TDK THESIS

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2021

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The digital transformation in veterinary medicine: Telemedicine

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Budapest
2021

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Abstract

Veterinary telemedicine is not as novel a field as it would seem, as it has basically been practised ever since consultations by telephone are possible. More recently, technological advances in telecommunication have made it an exciting addition to analogue medicine, a fact that remains especially relevant during the global Covid-19 pandemic. This study aimed to survey animal owners' perception and acceptance of digitalised animal healthcare, as it is an increasingly used tool in veterinary medicine.

An online survey was developed using the platform SurveyMonkey and distributed via social media and internet forums. The questionnaire was also presented to actual veterinary institutions and telehealth providers. 362 responses were gathered between March and August of 2021 from all the states of Germany. A descriptive statistical analysis and hypotheses testing were performed, using Kruskal-Wallis, Spearman and Wilcoxon rank sum tests.

The results show that while 71% of responding pet owners view telemedicine as an asset to their clinic or practice of choice, 84% have never used telemedical services of any kind. The main factors contributing to hesitancy toward online consultations among pet owners were limited examination methods (82%), lack of personal component (32%), technical complications (13%) and insufficient broadband connection (10%). The main disruptive elements in connection with clinical visits according to respondents were waiting times (59%), aggressive or nervous pets (55%), and general stress (39%).

Correlation testing revealed no significant relationship between regionality and willingness to participate in online consultations (p=0,8187 Spearman-test) (p=0,06 Kruskal-Wallis-test), nor between the age of the respondent and likelihood to make use of online consultations (p=0,077 Spearman-test) (p=0,63 Kruskal-Wallis-test), and neither between owning small animals and likelihood to take part in telemedical consultations (p=0,595 Wilcoxon rank sum test).

We can conclude that there is great potential for telemedicine as an addition to traditional veterinary sciences as researchers, veterinarians, owners, and animals can profit from its benefits. Commonly occurring difficulties in connection with veterinary sciences can be improved upon. The collected data shows, that despite many respondents having a positive attitude towards telemedicine, it is still underused in clinical practice in Germany. Further research into possibilities of improving implementation into everyday practice is needed. Educational institutions should also consider teaching about telemedicine as it is becoming an important part of all medical fields at an increasingly fast rate.

1. Introduction

Veterinary telemedicine has been part of veterinary sciences for decades, made possible by long distance telecommunication devices such as the telephone or telefax (Mars and Auer, 2006). More recently the Covid-19 pandemic has made online communication with medical professionals a necessity (Magalhães-Sant'Ana et al., 2020). Though it should be said that even before these circumstances, the field experienced rapid growth, since it is bound to modern technological progress. While telemedicine has been well established as a useful tool in human medicine, veterinarians are comparatively conservative when it comes to modern videotelecommunication (VTC) being used for healthcare purposes. This paper will examine the reasons for this according to the scientific literature, as well as provide insight into potential benefits of transferable human telemedical services for veterinary medicine. Further, a survey was distributed and collected data concerning perception and acceptance of telemedical methods among German animal owners. According to this, the paper will try to provide a theoretical framework for increasing digitalisation successfully in the veterinary field, based on animal owner preferences. This topic is more relevant than ever due to the global pandemic and concurrent restrictions to personal contact, which should permit a more open discussion regarding the upsides and limitations of veterinary telemedicine. But the current surge in interest should not outshine the already established advantages of the field. Economising workflow, improving standard of healthcare, reducing customers', patients' and ultimately veterinarians' stress and reducing the carbon footprint are only some of the scientifically researched upsides in connection with digitalising medicine. Use in teaching, not only during lockdowns, can help aspiring medical professionals increase their level of education. However, one of the most significant differences of veterinary medicine in comparison to its human counterpart – veterinarians being essentially service providers – appears to be commonly disregarded. In order to establish telemedical services in the veterinary field, the customer has to make use of them, even when not forced to do so by a global health crisis. According to this, the analysed data will try to quantify customer perception and acceptance of veterinary telemedical services, showing how the possible benefits of digitalisation can be made available in everyday practice.

2. Literature review: Digitalisation in veterinary medicine

2.1 The construct of a digital veterinary branch – telehealth and telemedicine

There are several definitions of the Telemedicine and Telehealth services. The American Veterinary Medical Association describes Telehealth as an umbrella term including all forms of technologically provided information, education and remote care, dividable into different subspecialities (AVMA). The German "Bund Praktizierender Tierärzte" (Bpt, transl.: Association of practicing veterinarians) specifically described veterinary telemedicine as the use of information and telecommunication technologies in order to provide assistance of medical care, if veterinarians and owners with their pets are physically separated ("Bundesverband Praktizierender Tierärzte e.V.). Telemedicine has also simply been classified as the use of telecommunication to discuss patient clinical data and management (Gyles, 2019; Voyer and Jordan, 2018; Watson et al., 2019). Telehealth and telemedicine as terms, however, are often used synonymously suggesting a potential lack of a formally accepted distinctions (Watson et al., 2019).
The most relevant fields of telemedicine as of now, telepathology, teleradiology, teledermatology and, teleconsulting (Mars and Auer, 2006) are examined further in the following passages.

2.1.1 Telepathology

Telepathology consists of employing online communication to transfer pathologically relevant data, including images and videos. Its main areas of use are to consult, educate, research, deliver or confirm diagnoses as well as give pathological insight remotely (Farahani and Pantanowitz, 2015). Veterinary pathologists mostly use computerized complete ("whole") slides that can then be saved, if needed for extremely long timespans, and examined at will. There is a significant difference in the traditional form of pathology as staff need to scan pathology slides, then upload, and store them appropriately. Slide scanners, equipped with their own light source, slide holder, objective lenses as well as a high-resolution camera can digitalize the slide by using image analysis software, like Imagej, Cellprofiler Analyst, L-measure, Icy, Digimizer. While this technical process has greatly improved accessibility and storage possibilities, the analysis of slides remains a task of pathologists themselves. Due to the distinctively human talent for comprehension and interpretation of visual information, automated interpretation is not routinely used as of yet,

but could in future greatly improve duplicability of pathological findings (Bertram and Klopfleisch, 2017). Setting up a laboratory that fulfils requirements to practice telepathology is mostly a question of network connectivity (based on broadband access) and wireless telecommunications. These technologies are widely accessible today and, therefore, telepathology systems are easily connectible to the web. Common telecommunication and online data sharing and storing platforms, e.g., Skype, Lync, Team Viewer, DropBox, etc., have been used successfully to establish professional exchange. More specifically SecondSlide and PathXchange are used as online file storage providers (Farahani and Pantanowitz, 2015).

Currently, education of students and young vets seems to be an excellent use of telepathology. Increased availability of virtual slides for students can help to deepen theoretical knowledge and allows educators to provide consistent and relevant cases. In combination with the analogue skills of light microscopy, this system could enhance the quality of education compared to an 'offline-only approach' (Bertram and Klopfleisch, 2017; Farahani and Pantanowitz, 2015). In an effort to keep education at the highest possible standard during the global pandemic in 2020/21, the University of Veterinary Medicine Budapest, for instance, has implemented online teaching in Pathology using Microsoft Teams for theoretical and practical lectures. For the histopathology laboratory lessons the students received log-in information for a Case Viewer, based on slides presented via 3DHISTECH's slide converter. Farahani and Pantanowitz (2015) provided an overview of static, dynamic, whole-slide imaging and hybrid telepathology methods, as can be seen in **Table 1.** These were compared concerning the image system, remote controllability, limitations pertaining to number of images per case, image selection, required bandwidth and required costs. This comparison creates a basis for orientation when it comes to telepathological methods.

Table 1 Comparison of different telepathology measures

Telepathology Method	Image System	Remote Control	Images Per Case	Image Selection	Bandwidth Needed	Cost
Static	Still	No	Limited	Host	Low	Low
Dynamic	Live	Yes	Unlimited	Telepathologist	High	High
Whole-slide Imaging	Still	Yes	Unlimited	Telepathologist	High	High
Hybrid	Still and Live	Yes	Unlimited	Telepathologist	High	High

Source: based on Farahani and Pantanowitz (2015)

An overview of advantages and disadvantages of telepathology is given in **Table 2** (Bertram and Klopfleisch, 2017). Focusing on aspects like practicality, operation, efficiency, health concerns storage, and how they can possibly complement or hinder diagnostic work. Notably, the table focuses on actual practical observations, granting it relevance in day-to-day application.

Table 2 Pros and Cons of Digital Pathology in a Diagnostic Service

Parameter	Pros	Cons
Feasibility/validation	Computerized workplace already standard equipment in all institutions and needs only little investment in larger screens	No validation and feasibility study in a veterinary setting available Risk of technical malfunction including scanner and network problems
Handling	Fast detection of relevant areas via thumbnail images, navigation window, and visualization of the whole section on a large screen Easy annotations and measurements on the slide, parallel analysis of several slides Z-scanning for better detection of (cellular) details	Inability to fine focus to detect cytological details in whole-slide images from most scanners Higher degree of standardization of tissue and glass slide preparation is necessary
Time efficiency and automatization	Shorter or similar diagnostic time with virtual microscopy Faster quantification of (simple) positive events (f.i. Ki67 index)	Longer diagnostic time with virtual microscopy Scanning as an additional working step for the lab personnel
Telepathology	Remote and fast consultation and mobile primary diagnosis (telediagnosis) possible	
Ergonomics	Decreased visual fatigue and increased ergonomics in optimized workstation	Negative effects of longer screen handling
Storage	Easier archival of whole-slide images; no need for physical slide storage	Large digital storage capacities and good information technology infrastructure required

Source: based on Bertram and Klopfleisch (2017), p. 761

2.1.2 Teleradiology

Teleradiology specializes in sharing diagnostic imaging from modalities like x-ray radiography, computed tomography, magnetic-resonance imaging as well as ultrasound or others (EKG, etc.). It has been around ever since telecommunication is usable in practice, but subsequent to major technological advances it has become more frequently used as a telemedical device to acquire diagnoses remotely (Essman, 2011). Arguably one of the more

easily applicable telemedical fields, teleradiology benefits from the mostly uniform way of performing diagnostic imaging. Furthermore, the Digital Imaging and Communications in Medicine (DICOM) system in connection with the Picture Archiving and Communication System (PACS), standardize the process of forwarding, retaining and presenting said digital pictures ("DICOM"; "RVC Clinical PACS"; Essman, 2011; Papageorges et al., 2001). **Table 3** illustrates a basic concept of areas in which Teleradiology is used.

