Perception of veterinarians on monitoring diabetic cats with emphasis on the flash glucose monitoring system

[*Percepção dos veterinários sobre o monitoramento de gatos diabéticos com ênfase no sistema flash de monitoramento de glicose*]

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ABSTRACT

This study aimed to understand the perception of veterinarians regarding monitoring blood and interstitial glucose levels in cats with diabetes mellitus and/or diabetic ketoacidosis, with emphasis on the flash glucose monitoring system (FGMS) (FreeStyle Libre, Abbott, Brazil). This research consisted of two stages. In all, 516 response forms were obtained, and of these, 480 (93%) were considered valid. In total, 333 (69.4%) veterinarians did not use the FGMS, while 147 (30.6%) did. The cost of the FGMS (116, 78%) was the greatest deterrent to acceptability. Veterinarians who use the device consider it indispensable in the hospital monitoring of diabetic ketoacidosis and a facilitator in the accurate monitoring of measurements. In addition, the preferred location for application of the sensor is the cranial lateral wall of the chest and it is quite tolerable. Monitoring a diabetic cat requires commitment from the owner and the veterinary team to ensure feline-friendly management.

Keywords: continuous monitoring system, glucometer, diabetic ketoacidosis, diabetes mellitus, friendly handling

RESUMO

Objetivou-se, com este estudo, conhecer a percepção dos médicos veterinários quanto à monitorização da glicose sanguínea e intersticial em gatos com diabetes mellitus (DM) e/ou cetoacidose diabética, com ênfase no sistema flash de monitoramento da glicose (SFMG) (FreeStyle Libre, Abbott, Brasil). Esta pesquisa foi composta por duas etapas. Ao todo, foram obtidos 516 formulários de resposta. Desses, 480 (93%) foram considerados válidos. No total, 333 (69,4%) veterinários não utilizavam o SFMG, enquanto 147 (30,6%) o utilizavam. O custo do SFMG (116, 78%) foi a maior barreira para a aceitabilidade. Os médicos veterinários que utilizam o dispositivo consideram-no indispensável no monitoramento hospitalar da cetoacidose diabética por ser um facilitador no acompanhamento preciso das aferições. Além disso, o local de preferência para aplicação do sensor é na parede lateral cranial do tórax e é bem tolerável. Monitorar um felino diabético requer comprometimento do tutor e da equipe veterinária e que assegure um manejo amigo do gato.

Palavras-chave: sistema de monitoramento contínuo, glicosímetro, cetoacidose diabética, diabetes melito, manejo amigável

INTRODUCTION

The standard method for monitoring diabetes mellitus (DM) in cats includes the development of blood glucose curves by collecting multiple blood samples over a defined period using portable glucometers, which have low cost and are easy to use. The major disadvantage of this approach is the need for a owner to actively monitor and constantly handle the animal.

The AlphaTRAK 2 glucometer (Zoetis, Michigan, United States) was designed for dogs and cats. This device is validated and provides accurate and precise measurements (Moretti *et al.*, 2010). Of the glucometers developed for use in humans, the Accu-Chek Guide (Roche Diabetes Care, São Paulo, Brazil) is the most accurate for measuring blood glucose levels, compared with the reference hexokinase laboratory analysis in cats (Reusch and Solov, 2019).

In 2016, a new tool called the flash glucose monitoring system (FGMS) (FreeStyle Libre, Abbott, Brazil) (Krakauer *et al.*, 2021) started to be marketed in Brazil, presenting innovative technology, being factory calibrated, and not requiring constant capillary punctures. This device measures glucose concentrations in the interstitial fluid every minute through a sensor with a small catheter containing the glucose oxidase enzyme that is inserted into the subcutaneous tissue (Shoelson *et al.*, 2021). The accuracy and validation of the FGMS have already been established in veterinary medicine for cats, with fairly accurate measurements in the euglycemic and hyperglycemic ranges, and slightly less accurate measurements in the hypoglycemic range (Shea and Hess, 2021). There is a good correlation between interstitial fluid and blood glucose concentrations, which makes the use of continuous monitoring devices promising (Hafner *et al.*, 2013).

