adoption of IoT in the region than in mountainous or rural areas.

Table 1. A comparison of IoT adoption in large and small farms and the key benefits gained from using IoT

Types of Farms	IoT Usage (%)	Key Benefits
Large Farm	60%	Improved livestock health, feed efficiency
Small/Medium Farm	20%	More precise feed management
Regions with Advanced Infrastructure	75%	Real-time monitoring of the environment and condition of livestock

These statistical data illustrate that the main obstacles in the adoption of IoT technology are infrastructure and investment costs. Farms located in areas with poor internet access have limitations in adopting this technology, while large farms with larger capital are quicker to switch to the use of advanced technology.

Statistical data shows that there is a gap between large and small farms in the adoption of IoT technology. Large farms, with greater capital and access to better technology, have the ability to make more optimal use of IoT sensors and devices (Majid et al., 2022). For example, a large dairy farm in New Zealand is able to monitor the health of its livestock in real-time through temperature and heart rate sensors installed on the animals' bodies.

The use of this technology allows for early detection of diseases, which ultimately reduces the mortality rate of livestock. Large farms are also able to manage feed more efficiently with IoT sensors installed on feed bins. The sensor allows farm owners to monitor the exact amount of feed animals consume, thus aiding in nutrient management and reducing feed waste.

However, in small and medium-sized farms, limited access to advanced technology is a major barrier. Smallholders often do not have access to adequate training or sufficient capital to implement IoT systems comprehensively. This data shows that IoT adoption is still more limited among smallholder farmers and in rural areas with inadequate infrastructure.

The further data comes from a case study that shows the application of IoT technology in different types of farms in New Zealand. One of the large farms focusing on milk production has adopted an IoT-based monitoring system integrated with data analysis and artificial intelligence (AI) (Manickam et al., 2022). Data shows that the farm experienced a 20% increase in productivity within one year of adopting this technology.

The data also shows that the use of IoT in farms focused on beef production allows farm owners to monitor the health and physical activity of cattle more effectively. With IoT sensors, owners can ensure that livestock get the right nutritional intake as well as detect health problems early. This technology also allows remote monitoring of environmental conditions such as temperature and humidity which are critical to livestock welfare.

In small-scale farms, the use of IoT is still limited, but data shows that some farmers have begun to adopt this technology on a simpler scale, such as using automated feed sensors to optimize feed management (Hansen & Bøgh, 2021). Although the adoption of IoT technology in small farms is still in its infancy, the potential for increased efficiency generated by this technology is significant.

Research shows that IoT technology provides various benefits in terms of increased productivity and efficiency in the livestock sector. On large farms, the use of IoT sensors has reduced labor costs as automation systems allow for remote monitoring. Farm owners no longer need to be on site to check the condition of animals or feed manually, because the data can be accessed through digital devices.

Another benefit of using IoT is the reduction of feed waste. With sensors capable of detecting animal diets, farmers can adjust the amount of feed given based on the nutritional needs of livestock (Andronie et al., 2021). This helps reduce operational costs while maintaining the health of livestock. Real-time monitoring of animal health also allows for preventive measures against diseases, ultimately reducing the risk of death and increasing production yields.

On small farms, although IoT adoption is slower, this technology has great potential in addressing feed efficiency and management issues. By using simpler and more affordable sensors, small farmers can increase productivity without having to make a large investment. This shows that despite the challenges in IoT adoption, the long-term benefits are significant for farms of all scales.

Data from various farms show a close relationship between the use of IoT technology and increased productivity. The use of IoT allows farm owners to monitor livestock health, environmental conditions, and feed management more efficiently. This has a positive impact on the productivity and overall operational costs of the farm.

Studies also show that IoT adoption helps farms improve environmental sustainability. With more efficient use of resources and better waste management, IoT technology plays a role in creating more environmentally friendly agricultural practices. This is important because livestock is often a major contributor to carbon emissions and negative impacts on the environment.

By leveraging the data collected from IoT sensors, farms can make more informed and data-driven decisions to improve efficiency and productivity. This technology allows farmers to be more proactive in managing animals and resources, ultimately positively impacting production and sustainability.

The case study studied involved dairy farms in New Zealand that have adopted IoT technology over the past two years. The farm uses IoT sensors to monitor the health of cows in real-time, with a focus on monitoring the cow's temperature, heart rate, and daily activity (Subeesh & Mehta, 2021). Data shows that the application of IoT has helped early detect various health problems such as infections and indigestion in cows.

