Review Article

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Veterinary telemedicine: Current trends, benefits, and challenges in clinical practice

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ABSTRACT

Telemedicine has emerged as a key innovation in veterinary practice, particularly in response to the growing demand for rapid, efficient, and accessible animal healthcare in the digital era. Its applications encompass remote consultations, health monitoring, emergency triage, and owner education through digital platforms and mobile devices. This review aims to analyze current trends, benefits, and limitations of veterinary telemedicine, as well as evaluate its implications for the quality of clinical services. Relevant literature was retrieved from PubMed, Scopus, and Web of Science using keywords such as "veterinary telemedicine," "telehealth in animals," and "remote veterinary consultation," with a focus on publications from the past decade. The findings indicate that telemedicine significantly improves service accessibility, particularly for owners in remote areas, while enhancing time and cost efficiency. It also supports chronic disease monitoring, facilitates collaboration among veterinary specialists, and strengthens owner education. Nevertheless, challenges remain, including inconsistent regulatory frameworks, diagnostic limitations due to restricted physical examinations, technical barriers such as poor internet connectivity, and difficulties in building owner trust in remote services. In conclusion, veterinary telemedicine holds substantial potential to strengthen modern clinical practice by improving efficiency and access to care. The development of standardized protocols, integration of advanced technologies such as artificial intelligence (AI) and the Internet of Things (IoT), and targeted training for both professionals and animal owners represent strategic measures to address current limitations. Further research is warranted to assess its effectiveness, safety, and user satisfaction, thereby ensuring optimal and sustainable implementation in veterinary medicine.

Introduction

Telemedicine is defined as the application of information and communication technologies to deliver medical services remotely, including consultation, diagnosis, monitoring, and education, without requiring the physical presence of either patients or healthcare providers (Haleem *et al*., 2021). In veterinary medicine, telemedicine, also referred to as veterinary telehealth, encompasses a wide range of services, such as online consultations between veterinarians and pet owners, real-time health monitoring through wearable devices, and clinical support among veterinary specialists located in different regions (Gyles, 2019). This concept has become increasingly relevant due to the advancement of digital technologies, the growing number of pet owners, and the demand for fast, efficient, and accessible animal healthcare services (Springer *et al*., 2024).

The history of veterinary telemedicine is relatively brief compared to its application in human healthcare; however, its adoption has expanded rapidly over the past decade (Juhro and Ridwan, 2021). Initially, such services were limited to consultations conducted via telephone or email. Today, veterinary telemedicine incorporates video conferencing platforms, mobile applications, electronic medical records, and Internet of Things (IoT)-based sensors that enable real-time physiological monitoring of animals (Hwang *et al*., 2021; Guintard *et al*., 2024). Global evidence demonstrates that telemedicine not only improves access to healthcare in remote areas but also serves as an essential tool for emergency triage, chronic disease management, and owner education on animal care, nutrition, and disease prevention (Saliba *et al*., 2012).

The principal benefits of telemedicine in veterinary medicine include improved accessibility, greater time and cost efficiency, and the capacity for continuous monitoring of animal health conditions (Efriyandi and Yulda, 2024). In addition, telemedicine facilitates collaboration among veterinarians in different locations, extends the reach of specialist services, and supports faster clinical decision-making (Rogers *et al*., 2017). From the perspective of animal owners, telemedicine can enhance treatment compliance, improve understanding of animal health conditions, and increase overall satisfaction with veterinary services (Abu-Seida *et al*., 2024).

Despite these advantages, the implementation of telemedicine faces several challenges and limitations (Hadian *et al*., 2024). Regulatory frameworks vary widely across countries, particularly concerning the legality of remote consultations, professional accountability, and the protection of medical data (Dubin *et al*., 2021; Raju and Sistla, 2022). Diagnostic limitations also pose a challenge, as many physical examinations, laboratory tests, and advanced diagnostic procedures still require in-person visits (Hosseini *et al*., 2024; Judijanto *et al*., 2024). Furthermore, technical barriers such as unreliable internet connectivity, limited digital literacy, and restricted access to suitable devices can reduce the effectiveness of telemedicine services (Jafarzadeh *et al*., 2022). Finally, factors such as pet owners' trust in the effectiveness of remote consultations and the readiness of veterinary clinics to adopt telemedicine fully remain significant

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obstacles to its widespread implementation (Sigesmund, 2022).

Considering these emerging trends, benefits, and limitations, this review aims to provide a comprehensive overview of telemedicine applications in veterinary practice. Specifically, the focus is on evaluating technological developments, the types of services currently available, clinical effectiveness, and key implementation barriers. The findings are expected to serve as a valuable reference for veterinary practitioners, policymakers, and researchers in developing optimal, safe, and sustainable telemedicine strategies. In addition, this review is intended to guide future research efforts aimed at enhancing the quality of animal healthcare through digital innovation.

Literature search methods

The literature reviewed in this study was obtained through a systematic search of major scientific databases, including PubMed, Scopus, Web of Science, and Google Scholar. The search strategy employed a combination of relevant keywords such as "veterinary telemedicine," "telehealth in animals," "remote veterinary consultation," "digital veterinary services," and other related terms. To capture recent developments in digital technology, the search was restricted to publications from the past ten years.

The inclusion criteria were as follows: (i) articles written in English; (ii) original research articles, review papers, or case reports related to telemedicine in veterinary practice; and (iii) studies providing empirical data or relevant analyses concerning the implementation, benefits, or limitations of telemedicine. Exclusion criteria comprised: (i) articles unrelated to veterinary clinical services or focusing solely on human telemedicine; (ii) editorials, opinions, or commentaries lacking scientific evidence; and (iii) studies with unclear objectives or low methodological quality.

