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Veterinarians' Perceptions about Information and Communication Technologies and Telemedicine in Clinical Practice Before and During the COVID-19 Pandemic

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Abstract

Background:

With advances in information and communication technologies (ICTs), the transfer of animal health data has increased in volume and velocity. These technologies empower animal owners to access health data and connect with veterinarians remotely. However, the landscape of ICT use and telemedicine continues to evolve, including changes in technologies, definitions, and regulatory frameworks that were accelerated during the COVID-19 pandemic but remain insufficiently documented. Therefore, the overall goal was to explore veterinarians' use of and attitudes toward telemedicine and specific ICTs in clinical settings during the pre-COVID and COVID-era.

Methods:

Two anonymous online questionnaires were distributed using snowball sampling. Descriptive and comparative analysis was performed using logistic regression, multinomial regression, and Fisher's exact test.

Results:

A total of 205 pre-COVID and 133 COVID-era veterinarians, predominantly from the United States and Canada, who provided care to client-owned animals were included. There was no clear evidence of a difference in telemedicine use between pre-COVID and COVID-era respondents (RRR = 1.13, 95% CI=0.65-1.97). However, COVID-era respondents were more likely than pre-COVID respondents to use telephone/voice (OR = 7.11, 95% CI = 1.36-37.2) and live video chats (OR = 3.42, 95% CI = 1.33-8.8) to interact with clients. They were also more likely to bill for remote communications (RRR = 12.18, 95% CI = 3.87-38.37) and to consider ICTs suitable for triage (OR = 4.67, 95% CI = 1.98-11.02), diagnosis (OR = 2.72, 95% CI = 1.62-4.59), and prescriptions (OR = 2.52, 95% CI = 1.27-5.01). However, many were still reluctant to rely fully on ICTs, especially when

used to perform diagnosis, which had the highest percentage of respondents opposed to ICT use (45%).

Conclusions:

During the COVID-19 pandemic, participating veterinarians have had higher utilization of different ICTs with clients than the pre-COVID participants, were more likely to bill for these interactions, and are more comfortable using ICTs for a variety of clinical tasks (assuming a VCPR was established and legal). However, many still did not label forms of ICT use as telemedicine and were generally hesitant to charge for such services.

Keywords: veterinary telemedicine; information and communication technologies; COVID-19 pandemic; digital health; remote consultations; veterinary practice; client communication; technology adoption

Background

Information and communication technologies (ICTs) have been used in veterinary medicine since the invention of the telephone but have greatly expanded starting in the 1980s with the transmission of electrocardiograms to cardiologists across the United States and the introduction of email communication.[1] With advancements and wider access to ICTs, medical information transfers much more rapidly[2] and extends healthcare beyond the confines of hospitals.[3,4] These technologies empower animal owners to access health data[1,5] and connect with veterinarians remotely,[6] thereby enhancing owner's caregiving capabilities.[7,8] One study revealed that although pet owners preferred face-to-face consultations with veterinarians, many were willing to consider virtual consultations.[9] Some clients may prefer scheduling appointments, discussing

71 treatments, and seeking quick advice via ICT platforms[10] and many are highly satisfied with their
72 use, such as in post-surgery follow-ups.[11,12] Digital communications may strengthen veterinary-
73 client relationships,[3,13] reduce patient stress,[11] and improve access for underserved populations.[14]
74 Telemedicine involves the electronic transfer of medical data between locations to
75 enhance a patient's clinical health.[15] This can include sharing medical advice, treatment, or
76 diagnostic communication using various ICTs such as email, text, telephone, or video chat.[16]
77 While ICTs are prevalent in veterinary practice, some veterinarians may not have recognized that
78 they were engaging in telemedicine.[12] This lack of awareness could have led to slower adoption
79 of ICTs, more structured workflows, and related business strategies to support use of
80 telemedicine. The dynamic landscape of telemedicine encompasses evolving definitions,
81 technologies, and regulatory framework, like the Veterinary-Client-Patient Relationship
82 (VCPR).[17]
83 This study was initially designed as a single cross-sectional study to measure veterinary
84 usage and perceptions towards telemedicine and ICTs. However, the original study period
85 (October 2019 - February 2020) concluded just before COVID-19 was declared a pandemic by
86 the WHO (March 2020). Analysis of these pre-COVID data was conducted, and results are
87 available elsewhere.[18] The onset of pandemic-related restrictions greatly increased the discussion
88 of telemedicine and its potential as a crucial tool for protecting animals, owners, and veterinary
89 staff from COVID-19 exposure.[19] The pandemic presented veterinarians with an opportunity to
90 gain practical experience in virtual consultations. To capture updated views during the COVID-
91 era, another round of data collection was conducted to provide insight into the immediate pre-
92 pandemic period and provide a basis for comparison.

The aim of this study was to compare veterinarians' use and attitudes towards telemedicine and specific ICTs for veterinary care before and during the COVID-19 pandemic. The four specific objectives of this study were to compare: (1) veterinary perceptions of telemedicine and ICTs, particularly whether veterinarians considered they were practicing telemedicine; (2) what ICTs veterinarians were using and would like to use more or less of; (3) how veterinarians were billing and would like to bill for time spent communicating with clients over ICTs; and (4) what clinical tasks (triage, diagnostics, treatment, prescription of medication) veterinarians felt they could adequately address over ICTs.

Methods

An online questionnaire-based repeated cross-sectional study of practicing veterinarians was performed on two time periods: October 10th, 2019 to February 18th, 2020 (pre-COVID) and July 27th, 2021 to August 18th, 2021 (COVID-era). The Checklist for Reporting Results of Internet E-Surveys guidelines were followed.[20] The study was reviewed by the University of Guelph Research Ethics Board for compliance with federal guidelines for research involving humans (REB #: 19-03-025).

Questionnaire design

The questionnaire (Additional File 1) underwent collaborative development and iterative pre-testing, including input from veterinarians, veterinary students, epidemiologists, and final evaluation by veterinary faculty. It consisted of two sections, with 13 identical questions for both time periods, and 4 additional questions in the COVID-era questionnaire (labeled "C1-C4").

Section 1 consisted of three questions. Question 1 was a screening question, where respondents who indicated that they provided care to client-owned animals could proceed with the rest of the questionnaire. Question 2 gathered data on the types of animals cared for, while Question 3 assessed veterinarians' perceptions of their telemedicine use in practice. Definitions were omitted to allow for individual participant's independent interpretations of telemedicine's scope and functionalities.

Section 2 consisted of 10 questions (pre-COVID) or 14 questions (COVID-era). Once participants proceeded to section 2, they could not return to section 1. Question 4 explored which ICTs were used by veterinarians for clinical tasks, like helping clients decide whether to bring their animal to the clinic ("perform triage"), facilitating or communicating diagnostics with clients ("facilitate diagnosis"), facilitating or communicating treatments with clients ("guide treatment"), providing educational content to clients ("provide educational content") and facilitating prescriptions for clients for their animals ("provide prescriptions"). ICTs evaluated included email, text/instant messaging ("TIM"), telephone and other live audio-only communication ("telephone") and live video chat. Email and TIM were further split into transmissions that included text only ("text-only") and transmissions that, in addition to text, included images, audio or video ("beyond-text"). Question C1 (additional COVID-era question) assessed ICT usage changes during the COVID-era on a scale from 1 (less use) to 5 (more use). Question C2 (additional open-ended COVID-era question) asked how the COVID-19 pandemic affected their opinion on communication technology use in practice. Question 5 addressed how veterinarians would like their current use of ICTs to change on a scale of one (use less) to five (use more). Question 6 and 7 assessed how veterinarians bill, and would like to bill, for time spent interacting with clients over ICTs. Question 8 examined which clinical tasks veterinarians

136 believed could be adequately addressed through ICTs under an established VCPR and assuming
137 it was legal. The list of clinical tasks was based on definitions of telemedicine provided by the
138 American Veterinary Medical Association (AVMA)[1]. Question C3 (additional open-ended
139 COVID-era question) asked veterinarians how they would change communication technologies
140 to better suit their needs. The remaining questions gathered participants' demographic
141 characteristics, and Question C4, an additional open-ended COVID-era question, identified the
142 specific Facebook group (or other location) where they accessed the questionnaire. Blank
143 responses were labeled as “unknown.”
144

145 **Participant recruitment**

146 Participants for both phases of the study were recruited using snowball sampling via Facebook’s
147 social media platform. The questionnaires were shared exclusively in veterinarian-specific
148 groups, defined as groups where either the group's purpose or admission criteria explicitly
149 included veterinarians. These groups were identified by searching Facebook for keywords like
150 "veterinary," "veterinarian," and "vets." Membership in these groups was not limited to
151 veterinarians alone; veterinary technicians or students could also join. To distribute the COVID-
152 era questionnaire, we targeted both the original Facebook groups used for the pre-COVID
153 questionnaire and newly identified groups. Permission from group administrators was secured
154 for posting the questionnaire on discussion boards. Out of 14 pre-COVID groups contacted, 10
155 granted permission, while out of 32 COVID-era groups contacted, 12 granted permission. The
156 pre-COVID questionnaire was also distributed to Ontario Veterinary College personnel via

organization-wide emails and website announcements, a method not repeated during the COVID-era recruitment.