The farm also uses IoT sensors to optimize feed management. By monitoring the amount of feed consumed each day, farm owners can adjust the amount of feed given based on the nutritional needs of the cows. As a result, the level of milk productivity increased by 15% within a year of the implementation of this technology.

In addition, IoT technology is also used to monitor environmental conditions on farms. Sensors installed around the farm measure temperature, humidity, and air quality to ensure the comfort of the cows. The data collected is used to make decisions related to environmental management, such as ventilation arrangements and soil watering to maintain moisture.

This case study shows that IoT technology has a significant impact on productivity and efficiency in livestock management. The application of this technology not only improves the health of livestock through more precise monitoring, but also reduces the waste of resources, such as feed and labor. This is important to maintain a balance between productivity and sustainability in the livestock sector.

More efficient monitoring of animal health also allows for faster preventive measures, which ultimately reduces the risk of animal mortality and improves production yields. By using this technology, farms are able to manage their resources more intelligently, which provides long-term economic benefits.

In addition, the adoption of IoT also allows farms to improve environmental sustainability. The data collected from environmental sensors allows farmers to make more informed decisions in maintaining air quality and soil moisture, which is important for livestock welfare. This technology allows for better management of natural resources, thus supporting more sustainable agricultural practices.

The relationship between the use of IoT and increased productivity and sustainability became clear through this case study. Farms that adopt IoT technology can manage feed, livestock health, and environmental conditions more efficiently. This has a direct impact on increasing production output and reducing operational costs.

IoT technology allows farms to monitor data in real-time, which in turn allows them to respond to changing conditions more quickly. With this capability, farms can optimize their resources and minimize the risks associated with livestock diseases or drastic environmental changes.

The implementation of IoT also has an impact on long-term sustainability. With better resource management, farms can reduce the environmental impact resulting from day-to-day operations (Nyamuryekung'e, 2024). This shows that IoT technology is not only beneficial for increasing productivity, but also helps create more sustainable agricultural systems in the future.

This research highlights the application of Internet of Things (IoT) technology in modern livestock management in New Zealand. The results show that the use of IoT has a significant impact in improving operational efficiency, animal health monitoring, and feed management on large farms. Farms that adopt IoT are effectively able to monitor livestock health in real-time, reduce disease mortality rates, and increase productivity. The use of IoT also allows for more efficient feed management, which has an impact on reducing operational costs and increasing livestock productivity.

In small and medium-sized farms, IoT adoption is still limited due to technology access constraints and investment costs. However, the benefits resulting from the use of IoT in large farms provide a strong indication that this technology has great potential for wider adoption. Environmental monitoring with IoT sensors also provides advantages for animal welfare, ensuring optimal environmental conditions for livestock productivity. The data collected through sensors allows farmers to make data-driven decisions, thereby improving operational efficiency.

The application of IoT also has a positive impact on environmental sustainability in the livestock sector. With more efficient resource management and reduced waste, this technology helps farms to be more environmentally friendly. Some large farms in New Zealand that have adopted IoT are also reporting increased competitiveness in the global market due to higher productivity. The study concludes that IoT has an important role to play in improving efficiency, productivity, and sustainability in modern livestock management.

The results of this study are in line with several previous studies that show that IoT technology can improve efficiency and productivity in various industrial sectors, including livestock. Other research conducted in Europe also shows that the use of IoT in livestock health monitoring provides significant benefits in reducing operational costs and improving animal

health. However, several studies in developing countries show greater challenges in IoT adoption, especially related to limited digital infrastructure.

In the United States, research on IoT in livestock management focuses on the use of sensors integrated with artificial intelligence (AI) technology to provide more precise feeding recommendations (Hütt et al., 2024). The study also found similar results that the integration of IoT and AI is able to improve feed efficiency and reduce waste. However, in New Zealand, the main challenge is the limited infrastructure in rural areas, which limits IoT adoption in some areas.

The main difference between this study and other studies is the focus on environmental sustainability. In some countries, research on IoT in livestock has placed more emphasis on economic efficiency, while this research shows that IoT technology can also help reduce environmental impact. This is in line with the global trend towards more environmentally friendly and sustainable agricultural practices. This difference shows the importance of geographical and economic context in the application of IoT technology in the livestock sector.