The selection process was carried out in several stages. First, titles and abstracts were screened to exclude publications that were clearly irrelevant. Second, the full texts of the remaining articles were evaluated to assess methodological soundness, topic relevance, and the quality of information provided. Eligible articles were then subjected to comprehensive analysis, including the identification of trends in telemedicine use, its benefits for veterinary practice, and the challenges associated with its implementation. The outcomes of the search and selection process are presented both quantitatively and qualitatively, including the initial number of records retrieved, the number retained after screening, and the final number of articles analyzed in depth, to ensure methodological transparency and reproducibility of this review.

History and development of veterinary telemedicine

Telemedicine in veterinary medicine began as a response to the need for faster and more widely accessible animal health services, especially in remote areas that are difficult to reach by physical clinics (Abu-Seida *et al*., 2024; Hadar, 2024). In its early stages, veterinary telemedicine was limited to remote communication via telephone, email, or electronic mail, which was used to provide simple clinical advice, triage cases, or consult on animal management (Karolina, 2023; Niemiec *et al*., 2024). Although effective in certain conditions, these early methods had significant limitations, particularly regarding the ability to perform physical examinations and verify health data accurately (Becker *et al*., 2023).

The next development came with advances in digital technology, particularly broadband internet and mobile devices, which enabled real-time video consultations between veterinarians and pet owners (Abu-Seida *et al*., 2024; Bök and Micucci, 2024). This service opens up the possibility of conducting initial triage, evaluating the patient's condition, and educating pet owners interactively, without having to bring the animal to the clinic. At this stage, telemedicine has also begun to integrate with electronic medical records (EMR), facilitating digital case documentation and long-term monitoring of animal health (Mishra and Sharma, 2023; Ratheesh *et al*., 2025).

In the last decade, the trend of veterinary telemedicine has grown with the advent of wearable devices and animal health sensors, which enable real-time physiological monitoring of animals, including heart rate, activity, and body temperature (Mitek *et al*., 2022; Zhao *et al*., 2025). Additionally, the integration of artificial intelligence (AI) and predictive algorithms has begun to be applied for health data analysis, early disease detection, and individualized treatment recommendations (Kothinti, 2024). This technology enables faster, more accurate, and evidence-based clinical decision-making, while expanding service capacity beyond physical clinics (Alowais *et al*., 2023).

This digital transformation marks a paradigm shift in veterinary practice, from a conventional consultation model based on physical visits to a hybrid model, where telemedicine complements traditional clinic services (Hadar, 2024; Ratheesh *et al*., 2025). Recent studies and reports show that the adoption of veterinary telemedicine not only improves the accessibility and efficiency of services but also supports collaboration between veterinary specialists, monitoring of chronic patients, and education of pet owners, thereby strengthening the overall quality of animal health services (Hadar, 2024; Nicolas *et al*., 2024).

Types of telemedicine services in veterinary practice

Veterinary telemedicine encompasses various types of services designed to improve the effectiveness, accessibility, and quality of animal health services (Abu-Seida *et al*., 2024). Table 1 summarizes the four main types of telemedicine services currently used in veterinary practice. Each service has specific functions that support accessibility, efficiency, and quality of animal care, ranging from initial consultations, remote patient monitoring, emergency treatment, to pet owner education. The integration of these services enables veterinary practices to be more modern, data-driven, and sustainable.

Online consultation

Online consultation allows veterinarians to interact directly with pet owners via video call, chat, or a dedicated mobile application (Sigesmund, 2022). This service is useful for initial assessment of the animal's condition, providing minor treatment advice, and answering owners' questions about symptoms and routine care (Sigesmud *et al*., 2024). Online consultations reduce the need for non-urgent physical visits, thereby improving the efficiency of clinic time and resources (Abu-Seida *et al*., 2024).

Remote monitoring

Remote monitoring uses wearable devices and animal health sensors to monitor physiological parameters such as heart rate, body tempera-

Table 1. The main types of telemedicine services are currently used in veterinary practice.

Types of Services	Brief Description	Benefits	Reference
Online consultation	Veterinarians provide advice via video or chat.	Reduce physical visits; save time.	(Abu-Seida *et al*., 2024)
Remote monitoring	Sensors or wearables monitor animal health in real time.	Early detection of problems; continuous monitoring.	(Nicolas *et al*., 2024)
Emergency triage	Assessment of emergency cases via telephone or video.	Prompt treatment reduces the risk of complications.	(Hadar, 2024)
Pet owner education	Nutrition education, care, and disease prevention.	Improving owner understanding and compliance.	(Ratheesh *et al*., 2025)

ture, activity levels, and eating patterns (Nicolas *et al*., 2024). This data can be sent in real-time to veterinarians, enabling continuous evaluation of patients, especially for animals with chronic diseases or those recovering from surgery (Hadar, 2024). This digital monitoring also supports data-driven clinical decision-making and early detection of changes in health status (DeWilde, 2021).

Emergency triage

Telemedicine enables veterinarians to perform initial triage of emergency cases before patients are brought to the clinic. Through video or telephone communication, veterinarians can assess the level of urgency, provide first aid instructions, and determine whether a physical visit is necessary (Care, 2022; Hadar, 2024). This triage service helps reduce the risk of complications, speeds up the handling of critical cases, and optimizes the allocation of clinic resources (Ireifej and Krol, 2023).

Pet owner education

Telemedicine also plays a role in educating pet owners about nutrition, routine care, disease prevention, and compliance with treatment protocols. This education can be provided through video tutorials, webinars, or interactive consultations, thereby increasing owners' understanding and involvement in maintaining the health of their pets (Dubin *et al*., 2021; Ratheesh *et al*., 2025).