The approach to managing feline DM patients must follow the recommendations of the American Association of Feline Practitioners, which aim at disease management, respecting the behavioral peculiarities of the species, and minimizing stress to the animal (Cat Friendly Practice®). Veterinarians are expected to seek efficient and safe monitoring techniques that provide a good cat-friendly practice and ensure quick and clear communication, thereby compiling the patient's history as reports that can be shared between the owner and the veterinarian. The preferences of and difficulties faced by health professionals as regards DM monitoring in cats should be known.

Thus, the objective of this study was to understand the perception of veterinarians regarding blood and interstitial glucose monitoring in cats with DM and/or diabetic ketoacidosis, with emphasis on the FGMS.

MATERIALS AND METHODS

This research was approved by the Human Research Ethics Committee of the Universidade Federal Rural do Rio de Janeiro, Brazil (protocol number 178/2021). All owners signed the Informed Consent Form.

The first stage of this study consisted of a questionnaire with eight multiple-choice and discursive questions. The eighth question had a dichotomous answer associated with the use of the FGMS. The second stage was characterized by a group that used the FGMS, and it included a questionnaire with nine multiple-choice questions. The Survey Monkey electronic platform (www.surveymonkey.com.br) was used as a survey tool, being validated for human and animal research in the medical field, and enabling single responses (Raphael *et al.*, 2018; Wilson *et al.,* 2016). As each veterinarian could mark more than one response per question, the number of responses to each question varied. The mean time to complete the questionnaire was 4 minutes. The questions were on information about the profile of veterinarians treating diabetic cats, and their diagnostic methods and follow-up tools of choice, emphasizing the use of the FGMS (Fig. 1). The professionals were selected by the non-probability sampling method through the social network applications: Instagram, Facebook, and WhatsApp. The responses were collected between December 2020 and August 2021. The inclusion criterion was veterinarians willing to answer the questionnaire. Incomplete or inadequate questionnaires were excluded.