Table 3. Applications of Teleradiology in Veterinary Medicine

Primary interpretations
Images directly sent to radiologists
Images indirectly sent to radiologists
On-Call coverage
Second opinion consultations
Image storage and archival
Database banking

Source: based on Poteet (2008), p.34

Moreover, technology at its current state ensures increasingly impressive results regarding image optimisation, swift transfer, storage and displaying at high quality. Digital renditions are more efficient to work with, since processing is streamlined and high resolutions allow in depth analyses, like zooming in and out of a picture – an impossibility on x-ray printouts (Poteet, 2008).

These factors have made it possible, that teleradiology has quickly found its place in everyday veterinary practice through supplying immediate input by radiologists. This allows more medical institutions, that would otherwise lack radiology expertise, to consult specialised veterinary professionals (Essman, 2011). Especially "cross-sectional imaging", as used in computed tomography or magnetic resonance imaging, benefits from modern technology. The sections produced by the equipment can be piled up and reviewed by scrolling through them, which is more convenient compared to the formerly used hard copies, where the radiologist had to go look for individual images in a sequence of "slices".

Veterinarians and especially practice owners need to consider the connectivity and practice management software, when planning on setting up teleradiology, since the "save and forward" approach, requires a reliable and fast internet connection, especially due to image quality and size of high-resolution radiographs. These systems require a significant computing power (Poteet, 2008).

2.1.3 Teledermatology

Veterinary teledermatology, as a subcategory of dermatology, deals with the remote assessment of skin lesions based on visual medical data provided via telecommunication services. Teledermatology is a field in which the advances of modern-day technology can be used in an advantageous manner; More specifically the quick and reliable image sharing mechanisms made possible by smart devices and computers nowadays. Thus, the nature of the diagnostic approach, the inspection of the lesions with the naked eye, is compatible with telemedical processes like video consultation and picture sharing. Teledermatology has the potential to achieve reliable results on a continuous basis. In this instance human medicine provides data that is likely transferable to veterinary medicine. Studies have shown that the overall precision of remote diagnoses in human dermatology settles in at around 70% (Eedy and Wootton, 2001; Lee and English, 2018), which is comparable to precision in face-to-face examinations.

The way teledermatology is implemented in human medicine as of now, can be divided in three basic ways of attaining information (Lee and English, 2018): 1. Live video conferencing ("Synchronous"), 2. Forwarding images ("Asynchronous") and 3. A combination of the two forms ("Hybrid"):

1. Using videotelecommunication, the (sub)specialist has a real-time video session with the patient, or, in the case of veterinary medicine, with the patient's owner. This is optimally used for getting an overall impression of the animal and for discussion of the patient, anamnesis, therapeutic approach, because image quality usually suffers from the high network demand of video calls.
2. Pictures of the affected tissue, either made by the attending vet or the owner, are sent to the teledermatologist for further review. This method is most commonly practiced when viewing lesions, as high-quality images can be taken and sent efficiently nowadays. This way a teledermatologist can also review cases at will, avoiding scheduling issues. Usually, the necessary images are sent along a written clinical history.
3. Lastly, teledermatologists can combine both the synchronous and asynchronous method, although it is not practiced as often.

In **Table 4,** further recommendations for special cases in human medicine with relevance for veterinary medicine can be seen. Pigmented lesions and lesions covered by hair, for example, are two problems that veterinary teledermatologists will encounter on a daily basis. There is also the concern of inadequate lighting possibly clouding the judgement of lesions, which must be attended to thoroughly (Lee and English, 2018).

Table 4 Teledermatologic examination: special considerations

Clinical scenario/context	Points of consideration
Total body skin examination	Feasible by both synchronous and asynchronous modalities but may not demonstrate sufficient detail May require special lighting and/or multiple angles and images for sufficient teledermatologic examination
Hair-bearing skin	Examination of skin bearing dense, thick hair (i.e., scalp) will require proper physical maneuvering or removal of hair as well as adequate lighting to ensure proper examination
Pigmented lesions	Represent a diagnostic challenge teledermatologically and requires higher index of suspicion and lower threshold to refer for in-person examination Adjunctive teledermatologic examination modalities, i.e., teledermoscopy, should be incorporated if available
Mucosal lesions	Requires careful attention to lighting and camera exposure to ensure adequate, detailed examination
Skin color	Different backgrounds, lighting conditions, and baseline skin color may alter the color of lesions captured teledermatologically

Source: based on Lee and English (2018)

Due to the similarities in the procedure of establishing a diagnosis in both veterinary and human medicine, the modus operandi for remote dermatology consultations could be adopted by veterinarians. This can be showcased when examining diseases like Atopic Dermatitis, a condition known to affect humans as well as pet and production animals. In both dogs and humans, for example, Atopic Dermatitis patients tend to present with common allergy-related symptoms like pruritus, skin inflammation and in both cases a genetic alteration seems to be at the root of the problem. Even immunological similarities have been noted in Atopic Dermatitis of humans and dogs (Arcique and Bajwa, 2020; “Atopic dermatitis (eczema) - Symptoms and causes” Mayo Clinic; “Atopic Dermatitis in Animals - Integumentary System” MSD Vet Manual).

As described by Giavina-Bianchi et al. (2020), teledermatologically acquired findings of Atopic Dermatitis in humans were concurrent with analogue ones in 84.4% of their 109

reviewed cases. Due to the resemblance of the disease in both humans and dogs for example it is fair to argue that successes in the remote treatment of this condition could be possible in the veterinary practice as well. In the same study, they found that telemedical consultations have been used successfully, to recommend treatment without need for the patient to be physically present at a clinic, in 72% of the cases. Besides, the study also showed that staff hours and costs were optimized, as well as patients' access to specialists and waiting time for an appointment was reduced (Giavina-Bianchi et al., 2020). Based on the similarity of the diseases, there is a realistic chance for achieving comparable success in treating afflicted animals remotely. This assessment is supported, by the fact that methods for increasing quality of dermatologic imaging are being developed for the use on animals. For example, researchers have worked out a "teledermatoscopy system" that could be used for further studies and in practice. By attaching a dermatoscope to an inexpensive smartphone, promising results have been attained by researchers. After working out colorimetric standards, skin discolourations could be distinguished more reliably and their extent judged more accurately (Cugmas and Štruc, 2020).

2.1.4 Teleconsultation

The terminology and definitions surrounding teleconsultation appear not to be universally well-known as inconsistencies in usage of the term occur within the literature. In professional circles, the term usually represents an exchange of two veterinarians, using some form of telecommunication to consult on a case, one of them encounters. Usually one of the veterinarians has a previously established business relationship with the customer and patient (or, a veterinarian-client-patient-relationship, a VCPR) (Pang et al., 2020). However, it is routinely used to describe the online consulting between customer and veterinarian, too. Also within a pre-existing VCPR ("Benefits of remote consultations in veterinary practice," 2021; "Der Online-Tierarzt: Telemedizin für Praktiker," Vet Line).

2.1.4.1 Teleconsultations between veterinarians

Pang et al. (2020) have presented a dentistry case, exemplifying how a teleconsultation could be made possible during the 2020 lockdown. In said case, the increased anaesthesia risk in a 13-year-old Shih Tzu cross led the attending vets to arrange for a teleconsult with an

anaesthesiologist. A precise scheme for the entire procedure pertaining to anaesthesia was worked out, along with "checklist items" in an effort to make up for possible restrictions that can accompany a teleconsultation. A day prior to the procedure, a test run of the devices that were used for the conference was performed (iPhone 7; mounted on an IV stand, MacBook Air 11-inch; used by the consulting anaesthesiologist, Zoom; videoconferencing platform). With the smartphone camera set up to provide a view from the front, anaesthesia was induced. Then the camera was placed to attain an angle in which the physiologic monitor, fluid pumps, ventilator bellows and the anaesthetic machine could be viewed. During the course of the procedure, the consultant offered adjustments a number of times. The post-operative check-up was attended by all members that were present during the procedure, including the consulting anaesthesiologist. The team recorded some interruptions due to poor signal, only maintaining audio function during those periods. They also encountered battery issues and visual inconsistencies from the monitors.

In this case, expert knowledge was made accessible in everyday practice, without the specialist having to be physically present. This made treatment of a formerly non-treatable patient possible, showing the way teleconsultations can improve veterinary care. It also shows that videoconferences using commonly available technological devices can be a viable option to improve patient care. Most veterinary institutions are probably already in possession of the required technical equipment (Bishop et al., 2018).

Teleconsultations are the combining factor between aforementioned fields of telepathology, teleradiology and teledermatology. By increasing the accessibility of expert evaluation through teleconsultations, the overall standard and efficacy of care is improved. Consulting (sub-) specialists enables general practitioners to diagnose and perform procedures based on expert knowledge. Thereby they gain reassurance as far as treatment options and planning are concerned. Wrongful diagnoses due to inexperience or insufficient knowledge could, consequently, be reduced (Massin Teller and Moberly, 2020).

Radiologists, for instance, undergo intensive, several years-long training prior to becoming experts in the field. By facilitating regular contact with highly trained personnel, the skillset of the consultee may also grow, thus increasing overall competence in a practice or clinic, which in turn acts reassuring towards pet owners. The overall case load is likely to increase as well, as time can be used more efficiently with help of an expert and the additional knowledge stemming from intensified exposure to the subject can reduce the occurrence of mistakes (Papageorges et al., 2001).

Similarly, being able to approach pathologists for online consults concerning digitalised case information would reduce processing time, costs and potential damage. This is because, instead of sending the actual sample, digitalising and forwarding it would circumvent the need for a delivery service. In turn, costs, spent on an intermediary are saved while simultaneously cutting away the delivery time and risks of impairment due to transport (Farahani and Pantanowitz, 2015). Pathologists in human medicine have demonstrated that these advantages are transferable into the everyday workflow. Despite being at the beginning of digital Pathology, veterinary pathologists are following the trend. In this regard digitalisation of the profession is desirable, as long-term opportunities for the use of veterinary teleconsultations are being developed (Bertram and Klopfleisch, 2017).