To participate in the questionnaire, veterinarians had to be providing care to client-owned animals. Informed consent was obtained electronically from all participants by proceeding with the questionnaire. Data was collected using standard commercial software for online surveys (Qualtrics).[21]

Questionnaire analysis

Only the first question (inclusion criterion) required a mandatory response. Questionnaires with blank responses to more than one non-demographic question were excluded from the analysis. The results are presented as proportions of respondents who answered the question, resulting in varying denominators due to missing values. In the previous analysis, which focused solely on pre-COVID data,[18] only fully completed questionnaires were included. For the current comparison study, the criterion for analysis was modified to include questionnaires in which not all questions were answered in order to gain more valuable feedback and increase the sample size. This adjustment raised the pre-COVID sample size from 194 to 205 respondents and the COVID-era sample size from 90 to 133 respondents. Importantly, this adjustment did not qualitatively impact pre-COVID results, maintaining overall analysis consistency. Sample size calculation was performed and details are provided in the Additional File 2.

Descriptive statistics were calculated for each question (frequencies). Birth years were grouped into decades, and the findings were presented for all participants and sorted by their country of practice. Respondents who reported using at least one ICT for any clinical task (Question 4) were considered ICT users. These findings were then analyzed in conjunction with

179 respondents' current telemedicine usage (Question 3) to assess whether veterinarians perceived
180 ICT use in clinical practice as equivalent to telemedicine. Respondents categorized as "existing-
181 users" of a specific ICT were deemed "satisfied" if they expressed a desire to maintain or
182 increase their usage of that ICT. Similarly, respondents classified as "non-users" of a specific
183 ICT were considered "satisfied" if they indicated a preference to maintain or decrease their usage
184 of that ICT.

185 Pre-COVID and COVID-era responses to questions were compared using logistic
186 regression for binary outcomes and multinomial regression models for outcomes with more than
187 two categories, controlling for gender, age in years, country of practice, and practice type
188 (animals cared for). Fisher's exact test was also used to compare demographics and ICT
189 satisfaction/adoption between Pre-COVID and COVID-era respondents (Figs 1 and 2). Data
190 processing and analysis was conducted in R version 4.3.0 and RStudio version 2023.06.0+421. A
191 *P* value < .05 was considered statistically significant.

192 Results

193 For the pre-COVID period, a total of 280 participants accessed the questionnaire online, of
194 which 231 participants met the inclusion criterion (treating client-owned animals) and 205
195 (88.7%; 205/231) had a maximum of one missing response to non-demographic questions and
196 were included in the final analysis. Of the 205 analyzed questionnaires, 5 (2.4%; 5/205) had a
197 blank response to one non-demographic question and 9 (4.4%; 9/205) were missing demographic
198 information (birth year, or birth year and country). For the COVID-era period, a total of 197
199 participants accessed the questionnaire online, of which 180 participants met the inclusion
200 criterion and 133 (73.9%; 133/180) had a maximum of one missing response to non-

demographic questions and were included in the final analysis. Of the 133 analyzed questionnaires, 30 (22.6%; 30/133) had a blank response to one non-demographic question and 12 (9.0%; 12/133) were missing demographic information (birth year, or birth year and country). Some pre-COVID and COVID-era respondents to Question 8 (regarding the use of ICTs for clinical tasks) marked both 'can be used' and 'should not be used,' and were labeled as 'unknown' due to the ambiguity.

The following results will focus on COVID-era statistics and how they compared to the pre-COVID period. About 51% (68/133) of COVID-era respondents (65% [134/205] of pre-COVID respondents) practiced in the United States, ~17% (23/133) practiced in Canada (21% [43/205] of pre-COVID respondents), ~26% (35/133) practiced in other countries (12% [24/205] pre-COVID), and ~5% (7/133) had an unknown location (2% [4/205] pre-COVID) (Table 1). Most respondents were female (80% [106/133], 75% [153/205] pre-COVID), born between 1980 and 1999 (65% [86/133], 79% [162/205] pre-COVID), worked full-time (86% [114/133], 78% [160/205] pre-COVID) and predominantly on dogs and cats (70% [93/133], 76% [155/205] pre-COVID) (Table 1). There was a significant difference in the distribution of respondents' age and country of practice between pre-COVID and COVID-era questionnaires (Fisher's exact test; $p<0.01$), while not for gender ($p>0.05$).

Table 1. Respondent characteristics, telemedicine use, ICT use, and billing practices.

	Total (%)* Pre-COVID COVID-era (n = 205 & 133)	Canada (% in Canada) Pre-COVID COVID-era (n = 43 & 23)	USA (% in USA) Pre-COVID COVID-era (n = 134 & 68)	Other (% in Other) Pre-COVID COVID-era (n = 24 & 35)
Gender				
Female	153 (75) 106 (80)	30 (70) 22 (96)	111 (83) 57 (84)	12 (50) 27 (77)
Male				

	41 (20) 16 (12)	11 (25) 1 (4)	18 (13) 8 (12)	12 (50) 7 (20)
Not provided	11 (5) 11 (8)	2 (5) 0 (0)	5 (4) 3 (4)	0 (0) 1 (3)
Date of birth				
1950 to 1959	3 (1) 4 (3)	0 (0) 0 (0)	3 (2) 3 (4)	0 (0) 1 (3)
1960 to 1969	5 (2) 8 (6)	1 (2) 1 (4)	4 (3) 4 (6)	0 (0) 3 (9)
1970 to 1979	24 (12) 22 (17)	8 (19) 4 (17)	10 (7) 11 (16)	6 (25) 7 (20)
1980 to 1989	139 (68) 47 (35)	25 (58) 11 (48)	103 (77) 27 (44)	11 (46) 9 (26)
1990 to 1999	23 (11) 39 (29)	9 (21) 7 (30)	8 (6) 20 (29)	6 (25) 12 (34)
Unknown	11 (5) 13 (10)	0 (0) 0 (0)	6 (4) 3 (4)	1 (4) 3 (9)
Which statement best describes your work as a veterinarian? (Question 1)				
Works full-time at a practice; provides care to client owned animals.	160 (78) 114 (86)	29 (67) 23 (100)	110 (82) 55 (81)	18 (75) 29 (83)
Works part-time at a practice; provides care to client owned animals.	29 (14) 13 (10)	12 (28) 0 (0)	13 (10) 7 (10)	4 (17) 6 (17)
Provides care to client-owned animals; does not work at a practice.	16 (8) 6 (4)	2 (5) 0 (0)	11 (8) 6 (9)	2 (8) 0 (0)
Which best describes your type of practice? Select all that apply. (Question 2)				
Companion animal (dogs, cats)	155 (76) 93 (70)	36 (84) 17 (74)	104 (78) 46 (68)	13 (54) 25 (71)
Exotic pets (reptiles, hamsters, gerbils, rabbits, ferrets)	32 (16) 19 (14)	10 (23) 3 (13)	20 (15) 9 (13)	2 (8) 5 (14)
Food animal	29 (14) 38 (29)	8 (19) 9 (39)	15 (11) 26 (38)	6 (25) 1 (3)
Equine	34 (17) 33 (25)	7 (16) 9 (39)	25 (19) 17 (25)	1 (4) 7 (20)
Other	23 (11) 10 (8)	4 (9) 1 (4)	10 (7) 5 (7)	8 (33) 3 (9)
Based on your current knowledge of veterinary telemedicine, which of the following best describes your use of telemedicine? (Question 3)				
I use telemedicine in clinical practice.	80 (39) 61 (46)	22 (51) 15 (65)	52 (39) 27 (40)	5 (21) 18 (51)