The Pearson's χ^2 test was used to compare nominal variables between professionals who used the FGMS and those who did not use this system. These variables included state of origin, level of experience in the profession, area of practice in veterinary medicine, preferred type of glucometer for clinical routine, and circumstances in which continuous monitoring was considered essential. All tests followed a 5% margin of error, that is, $p < 0.05$ was considered statistically significant. Microsoft Excel and IBM SPSS Statistics (version 24.0) software were used for data analysis in Windows 7.
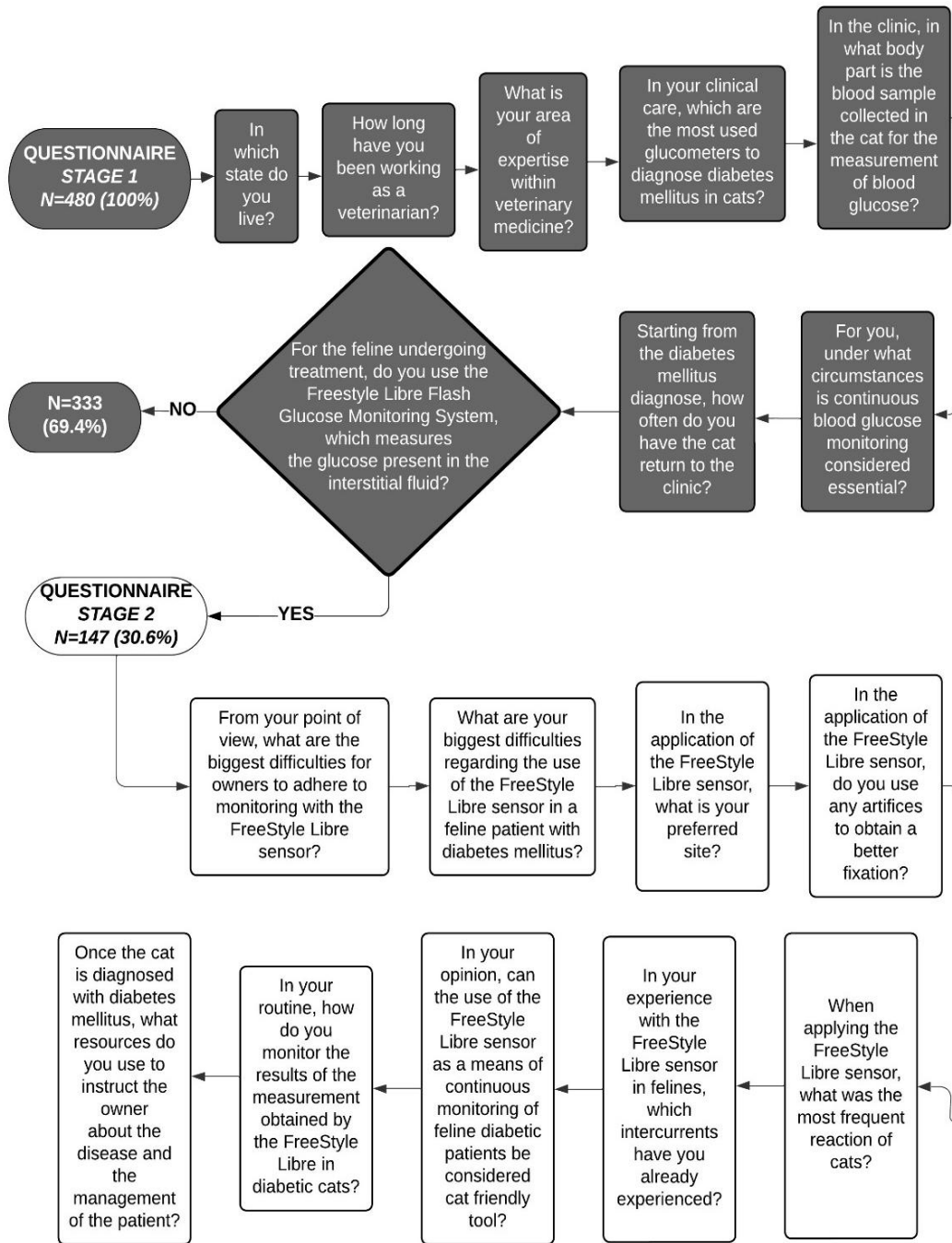
Figure 1. Flowchart of steps one and two of the questionnaire, each with eight and nine questions, respectively. [Source: Designed by the author (2022)].

RESULTS

A total of 516 questionnaires were received. Of these, 36 (7%) were excluded for incomplete or partial responses. Thus, 480 questionnaires were considered valid according to the inclusion and exclusion criteria. Of the valid questionnaires, 333 (69.4%) veterinarians did not use the FGMS, while 147 (30.6%) used this system.