2.1.4.2 Teleconsultation between veterinarian and client

Client-veterinarian teleconsultation is a telemedical service using telecommunication tools allowing the veterinarian to get in contact with the client and assess the overall medical status of the patient without relying on a physical examination ("Benefits of remote consultations in veterinary practice," 2021; "Der Online-Tierarzt: Telemedizin für Praktiker," Vet Line). It is important to point out that teleconsultation is indeed a branch of telemedicine and should be treated as such, instead of using the terms telemedicine and teleconsultation synonymously, which creates a confusing space for argumentation, and has occurred in scientific literature and discussion (Hess, 2017).

This topic seems to be divisive among the veterinary medical community. Some practitioners see the benefits of it, like the chance to view patients via video chat under everyday circumstances, rather than a stressed or fearful animal at their workplace. Also the patient development is easier to follow through picture and video exchange on smart devices (Chitty, 2019). Therefore, advocates of remote care, see teleconsultation as an addition to their in-house work. It has also become incredibly relevant due to recent Covid-19 mandated lockdowns, as a way of assuring patient care despite adverse conditions ("Benefits of remote consultations in veterinary practice," Veterinary Record, 2021).
Opponents of digitalisation on the other hand, often criticise the idea of remote prescriptions and argue that only with an established VCPR and in person should a practitioner be able to prescribe medication to a patient. As this is being written, remote prescriptions are not legal in Germany. The opposing experts fear that if it were to become a reality, the standard of

diagnosing would suffer (Mars and Auer, 2006) and that the already criticised overuse of antibiotics would increase even further (Massin Teller and Moberly, 2020). Some also view online examinations as insufficient to properly assess animals and argue that they would lead to misdiagnoses. And, finally, some experts fear that the overall development of digitalisation could result in an increased use of artificial intelligence (AI) in diagnostic procedures, accompanied by a set of problems such as unclear liability, accuracy of AI diagnoses or customers demanding a certain treatment based on results from AI-diagnosing (Richards, 2019). It should be the veterinary community's goal to clear misconceptions, develop rules, laws and limitations of practicing telemedicine and instil confidence in the topic among practitioners.

2.2 Current state of telemedical veterinary services

Despite heavily benefitting from modern technological advances, telemedicine is still not widely practiced in veterinary medicine as of writing this. The following chapter is meant to analyse what the reasons for this development are, and how promoting digitalisation in veterinary medical care can positively influence the field.

2.2.1 Causes affecting the growth of telemedical services

As shown in the previous chapter the human medical field already acknowledges the value of using advanced telecommunication systems to their advantage and determined ways of applying telemedicine efficiently and accurately. The veterinary field is lagging behind. The reasons for this are various.

For example, a combination of unwillingness and lack of technical know-how by veterinarians results in a shortage of capable, forward-thinking practitioners in the field. Data shows practitioners as well as students are hesitant towards digitalisation itself as well as acquiring knowledge in IT-related subjects compared to workers in the industrial sector or service providers. Consequentially their already subpar capabilities to work with modern day (online-) technology are not improved upon since opportunities for further training are rarely seized (Stumpp et al., 2020). Understandably the deficit in technical knowledge raises questions about internet security. This issue is also often addressed by animal owners when confronted with the topic of telemedicine (Drewry et al., 2019).

Research has shown, a large number of veterinarians do not favour using telemedical services, no matter their age (Watson et al., 2019). This implicates that a general hesitancy

toward the advancement of technological modalities stems from a lack of knowledge of the topic.

Another issue that keeps coming up with telemedicine is that of remote prescription – so whether a veterinarian should be able to prescribe medicine without a physical examination. Many practicing veterinarians reject this due to the risk of missing symptoms, difficulty gauging vital signs and other measurements and mitigation of responsibility which could lead to misdiagnoses. Further, there is a risk for over-prescription of antibiotics, which has happened in human telemedicine settings before (Massin Teller and Moberly, 2020). They also lament that the practice of online consultations and counselling has the potential to further competition for clients, among vets, forcing less technology-experienced practitioners to forfeit customers (Loeb, 2019).

Especially Germany has problems when it comes to digitalisation in comparison to other highly developed countries. In Japan and South Korea, a quarter of private households have high speed internet connections. In Germany it is about 2%. Most of high-speed broadband access is concentrated in urban regions (tagesschau.de, 2019). This poses a very real problem to German telemedical services, since geographically isolated people are supposed to be among the beneficiaries of remote care using telecommunication. Internet connectivity problems are not uncommon in those areas. Hence, a reliable broadband network seems to be necessary to instil trust in country-side animal owners, concerning telemedicine services. Having identified these as the main difficulties hindering advancement of digitalising the veterinary profession the following paragraphs are supposed to illustrate possible solutions as well as highlight the potential of telemedicine.

2.2.2 Practical upsides of veterinary telemedicine

2.2.2.1 Prerequisites for routine use of veterinary telemedicine

Under normal circumstances, prior to speculating about digitalisation and implementing telemedicine in the veterinary field, it is necessary to ask, whether existing or potential clients are receptive to the idea. Veterinary medicine is part of the service sector; therefore, profitability is a factor when discussing the topic. If clients are not prepared to pay for online

services, the discussion about implementation is irrelevant in the first place. Widmar et al. (2020) showed that dog and cat owners, that participated in their survey, were willing to pay for online counselling, subsequently exerting disutility for vets and owners that decline veterinary telemedicine opportunities. Based on this information one could argue that there is a market for telemedicine in the veterinary field that is not being explored. Especially since telemedicine is an effective method to extend business hours and therefore increase overall amount of patient visits, a number that has gone down, partly due to pet owners' increased use of the internet (Volk et al., 2011). A more direct approach with online care would therefore increase revenue while most likely decreasing false diagnoses by inexperienced owners upon conducting an internet search of their pet's symptoms.

Another deciding factor is usability. Taking human medicine as an example, parallels to the veterinary field can be drawn. There is extensive research on teledermatology consultations in human medicine. As already stated, Eedy and Wootton (2001) and Lee and English (2018) determined the accuracy and efficacy of dermatology related remote diagnosis at around 70% after reviewing several studies of teledermatology. As a result the institutions that were studied were economising their workflow, cutting back on waiting time for surgeries and saving money in favour of both patients (£1.70 saved per patient) and healthcare (18% savings) (Heijden et al., 2011; Lee and English, 2018). The authors concluded that in human medicine *"Studies on diagnostic accuracy, effects of treatment and adverse events have proven that teledermatology is as effective as live visits."* (Heijden et al., 2011). Results like these should serve as motivation for the veterinary field to facilitate change in the same direction.

Some literature draws a more concrete comparison between paediatrics and veterinary medicine. As neither animals nor toddlers and infants can reliably express their symptoms, it is interesting to look at human medicine studies that deal with telemedicine used in paediatrics. In both cases the patient relies on a guardian to explain the medical issue(s) to the best of their ability. A literature review by Massin Teller and Moberly (2020) examined this comparison. They found that paediatric telemedicine showed promising results in general practice as well as serious acute cases. The studies that were reviewed also concluded that overall standard and accessibility of medical care were improved for the examined patients.

2.2.2.2 Telemedical considerations during the Covid-19 pandemic

The highly unusual circumstances in connection with the global pandemic-induced lockdowns, have shifted the discussion from profitability to necessity. As with many other areas of life, veterinary medicine has been impacted by the circumstances in connection with SARS-Cov-2. **Table 5** shows how patients' wellbeing might have been affected due to the concurrent changes. Out of a pool of 188 consultations, the possible impacts of Covid-19 are quantified, showcasing that it had definite effects on routine procedures and everyday appointments, thus highlighting the need for more sophisticated solutions concerning online veterinary medical care. Practicing remote care wherever possible, would decrease the risk of exposure for both personnel and clients. Advice given using telemedicine has been shown to decrease in-person visits (Littlehales et al., 2020).

Table 5 Description of consultations (n=188) where changes associated with Covid-19 might impact animal health and welfare

Context of discussion (n)	**Most common specific issues discussed**
Delayed investigation or referral (n=39)	Pruritic skin/ear disease (n=9), orthopaedic (n=7), masses (n=7), ophthalmology (n=3)
Vaccinations (n=37)	Mostly delayed
Delayed monitoring/blood tests for long-term conditions (n=22)	Endocrinopathies (n=8), orthopaedic/mobility issues (n=5), cardiology (n=4)
Prescribing a different or longer course of treatment (n=21)	Longer courses of analgesia (n=4) or antibiotics (n=1), use of different remotely prescribed treatments to avoid patients visiting the practice (n=6) and avoiding changing drug doses (n=3)
Delayed dental (n=17)	
Delayed neutering (n=13)	
Change in household routine possibly having an impact on animal health (n=14)	Cystitis (n=4), overgrooming (n=3), increased seizure frequency (n=1), stress-induced anorexia (n=2), inappropriate urination (n=1), lameness from increased activity (n=1)
Impact on animal health due to other services being cancelled (n=11)	Grooming (n=4), behaviourists (n=3), physiotherapists/chiropractors (n=3), hydrotherapy (n=1)

Source: based on Littlehales et al., (2020)

Veterinarians, technicians and students should try to stay up to date with the concept of telehealth, and not pass on opportunities to improve in this matter (Watson et al., 2019).
Many veterinarians simply dismiss the implementation of telemedicine due biases ranging from lack of potential customers to network connectivity problems with the inhouse practice management software, showcasing a lack of understanding of how telemedicine works. Meanwhile telehealth companies have experienced rapid growth during the Covid-19 pandemic. The first quarter of 2021 achieving a record high $4.2 billion in equity worldwide (Tech Monitor, 2021). Multinational corporations like Amazon and Google as well as hospital-owning businesses and software producers are heavily investing into telehealth providers for human medicine (Ärzteblatt, 2020; "Telehealth investments soar even as market matures," Healthcare Dive; Welt, 2021). This has led to increased use of areas connected to telehealth like online scheduling, online consultations and digital health applications. In 2020 over 90.000 new telehealth applications have entered the market as a result of increased investment into telehealth (Medicaldevice Network, 2021).

2.2.2.3 Economic and ecological benefits of veterinary telemedicine

If more colleagues in the practical aspect of veterinary sciences would familiarise themselves with telemedical concepts, they would more readily discern their potential benefits and necessity. Therefore, this chapter aims to illustrate the positive insights gained from reviewing literature relevant to veterinary telemedicine.