I do not use telemedicine in clinical practice.	85 (41) 57 (43)	12 (28) 7 (30)	60 (45) 33 (48)	11 (46) 14 (40)
Unsure.	40 (20) 15 (11)	9 (21) 1 (4)	22 (16) 8 (12)	8 (33) 3 (9)
Which of the following do you currently use to communicate remotely with clients in your practice and for what purpose? Select all that apply - ICTs. (Question 4a)				
Email	183 (89) 119 (89)	41 (95) 22 (96)	125 (93) 59 (87)	13 (54) 31 (89)
Text/instant messaging	90 (44) 82 (62)	17 (40) 12 (52)	50 (37) 44 (65)	19 (79) 22 (63)
Telephone/voice	191 (93) 130 (98)	39 (91) 23 (100)	130 (97) 67 (99)	18 (75) 33 (94)
Live video chat	8 (4) 19 (14)	1 (2) 3 (13)	3 (2) 11 (16)	4 (17) 4 (11)
Which of the following do you currently use to communicate remotely with clients in your practice and for what purpose? Select all that apply - clinical tasks. (Question 4b) [abbreviation]				
Help clients decide whether to bring animal to clinic. [perform triage]	195 (95) 133 (100)	37 (86) 23 (100)	131 (98) 68 (100)	23 (96) 35 (100)
Facilitate or communicate diagnostics with clients. [facilitate diagnosis]	196 (96) 131 (98)	40 (93) 23 (100)	129 (93) 68 (100)	23 (96) 33 (94)
Facilitate or communicate treatments with clients. [guide treatment]	193 (94) 131 (98)	40 (93) 23 (100)	127 (95) 68 (100)	22 (92) 33 (94)
Provide educational content to clients. [provide educational content]	185 (90) 126 (95)	38 (88) 22 (96)	123 (92) 64 (94)	20 (83) 33 (94)
Facilitate prescriptions for clients for their animals. [provide prescriptions]	174 (85) 118 (89)	31 (72) 22 (96)	120 (90) 61 (90)	20 (83) 29 (83)
Other.	4 (2) 34 (26)	2 (5) 7 (30)	0 (0) 18 (26)	2 (8) 8 (23)
Do you currently bill your clients for any communication via email, text/instant message, voice or live video chat? (Question 6)				
Yes.	4 (2) 27 (20)	1 (2) 5 (22)	1 (1) 10 (15)	2 (8) 12 (34)
No.	185 (90) 93 (70)	40 (93) 16 (70)	122 (91) 52 (76)	19 (79) 19 (54)
In general, I don't consult with my clients via remote communication.	16 (8) 13 (10)	2 (5) 2 (9)	11 (8) 6 (9)	3 (12) 4 (11)

Would you like to bill your clients for any communications via email, text/instant message, voice or live video chat? (Question 7)				
Yes.	118 (59) 61 (58)	24 (57) 11 (61)	80 (60) 37 (64)	13 (59) 9 (41)
No.	71 (35) 29 (28)	17 (40) 4 (22)	45 (34) 16 (28)	6 (27) 8 (36)
I prefer not to consult with my clients via remote communication.	12 (6) 15 (14)	1 (2) 3 (17)	8 (6) 5 (9)	3 (14) 5 (23)

ICT = information and communication technologies; Pre-COVID = questionnaires collected from October 2019 to February 2020; COVID-era = questionnaires collected from July 2021 to August 2021.
Missing values account for discrepancies in totals - respondents that didn't answer the question or selected both answers.
*Total includes 11 respondents without country information that is not shown here separately.

Veterinary perceptions of telemedicine

When questioned about their telemedicine practices, 11% (15/133) of COVID-era respondents (20% [40/205] pre-COVID) were unsure if they utilized telemedicine in their clinical work (Table 1, Question 3). Among the remaining respondents (responding yes or no), 52% (61/118) reported using telemedicine in clinical practice (48% [80/165] pre-COVID) (Table 2). All respondents (same as pre-COVID) who indicated they did not use telemedicine in clinical practice, stated that they did use ICTs for remote client communication (Table 2). Yes-respondents tended to use more of each ICT than no-respondents and unsure-respondents (Table 2). After accounting for gender, age, country of practice, and practice type, there was no significant difference in reporting the use of telemedicine versus not using telemedicine between pre-COVID and COVID-era respondents (RRR = 1.13, 95% CI = 0.65-1.97). However, in comparison to pre-COVID respondents, COVID-era respondents showed significantly higher odds of reporting that they were either using telemedicine (RRR = 3.13, 95% CI = 1.39-7.04) or not using telemedicine (RRR = 2.76, 95% CI = 1.22-6.27) relative to being unsure about their telemedicine use (Table 3).

240 **Table 2. ICT use according to veterinarians' reported telemedicine use.**

		Currently used ICTs in practice			
Do you use telemedicine in practice? (n; % of total) **Pre-COVID** **COVID-era**	**Uses at least one ICT (% of stratum)** **Pre-COVID** **COVID-era**	**Email (% of stratum)** **Pre-COVID** **COVID-era**	**Text/instant messaging (% of stratum)** **Pre-COVID** **COVID-era**	**Telephone (% of stratum)** **Pre-COVID** **COVID-era**	**Live video chat (% of stratum)** **Pre-COVID** **COVID-era**
All responses					
Yes. (80; 39%) (61; 46%)	80 (100) 61 (100)	77 (96) 55 (90)	36 (45) 46 (75)	77 (96) 60 (98)	5 (6) 14 (23)
No. (85; 41%) (57; 43%)	85 (100) 57 (100)	72 (85) 50 (88)	35 (41) 27 (47)	77 (91) 56 (98)	1 (1) 3 (5)
Unsure. (40; 20%) (15; 11%)	39 (98) 15 (100)	33 (82) 14 (83)	19 (48) 9 (60)	37 (92) 14 (93)	2 (5) 2 (13)
Total (205) (133)	204 (99) 133 (100)	182 (89) 119 (89)	90 (44) 82 (62)	191 (93) 130 (98)	8 (4) 19 (14)
Canada					
Yes. (22; 51%) (15; 65%)	22 (100) 15 (100)	22 (100) 15 (100)	10(45) 10 (67)	20 (91) 15 (100)	1 (5) 2 (13)
No. (12; 28%) (7; 30%)	12 (100) 7 (100)	12 (100) 6 (86)	3 (25) 2 (29)	11 (92) 7 (100)	0 (0) 1 (14)
Unsure. (9; 21%) (1; 4%)	8 (89) 1 (100)	7 (78) 1 (100)	4 (44) 0 (0)	8 (89) 1 (100)	0 (0) 0 (0)
Total (43) (23)	42 (98) 23 (100)	41 (95) 22 (96)	17 (40) 12 (52)	39 (91) 23 (100)	1 (2) 3 (13)
United States of America					
Yes. (52; 39%) (27; 40%)	52 (100) 27 (100)	51 (98) 23 (85)	20 (38) 21 (78)	52 (100) 27 (100)	3 (6) 8 (30)
No. (60; 45%) (33; 49%)	60 (100) 33 (100)	54 (90) 28 (85)	21 (35) 17 (52)	57 (95) 32 (97)	0 (0) 1 (3)
Unsure. (22; 16%) (8; 2%)	22 (100) 8 (100)	20 (91) 8 (100)	9 (41) 6 (75)	21 (95) 8 (100)	0 (0) 2 (25)
Total (134) (68)	134 (100) 68 (100)	125 (93) 59 (87)	50 (37) 44 (65)	130 (97) 67 (99)	3 (2) 11 (16)
Other					
Yes. (5; 21%) (18; 51%)	5 (100) 18 (100)	3 (60) 16 (89)	5 (100) 14 (78)	4 (80) 17 (94)	1 (20) 4 (22)
No. (11; 46%) (14; 40%)	11 (100) 14 (100)	5 (45) 13 (93)	9 (82) 7 (50)	7 (64) 14 (100)	1 (9) 0 (0)

Unsure. (8; 33%)	8 (100)	5 (62)	5 (62)	7 (88)	2 (25)
(3; 9%)	3 (100)	2 (67)	1 (33)	2 (67)	0 (0)
Total (24)	24 (100)	13 (54)	19 (79)	18 (75)	4 (17)
(35)	35 (100)	31 (89)	22 (63)	33 (94)	4 (11)

ICT = information and communication technologies; Pre-COVID = questionnaires collected from October 2019 to February 2020; COVID-era = questionnaires collected from July 2021 to August 2021.