Most of the interviewees were from the southeast region (270; 56%), followed by the south (98; 20%), northeast (72; 15%), center-west (27; 6%), and north regions (12; 2%) of Brazil. Of the Brazilian veterinarians, 141 (29%) live in the state of Rio de Janeiro and, of these, 46 (31.3%) use the FGMS, which shows an explicit trend (p < 0.05) (Fig. 2).
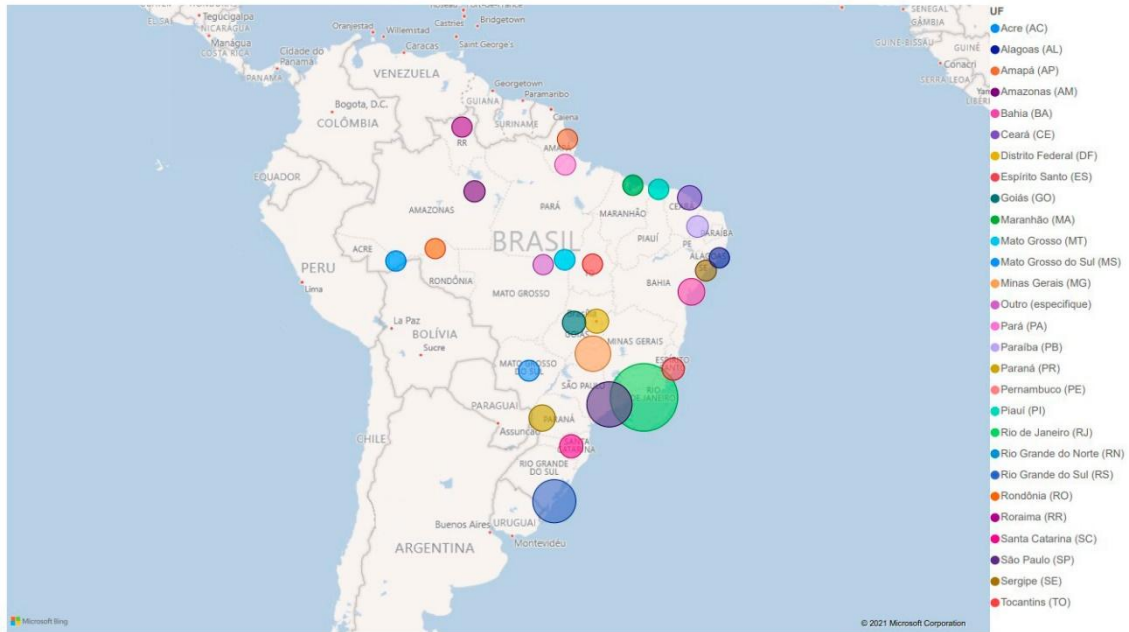

Figure 2. Distribution of the Brazilian veterinarians who participated in the study by state of residence. The participants were broadly distributed in the national territory. [Source: Designed by the author (2022).]

The veterinarians included in this study worked in small animal clinics (250; 52%), cat clinics (132; 28%), small animal endocrinology (81; 17%), and small animal surgery (40; 8%). As regards level of experience, 43 (9%) participants were recently graduated professionals, and 190 (40%) participants were professionals who graduated 1–5 years before this study. The others had 6–10 years of experience (109; 23%) or graduated more than 10 years before this study (128; 27%). Regarding the area of practice in veterinary medicine, a significant difference was observed between the proportion of veterinarians who use the FGMS and those who do not use it (p < 0.05). Most professionals who use the system work in veterinary clinics exclusively for cats, while those who do not use it work in small animal clinics (Table 1).

The results are based on non-empty rows and columns in each innermost sub-table. The statistical test does not consider the frequency of the 'no information' group.

In both groups (among all veterinarians included in the survey; n = 480), the FreeStyle Optium Neo (Abbott, São Paulo, Brazil) was the most used glucometer for diagnosis (194; 40%), followed by the Accu-Chek Performa (Roche Diabetes Care, São Paulo, Brazil) (187; 39 %), Accu-Chek Guide (Roche Diabetes Care, São Paulo, Brazil) (179; 37%), FreeStyle Freedom Lite (Abbott, São Paulo, Brazil) (67; 14%), and AlphaTRAK 2 (Zoetis, Michigan, United States) (13; 3%). The Accu-Chek Guide (Roche Diabetes Care, São Paulo, Brazil) (127; 38.1%) was the most used glucometer to diagnose DM in cats by veterinarians who did not use the FGMS (n = 333). Most veterinarians who used the FGMS (n = 147) used the FreeStyle Optium Neo (Abbott, São Paulo, Brazil) (194; 56.5%) for diagnosis.