Teleconsulting is arguably the most efficient way to confer with peers. Using virtual meeting platforms, not only history and clinical data can be exchanged, but patients can be viewed by the consultant without having to be present. Especially if the consulting veterinarian is a specialist, the use of teleconsulting can improve the level of care given to a patient, as has already been explained in chapter 2.1.4.1.
Further, a general practitioner could use teleconsulting to immediately refer patients to specialists without having to see them in person – for example in case of pathognomonic signs requiring procedures they are not equipped for. This way they would alleviate the patient, as well as the owner, from unnecessary stress caused by extra journeys and amount of time spent in a clinic environment. Moreover, a practice visit can significantly falsify basic clinical values like temperature, blood pressure and respiratory rate (Bragg et al., 2015).

Along with this, some veterinary tasks could be performed online completely, the best example being post-surgical follow-up examinations. After everyday procedures like spaying or neutering, removal of superficial growths or dental extractions, online review of the patient is favourable. Checking the overall condition along with e.g., sutures, via video conferencing saves time and enables an examination of the patient under familiar circumstances and therefore less stressful conditions. As Bishop et al., (2018) found in their study, owners were pleased with the results of a remote check-up service and opted to make use of it on other occasions. In addition, visits that could be deemed unnecessary can be avoided altogether by first presenting the animal to a veterinarian in a teleconsulting session (Chitty, 2019), or similarly, obtaining a second opinion is made easier ("Benefits of remote consultations in veterinary practice," 2021).

The implementation of veterinary telemedicine could also help practice management to optimise workflow. An increased capability to take on cases (Voyer and Jordan, 2018) in combination with improved distribution of labour (by more efficiently distributing patients to specialists after online counselling) would provide more preferable conditions for employees. Therefore, this could improve retention of personnel, by creating a more harmonious company culture, within the usually stressful workspace that is the veterinary field. Moreover, telemedicine could be used to re-introduce inactive veterinarians into work. For example, parents on parental leave, disabled veterinarians or pensioners could, if willing of course, work from home, creating their individual schedule, stay involved and contribute. On a similar note, pet owners that may experience difficulties in context of in-house visits (geographically isolated or disabled clients) would benefit from increased accessibility of veterinary expertise, if telemedical services increased in range (Hess, 2017).

Finally, like every other part of society, the veterinary medical sector should be hard-pressed to find ways to reduce carbon emissions, waste production and strive for playing its role in decelerating global climate change. Telemedicine is an eco-friendlier option to treat patients, as it has potential to reduce carbon dioxide production in connection with the health sector by 40-70 times. Transportation plays a huge part in global warming. Regarding healthcare personnel as well as clients, videotelecommunication helps circumventing the need to drive, if remote treatment is a possibility. Conclusively, it is an effective way to reduce the amount of greenhouse gases emitted in relation to medical appointments. If telemedicine was to be used more widely, it could have considerable effects in decreasing emissions (Holmner et

al., 2014). **Table 6** contains measured values comparing kilowatt hours (kWh) and Carbon Dioxide equivalent ($kgCO_2e$) costs for in-house and telemedical appointments, respectively. In the research that provided these values, both generous and conservative calculations were used in order to offset possible differences in hardware, traffic, or other unforeseeable factors.

Table 6 Accumulated life cycle carbon costs of telemedicine versus face-to-face meetings.

	Speech therapy (481 visits)		Hand rehabilitation (238 visits)	
	kWh	$kgCO_2e$*	kWh	$kgCO_2e$
Telemedicine				
Authentic conditions‘			1004	602
Lower bound	741	409	305	183
Upper bound	3307	1984	818	1364
Face-to-face visit				
Travel by car (Lenzen)		79 909		42 472
Travel by car (Leduc)		40 258		21 400
Emissions with respect to car travel (Lenzen/Leduc)				
Authentic conditions			1.4%/2.8%	
Lower bound	0.6%/1,0%		0.4%/0.9%	
Upper bound	2.5%/4,9%		3.2%/6.4%	

*Based on a conversion factor of 0.6 CO2e/kWh
‘Based on 157 connections to primary health centres using videoconferencing solutions and 81 connections to the patients home using desktop solutions. Such detailed data were not available in the speech therapy section.
Source: based on (Holmner et al., 2014)

3. Material and Methods

A Questionnaire consisting of 16 questions was created using the platform SurveyMonkey. The aim was to gain insight into participants views and acceptance of telemedical services among different sociodemographic groups in Germany. The questionnaire was available online and invitations that included a link to the questionnaire were distributed by email, via Facebook groups as well as veterinary news platforms. National Veterinary Associations in Germany were asked to further spread information to the questionnaire. The Questionnaire was anonymous, available from March to August 2021 and completed within 5 minutes. A

total of 362 participants completed the survey. The results were evaluated using different statistical methods such as descriptive and correlation analyses.

4. Results

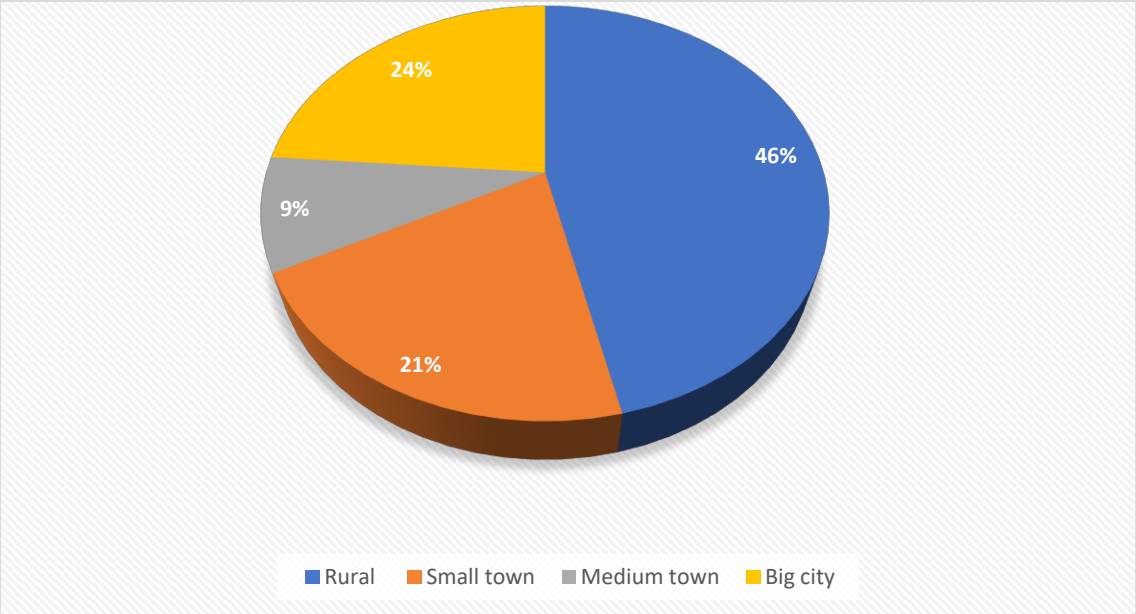
4.1 Sociodemographic data of the study population

The sociodemographic analysis consisted of five questions. The aim was to identify whether different backgrounds have an influence on perception of telemedicine in the veterinary field. Therefore, the participants were asked about the population of the area they live in, their age, gender, profession and, which German state they originated from.

4.1.1 Geographical distribution of surveyed population

362 responses were gathered that provide geographical information concerning the surveyed population. Of the respondents 46% came from a rural background, followed by urban (24%), small town (21%), and medium town (9%) inhabitants as shown in **Graph 1**.

Graph 1: "Where do you live?" (n=362)

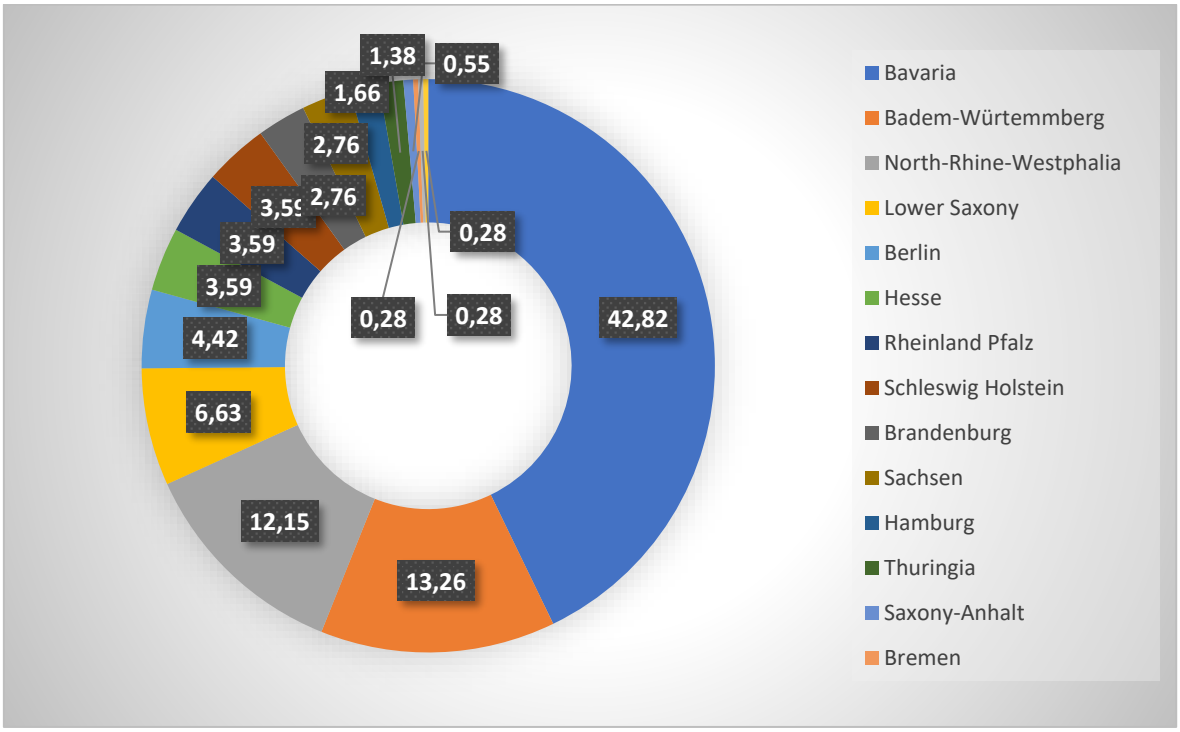


Note: Large City: >100.000 inhabitants, medium town: 50.000-100.000, small town: 10.000-49.999, rural: <10.000

Of those 362 people, the majority came from the southernmost states of Germany. So, despite trying to evenly distribute the survey, the largest portion of participants came from Bavaria (42.82%), followed by people living in Baden-Württemberg (12.26%) and North

Rhine-Westphalia (12.15%). This does however somewhat reflect the distribution of population in Germany, as those three states are the most densely populated (Bundeszentrale für politische Bildung). Only 1 answer each, was obtained from people calling Mecklenburg-Western Pomerania, Bremen or the Saarland their home. **Graph 2** was used to illustrate the discrepancies.