The main types of telemedicine services currently applied in veterinary practice are summarized in Figure 1, including online consultation, remote monitoring, emergency triage, and pet owner education.

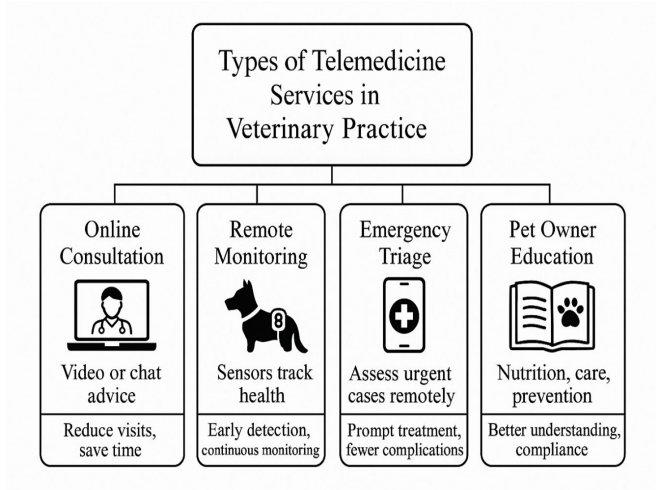

Figure 1. Types of telemedicine services in veterinary practice.

Technology adoption in veterinary telemedicine

The development of telemedicine in veterinary medicine is highly dependent on advances in digital technology, which enables remote animal health services to be carried out with high effectiveness (Abu-Seida *et al*., 2024). Table 2 describes the four main technologies adopted in veterinary telemedicine. Each technology plays a role in improving access, efficiency, and quality of animal health services. Currently, technology adoption covers several key aspects, namely mobile applications, video call platforms, wearable devices, and artificial intelligence (AI), each of which contributes to improving service quality (Becker *et al*., 2023; Diez *et al*., 2023).

Mobile applications

Mobile applications specifically designed for veterinarians provide an interface that facilitates real-time interaction between pet owners and veterinarians (Becker *et al*., 2023). Through these applications, pet owners can upload photos or videos of their pets' conditions, monitor vaccination schedules, access electronic medical records, and receive notifications related to care or treatment. The mobile application also allows integration with clinic systems for case documentation and animal health data analysis (Iqabal *et al*., 2021; Bök and Micucci, 2024).

Video call platform

The video call platform enables direct visual consultation between veterinarians and pet owners. This service is useful for initial triage, symptom examination, and educational consultations (Diez *et al*., 2023). Video calls allow veterinarians to assess behavior, mobility, or clinical signs that can be observed visually, thereby improving the accuracy of initial assessments without the need for physical visits (Lu *et al*., 2022).

Wearable devices

Wearable devices, such as physiological sensors and animal activity trackers, enable continuous monitoring of vital parameters, including heart rate, body temperature, sleep patterns, and activity levels (Zhao *et al*., 2025). Data collected in real-time can be uploaded to applications or cloud platforms, providing veterinarians with important longitudinal information for chronic health assessment, early detection of condition changes, and evaluation of therapeutic responses (George *et al*., 2023).

Artificial Intelligence (AI)

AI and machine learning algorithms are beginning to be applied in animal health data analysis, disease risk prediction, and individualized treatment recommendations (Ezanno *et al*., 2021). AI systems can process data from wearable devices, electronic medical records, or clinical histories to generate evidence-based clinical insights (Elhaddad and Hamam, 2024). The use of AI improves decision-making efficiency, aids in early diagnosis, and enables more effective animal population management (Rogers *et al*., 2024).

The development of veterinary telemedicine relies on the adoption of several digital technologies, including mobile applications, video call platforms, wearable devices, and artificial intelligence (AI), each of which contributes to improved accessibility, efficiency, and service quality (Figure 2).

Case studies and statistical data on the use of telemedicine in animals

A number of case studies and statistical reports show a significant increase in the adoption of telemedicine in veterinary practice (Bishop *et al*., 2021). For example, a national survey conducted in the United States reported that approximately 30–40% of veterinary clinics have im-

Table 2. Key technologies adopted in veterinary telemedicine.

Technology	Function	Benefits	Reference
Mobile application	Consultation, photo/video upload, medical record access	Facilitating communication and monitoring of animals	(Becker *et al*., 2023)
Video call	Initial triage and visual examination	Assessing symptoms without a physical visit	(Diez *et al*., 2023)
Wearable devices	Animal health and activity sensors	Monitor the condition of the animals continuously	(Zhao *et al*., 2025)
Artificial intelligence	Data analysis and disease risk prediction	Helping clinical decisions faster	(Rogers *et al*., 2024)

Table 3. Various case studies and statistical reports demonstrate the effectiveness and benefits of telemedicine in veterinary practice.

Types of telemedicine services	Studies / Sources	Key findings	Clinical impact / Benefits	Reference
Online consultation	National survey, USA	30–40% of veterinary clinics use online consultations	Improving service access, time efficiency, and owner satisfaction	(Abu-Seida *et al*., 2024)
Pet owner satisfaction	Telemedicine user survey study	>50% of owners are satisfied with the ease of access and speed of response	Improving adherence to medication and mild care protocols	(Putri, 2023)
Remote monitoring	Research on cats and dogs with chronic diseases	Wearable monitoring enables real-time adjustment of medication dosage	Reduce the risk of complications and decrease emergency visits	(Benis *et al*., 2023)
Postoperative monitoring	Longitudinal study	Reducing physical control visits by 25–30%	Improving owner compliance and ongoing patient management	(Dhaliwal *et al*., 2023)
Emergency teletriage	Case study	Video consultation before the animal's arrival speeds up treatment by 15–20 minutes	Improving the survival rate of critically ill patients	(Hadar, 2024)
Pet owner education	Tele-education program (webinars, mobile applications)	Increasing knowledge about disease treatment and prevention	Strengthening compliance with animal treatment and health management protocols	(Juodžentė *et al*., 2024)

plemented online consultation services as part of their routine practice over the past decade, with faster growth occurring during the COVID-19 pandemic due to mobility restrictions and the need for remote services (Abu-Seida *et al*., 2024). Another study shows that more than 50% of pet owners who use telemedicine services are satisfied with the ease of access and speed of response, especially for minor cases such as nutritional consultations, minor wound care, or monitoring of animals with chronic conditions (Putri, 2023).