Table 1. Distribution of veterinarians included in the survey regarding the use of the flash glucose monitoring system according to the characteristics of their professional performance, in Brazil, 2021

Characteristics of professional performance		For the cats undergoing treatment, do you use the flash glucose monitoring system that measures the glucose in the interstitial fluid?				Total		P-Value [*]
		No (N = 333)		Yes (N = 147)				
		N	%	N	%	N	%	
What is your area of expertise within veterinary medicine?	Small animal clinic	195	58.6%	55	37.4%	250	52.1%	0.000[†]
	Cats only veterinary clinic	73	21.9%	59	40.1%	132	27.5%	
	Small animal endocrinologist	38	11.4%	43	29.3%	81	16.9%	
	Small animal surgery	29	8.7%	11	7.5%	40	8.3%	
	Other	71	21.3%	17	11.6%	88	18.3%	
How long have you been working in this profession?	Over 10 years	97	29.1%	37	25.2%	134	27.9%	0.119[‡]
	Between 1 and 5 years	123	36.9%	67	45.6%	190	39.6%	
	Between 6 and 10 years	74	22.2%	35	23.8%	109	22.7%	
	Recently graduated	39	11.7%	8	5.4%	47	9.8%	
In your clinical care, which are the most used glucometers to diagnose diabetes mellitus in cats?	AlphaTRAK 2	4	1.2%	9	6.1%	13	2.7%	0.002 [†]
	FreeStyle Optium Neo	111	33.3%	83	56.5%	194	40.4%	
	FreeStyle Freedom Lite	34	10.2%	33	22.4%	67	14.0%	
	Accu-Chek Guide	127	38.1%	52	35.4%	179	37.3%	
	Accu-Chek Performa	119	35.7%	68	46.3%	187	39.0%	
	I do not use a glucometer	23	6.9%	3	2.0%	26	5.4%	
	Other	30	9.0%	15	10.2%	45	9.4%	
In the clinic, in what body part is the blood sample collected in the cat for the measurement of blood glucose?	Tail	20	6.0%	9	6.1%	29	6.0%	0.379 [‡]
	Cushion	23	6.9%	8	5.4%	31	6.5%	
	Inner lip	6	1.8%	1	0.7%	7	1.5%	
	Ear tip	179	53.8%	96	65.3%	275	57.3%	
	Venipuncture	104	31.2%	41	27.9%	145	30.2%	

[Source: Research Protocol (2021)]
[*] Pearson's χ^2 test (P <0.05), [†] significant difference, [‡] non-significant difference.

In total, 344 (72%) and 285 (59%) veterinarians considered continuous glucose monitoring essential in hospital settings for patients with diabetic ketoacidosis and at home for patients with DM, respectively. Continuous glucose monitoring for hospital monitoring of diabetic ketoacidosis was considered essential by most veterinarians who use the FGMS (120; 81.6%) and by most veterinarians who do not use it (224; 67.3%).

At initial DM diagnosis, a relative majority of veterinarians (283; 59%) requested follow-up after one week, 130 (27%) requested follow-up after two weeks, and 46 (10%) requested follow-up after four weeks. Most veterinarians in both groups (88 [59.9%] in the FGMS group and 195 [58.6%] in the non-FGMS group) requested follow-up after one week of initial DM diagnosis.

From the perspective of veterinarians, the cost of the FGMS (116; 78%) was the biggest deterrent for feline ownerss in terms of adherence to continuous monitoring, followed by reading errors (66; 44%), and spontaneous detachment or removal of the sensor by the animal. In all, 49 (33%) veterinarians reported that sensor durability (14 days) was short.

Spontaneous detachment of the sensor or removal of the sensor by the animal (84, 57%) was the most mentioned problem faced by veterinarians who use the FGMS for cats with DM. A considerable proportion (68; 46%) of veterinarians believed it was challenging for the owners to implement the system. In addition, 26 (17%) stated that they had little experience regarding the proper functioning of the device.