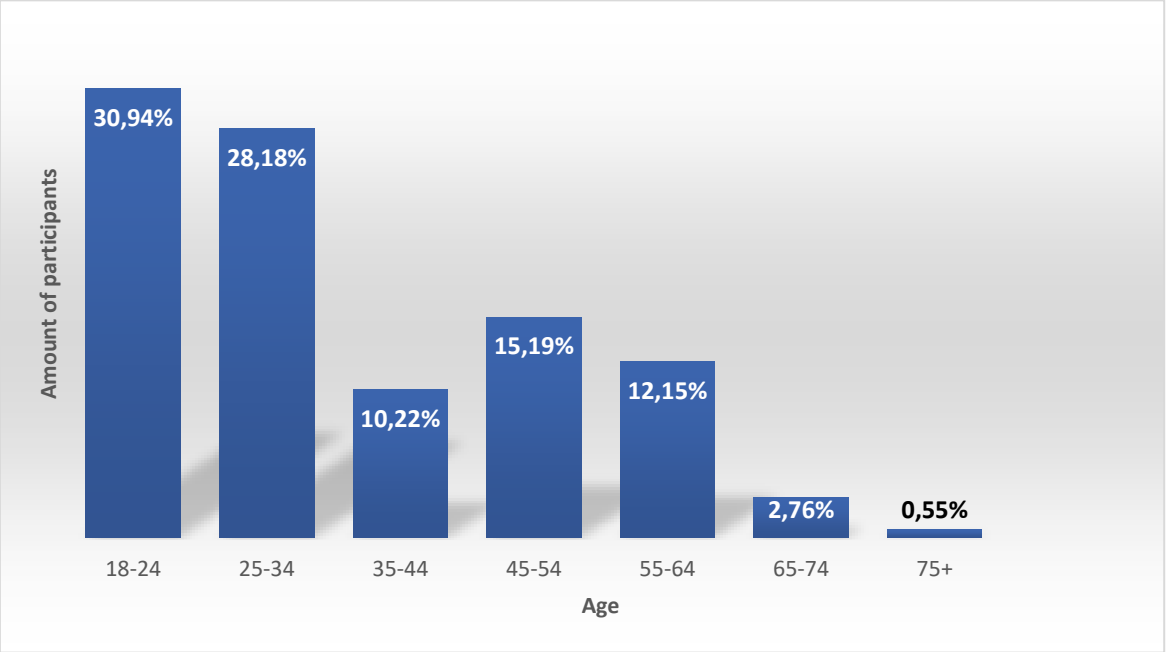
Graph 2 "Which German state are you from?" (n=362)



4.1.2 Social categorization of surveyed population

Socially determining parameters for this questionnaire were identified as sex, age and occupation. All participants (n=362) were required to provide information about their gender. The sex of this population leaned toward the female side with 247 (68.23%) of participants being women. Leaving 114 (31.97%) males, and 1 person (0.27%) that identified as divers. The different age groups were distributed as shown in **Graph 3.**

Graph 3: "How old are you?" (n=362)



The majority of questioned people belonged to the younger age groups. Out of 362 participants, 112 people (30.94%) were among the 18–24-year-olds and 102 (28.18%) counted themselves among the 25-34-year-olds. Only 37 respondents (10.22%) were aged 35-44, meaning they were slightly less represented than both of the following groups with 55 participants (15.19%) between 45 and 54 and 44 participants (12.15%) between 55 and 64. The older generations are even less depicted in this study, since merely 10 people (2.76%) aging 65 to 74 and 2 people (0.55%) over 75 years participated.
Accordingly, more than half of the respondents (59.12%) were under the age of 35, followed by 37.96% ranged between 35 and 64 years of age and only 3.31% were 65 or older.

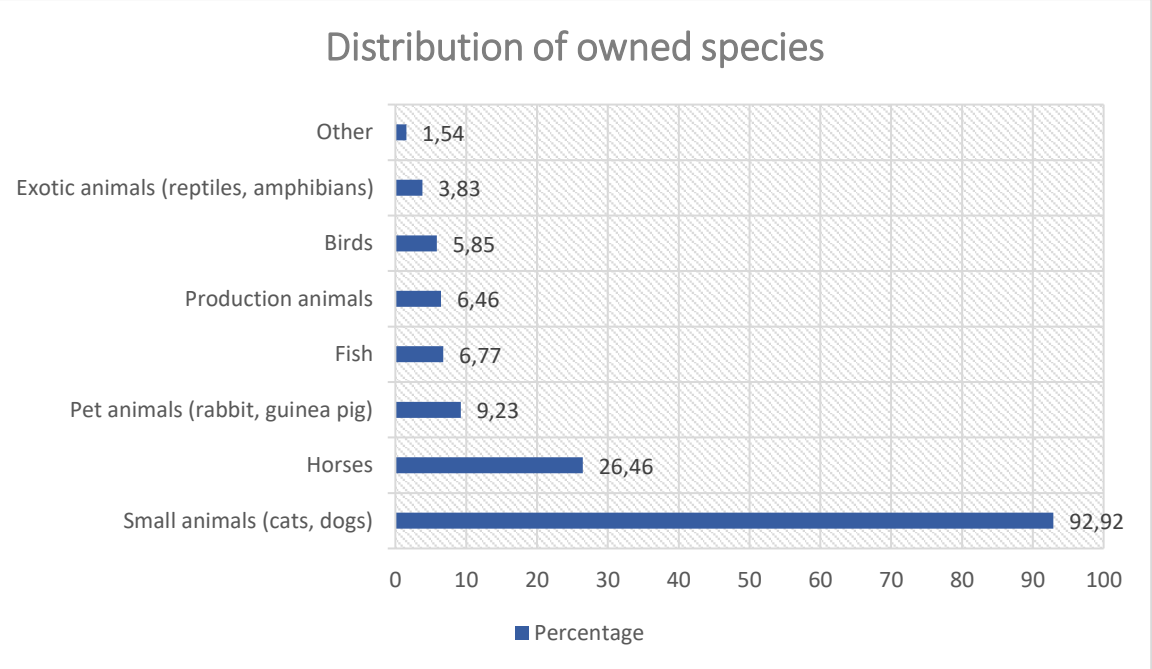
The demographic described in the performed survey mostly worked in the public health and medicine sector (34.63%) or were students or pupils (25.48%). The service sector (5.82%), pedagogues and social workers (5.82%), administrators (3.05%) agricultural/nature/environmental workers (2.77%), economists (2.77%), pensioners (2.77%) and people working in natural sciences (2.49%) were the other most relevant groups. 1.39% of respondents worked in the information technology sector, in construction and architecture, art and design, metal/steel engineering industry, production. People working for the law (policemen, lawyers) were each represented with 1.11%. Finally, 0.83% worked in electronics and technology respectively, while merely 1 respondent (0.28%) worked as a journalist and there were no representatives of the logistics and traffic sector.

Respondents that chose “other” (5.54%) could mostly be allocated to one of the given categories. There were two outliers; one person entered “housewife”, another said they were in “partial retirement”.

4.1.3 Target Group

The questionnaire was purposely directed at possible clients of veterinarians. Regarding this, the distribution focused on forums, websites and social media groups that are animal related. More specifically, several veterinary clinics and practices as well as veterinary telemedical service providers were contacted and asked to share the survey with their established customer base. This resulted in 325 people or 89.75% answering yes when asked whether they owned pets. Additionally, respondents were asked to specify what animals they owned. **Graph 4** shows the distribution of pet animal species among the represented owners.

Graph 4: “If you do own a pet, what kind?” (n=325)



Among the animal-owning respondents, as many as 302 (92.92%) have small animals, making cats and dogs the most popular pets within this survey. The second most prevalent animals are horses, which are owned by 86 respondents (26.46%). 30 (9.23%) people take care of other pet animals like rabbits, guinea pigs and such, while 22 (6.77%) own fishes, another 21 (6.46%) own production animals, and 19 (5.85%) own birds. Lastly, 11 respondents (3.38%) own exotic animals. 5 animal owners (1.54%) chose the option ‘other’ and subsequently specified that they owned either donkeys, alpacas, miniature chickens.

Based on the way this survey was distributed, it was unsurprising that a large number of participants owned small animals. Further examining this data, revealed that most participants owned several species at once, most noticeably was the combination of small animals with any of the other options. This is exemplified by the fact that 93.02% of respondents who indicated that they owned horses also owned small animals according to their selection. Similarly, 80% of pet animal (rabbit, guinea pigs, etc.) owners and 80.95% of production animal owners had cats and dogs as well. The rest of the statistics present themselves along with this pattern, since 81.82% of participants that own exotic animals, 78.95% of bird owners and 81.82% of fish care-takers are also accompanied by at least one cat or dog.