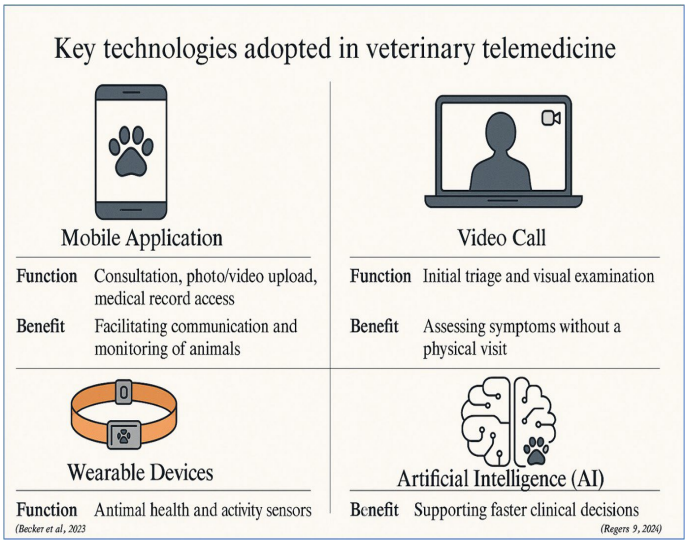

Figure 2. Key technologies adopted in veterinary telemedicine.

In the case of remote monitoring, studies on cats and dogs with chronic diseases (such as diabetes or heart disease) show that monitoring via wearable devices allows veterinarians to adjust medication doses and interventions in real time, thereby reducing the risk of complications and reducing emergency visits to the clinic (Benis *et al*., 2023; Hadar, 2024). A longitudinal study reported that the use of telemedicine for post-operative monitoring in dogs and cats reduced physical control visits by 25–30%, while increasing owner compliance with control and treatment schedules (Dhaliwal *et al*., 2023). Table 3 summarizes various case studies and statistical reports that demonstrate the effectiveness and benefits of telemedicine in veterinary practice. Telemedicine services not only improve clinic accessibility and operational efficiency but also have a positive impact on clinical outcomes, pet owner satisfaction, and sustainable animal health management (Juodžentė *et al*., 2024). This data reinforces the role of telemedicine as an integral part of modern veterinary practice.

In addition, a case study on emergency teletriage shows that the use of video consultations before the animal arrives at the clinic can speed up the handling of critical cases by 15–20 minutes, which can be an important factor in patient survival (Lu *et al*., 2022). On the educational side, tele-education programs for pet owners through webinars and mobile applications have successfully increased knowledge about animal care, disease prevention, and compliance with treatment protocols (Hanna, 2023). These data show that telemedicine not only improves the accessibility and efficiency of services, but also has a real impact on clinical outcomes, owner satisfaction, and sustainable animal health management (Dewsbury *et al*., 2022; Juodžentė *et al*., 2024). With this empirical evidence, telemedicine is increasingly recognized as an integral part of modern veterinary practice, especially in the digital age where distance and time constraints are major challenges in animal health services (Wu *et al*., 2021). The effectiveness of telemedicine in veterinary practice is illustrated in Figure 3.

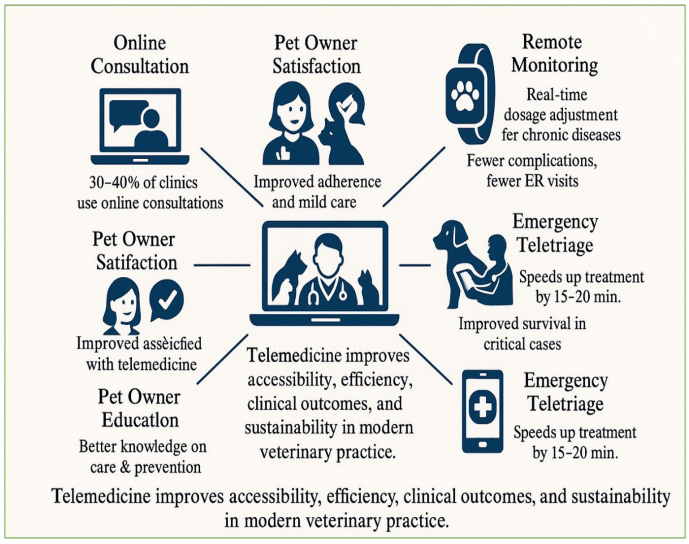

Figure 3. Adoption of telemedicine in veterinary practice.

The benefits of telemedicine in veterinary practice

Telemedicine has been proven to offer numerous significant benefits for veterinary practices, from both the veterinarian's and pet owner's perspectives.

Accessibility

One of the main benefits of telemedicine in veterinary practice is increased accessibility to healthcare services, especially for pet owners who live in remote areas or have limited mobility (Wu *et al*., 2021). Remote services allow pet owners to consult with veterinarians without having to

travel long distances to physical clinics, thereby reducing geographical and time barriers. This is important because limited access is often a factor in hindering early disease detection, monitoring chronic conditions, and providing timely medical interventions (Perez *et al*., 2025; Schürmann *et al*., 2025).