The cranial lateral chest wall was the most used site for the FreeStyle Libre sensor (71.48%), followed by the cervical region (42.29%), and the caudal lateral chest wall (27.18%). The sacral region was used by 3.2% of the veterinarians, and the others used other locations (3.2%).

Of the devices used to prevent early sensor removal, surgical dressings (87; 59%) were the most used, followed by ethyl cyanoacrylate glue (84; 57%). Almost half of the respondents (75; 51%) shaved the cats' underhair, 25 (17%) used an adhesive to cover the sensor, and six (4%) used stiches.

No signs of pain or discomfort in the animal were reported by 61 (41%) veterinarians during sensor installation. Others (50; 34%) indicated that the animal startled, and 25 (17%) stated that the animal was indifferent.

Major complications included early sensor removal by the animal (96; 65%), spontaneous detachment of the sensor (67; 45%), function cessation before 14 days of use (63; 42%), contact dermatitis (41; 29%), and reading errors within the first 24 hours (36; 24%).

Most veterinarians who use the FGMS (125; 85.0%) contacted the animal's owners via WhatsApp or e-mail to monitor the results of interstitial glucose measurements, while 29 (20%) respondents reported direct monitoring via the LibreView platform.

Once a cat was diagnosed with DM, a considerable proportion (140; 95.2%) of veterinarians stated that they advised the owner about the disease and its management during the veterinary appointment. Most veterinarians (144, 98%) considered the FGMS a cat-friendly system, which shows a significant trend (p < 0.05).

DISCUSSION

The main advantage of using the FGMS is the possibility of measuring interstitial glucose levels from a small distance between the reader and the sensor, so that direct contact with the cat is not necessary (Deiting and Mischke, 2020). This was shown by the preference of veterinarians working in cat clinics, who expressed concern to minimize approaching and puncturing the animal several times, since the data are transmitted from the sensor to the reader or a smartphone by radiofrequency (Haak *et al.*, 2017). However, most respondents do not use this system, which highlights the need to publicize the use of the FGMS. In addition, this device has just recently been validated for use in cats (Shea and Hess, 2021).

A major disadvantage of using the FGMS reported by veterinarians was the cost of the system for the owners, and spontaneous detachment or removal of the device by the animal, which shortens the sensor durability. In humans, horses, and dogs, the sensor has a durability of up to 14 days, but in cats it is approximately five to seven days (Del Baldo *et*

al., 2021). Despite a shorter period of use in this species, the advantages of the FGMS outweigh its disadvantages. The data collected can be accessed online and for free through the LibreView platform. An advantage of this system is the possibility of reading the sensor every minute, which allows the sharing of complete reports on interstitial glucose levels, use of insulin, and feeding (Zhang *et al.,* 2019). In addition, each sensor reading provides updated interstitial glucose data and a graphical plot of the values within the last 8 hours of data collection. Another benefit is that the top right of the reader shows an arrow that indicates whether the glucose level is rising, falling, or slowly changing (Bailey *et al.*, 2015). We believe it is important to present all available glucose monitoring options to the owners and to have an appointment to provide instructions on the management of diabetic cats.

A preliminary study analyzed the feasibility and accuracy of sensors placed on the cranial lateral chest wall, dorsal cervical region, and lateral bend of the knee of diabetic cats using the Guardian Real-Time (Medtronic, United States) continuous monitor, which requires constant calibration, showing that the cervical region provided more accurate and reliable data compared to the cranial lateral wall of the thorax and the lateral bend of the knee. However, blood perfusion, blood flow in adipose tissue, and vascularity in different regions may interfere with device accuracy. Further investigation with a larger number of cases would be necessary to confirm this finding (Hafner *et al.*, 2013).