Table 3. Regression models comparing telemedicine and ICT outcomes before and during COVID-19.

Model	Question	Coefficient	Odds Ratio/ Relative Risk Ratio (95 CI)	*P* value
M1‡	Q3 – Reference – Unsure if Using Telemedicine (Pre-COVID)	-	-	-
M1‡	**Q3 – Using Telemedicine**	**1.14**	**3.13 (1.39 - 7.04)**	**<0.01***
	Q3 – Not Using Telemedicine	**1.02**	**2.76 (1.22 - 6.27)**	**0.01***
M2-5†	Q4a – Reference – Not using the ICT (Pre-COVID)	-	-	-
M2†	Q4a – Using Email	0.21	1.23 (0.55 - 2.77)	0.61
M3†	Q4a – Using TIM	0.44	1.56 (0.93 - 2.61)	0.09
M4†	**Q4a – Using Telephone/Voice**	**1.96**	**7.11 (1.36 - 37.2)**	**0.02***
M5†	**Q4a – Using Live Video**	**1.23**	**3.42 (1.33 - 8.8)**	**0.01***
M6-11†	Q4b – Reference – Not using ICTs to perform the clinical task (Pre-COVID)	-	-	-
M6†	Q4b – Using ICTs to Perform Triage	17.83	-	0.99
M7†	Q4b – Using ICTs to Facilitate Diagnosis	1.29	3.62 (0.65 - 20.18)	0.14
M8†	Q4b – Using ICTs to Guide Treatment	1.43	4.17 (0.83 - 21.08)	0.08
M9†	Q4b – Using ICTs to Provide Educational Content	0.67	1.96 (0.71 - 5.4)	0.20
M10†	Q4b – Using ICTs to Provide Prescriptions	0.59	1.81 (0.82 - 3.98)	0.14
M11†	**Q4b – Using ICTs for Other Purposes**	**2.84**	**17.11 (5.65 - 51.79)**	**<0.01***
M12-17‡	Q5 – Reference – Would like the same ICT use (Pre-COVID)	-	-	-
M12‡	Q5 – Would Like Less Email Text-Only Use	0.06	1.06 (0.47 - 2.36)	0.89
	Q5 – Would Like More Email Text-Only Use	-0.44	0.64 (0.37 - 1.11)	0.11
M13‡	Q5 – Would Like Less Email Beyond-Text Use	-0.20	0.82 (0.34 - 1.97)	0.65
	Q5 – Would Like More Email Beyond-Text Use	-0.22	0.80 (0.46 - 1.39)	0.44

M14‡	Q5 – Would Like Less TIM Text-Only Use	-0.45	0.82 (0.32 - 1.26)	0.20
	Q5 – Would Like More TIM Text-Only Use	-0.33	0.80 (0.41 - 1.28)	0.26
M15‡	Q5 – Would Like Less TIM Beyond-Text Use	-0.44	0.64 (0.32 - 1.28)	0.21
	Q5 – Would Like More TIM Beyond-Text Use	-0.34	0.71 (0.4 - 1.26)	0.24
M16‡	**Q5 – Would Like Less Telephone/Voice Use**	**-0.69**	**0.5 (0.26 - 0.97)**	**0.04***
	Q5 – Would Like More Telephone/Voice Use	0.05	1.05 (0.55 - 2.03)	0.88
M17‡	**Q5 – Would Like Less Live Video Use**	**-0.96**	**0.38 (0.2 - 0.72)**	**<0.01***
	Q5 – Would Like More Live Video Use	**0.71**	**2.03 (1.01 - 4.07)**	**<0.05***
M18-23†	Q4&5 – Reference – Not satisfied with the ICT (Pre-COVID)	-	-	-
M18†	Q4&5 – Satisfied with Email Text-Only Use	-0.16	0.85 (0.4 - 1.78)	0.66
M19†	Q4&5 – Satisfied with Email Beyond-Text Use	0.41	1.5 (0.69 - 3.26)	0.30
M20†	Q4&5 – Satisfied with TIM Text-Only Use	0.00	1 (0.56 - 1.79)	0.99
M21†	Q4&5 – Satisfied with TIM Beyond-Text Use	0.24	1.27 (0.7 - 2.32)	0.43
M22†	Q4&5 – Satisfied with Telephone/Voice Use	0.53	1.7 (0.91 - 3.2)	0.10
M23†	**Q4&5 – Satisfied with Live Video Use**	**-1.24**	**0.29 (0.14 - 0.59)**	**<0.01**
M24‡	Q6 – Reference – Does not bill for remote communications (Pre-COVID)	-	-	-
M24‡	**Q6 – Bills for Remote Communications**	**2.50**	**12.18 (3.87 - 38.37)**	**<0.01**
	Q6 – Prefers Not to Use Remote Communications	0.52	1.69 (0.7 - 4.08)	0.24
M25‡	Q7 – Reference – Would not like to bill for remote communications (Pre-COVID)	-	-	-
M25‡	Q7 – Would like to bill for Remote Communications	0.18	1.2 (0.67 - 2.15)	0.54
	Q7 – Prefers Not to Use Remote Communications	0.88	2.41 (0.89 - 6.51)	0.08
M26-29†	Q8 – Reference – Thinks ICTs are not adequate for the clinic task (Pre-COVID)	-	-	-
M26†	**Q8 – Thinks ICTs are Adequate to Perform Triage**	**1.56**	**4.67 (1.98 - 11.02)**	**<0.01***
M27†	**Q8 – Thinks ICTs are Adequate to Perform Diagnosis**	**1.00**	**2.72 (1.62 - 4.59)**	**<0.01***
M28†	Q8 – Thinks ICTs are Adequate to Guide Treatment	0.61	1.85 (0.89 - 3.82)	0.10
M29†	**Q8 – Thinks ICTs are Adequate to Provide Prescriptions**	**0.92**	**2.52 (1.27 - 5.01)**	**0.01**

ICT = information and communication technologies; Pre-COVID = questionnaires collected from October 2019 to February 2020; COVID-era = questionnaires collected from July 2021 to August 2021

***(p<0.05) – significant outcomes bolded**
**Reference group for outcomes (questionnaire response) and the predictor variable (time period) are highlighted for each question
Adjusted for age, sex, country, and practice type
†Analyzed with basic logistic regression; odds ratio presented
‡Analyzed with multinomial logistic regression; relative risk ratio presented

Use and satisfaction with ICTs among veterinarians

The COVID-era respondents predominantly utilized telephone/voice (98% [130/133], 93% [191/205] pre-COVID) and email (89% [119/133], 89% [183/205] pre-COVID), with live video chats (14% [19/133], 4% [8/205] pre-COVID) being the least common (Table 1, Question 4a). These ICTs were commonly used to perform triage (100% [133/133], 95% [195/205] pre-COVID), facilitate diagnostics (98% [131/133], 96% [196/205] pre-COVID), guide treatments (98% [131/133], 94% [193/205] pre-COVID), provide educational content (95% [126/133], 90% [185/205] pre-COVID), provide prescriptions (89% [118/133], 85% [174/205] pre-COVID) and for 'other' reasons (26% [34/133], 2% [4/205] pre-COVID) (Table 1, Question 4b). Some of the 'other' reasons included: reminders to clients, updates to clients (e.g. hospitalized patients), appointment follow up (e.g. diagnostic results, response to treatment), and to schedule appointments.

Most COVID-era respondents reported they had an increase in their usage of telephone/voice (62% [76/123]), text-only email (56% [64/115]), and beyond-text email (55% [66/119]) since the COVID-19 pandemic was declared (Table 4). Many also noted an increase of their use of beyond-text TIM (45% [65/121]), text-only TIM (40% [47/117]), and live video chat (18% [20/111]). There were a relatively small number of respondents that stated they use less ICTs since COVID, with live video chat being the highest (13% [14/111]) among this group. However, after accounting for gender, age, country of practice, and practice type, COVID-era respondents overall were significantly more likely than pre-COVID respondents to use

telephone/voice (OR = 7.11, 95% CI = 1.36-37.2; Table 3) and live video chats (OR = 3.42, 95% CI = 1.33-8.8; Table 3). There was no significant difference noted between pre-COVID and COVID-era respondents for the use of email (OR = 1.23, 95% CI = 0.55-2.77; Table 3), TIM (OR = 1.56, 95% CI = 0.93-2.61; Table 3), or for any of the clinical tasks the ICTs were used for.