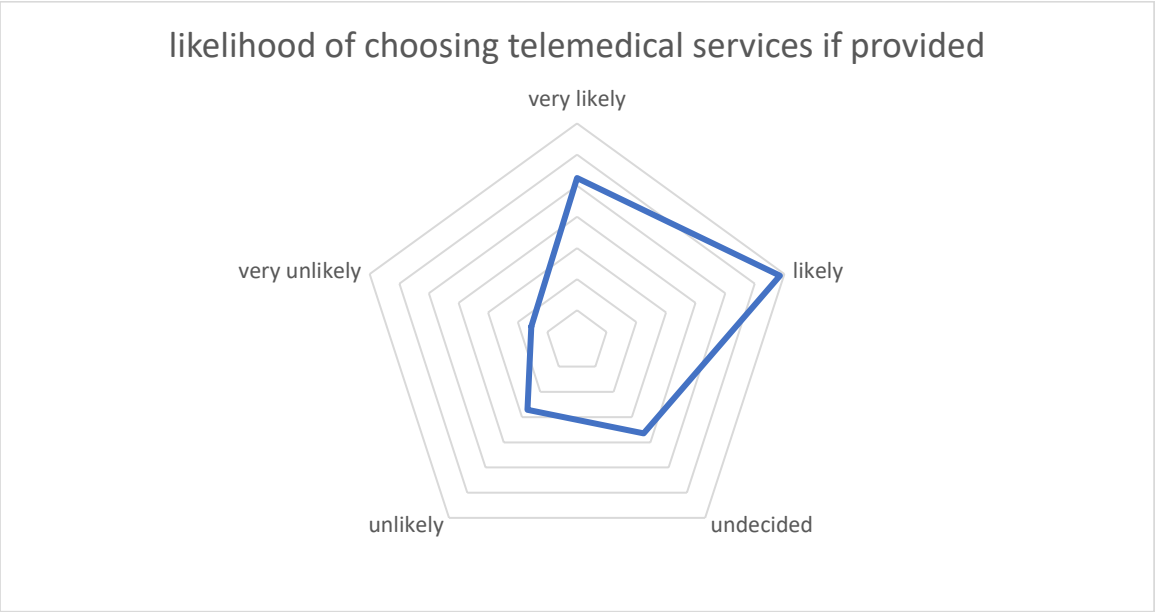
4.2 Quantifying customer perception and acceptance of veterinary telemedical services

In order to contextualise how animal owners' view remote healthcare, participants were asked how likely they are to make use of telemedical services. Based on these values, sociodemographic influences were tested, as well as whether small animal owners in general are open to such procedures according to the following pre-determined hypotheses:

1) H1: If an animal owner has small animals, they are likely to make use of telemedical consultations
   H0: Owning small animals has no effect on likelihood of using telemedical consultations
2) H2: Younger animal owners are more likely to make use of telemedical consultations
   H0: Age of animal owners has no effect on likelihood of telemedical consultation usage
3) H3: Rural and small-town populations are more likely to use telemedical consultations
   H0: There are no regional differences in likelihood of telemedical consultation usage

To identify consumer acceptance and attitude of telemedical services in general likelihood of using telemedical services was converted into a 5-point scale ranging from very likely to very unlikely. As already mentioned, people were asked to choose the option they most tended to as can be seen in **Graph 5**. For statistical evaluation each subjective likelihood was allocated a numeric value as follows: (1) Very likely, (2) Likely, (3) Undecided, (4) Unlikely, (5) Very unlikely.

Graph 5: "How likely are you to choose a virtual consultation if your veterinarian can offer it?" (n=362)



Overall, 95 respondents (26.24%) chose option 1, "very likely". A majority of 124 surveyed people (34.25%) chose option 2," likely". The 66 (18.23%) respondents that were undecided chose option 3 and 49 (13.54%) chose option 4, "unlikely". Only 28 participants (7.73%) chose option 5 "very unlikely". The graph visualises the overall attitude towards telemedicine of this population. The trend points toward telemedicine being likely to be used by respondents, if offered. This is supported by basic statistical calculations based on the numeric values (1-5), as the median reigned it at 2.00, the mean was 2.42 and the standard deviation was calculated at 1.23.

The testing of the Hypotheses was done using correlation testing, namely the Spearman-, Kruskal-Wallis-, and Wilcoxon rank sum tests. The goal was to identify whether sociodemographic differences (age, place of origin) would significantly influence willingness to participate in telemedical services, and whether the species of the pet would significantly influence said willingness to participate.

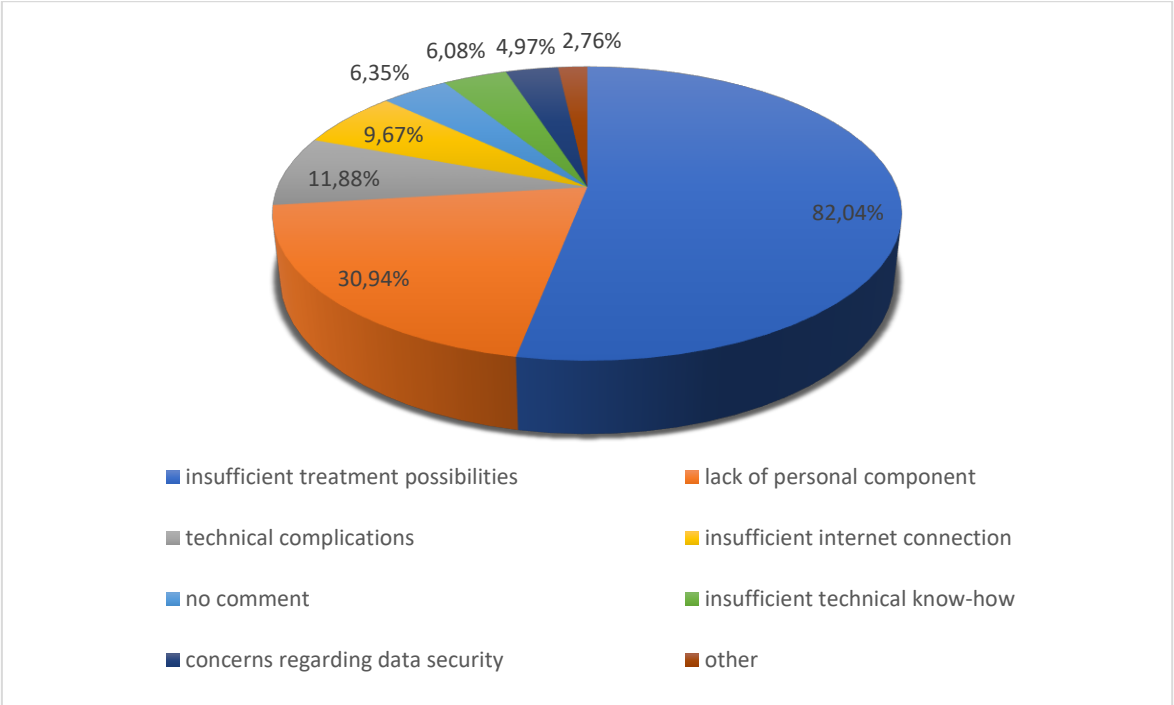
The calculations, however, revealed no measurable relationship between regionality and willingness to participate in online consultations (p=0,8187 Spearman-test) (p=0,06 Kruskal-Wallis-test). Between the age of the respondent and likelihood to make use of online consultations (p=0,077 Spearman-test) (p=0,63 Kruskal-Wallis-test), there was also no significant correlation. Lastly, there seems to be no connection between owning small animals and likelihood to take part in telemedical consultations (p=0,595 Wilcoxon rank

sum test). This results in failing to reject all three of the null hypotheses. A possible interpretation of this outcome is, that there are no preferences between different sociodemographic groups and owners of different pets, concerning the use of telemedicine. In combination with the rather high likelihood to take part in online healthcare among the test group, it is arguably more universally accepted than previously assumed. But it is important to note that because of the small sample size and their rather one-sided geographical distribution, these results cannot be seen as a fair representation of the general public. These are therefore merely directions which more broadly distributed surveys could explore.

4.3 Identifying limiting factors of veterinary digitalisation according to the surveyed population

Despite the data looking promising, since the average respondent appears to be more likely to make use of telemedicine offers than not, it is still necessary to identify reasons that, in the eye of the customer, are limiting the potential of digital healthcare. As a means to work out limitations, possible factors that would prompt respondents to decline online consultations were offered in the survey, which can be reviewed in **Graph 6.**

Graph 6: "Which factors would discourage you from engaging in a virtual consultation?" (n=362)



The most common reason (82.04%) why participants would decline a telemedical consultation was, the issue of insufficient treatment possibilities. There was also considerable concern with the lack of personal component (30.94%) among animal owners. Other inconveniences that could occur alongside online consultations were technical complications (11.88%), insufficient internet connection (9.67%). From the owner's point of view, insufficient technical know-how (6.08%), as well as concerns regarding data security (4.97%) were only viewed as minor problems. 23 respondents (6.35%) chose not to answer.

Interestingly, among the 2.76% that chose "Other, please specify", 3 respondents that identified themselves as veterinarians offered criticism towards telemedicine by statements like: "remote diagnoses are almost always false", "You can only diagnose a colic, for example, by performing a rectal exam, therefore it is pointless to talk on the phone" or "I am a veterinarian and I do not believe in telemedicine". It should be mentioned here that the survey was in no way stating that definitive diagnoses should be the result of telemedical consultations, nor was otherwise specified how telemedicine should be used. It is necessary to add, that there is no way to prove or disprove that these responses came from actual veterinarians, however the potential discussion about means of utilisation of telemedicine is of considerable interest. Future research should aim to identify perception among veterinarians as well as customers more specifically, and in doing so aim to describe discrepancies in intended application among vets and clients respectively.

4.3.1 Assessing framework conditions for implementation of digital healthcare systems

The field of telemedicine offers solutions for several problems and inconveniences that are interlocked with a typical visit to or from a veterinarian. Some of these issues could be addressed by telemedicine if the broad population is willing to participate more proactively. So, in order to judge acceptance of some of these methods, the survey was set up to gain insight into customers' negative experiences at the veterinarians, as well as their perception of possible solutions and improvements. Naturally, to work solution-oriented, one has to first identify the major problems – **Graph 7** gives an overview over what negative experiences the participants in this survey have encountered most commonly, in an effort to gauge where there is room for improvement with help of virtual tools.