In this study, the cranial lateral wall of the chest was the preferred location for application of the sensor, as it was painless and well tolerated by cats. Surgical dressing and ethyl cyanoacrylate glue were the most used artifices to keep the sensor adhered to the animal's skin, followed by adhesive fixation, and skin stitches. A study using skin stiches reported that local anesthesia was not necessary, and the most expressive reaction of the animal was head rotation (Deiting and Mischke, 2021). These resources may cause discomfort; however, possibly to a lesser degree of stress than successive blood glucose measurements. These findings corroborate a study conducted on human users, which showed that 80% of participants experienced significantly less pain than those who were conventionally monitored with digital punctures

(Bailey *et al.*, 2015). Further analysis should be conducted to evaluate the relationships between sensor performance and durability, acceptance by the cat, degree of stress, accuracy of the installation site, and feasibility at different body sites.

Another great advantage of the FGMS is the continuous monitoring of cats with diabetic ketoacidosis in the hospital environment. This is also indicated at home and in hospital monitoring of DM, since remission rates in newly diagnosed cats with excellent glycemic control are considerable. Assiduous follow-up and a return to the clinic within 1–2 weeks are recommended for a newly diagnosed diabetic cat (Reusch and Solov, 2019). This recommendation was followed by most participants in this study.

One of the disadvantages of the FGMS is that blood glucose changes do not immediately reflect in the interstitial glucose concentration. There is a lag of 11 minutes between intravascular and interstitial glucose measurements. Therefore, it is recommended to check blood glucose levels with a portable glucometer whenever the interstitial glucose concentration is below 70mg/dL or when an unexpected value is obtained (Fleeman and Gostelow, 2020). In our survey, the two most used glucometers by veterinarians were the FreeStyle Optium Neo (Abbott, São Paulo, Brazil) and the Accu-Chek Performa (Roche Diabetes Care, São Paulo, Brazil). However, the Accu-Chek Guide (Roche Diabetes Care, São Paulo, Brazil) is considered the most accurate for cats. The AlphaTRAK 2 (Zoetis, Michigan, United States) glucometer was developed for dogs and cats and is the gold standard for blood glucose monitoring. However, few veterinarians reported using this device, since it is not marketed in Brazil and has higher costs than other portable glucometers developed for use in humans.

Another disadvantage of the FGMS is that it requires technical know-how to avoid frequent sensor removals, as these are uncomfortable for the cat and can even cause contact dermatitis (Shoelson *et al.*, 2021). In this study, a small number of respondents attached a protective sensor patch to the animal's skin, similar to that used in human medicine. However, most veterinarians used a surgical cloth and an ethyl

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cyanoacrylate glue to increase the adherence of the sensor to the animal's skin.

Less than half of the respondents reported using the LibreView digital platform; this may be due to the lack of knowledge about the advantages of its use. This platform provides a simple and easy-to-understand visual report, with information that can help monitor and treat diabetic patients (Fleeman and Gostelow, 2020). There is a need for greater dissemination of this innovative tool.

The limitations of this study were the non-dissemination in professional research sites, as well as the need for internet access by the target population. Incentives were not given to the respondents, and no assistance or clarifications were provided when they had questions. It was also not possible to have a significant sample control of each specialty. Anonymity improved data collection and veracity; however, the professional registration number of the interviewees was not obtained.

CONCLUSION

This study provides important data on the perception of difficulties, preferences, and limitations of Brazilian veterinarians regarding the glycemic monitoring of diabetic cats. The FGMS is a promising device but still has low adherence due to high costs, reading errors, and spontaneous detachment or early removal of the sensor by the animal. Veterinarians who use the device consider it indispensable in the hospital monitoring of diabetic ketoacidosis and a facilitator for accurate monitoring. The site of choice to install the sensor is the cranial lateral wall of the thorax, which is well tolerated. Monitoring a diabetic cat requires commitment from the owner and the veterinary team to ensure cat-friendly management.

ACKNOWLEDGMENTS

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