Studies show that telemedicine enables digital triage, whereby veterinarians can assess the urgency of a case before determining further action (Abu-Seida *et al*., 2024). Thus, emergency cases can be identified immediately, while non-emergency cases can still be handled through remote consultation, thereby optimizing clinic resources and reducing the risk of delayed treatment (Hadar, 2024). Additionally, increased accessibility through telemedicine promotes equity in animal health services, as owners from various socioeconomic backgrounds and geographic locations can obtain professional medical advice without the barriers of transportation costs or time (Angelopoulou and Papageorgiou, 2025). The integration of mobile applications, video calls, and electronic medical record systems further facilitates continuous monitoring and effective communication between veterinarians and pet owners (Sharun *et al*., 2024).

Time and cost efficiency

Telemedicine in veterinary practice contributes significantly to time and cost efficiency, both for veterinarians and pet owners (Springer *et al*., 2024). With remote services, many initial consultations, follow-ups, or minor cases can be handled without the need for a physical visit to the clinic. This allows veterinarians to optimize consultation schedules, reduce waiting times, and prioritize emergency cases that require immediate attention (Juodžentė *et al*., 2024; Niemiec *et al*., 2024).

From the pet owner's perspective, telemedicine reduces transportation costs and travel time, especially for those who live in remote areas or far from clinics (Springer *et al*., 2024). Reducing unnecessary physical visits also lowers the risk of stress on animals, as trips to the clinic often cause anxiety or fatigue in animal patients, especially those with sensitive health conditions (von der Beck *et al*., 2024). In addition, this efficiency supports more optimal management of clinic resources. For example, veterinarians can treat more patients in the same amount of time, as some consultations are conducted digitally (Juodžentė *et al*., 2024). Clinic administration can also be simplified through the integration of electronic medical records and telemedicine systems, which reduce the need for manual recording and increase the speed of patient data access (Lee *et al*., 2025).

Several empirical studies show that the application of telemedicine for post-operative follow-ups or chronic disease monitoring can reduce the number of physical visits by 25–30%, while maintaining service quality and owner compliance with doctor recommendations (Brookes *et al*., 2024). This efficiency in time and cost shows that telemedicine not only facilitates access to services but also increases clinic productivity and the overall well-being of animal patients (Ezeamii *et al*., 2024).

Continuous health monitoring

One of the main benefits of telemedicine in veterinary practice is the ability to continuously monitor animal health, especially in cases of animals with chronic diseases or post-surgery (Hadar, 2024). This continuous monitoring is carried out through the integration of wearable devices, physiological sensors, and mobile applications that enable real-time data collection, including heart rate, body temperature, activity patterns, feeding levels, and response to treatment (Shajari *et al*., 2023).

This continuously collected data allows veterinarians to identify changes in an animal's condition earlier, so that medical intervention can be carried out before the condition worsens (Singh, 2024). For example, animals with heart disease, diabetes, or metabolic disorders can be monitored digitally so that adjustments to medication doses, nutritional therapy, or other medical interventions can be made in a timely manner. This monitoring also supports post-operative patient management, where the risk of complications can be minimized through regular remote evaluations (Coman *et al*., 2024; Chortara *et al*., 2025).

In addition to clinical aspects, continuous monitoring through telemedicine improves pet owners' compliance with treatment and examination schedules (Abu-Seida *et al*., 2024). Owners receive notifications, reminders, or health status reports periodically through a mobile application, making it easier for them to follow the doctor's instructions accurately (Tauseef *et al*., 2024). Empirical studies show that continuous monitoring through telemedicine can reduce the number of physical visits by 25–30% for chronic or post-operative cases, without compromising the quality of health management (Akchurin *et al*., 2024). This not only improves clinic efficiency, but also reduces animal stress caused by travel to the clinic, as well as lowering the risk of nosocomial infections in sensitive animals (Boone *et al*., 2025).

Educating pet owners through telemedicine

In addition to consultations and health monitoring, telemedicine in veterinary practice plays an important role in educating pet owners in real time (Tauseef *et al*., 2024). This education covers various aspects, ranging from nutrition, routine care, disease prevention, to compliance with treatment protocols prescribed by veterinarians. With digital services, veterinarians can provide accurate and up-to-date information through video calls, mobile applications, webinars, and interactive educational modules (Wenzel *et al*., 2023; Gobinath and Ayyaswamy, 2024).

Providing education digitally has several clinical advantages. First, information is delivered in a personalized and contextual manner, so that pet owners better understand the specific conditions of their pets and how to care for them appropriately (Culduz, 2024; Kaswan *et al*., 2024). Second, real-time education allows pet owners to immediately follow up on the veterinarian's instructions, for example, in administering medication, changing diets, or managing mild symptoms at home. This increases compliance with medical recommendations and reduces the risk of complications or care errors (Zarei *et al*., 2024).

Several studies show that digital education programs, such as mobile applications that provide medication reminders, health records, or care tutorials, increase owners' knowledge by 40–50% compared to conventional education (Vaismoradi *et al*., 2025). In addition, pet owners who receive digital education tend to be more responsive to early warnings regarding their pets' health conditions, thereby supporting early disease detection and quick decision-making in critical cases (Al-Ghuraybi *et al*., 2024).

Clinical support and collaboration among veterinarians

Telemedicine not only facilitates interaction between veterinarians and pet owners, but also plays an important role in clinical support and collaboration among veterinarians or specialists (Shrivastava *et al*., 2025). In modern veterinary practice, some cases require multidisciplinary treatment, such as complex diseases, rare genetic conditions, or surgical cases that require specialist opinions (Han *et al*., 2024). Telemedicine enables remote consultation with specialists without the need to physically transfer patients, thereby speeding up the clinical decision-making process and reducing the risk of complications (Vallée and Arutkin, 2024).