Table 4. Changes in ICT use during the COVID-19 pandemic.

Currently used ICTs to communicate with clients (n; % of total)	Less Scores 1 & 2 (%)	Same Score 3 (%)	More Scores 4 & 5 (%)
Email - text only: Use less, same or more?			
All responses (115)*	2 (2)	49 (42)	64 (56)
Canada (21; 18%)	0 (0)	10 (48)	11 (52)
United States (60; 52%)	1 (2)	25 (42)	34 (56)
Other (30; 26%)	1 (3)	11 (37)	18 (60)
Email - text with images, audio and/or video: Use less, same or more?			
All responses (119)*	8 (7)	45 (38)	66 (55)
Canada (22; 19%)	1 (5)	8 (36)	13 (59)
United States (59; 50%)	2 (4)	25 (42)	32 (54)
Other (32; 27%)	4 (13)	9 (28)	19 (59)
Text/instant messaging - text only: Use less, same or more?			
All responses (117)*	5 (4)	65 (56)	47 (40)
Canada (21; 18%)	1 (5)	11 (52)	9 (43)
United States (60; 51%)	2 (4)	32 (53)	26 (43)
Other (32; 27%)	2 (6)	20 (63)	10 (31)
Text/instant messaging - text with images, audio and/or video: Use less, same or more?			
All responses (121)*	6 (5)	60 (50)	65 (45)
Canada (22; 18%)	1 (4)	10 (46)	11 (50)
United States (62; 51%)	4 (7)	30 (49)	28 (45)
Other (33; 27%)	1 (3)	18 (55)	14 (42)
Telephone/voice - audio only (includes phone calls, FaceTime audio only, Skype audio): Use less, same or more?			
All responses (123)*	5 (4)	42 (34)	76 (62)

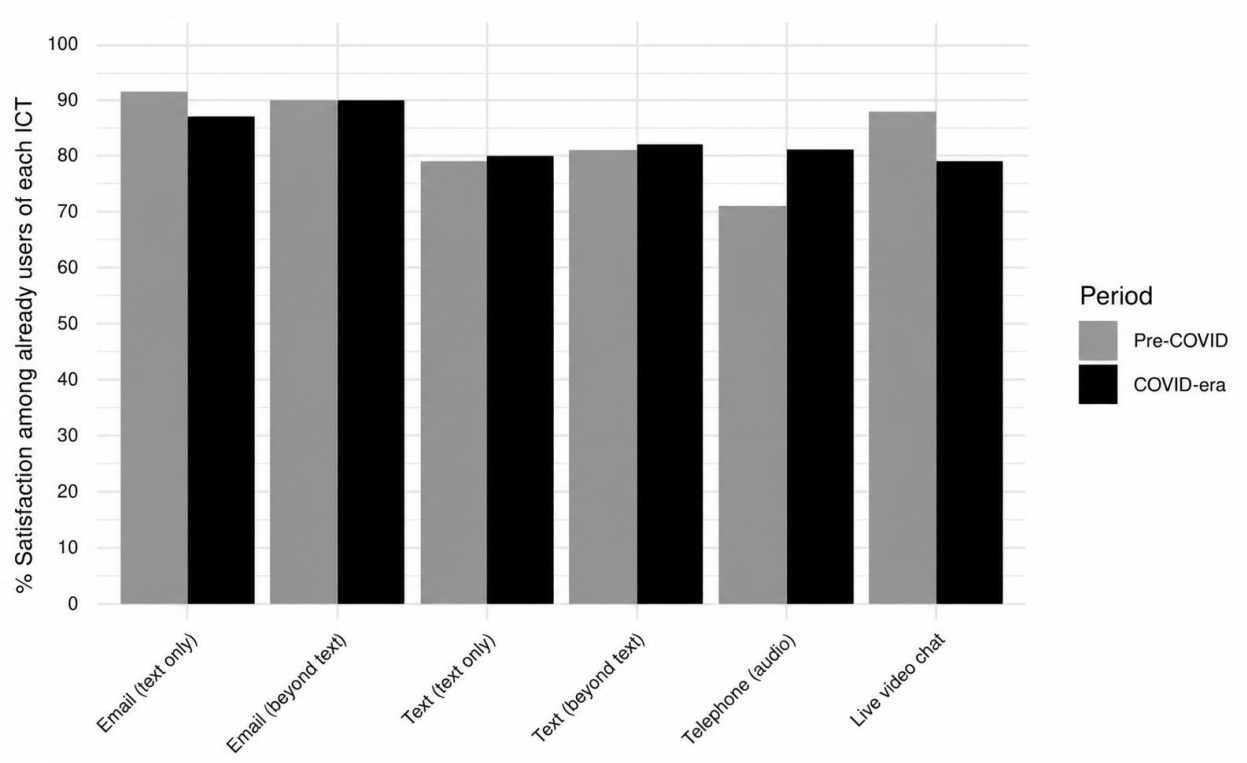
Canada (22; 18%)	0 (0)	7 (32)	15 (68)
United States (64; 52%)	1 (2)	24 (37)	39 (61)
Other (32; 26%)	3 (9)	9 (28)	20 (63)
Live video chat: Use less, same or more?			
All responses (111)*	14 (13)	77 (69)	20 (18)
Canada (21; 19%)	2 (9)	13 (62)	6 (29)
United States (54; 49%)	6 (11)	42 (78)	6 (11)
Other (32; 29%)	5 (16)	20 (62)	7 (22)

ICT = Information and Communication Technology.
Missing values account for discrepancies in totals - respondents that didn't answer the question were excluded from this table.
*Total includes respondents without country information that is not shown here.

Across all ICTs, existing-users expressed high levels of satisfaction with their usage: 87% (95/109) for text-only email, 90% (98/109) for beyond-text email, 80% (60/75) for text-only TIM, 82% (61/74) for beyond-text TIM, 81% (95/117) for telephone/voice, and 79% (15/19) for live video chat (Fig 1, Table 5). There were no significant differences in satisfaction of each ICT between pre-COVID and COVID-era existing-users (Fig 1; Fisher's exact test, $p>0.05$). However, after accounting for gender, age, country of practice, and practice type, COVID-era satisfaction of all respondents with their current level of live video chat use (either using or not using) was significantly lower than pre-COVID satisfaction (RRR = 0.29, 95% CI = 0.14-0.59; Table 3). Pre-COVID and COVID-era respondents were more willing to increase usage for the beyond-text versions of both email and TIM than for the text-only versions (Table 3). Overall, COVID-era respondents were less likely to want a decrease in telephone use (RRR = 0.5, 95% CI = 0.26-0.97) and live video chat use (RRR = 0.38, 95% CI = 0.2-0.72), and more likely to want an increase in live video chat use (RRR = 2.03, 95% CI = 1.01-4.07), vs keeping the same usage (Table 3). Non-users were most willing to adopt beyond-text email and text-only TIM (38% [5/13] and 32% [16/50] respectively) and least willing to adopt live video chat (24%