Graph 7: "During a visit to a veterinarian, what are factors that would bother you?" (n=362)

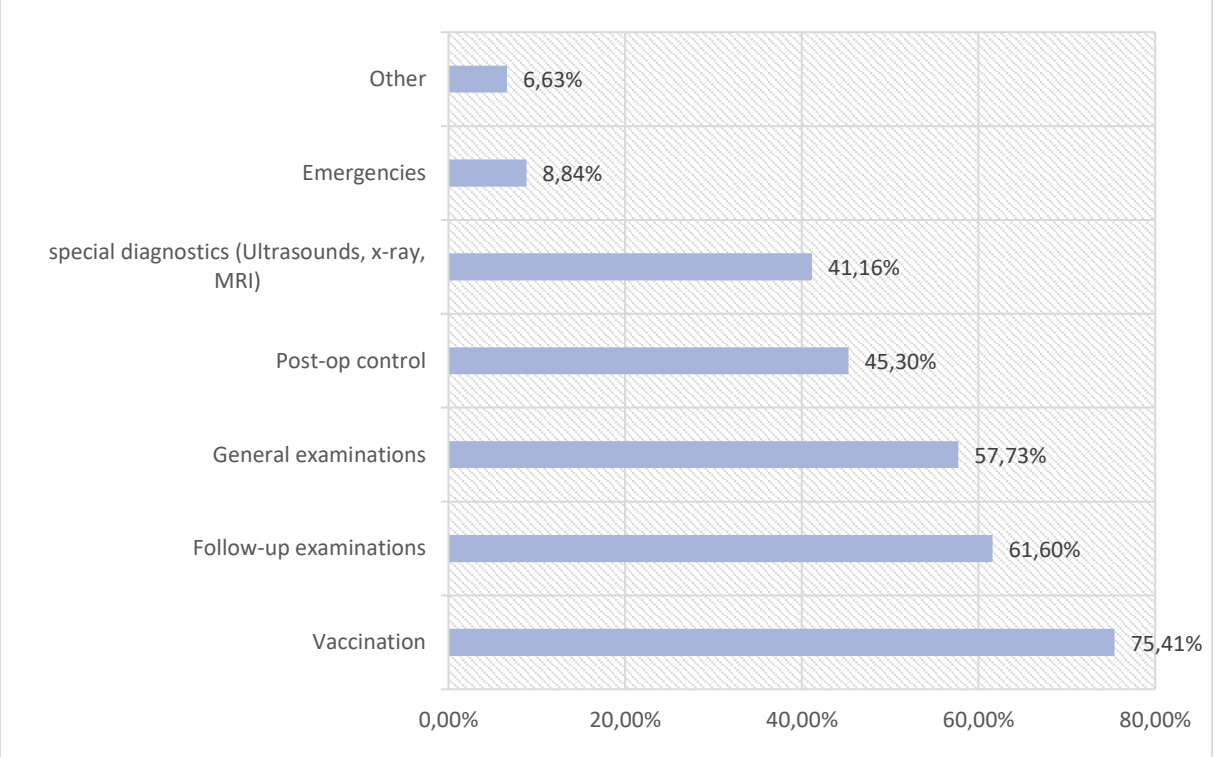
When asked about things that would make a visit to the veterinarian undesirable, waiting times (59.21%) and aggressive or rather nervous pets (54.97%) were the two most chosen answers. General stress seems to be another negative factor in connection with a visit to a veterinarian, as it is experienced by 38.40% of participants. 107 people (29.56%) were bothered by the travel distance and, similarly, the time expenditure was a nuisance for equally as many respondents (also 29.56%). The costs (11.05%) are not among the priority problems. 34 people (9.39%) did not give an answer to this question. The suggestions made by way of selecting the point „Other" were either too specific, or aligned with one of the given options.

Specifically travel distance and time expenditure are problems that, assumably, affect rural populations or horse owners. However neither of those two groups was, according to this survey, significantly more impaired by these problems than others. In fact, slightly fewer (28.57%) inhabitants of rural areas experienced the travel distance as a negative side effect of clinical visits and only 21.43% minded the time expenditure. Comparably, 27.91% of horse owners are unsatisfied with the required distance they have to travel to a veterinarian and 31.40% find the loss of time to be regrettable. The literature review already showed how overall stress for both animals and their owners could be reduced, and that physiological values are closer to base values in animals being examined in their home environment (Bragg et al., 2015).

A way to work around some of the other mentioned problems is online scheduling, especially waiting times and time expenditure are supposed to be cut away drastically by this. Despite this already being commonplace in some countries, in Germany, it is not as widely spread.

Although, as is represented in **Graph 8**, when asked about online scheduling and provided possible options, respondents reacted overall positively.

Graph 8: Preferable services to be scheduled online (n=362)

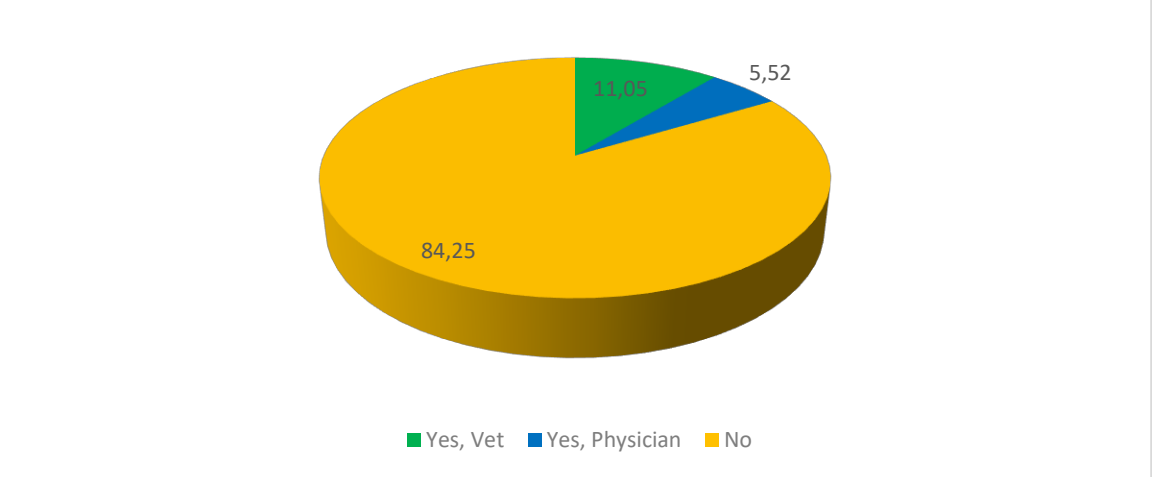


The following options were considered preferable for online scheduling; vaccinations (75.41%,), follows-ups (61.60%), general examinations (57.73%), post-operative control (45.30%), special diagnostics like ultrasound, x-rays and blood work (41.16%). On the other hand, emergencies seem to be a different matter, as only 8.84% of the questioned people regard the situation as online-schedulable. Out of the 24 answers in the „Other" column, 10 (2,76%) were variations of either „general examinations" or „check-ups" and the remaning 14 answers (3,87%) can be summarised as „online scheduling should not be practiced".

Another, similarly time-saving possibility in routine veterinarian practice is the so-called online prescribing. Earlier chapters (2.1.4.2) have already dealt with the discussion of the matter. Notably, while conducting the survey, online prescriptions were not legal in Germany. According to the results, however, 215 respondents (59.72%) were in favour of it to be legal for veterinarians to diagnose and prescribe patients virtually, while 145 (40.28%) were against it. Naturally, the matter first needs more research aiming to establish a clear set of regulations based on clinical trials if it is ever to become a practical reality. But at least in this population, participants seemed to be in favour of it.

As already stated, acceptance of telemedicine among the general public was meant to be measured with the help of this questionnaire. Therefore the participants were asked, whether they thought telemedical services would be an addition to their veterinarians clinic or practice. The results suggest, that a majority of respondents (70.72%) think that telemedicine would indeed be beneficial, while the rest (29.28%) are not convinced. On the other hand, when asked whether they have ever made use of telemedical consulting with either a veterinarian or a physician, responses showed that there was little experience with the topic among this test group (see also **Graph 9**).

Graph 9: „Have you ever made use of an online consultation with your physician or veterinarian?" (n=362)

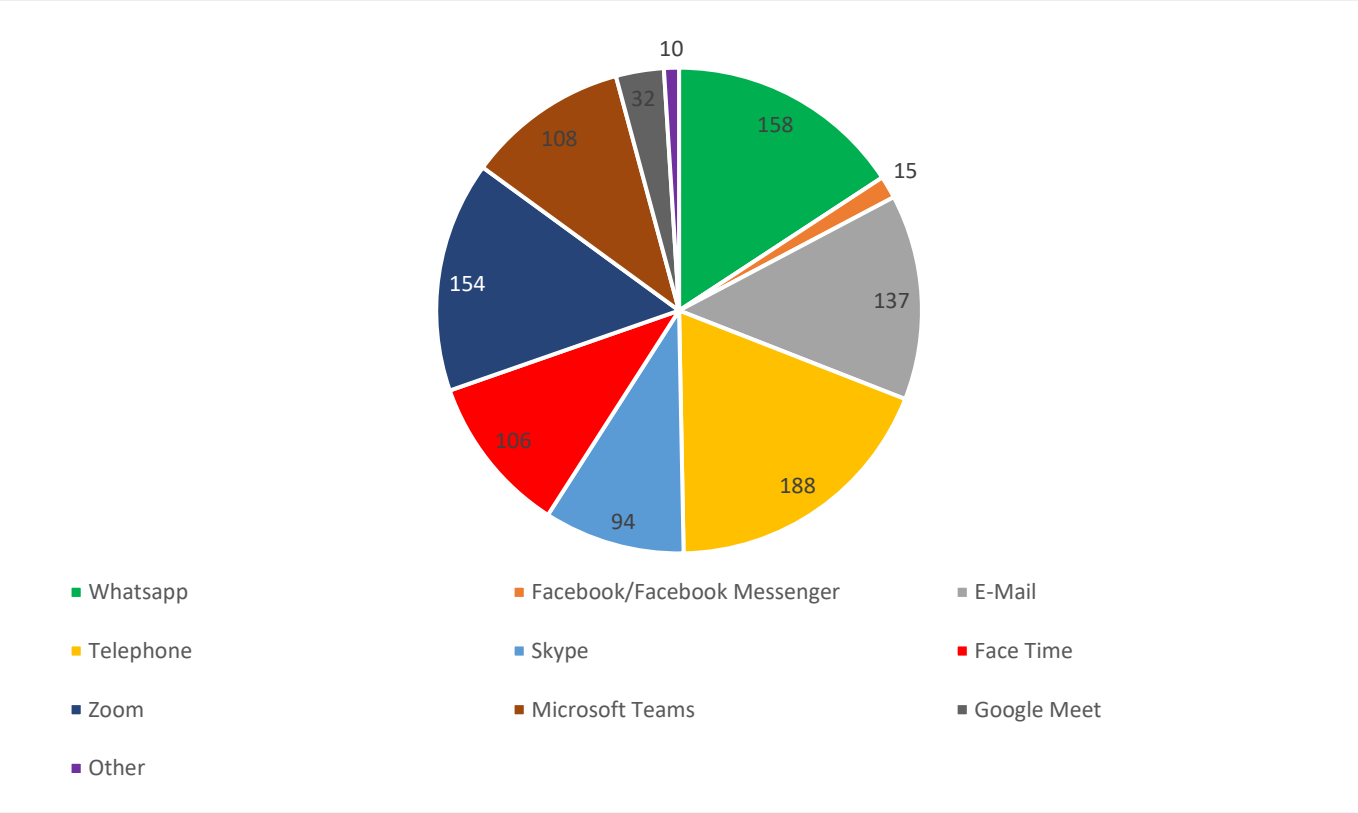


As is also shown in the graph, out of 362 surveyed participants, merely 40 (11.05%) have made use of a telemedical consultation with a veterinarian. Another 20 have had experiences in this regard with a physician (5.52%). A vast majority of 84.25% answered "No" when asked whether they had used any sort of online consultation. So, despite many people regarding it as an asset to a veterinary facility, there is little to no use of it in reality. The exact reasons accountable for this suggested gap in supply and demand are hard to gauge and would make for interesting research in the future.