Through digital platforms, veterinarians can securely share patient clinical data, including electronic medical records, radiographic images, laboratory results, or physiological monitoring data from wearable devices (Bök and Micucci, 2024). This collaboration enables joint assessment, differential diagnosis discussions, and the formulation of more accurate and evidence-based treatment plans. This collaborative approach also supports increased clinic capacity as veterinarians can leverage specialist expertise without geographical limitations, and enables peer-to-peer

mentoring or consultation that strengthens professional competence (Akinsulie *et al*., 2024; Gomes *et al*., 2025).

Studies show that telemedicine-based collaboration increases the efficiency of handling complex cases by 20–30% and improves diagnostic accuracy through multidisciplinary confirmation (Vincent *et al*., 2024). In addition, digital clinical support enables more consistent patient follow-up, as specialists can be involved in post-operative monitoring or long-term therapy, even though physical distance separates the clinic and the specialist's location (Azzellino *et al*., 2025). Figure 4 demonstrates the major benefits of telemedicine in veterinary practice, emphasizing its role in increasing accessibility, reducing costs, supporting continuous monitoring, educating pet owners, and facilitating professional collaboration.

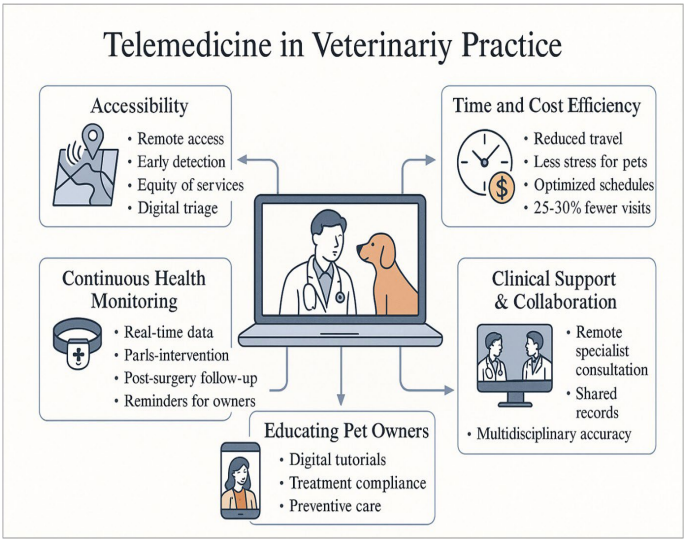

Figure 4. Benefits of telemedicine in veterinary practice.

Limitations and challenges of telemedicine

Although telemedicine offers various benefits, its implementation in veterinary practice faces a number of limitations and challenges that need to be considered.

Regulations and ethics

The implementation of telemedicine in veterinary practice faces significant challenges related to regulations and ethics. The legality of these online services varies from country to country, depending on regulations related to veterinary practice, telecommunications, and data protection (Airaj, 2024; Abu-Seida *et al*., 2024). Some jurisdictions stipulate that telemedicine can only be used as a supplement to face-to-face consultations, while others allow diagnosis and prescription through digital platforms with certain protocols (Raposo, 2016). This regulatory uncertainty can pose legal risks for veterinary practices and limit the widespread adoption of telemedicine (Hadar, 2024).

In addition to legal aspects, data protection and privacy are major concerns. Information about animal health conditions and owner data sent through digital platforms must be kept confidential in accordance with cybersecurity standards and data protection regulations (Neethirajan, 2025; Barton *et al*., 2025). Misuse or leakage of information can damage the clinic's reputation and have legal implications (Seh *et al*., 2020).

Practice ethics also require veterinarians to ensure professional competence and responsibility in remote services (Davis *et al*., 2025). Veterinarians must ensure that diagnoses, medical advice, and treatments provided through telemedicine comply with clinical practice standards and understand the limitations of telemedicine in replacing physical examinations (Anawade *et al*., 2024). In addition, clear communication about the limitations of telemedicine services to pet owners is necessary to maintain trust and professional integrity (Springer *et al*., 2024).

Diagnostic limitations in veterinary telemedicine

One of the main limitations of telemedicine in veterinary practice is the restriction on performing direct diagnostic examinations (Abu-Seida *et al*., 2024). Although digital platforms enable remote consultation, triage, and monitoring of animal physiological data, some diagnostic procedures still require physical interaction with the patient (Bök and Micucci, 2024). Examples of examinations that cannot be replaced by telemedicine include palpation, auscultation, blood sampling, urine or fecal examination, and radiography or ultrasonography (Restrepo *et al*., 2024).

These limitations have important clinical implications. Without a physical examination, veterinarians can only make preliminary or provisional diagnoses based on reports from animal owners, images or videos sent, and data from remote monitoring devices (Berlet *et al*., 2024). The accuracy of assessments may be reduced, especially in cases requiring in-depth evaluation or detection of clinical signs (Tong *et al*., 2024).

Several studies indicate that telemedicine is most effective for mild cases, post-operative follow-ups, or monitoring chronic conditions, but is less appropriate for definitive diagnosis of acute or complex diseases (Gordon *et al*., 2023). Therefore, telemedicine should be used to support face-to-face services, where final decisions on diagnosis and specific therapies still require physical examination (Mahdi *et al*., 2022).

Technical challenges

The implementation of telemedicine in veterinary practice is highly dependent on the availability and quality of technological infrastructure, making technical challenges one of the main obstacles (Becker *et al*., 2023). The main factors that influence the effectiveness of telemedicine services include the quality of the internet connection, user capabilities, and the quality of the hardware or software used (Alenoghena *et al*., 2023).