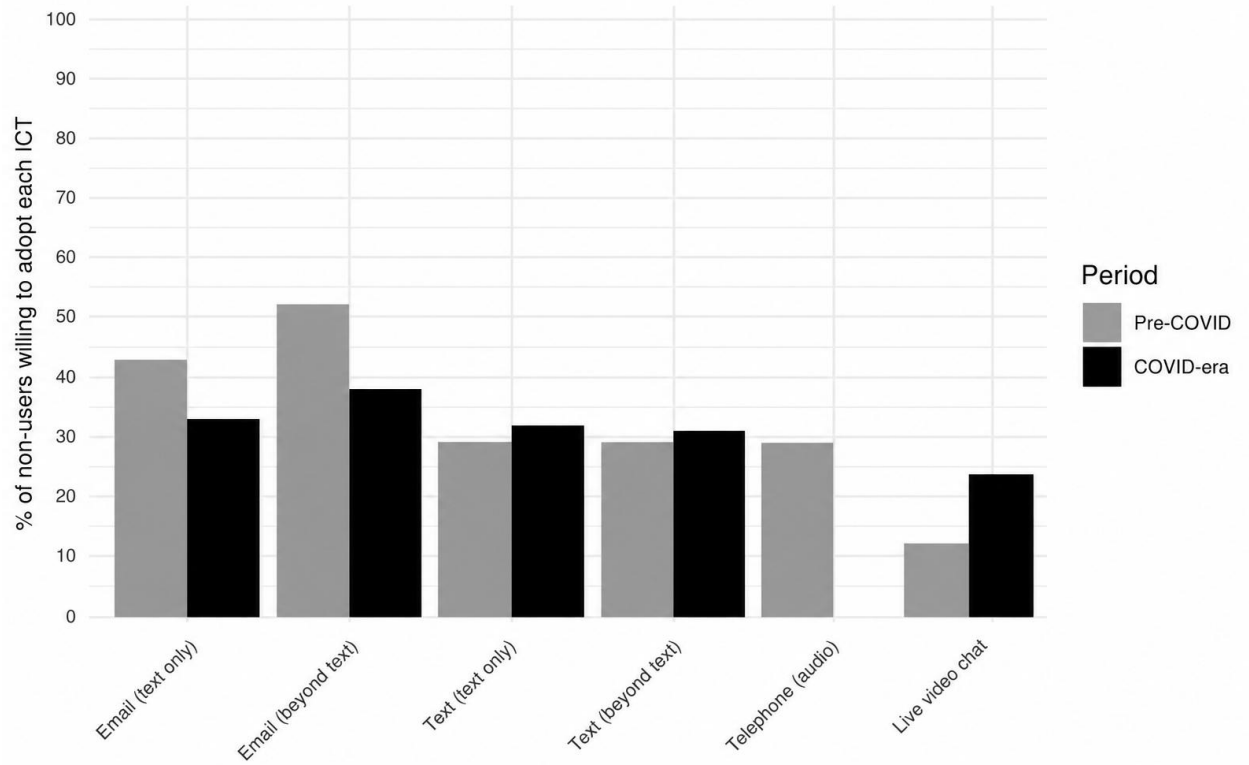
[24/99]) and telephone/voice (0% [0/3]) (Fig 2, Table 5). There was a significant increase (12%) in the willingness to adopt live video chat in the COVID-era group vs pre-COVID group (Fig 2; Fisher's exact test, $p<0.05$).

Fig 1. Existing users' satisfaction with ICT use.



ICT = information and communication technologies; Pre-COVID = questionnaires collected from October 2019 to February 2020; COVID-era = questionnaires collected from July 2021 to August 2021.
There were no statistically significant differences in veterinary satisfaction of ICTs ($p>0.05$) between Pre-COVID and COVID-era respondents (Fisher's exact test).

Fig 2. Non-users' willingness to adopt ICTs.



ICT = information and communication technologies; Pre-COVID = questionnaires collected from October 2019 to February 2020; COVID-era = questionnaires collected from July 2021 to August 2021. Live video chat was the only ICT with a statistically significant difference (Fisher's exact test, $p<0.05$) in willingness to adopt between Pre-COVID and COVID-era veterinary respondents.

Table 5. Preferred changes in ICT use among current users and non-users.

Currently used ICTs to communicate with clients (n; % of total) Pre-COVID COVID-era	Less Scores 1 & 2 (%) Pre-COVID COVID-era	Same Score 3 (%) Pre-COVID COVID-era	More Scores 4 & 5 (%) Pre-COVID COVID-era	Satisfied Pre-COVID COVID-era
Email - text only: Use less, same or more?				
Uses email currently. (182; 89%) (109; 90%)	17 (9) 14 (13)	81 (45) 56 (51)	84 (46) 39 (36)	165 (91) 95 (87)
Does not use email currently. (23; 11%) (12; 10%)	7 (30) 3 (25)	6 (26) 5 (42)	10 (43) 4 (33)	13 (57) 8 (67)
Total. (205) (121)*	24 (12) 17 (14)	87 (42) 61 (50)	94 (46) 43 (36)	
Email - text with images, audio and/or video: Use less, same or more?				
Uses email currently. (182, 89%) (109; 89%)	18 (10) 11 (10)	59 (32) 39 (36)	105 (58) 59 (54)	164 (90) 98 (90)

Does not use email currently.				
(23; 11%)	4 (18)	7 (30)	12 (52)	11 (48)
(13; 11%)	3 (24)	5 (38)	5 (38)	8 (62)
Total. (205)	22 (11)	66 (32)	117 (57)	
(122)*	14 (11)	44 (36)	64 (52)	
Text/instant messaging - text only: Use less, same or more?				
Uses text/instant messaging currently.				
(90; 44%)	19 (21)	33 (37)	38 (42)	71 (79)
(75; 60%)	15 (20)	34 (45)	26 (35)	60 (80)
Does not use text/instant messaging currently.				
(115; 56%)	35 (30)	47 (41)	33 (29)	82 (71)
(50; 40%)	10 (20)	24 (48)	16 (32)	34 (68)
Total. (205)	54 (26)	80 (39)	71 (35)	
(125)*	25 (20)	58 (46)	42 (34)	
Text/instant messaging - text with images, audio and/or video: Use less, same or more?				
Uses text/instant messaging currently.				
(90; 44%)	17 (19)	21 (23)	52 (58)	73 (81)
(74; 60%)	13 (18)	25 (34)	36 (49)	61 (82)
Does not use text/instant messaging currently.				
(115; 56%)	34 (30)	47 (41)	34 (29)	81 (71)
(49; 40%)	11 (22)	23 (47)	15 (31)	34 (69)
Total. (205)	51 (25)	68 (33)	86 (42)	
(123)*	24 (20)	48 (39)	51 (41)	
Telephone/voice - audio only (includes phone calls, FaceTime audio only, Skype audio): Use less, same or more?				
Uses telephone/voice currently.				
(191; 93%)	55 (27)	107 (56)	32 (17)	135 (71)
(117; 98%)	22 (19)	68 (58)	27 (23)	95 (81)
Does not use telephone/voice currently.				
(14; 7%)	8 (57)	2 (14)	4 (29)	10 (71)
(3; 2%)	2 (67)	1 (33)	0 (0)	3 (100)
Total. (205)	60 (29)	109 (53)	36 (18)	
(120)*	24 (20)	69 (58)	27 (22)	
Live video chat: Use less, same or more?				
Uses live video chat currently.				
(8; 4%)	1 (13)	2 (25)	5 (62)	7 (88)
(19; 16%)	4 (21)	6 (32)	9 (47)	15 (79)
Does not use live video chat currently.				
(197; 96%)	85 (43)	89 (45)	23 (12)	174 (88)
(99; 84%)	23 (23)	52 (53)	24 (24)	75 (76)
Total. (205)	86 (42)	91 (44)	28 (14)	
(118)*	27 (23)	58 (49)	33 (28)	

ICT = information and communication technologies; Pre-COVID = questionnaires collected from October 2019 to February 2020; COVID-era = questionnaires collected from July 2021 to August 2021.

*Missing values account for discrepancies in totals - respondents that didn't answer either question (per stratum) were excluded.

Billing behavior for communication with clients over ICTs

A majority of the COVID-era respondents (58% [61/105], 59% [118/201] pre-COVID) stated that they would like to bill for ICT communication with clients (Table 1, Question 7), while only 20% (27/133) were doing so (2% [4/205] pre-COVID) (Table 1, Question 6). Some respondents preferred not to consult with clients over ICTs (14% [15/105], 6% [12/201] pre-COVID) and therefore did not choose a billing preference. After accounting for gender, age, country of practice, and practice type, COVID-era respondents were significantly more likely than pre-COVID respondents to be billing for remote communications (RRR = 12.18, 95% CI = 3.87-38.37; Table 3). However, both periods' respondents expressed similar interest in billing for remote communications (Table 3), with no significant difference noted.

Veterinarians' perceptions on potential uses of ICTs in clinical practice

Performing triage was the top clinic task most COVID-era respondents felt could be accomplished over ICTs (92% [118/128], 72% [141/196] pre-COVID), followed by guiding treatment (87% [104/120], 82% [159/194] pre-COVID), which was the top clinical task for pre-COVID respondents (Table 6). Respondents also felt that providing prescriptions (83% [104/125], 76% [150/197] pre-COVID) and diagnosis of some diseases (55% [68/124], 31% [62/200] pre-COVID) were accomplishable over ICTs (Table 6). After accounting for gender, age, country of practice, and practice type, COVID-era respondents were significantly more likely than pre-COVID respondents to think ICTs were adequate to perform triage (OR = 4.67,

95% CI = 1.98-11.02; Table 3), perform diagnosis (OR = 2.72, 95% CI = 1.62-4.59), and provide prescriptions (OR = 2.52, 95% CI = 1.27-5.01). No significant difference was noted between pre-COVID and COVID-era views on guiding treatment. The overall trends were similar amongst respondents from the US, Canada, and other countries.