A major aspect that should be part of telemedical services, is, making medical services more attainable for animal owners. Therefore, the efficient use of modern technology, that can establish and retain high-speed, live connections, seems indispensable. Especially since these devices and accompanying applications are already commonplace in most households and clinics or practices. It therefore can be deemed logical to search for information

concerning preferred communication tools among the respondents. **Graph 10** provides insight into how some of the most used telecommunication tools are viewed as potential candidates for utilisation in telemedical services.

Graph 10: "What would be your preferred way of communication with your vet under virtual circumstances?" (n=362)



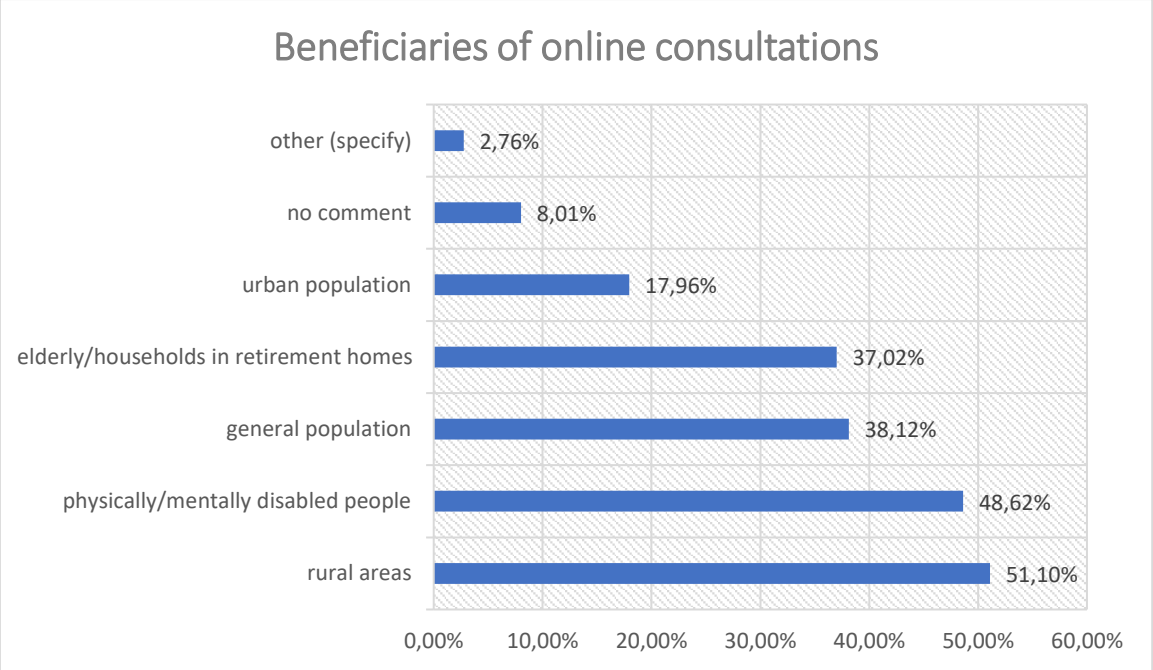
Note: numbers represent total amount of times an answer was chosen

The preferences of respondents as illustrated in **Graph 10** were distributed relatively broadly, excluding Facebook and its messenger (4.14%) and Google Meet (8.84%) which are the two least favourite options of the provided pool. The video-chat-focused tools as a group, Skype (25.97%), Face Time (29.28%) and Microsoft Teams (29.83%) were within similar margins to each other. The exception being Zoom, another video communication platform, with 42.54% approval among participants. The more text-based group of applications also scored within range of each other. 37.85% consider E-mail a decent option, while Whatsapp gathered 43.65% overall. Using the telephone to communicate with their veterinarians was the preferred way of more than half of the respondents (51.93%) and thus the most popular tool. Other communication tools suggested by participants in the respective

column were Signal Messenger, RED medical. The remaining answers provided can be summarised as “None of the above”.

Finally, participants were asked to assess, which sociodemographic group(s) would benefit from telemedical solutions in their opinion. A pool of answers was provided, as well as the option to add more individual answers. The results can be seen in Graph 11.

Graph 11: “In your opinion, who would benefit the most from an online consultation?” (n=362)



185 people (51.10%) thought that the rural population would be among the main beneficiaries of telemedicine or more specifically, online consultations. 176 (48.62%) respondents opted for people with disabilities. 138 (38.12%) people chose the general population and another 134 (37,02%) picked the elderly and inhabitants of retirement homes. The urban population was in seen as less dependent on digital solutions, since 65 (17.96%) respondents selected this answer. Also, 29 (8.01%) people chose not to answer at all. The individual answers provided (2.76%) do not contribute to the discussion.

5. Discussion

Digitalisation is present in every aspect of modern society, also in medicine. As already stated, veterinarians are somewhat lagging behind in this regard. There are various reasons mentioned in 2.2.1. However, the literature suggests that there is a lot of progress made in practicing telemedicine on a vet-to-vet basis, and it is the vet-to-patient aspect of telemedicine that is less developed than its human medicine counterpart. What seems to be disregarded in most of the described literature is one of the big differences in veterinary medicine compared to human medicine; veterinarians are, in basic terms, service providers toward the owner's "possession", the pet. Therefore, the clients need to be asked what their perception of veterinary telemedicine is and how they accept it. Since it only makes sense for a service provider to offer something if the request is adequate.

Accordingly, this study set out to quantify general perception of veterinary telemedical services among a customer population and investigate which problems, that could be helped to solve with digitalised methods, are the most prevalent. Part of this was testing the mentioned hypotheses, to find informative trends in connection to different customers' preferences. The correlation testing revealed however, that none of the null hypotheses could be rejected:

1) Owning small animals has no effect on likelihood of using telemedical consultations
2) Age of animal owners has no effect on likelihood of telemedical consultation usage
3) There are no regional differences in likelihood of telemedical consultation usage

This shows that there are limitations to this survey within which the results need to be interpreted. The questionnaire was supposed to be a larger scale, as it sought to gain a broad overview concerning perception of telemedicine in different sociodemographic groups. The sample size was therefore, despite the author's best efforts, not quite satisfactory for making broader assumptions or recommendations. There was also a geographical bias in responses from Bavaria, which is most likely due to the author being from there.
The survey itself was limited by the manner of questions asked. The option to select several choices for most answers made the collected data less quantifiable and therefore decreased

mathematical relevancy. As a result, testing the Hypotheses proved more challenging than anticipated.

However, it should be noted, that the paper overall still provides meaningful points for further research, especially more large-scale surveys into customer's perception. There were for example some insights into animal owners' acceptance of telemedicine.

The most common reason identified for customers declining online consultations was insufficient treatment possibilities. Technological problems were not seen as such substantial issues as the literature would suggest (Drewry et al., 2019). Data security was for example not seen as a big problem (4.97%) by this study group. Previous studies also implied that in general customers are willing to pay for telemedical services (Widmar et al., 2020), which is somewhat supported by the fact that people partaking in this questionnaire are overall likely to use online consultations. It is therefore feasible to argue that an increased supply of, e.g., teleconsultations can be a source of additional income for veterinarians, alongside established benefits for patient healthcare such as less stress for owner and animal. As Bragg et al. (2015) established, there are measurable differences in physiological values of patients due to in-house physical examinations. This study also found that aggressive and nervous behaviour of patients, likely due to stress during visits, was a problem for more than half (54.97%) of animal owners.

This survey also showed that, while participants were likely to take part in consultations and 70.72% thought that telemedicine would be an asset to a veterinary institution, only 11.05% have ever made use of online consultations with a veterinarian. It would be speculation to establish the reasons for this based on the collected data of this survey. It is recommended to conduct further research into the reasons for inconsistencies such as this. Nevertheless, the data of this survey supports that overall, animal owners are likely to use telemedical services if offered. This implicates that if veterinary institutions directed their attention towards this matter, they could reap the financial and professional benefits that were illustrated in previous chapters. There are already studies that support this assessment (Voyer and Jordan, 2018). It would also be advisable to implement online scheduling for routine services. Participants of this survey were in favour of making appointments online for basic practices like vaccinations, general examinations, follow-up, and post-op examinations as well as special diagnostics. This is an inexpensive method to save time and redistribute work force in a more economical way.

In conclusion regarding both the literature as well as the conducted survey it can be stated that, overall, telemedicine has more benefits than disadvantages and is accepted among customers, if not always well understood in its entirety. Since it is a method of facilitating interaction between two parties, more studies should focus on this bilaterality – rather than on either the professional or the customer's side.

6. References

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7. Acknowledgements

I would like to thank my supervisor Dr. Erik Diez for his guidance. Especially for the amount of effort he put into mentoring me during the process of this paper. Also, I would like to acknowledge Dr. László Ózsvári for granting me the opportunity to write a TDK in his department. Of course, I want to extend my gratitude to everyone that helped in distributing the survey, especially my friends and family. Finally, thank you Ben and Steffi for the moral support.

Supervisor's consent

I hereby confirm that I am familiar with the content of the thesis entitled

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…….

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Title of document (to be uploaded): Digitalisation in veterinary medicine: Telemedicine

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