Telemedicine requires a stable and fast internet connection to enable real-time video consultations, transmission of physiological data from wearable devices, and access to electronic medical records (Alenoghena *et al*., 2023). Network disruptions or low bandwidth can reduce video and audio quality, making it difficult for veterinarians to observe clinical signs, triage, or educate pet owners. This condition is particularly problematic in remote areas or regions with limited internet infrastructure (Abu-Seida *et al*., 2024; Hadar, 2024).

Pet owners need to have basic skills in using digital devices and telemedicine platforms, including uploading photos or videos, reading monitoring results, and following the veterinarian's instructions (Mitek, 2022). Lack of digital literacy can lead to data transmission errors, misinterpretation of information, or non-compliance with medical recommendations, thereby affecting the accuracy of diagnosis and the effectiveness of interventions (Fitzpatrick, 2023).

The quality of hardware, such as cameras, microphones, wearable sensors, and computers or smartphones, affects veterinarians' ability to visually evaluate animal conditions and collect physiological data (Zhao *et al*., 2025). Devices that are less precise or incompatible with telemedicine platforms can produce inaccurate information, thereby limiting the clinical value of digital services (Shen *et al*., 2021).

Pet owners' trust in telemedicine

The success of telemedicine in veterinary practice is determined not only by technology and the capabilities of veterinarians, but also by the level of trust pet owners have in the effectiveness of online services (Juodžentė *et al*., 2024). Pet owners' perceptions play an important role in the adoption, compliance with medical recommendations, and continued use of telemedicine (Dubin *et al*., 2021).

Several studies show that some pet owners still doubt the ability of telemedicine to replace direct physical examinations (Springer *et al*.,

2024). These concerns are usually related to the accuracy of diagnosis, the ability of veterinarians to assess complex conditions virtually, and the limitations of physical observation (Burti *et al*., 2024). Pet owners who are unsure about online services tend to prefer face-to-face consultations, even though telemedicine offers ease of access and time efficiency (Sigesmund *et al*., 2024).

Other factors that influence trust are user experience, quality of interaction, and transparency of communication (Wanner *et al*., 2024). Telemedicine services that provide clear guidance, complete medical records, and professional interaction with veterinarians can increase pet owners' positive perceptions (Sigesmund, 2022). In addition, education about the limitations and advantages of telemedicine helps owners understand when online services are adequate and when physical visits are necessary (Springer *et al*., 2024).

Pet owners' trust also has a direct impact on compliance with treatment protocols and patient follow-up (Janke *et al*., 2021). Owners who trust digital services tend to be more responsive to veterinary instructions, more diligent in monitoring their pets' conditions, and more active in using monitoring applications or devices (Ackerman, 2021). Conversely, distrust can reduce the effectiveness of telemedicine and limit its potential clinical benefits (Yee *et al*., 2022).

Implementation and training costs

The implementation of telemedicine in veterinary practice requires a significant initial investment in digital infrastructure, hardware, software, and data security systems (Becker *et al*., 2023). Veterinary clinics must provide facilities that enable remote consultations, patient data monitoring, and integration with electronic medical records (Iqbal *et al*., 2021). This investment includes the procurement of high-quality cameras, microphones, physiological sensors for wearable devices, servers or cloud platforms for data storage, and adequate mobile applications (Picozzi *et al*., 2024).

In addition to the cost of equipment and infrastructure, the success of telemedicine also depends on the training of medical personnel and clinic staff (Alenoghena *et al*., 2023). Veterinarians and clinic assistants need to understand online consultation protocols, the use of telemedicine platforms, the interpretation of physiological data from wearable devices, and data security and privacy procedures (Mitek *et al*., 2022). This training is important so that telemedicine services continue to meet clinical practice standards and maintain the quality of medical decision-making (Chen *et al*., 2023).

The costs of implementation and training can be a barrier, especially for small practices or clinics in areas with limited resources (Reis *et al*., 2022). However, this initial investment can be offset by long-term efficiencies, including a reduction in unnecessary physical visits, optimization of consultation schedules, and increased pet owner satisfaction (Blackwell *et al*., 2024). Studies show that clinics that have systematically implemented telemedicine are able to increase productivity by 20–30% and reduce operational costs related to administration and patient transportation (Vincent *et al*., 2024).

Future outlook and recommendations

The development of telemedicine in veterinary practice has opened up new opportunities to improve the quality of animal health services through the integration of digital technology, standardization of remote consultation protocols, training of medical personnel and animal owners, and evidence-based research on effectiveness, costs, and user satisfaction (Becker *et al*., 2023).

Integration of AI and IoT in veterinary telemedicine

Advances in digital technology are driving the evolution of telemedicine in veterinary practice through the integration of Artificial Intelligence (AI) and the Internet of Things (IoT) (Gouiza *et al*., 2024). AI enables automatic analysis of patient data, including processing information from wearable devices, interpreting radiology or ultrasound images, and predicting disease risk based on physiological patterns and clinical history of animals (Li *et al*., 2024). Thus, veterinarians can make faster and more accurate diagnoses, identify early signs of disease, and design more appropriate interventions (Bard *et al*., 2023).

Meanwhile, IoT supports continuous monitoring of animal conditions through wearable devices or sensors that are connected in real-time (Arshad *et al*., 2022). These devices can measure heart rate, body temperature, daily activity, eating patterns, and other health parameters, then automatically send the data to a telemedicine platform (Busnatu *et al*., 2022). This information enables veterinarians to perform remote triage, post-operative monitoring, and chronic disease management without the need for frequent physical visits, thereby reducing stress on animals and improving clinic efficiency (Sigesmund, 2022).