Table 6. Veterinarians' perceived suitability of ICTs for clinical tasks.

Potential use	Can be used (%) Pre-COVID COVID-era	Should not be used (%) Pre-COVID COVID-era
Overall		
Perform triage (assign a level of urgency and direct clients and their animals to the appropriate caregiver).[1]	141 (72) 118 (92)	55 (28) 10 (8)
Diagnose some diseases in an animal.[2]	62 (31) 68 (55)	135 (69) 56 (45)
Guide clients in the treatment of some diseases for their animal.[3]	159 (82) 104 (87)	36 (18) 16 (13)
Provide prescriptions to clients for their animal.[4]	150 (76) 104 (83)	47 (24) 22 (17)
Canada		
Perform triage (assign a level of urgency and direct clients and their animals to the appropriate caregiver).[1]	31 (72) 22 (100)	12 (28) 0 (0)
Diagnose some diseases in an animal.[2]	14 (33[a]) 16 (70)	29 (67[a]) 7 (30)
Guide clients in the treatment of some diseases for their animal.[3]	32 (78) 22 (96)	9 (22) 1 (4)
Provide prescriptions to clients for their animal.[4]	30 (71) 20 (91)	12 (29) 2 (8)
United States		
Perform triage (assign a level of urgency and direct clients and their animals to the appropriate caregiver).[1]	95 (73) 62 (93)	36 (27) 5 (7)
Diagnose some diseases in an animal.[2]	42 (32[a]) 34 (52)	89 (68[a]) 31 (48)
Guide clients in the treatment of some diseases for their animal.[3]	109 (83) 53 (84)	22 (17) 10 (16)
Provide prescriptions to clients for their animal.[4]	105 (80) 51 (77)	27 (20) 15 (23)
Other		
Perform triage (assign a level of urgency and direct clients and their animals to the appropriate caregiver).[1]	15 (68) 33 (94)	7 (32) 2 (6)
Diagnose some diseases in an animal.[2]	6 (26) 16 (50)	17 (74) 16 (50)

Guide clients in the treatment of some diseases for their animal.[3]	18 (78) 27 (87)	5 (22) 4 (13)
Provide prescriptions to clients for their animal.[4]	15 (65) 30 (88)	8 (35) 4 (12)

ICT = information and communication technologies; Pre-COVID = questionnaires collected from October 2019 to February 2020; COVID-era = questionnaires collected from July 2021 to August 2021.
[1]Abbreviated to "perform triage".
[2]Abbreviated to "perform diagnosis".
[3]Abbreviated to "guide treatment".
[4]Abbreviated to "provide prescriptions".

Discussion

Veterinary perceptions of telemedicine

While veterinarians might employ ICTs for remote client communication, they may not perceive this activity as telemedicine. Although veterinarians were less unsure about their telemedicine use in the COVID-era relative to pre-COVID, there was not a significant increase in the reported use of telemedicine, but there was a significant increase in the reported use of different ICTs. This suggests that veterinarians through COVID continued to believe that telemedicine excludes certain uses of ICTs. One possible reason is due to ongoing variations in telemedicine definitions. The American Veterinary Medical Association (AVMA) defines telemedicine as a "subcategory of telehealth that involves use of a tool to exchange medical information electronically from one site to another to improve a patient's clinical health status".[15] This broad definition, which has not changed since the pre-COVID period, may include activities such as scheduling appointments, even when no medical advice, treatment, or diagnosis is provided. The College of Veterinarians of Ontario (CVO) defines telemedicine as "the provision of specific veterinary medical advice and veterinary treatment of an animal(s) or group of animals based on the virtual assessment by means of telecommunications technology where no in-person physical examination or in-person premise visit of the animal(s) or group of animals by the veterinarian

takes place".[16] This slightly narrower definition specifically states that telemedicine involves providing medical advice and treatment solely based on a virtual assessment and was revised from the pre-COVID period to no longer require a remote diagnosis.

Discourse among veterinarians and veterinary telemedicine companies may overlook these subtleties, potentially adding to the confusion. Many veterinary telemedicine companies portray telemedicine as a veterinary consult conducted via a video chat platform. This portrayal may make veterinarians think of telemedicine as solely the use of new ICTs for appointments instead of recognizing their longstanding telemedicine use of simpler ICTs for various clinical tasks (e.g., telephone). As innovative ICT applications emerge, terminology must evolve accordingly. More specific terminology is being adopted to distinguish between various clinical activities. The AVMA has started to do this by defining telehealth as "the overarching term that encompasses all uses of technology to deliver health information, education or care remotely" with multiple subcategories including: telemedicine, teletriage, teleadvice, telemonitoring, telecommunication, teleconsulting, e-prescription.[15] Precise terminology may enhance communication with clients and colleagues, fostering a shared understanding of specific services provided. This is important for practicing veterinarians as it may directly influence their perception, adoption, and delivery of virtual care. Clear definitions can also help with accurate interpretation of regulations and standards, potentially impacting legal compliance and overall quality of care. Veterinary students and practitioners may not be exposed enough to the latest telemedicine practices and are likely not aware of the nuances. Improving educational resources and support of virtual care and other medical technologies is critical to help the veterinary community understand the terminology and to figure out best ways to implement these services in clinical practice.

Current use and satisfaction with ICTs among veterinarians

For both time periods, telephone/voice was used the most, followed by email, TIM, and live video chat. As expected, the COVID-19 pandemic has likely increased telemedicine practices in healthcare.[22] There was a significant increase in the use of telephone/voice and live video chat with COVID-era respondents compared to pre-COVID respondents. These findings align with other veterinary and human healthcare studies showing substantial increases in their use during the COVID-19 pandemic.[22–25] However, there was no significant rise noted in asynchronous telemedicine forms. While COVID-era respondents reported increased usage of all ICTs since the pandemic began, specifically, there was no significant difference observed between the pre-COVID and COVID-era respondents' usage of email and TIM. This may suggest that COVID-era respondents shifted toward immediate and interactive ICT methods like phone calls and live video chat due to pandemic-related limitations on face-to-face interactions, while maintaining their usage of email and TIM for non-urgent tasks in a manner similar to pre-COVID. This contrasts with another study that indicated a significant rise in veterinary use of asynchronous texting/messaging during the COVID-19 pandemic.[25] However, there were differences in the study period, data collection method, and sample populations between that study and the current one that may account for these differences. The study period for that research was December 2020 to April 2021, which falls between the two periods in this study. The pandemic caused rapid and constant changes, potentially leading to differences due to the varying time frames. Additionally, that study's sample was exclusively companion animal veterinarians and predominantly in Ontario, a region that experienced prolonged and stringent lockdowns. Moreover, the current study measured current use at different points, while that study relied on self-reported pre-pandemic use, which is susceptible to recall bias.

While existing-user satisfaction of ICT use was relatively high (71-91%), it was highest for email (90-91%). Another study also showed that email was the top ICT that most veterinarians were comfortable with (93.8%) and that many vets preferred it over telephone use (48.6%).[3] Perhaps this is because of its widespread familiarity and its ability to exchange extensive information including typed-out text, images, videos, documents (i.e. handouts), and links to other resources, enabling them to convey details more efficiently and adequately than text or voice alone. Email, as an asynchronous communication method, does not typically require an immediate response, allowing veterinarians more flexibility and control over their schedules while also reducing emotional and non-verbal elements for both parties. This ICT also allows for easy client communication records that can be integrated directly into veterinary practice information management software (PIMS). Another study revealed that most veterinary participants expressed extreme comfort with telephone use, email, asynchronous messaging, and synchronous messaging, while being slightly less comfortable with videoconferencing technology.[25] That study also found that although most participants did not believe virtual consultations led to greater job satisfaction compared to traditional face-to-face veterinary care, a subset of participants saw virtual care as a chance to enhance work-life balance and mental well-being.