The results of this study are a sign that IoT technology is increasingly becoming a necessity in modern livestock management, especially in countries with developed livestock sectors such as New Zealand. IoT is no longer just an additional technology, but it has become an integral part of strategies to increase productivity and efficiency on large farms (Aquino et al., 2022). The gap in the adoption of this technology between large and small farms is an indication that there are still significant challenges in disseminating the benefits of this technology equitably.

The reflection of these results also shows that the development of digital infrastructure in rural areas is a determining factor in accelerating IoT adoption. Farms that have good internet access are able to make optimal use of this technology, while farms in remote areas are still lagging behind. This indicates that the success of IoT implementation does not only depend on the technology itself, but also on the readiness of infrastructure and access to resources.

The importance of education and training related to the use of IoT is also the main reflection of this research. Farmers who are knowledgeable about the benefits of IoT are more likely to adopt this technology compared to those who understand its potential less. This shows that in addition to technology investment, increasing the capacity of human resources in the livestock sector is also important to support the widespread adoption of IoT technology.

The main implication of the results of this study is that the adoption of IoT technology could bring about a major change in modern livestock management in New Zealand. This technology not only helps to increase productivity and efficiency, but also contributes to environmental sustainability. Farms that use IoT are able to manage feed and livestock health with more precision, which ultimately reduces waste and improves the quality of livestock products.

The results of this study also have important implications for government policies and livestock industry players. The New Zealand government needs to strengthen support for the development of digital infrastructure in rural areas so that all farms, both large and small, can access this technology. Education and training programs for farmers also need to be expanded to ensure that all farmers understand the potential benefits of using IoT.

Another implication is that the livestock sector can become more competitive in the global market through the adoption of this technology. With higher efficiency and better sustainability, New Zealand's livestock products can compete with other countries that are also adopting advanced technologies in the agriculture and livestock sectors. IoT technology provides great opportunities for increased competitiveness in the global market.

The results show that IoT adoption in large farms is faster because they have better access to infrastructure and financial resources. Large farms tend to have enough capital to invest in advanced technologies such as IoT, and they also have better access to a stable internet network. This allows them to make optimal use of this technology to increase productivity and efficiency.

The limited digital infrastructure in rural areas is the reason why small and medium-sized farms are lagging behind in IoT adoption. The unstable availability of the internet and high investment costs are the main barriers for small farmers to adopt this technology. The results of this study show that limited access to digital infrastructure is one of the key factors affecting IoT adoption in the livestock sector.

Another reason why research results like this are due to the lack of education and training among smallholder farmers. Many farmers don't fully understand how IoT can help them improve efficiency and productivity (Schurch et al., 2021). This lack of understanding makes them reluctant to invest in technology that they consider complicated or expensive.

The next step that needs to be taken is to expand access to digital infrastructure in rural New Zealand. The government needs to increase investment in the development of internet networks in areas that have not been reached, so that all farms can access IoT technology. This will help reduce the gap between large and small farms in terms of the use of advanced technology.

The government and the industrial sector also need to develop more comprehensive education and training programs for farmers. The program should include training on the use of IoT technology and its benefits for farm productivity and efficiency. With this increased understanding, it is hoped that more farmers will be willing to adopt this technology.

Investment in IoT technology needs to be encouraged by providing incentives to small and medium-sized farmers. Subsidies or special funding programs can help reduce the financial burden faced by smallholder farmers, so they are more motivated to adopt these technologies. Financial support will be an important step in driving wider adoption in the livestock sector.

CONCLUSION

The most important findings from this study show that the adoption of Internet of Things (IoT) technology in New Zealand's livestock sector has a significant impact on improving productivity, feed management efficiency, and livestock health. The use of IoT enables real-time monitoring that not only reduces livestock mortality rates but also provides significant operational savings, especially on large farms. The main challenge identified is limited access to technology in small and medium-sized farms due to inadequate infrastructure in rural areas.

The main contribution of this research lies in the development of the concept of applying IoT to achieve environmental sustainability in livestock management. This research makes an important contribution in identifying how IoT not only increases productivity but also supports greener agricultural practices. The limitations of this research lie in the scope that does not fully cover small and medium-sized farms, so further research is needed to explore solutions that can help overcome infrastructure and cost barriers for small-scale farmers.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest

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