The collaboration between AI and IoT in telemedicine also strengthens data-driven approaches, supports evidence-based decisions, and improves pet owners' compliance with care protocols (Mbanugo, 2025). For example, automatic notifications from IoT sensors can provide reminders for medication or specific activities, while AI processes data to identify significant changes in the animal's condition (Zhang *et al*., 2024). However, this integration requires adequate digital infrastructure, staff training, and strict data security protocols to ensure accuracy, privacy, and clinical effectiveness (Ibrahim *et al*., 2024). With proper management, AI and IoT can become crucial components of veterinary telemedicine, expanding access to services, improving the quality of care, and promoting efficient, evidence-based, and sustainable modern veterinary practices (Zhang *et al*., 2024).

Standardization of remote consultation protocols

Standardization of remote consultation protocols is a crucial aspect of veterinary telemedicine practice to ensure the safety, effectiveness, and consistency of services (Abu-Seida *et al*., 2024). These protocols include guidelines on case triage, virtual consultation procedures, digital medical record documentation, and patient data security, enabling veterinarians to provide services that meet clinical standards even when conducted online (Hadar, 2024). Case triage serves to determine the types of consultations that can be conducted virtually and those that require physical examination (Lee *et al*., 2021). This standardization helps veterinarians group patients based on urgency, complexity, and risk, so that medical interventions can be carried out appropriately and efficiently (Quain *et al*., 2021).

Virtual consultation procedures include instructions for communicating with pet owners, using video calls, sending photos or videos, and interpreting data from monitoring devices (Wenzel *et al*., 2023). Systematic digital medical record documentation is important for recording medical history, consultation results, and follow-ups, thereby maintaining service quality and facilitating coordination between professionals (Salleh *et al*., 2021). Data security is also a major focus. Standardized protocols ensure that patient and pet owner information is protected in accordance with data protection regulations and minimize the risk of information leaks or misuse (Sargiotis, 2024). In addition, these protocols increase pet owners' trust in telemedicine services and support the accuracy of clinical decision-making (Janke *et al*., 2021).

Training for veterinarians and pet owners

The success of telemedicine in veterinary practice is highly dependent on the competence of veterinarians and the understanding of pet owners in using digital technology. Training is a crucial component to ensure that online services can be carried out safely, effectively, and in

accordance with clinical standards (Iqbal *et al*, 2021).

For veterinarians, training includes the ability to operate telemedicine platforms, interpret physiological data from wearable devices, communicate professionally over long distances, and manage digital medical records (Mitek *et al*., 2022). Veterinarians also need to understand the limitations of telemedicine in diagnosing and treating diseases, so they can determine when an online consultation is sufficient and when a physical visit is necessary (Caney *et al*., 2022). This training improves clinical accuracy, service efficiency, and compliance with data security protocols (Becker *et al*., 2023).

Meanwhile, training for pet owners focuses on using the app, sending clear photos or videos, monitoring the condition of animals at home, and complying with the doctor's instructions (Haase *et al*., 2025). This education helps owners understand the limitations and benefits of telemedicine, increases active participation in animal care, and minimizes errors in administering medication or performing simple care procedures (Springer *et al*., 2024). Research shows that effective training increases owners' trust in online services, improves compliance with treatment protocols, and supports early detection of changes in animal condition (Dewsbury *et al*., 2022). Additionally, veterinarians trained in telemedicine can maximize the use of technology, reduce unnecessary physical visits, and improve clinic operational efficiency (Hadar, 2024).

Further research

Although telemedicine shows great potential in veterinary practice, further research is needed to empirically evaluate its impact on clinical outcomes, operational efficiency, and pet owner satisfaction (Juodžentė *et al*., 2024). Systematic studies can provide quantitative data to support telemedicine adoption policies at the clinic and national levels (Bell-Aldeghi *et al*., 2023).

Research on the effectiveness of telemedicine includes diagnostic accuracy, treatment success, and patient outcomes compared to conventional face-to-face consultations (Verma *et al*., 2023). This evaluation is important for identifying the types of cases that can be safely managed online, as well as for understanding the limitations of telemedicine in diagnosing acute or complex diseases (Maita *et al*., 2023). Empirical data helps veterinarians determine when telemedicine is sufficient and when a physical visit is necessary (Becker *et al*., 2023).

A cost study is needed to assess the initial investment, operational savings, and potential reduction in unnecessary physical visits. Economic analysis also includes a comparison between the costs of implementing a telemedicine platform, staff training, and digital infrastructure with the long-term benefits of time efficiency, increased productivity, and reduced risk of complications due to delayed diagnosis (Sigesmund, 2022; Abu-Seida *et al*., 2024). Evaluating pet owner satisfaction is an important component to ensure the long-term adoption of telemedicine (Akchurin *et al*., 2024). Surveys and interviews can identify owners' perceptions of the platform's ease of use, trust in online services, quality of communication with veterinarians, and compliance with medical instructions. These findings can be used to improve platform design, consultation procedures, and education strategies (Janke *et al*., 2021; Karolina, 2023).

Conclusion

Telemedicine in veterinary practice has shown significant growth, facilitating remote services, continuous health monitoring, pet owner education, and collaboration between professionals. Its main benefits include increased accessibility, time and cost efficiency, and improved quality of animal care. However, limitations such as inconsistent regulations, diagnostic limitations, technical constraints, implementation costs, and owner perceptions still need to be addressed. Practically, telemedicine can support traditional clinical services, expand service coverage, and improve operational efficiency. Further research and technological development, including the integration of AI and IoT, are needed to optimize the clinical effectiveness and sustainability of telemedicine in modern veterinary practice.

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Conflict of interest

The authors have declared no conflict of interest.

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