Veterinarians spend many hours a week on the phone communicating with clients,[3] which many respondents in this study expressed a desire to reduce. However, COVID-era respondents were less likely to want to decrease their telephone usage and more likely to want to increase their live video chat usage compared to pre-COVID respondents. The pandemic heightened reliance on remote healthcare to address public health concerns and overcome healthcare delivery challenges (i.e. social distancing). This may have fostered greater familiarity

with and recognition of live video chat as a viable alternative in many situations to in-office appointments. New telemedicine platforms and PIMS features may have provided easy accessibility to live video chat for medical use during the pandemic. This potentially made it easier to incorporate into clinic workflow and develop payment structures for their use. Increased billing for live video chats may have also contributed to the rise in the willingness to adopt and increase its usage in the COVID-era. While overall satisfaction with live video chat remained high, COVID-era respondents exhibited decreased satisfaction with their current usage or non-usage compared to pre-COVID respondents. More non-users wanted increased usage and more existing-users preferred decreased usage. This may be due to an increase in overestimated expectations for video-chatting during the pandemic. It is essential to provide better guidance and resources to help veterinarians integrate ICTs effectively into their practice, manage expectations for both providers and clients, and develop sustainable billing practices.

Billing behavior for communication with clients over ICTs

The present study found COVID-era veterinarians were significantly more likely to charge for remote communications than pre-COVID respondents, indicating a shift in how these services are valued. However, this study did not distinguish which ICTs were being charged for, leaving it unclear if this largely represents live video chats or other ICTs. Incorporating billing into virtual veterinary appointments, particularly live video sessions, could be more straightforward, as they can serve as substitutes for in-person visits that pet owners are accustomed to paying for. In contrast, billing for client communication via TIM, email, and even telephone is likely more uncommon and may be more challenging to justify based on historical precedent. Unlike video

chat appointments, practical compensation models for these ICTs are likely less clear. To streamline clinic workflow and enhance billing viability, improved client communication strategies and innovative business models are needed. This may involve establishing formal procedures for clients to schedule and pay for remote healthcare services that many veterinarians may currently provide for free. Such measures could help in managing communication boundaries with clients and may contribute to improving the work-life balance and mental well-being of veterinarians.

A majority of veterinarians (58%) participating in the present study expressed a desire to charge for the time they spend with clients using ICTs. In a previous study, over 45% of veterinarians were found to devote six or more hours per week to phone interactions with clients, yet they seldom billed for this time,[3] resulting in a notable amount of uncompensated work. Interestingly, the proportion of veterinarians wanting to charge for their time spent with clients on ICTs did not significantly change from the pre-COVID period. One possible explanation is a common belief of veterinarians that their clients would be hesitant to pay for consultations delivered electronically,[3] especially those accustomed to receiving such services at no cost, and fear that implementing such charges could be a deterrent. Therefore, charging for services seen as novel or innovative, such as live video appointments, phone app chat, and remote monitoring device assessments, may appear more achievable.

As veterinarians and pet owners become more comfortable with new client communication systems, their acceptance of corresponding compensation models is likely to increase. To facilitate this transition, veterinary professionals should enhance education and training on the use of ICTs, establish clear billing guidelines, and foster a culture that values remote care. Encouraging communication and transparency with clients about the benefits and

costs of telemedicine can also help gain acceptance for these services. Additionally, pilot programs and case studies demonstrating successful billing for ICTs can serve as valuable examples, providing insights and building confidence among practitioners.

Veterinarians' perceptions on potential uses of ICTs in clinical practice

Most participating veterinarians (89-100%) utilized ICTs for triage, diagnostics, treatments, and prescriptions and many veterinarians (55-92%) believe they can fully conduct these clinical tasks using ICTs. Significantly more COVID-era respondents felt ICTs were adequate to perform triage, diagnosis, and prescriptions compared to pre-COVID respondents. However, many were still reluctant to rely fully on ICTs, especially when used to perform diagnosis, which had the highest percentage of respondents opposed to ICT use (45%). This reluctance is consistent with findings from a recent study where veterinarians reported feeling less confident in reaching a diagnosis with a virtual examination compared to a hands-on patient examination.[25] That study also indicated a notable unwillingness among veterinarians to recommend virtual consultations. This supports previous suggestions of veterinarians' hesitation to provide veterinary care without a hands-on patient examination.[26,27] This is likely due to a variety of reasons, including perceived concerns about the quality of medicine, setup difficulty, legal issues, effect on revenue, and impact on work-life balance. Common perceptions may include the belief that telemedicine is less effective, only suitable for basic triage or minor issues, difficult to implement, increases liability, will not be paid for by clients, can lead to fewer in-person visits and revenue loss, will worsen client communication boundaries, and will increase workload. Many of these concerns were mentioned in this study. Addressing these perceptions through better education and support

may help build trust and acceptance of telemedicine among both veterinarians and pet owners. Further research is needed to explore the impacts of virtual care on veterinary job satisfaction, client satisfaction, the veterinarian-client relationship, access to care, cost-effectiveness, health outcomes, and the overall quality of healthcare delivery.

Ideally, a multidisciplinary team of clinicians, veterinary communication experts, virtual technology experts, legal experts, and representatives from governing bodies would collaboratively address these challenges and establish evidence-informed guidelines for implementing and utilizing telemedicine in veterinary practice. These guidelines could cover standards of care, legal and ethical considerations, billing and compensation models, technology integration, client communication strategies, and how to maintain work-life balance for veterinarians. This could boost virtual care acceptance and adoption by providing clear, standardized practices that build confidence among veterinarians and pet owners and make it easier for practitioners to integrate telemedicine into their routines. Improving the quality and reliability of virtual care could make it a viable alternative for a wider range of medical situations and ensure that both veterinarians and clients experience more consistent and satisfactory outcomes. Ultimately, this would lead to broader use and application of virtual care in veterinary medicine, optimizing care delivery and expanding access to veterinary services.

Continuing education courses may also be helpful for practicing veterinarians trying to navigate the use of technology in veterinary practice. Additionally, increasing veterinary students' training in remote physical examinations, client communication techniques, and other virtual care tools during their education may help better equip them to effectively utilize these technologies in their future practice. Integrating telemedicine and related topics like practice

management software, remote monitoring sensors and other devices, big data, and social media into veterinary school curricula can play a significant role in this preparation.[28]

Limitations

Online sampling via Facebook was chosen due to its facilitation of quick, safe access to a broad population. Social media platforms like Facebook are widely used across demographics and have proven to be effective recruitment tools in similar studies.[9,25,29,30] However, this sampling approach resulted in a source population that was not clearly defined. This may limit the generalizability of the findings, especially to veterinarians who do not use social media regularly or do not respond to survey requests. The demographics of questionnaire respondents somewhat aligned with AVMA and CVMA industry data from the same periods, but did not fully match. Females, veterinarians aged 31-40, and food animal and equine practitioners appeared to be overrepresented. The largest proportion of participants resided in the US and Canada, which may also restrict the applicability of findings to other countries. Due to the anonymity of respondents, Pre-COVID and COVID-era participants were recruited separately from a similar (but not identical) list of Facebook groups, resulting in different source populations. Therefore, results should not be interpreted as a direct comparison of the same individuals' views between pre-COVID and COVID-era time periods. We attempted to account for potential confounders by controlling for demographic differences. The present study also focused solely on the veterinarian's viewpoint. Further research involving other veterinary team members, practice managers, and pet owners is required for a more comprehensive understanding. Veterinarians'

perceptions and use continue to evolve, and this study is a snapshot in time before and during the COVID pandemic.

Conclusions

There was a notable change in the way veterinarians who responded to two surveys viewed and used ICTs in the pre-COVID and COVID-era periods. Veterinarians commonly used ICTs for client communication, and while COVID-era respondents had higher ICT usage and billing, many still do not classify ICTs as telemedicine or want to bill for these services. Further research and education are needed to enhance the veterinary profession's understanding and implementation of virtual veterinary care.

Declarations

Ethics approval and consent to participate

The study was reviewed and approved by the University of Guelph Research Ethics Board for compliance with federal guidelines for research involving humans (REB #19-03-025). Electronic informed consent was obtained from all participants prior to beginning the online questionnaire.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

BNH and ZBO contributed to study development, questionnaire development, data collection, analysis and interpretation, and manuscript drafting. TMB, ZP, JC, and EAS contributed to study development and manuscript revision. EH contributed to questionnaire distribution, analysis and interpretation, and manuscript revision.

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Additional Files

Additional File 1

File format: .docx

Title: Questionnaire (COVID-era)

Description: The full set of questions administered during the COVID-era portion of the study, including demographic and response items.

Additional File 2

File format: .docx

Title: Sample size and power calculation

Description: Power calculation and sample size estimation used for study planning.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AdditionalFile1.docx
- AdditionalFile2.docx