UNIVERSITI MALAYSIA KELANTAN

STUDY OF DIABETES MELLITUS AMONG DOGS IN SELECTED CLINICS IN SELANGOR FROM YEAR 2021 TO 2023

BY

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Thank you.

DEDICATION

First, I would like to express my gratitude towards the people who granted help to me when carrying out the research project, so I can finish this project successfully. I would also like to express my gratitude towards my family, who have been supportive throughout this process.

Next, I would also like to dedicate this thesis to my supervisor and my co-supervisors for the guidance and support I required throughout the project. I would also like to dedicate this work to the selected veterinary clinics that are involved in this study, allowing me to do data collection and provide necessary help and support to me.

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ABSTRACT

An abstract of the research paper presented to the Faculty of Veterinary Medicine, Universiti Malaysia Kelantan, in partial requirement on the course DVT 55204 Research Project.

Diabetes mellitus is an endocrine disease in which there is persistent hyperglycemia and glycosuria, due to insufficient or no insulin production from the pancreas. It has been classified into two main types, Type I and Type II. Dogs are most commonly affected by Type 1 diabetes mellitus. The characteristic clinical signs of diabetes mellitus observed include polyuria, polydipsia, and polyphagia with weight loss. The research objectives are to determine the prevalence of diabetes mellitus among dogs in Selangor, Malaysia, and also to determine the association of diabetes mellitus in dogs with their demographic variables, including age, sex, physiological status, breed, body weight, diet and animal management. Data was collected from three selected veterinary clinics by reviewing the available electronic or physical files of medical records of all dogs presenting to these selected clinics between Year 2021 to Year 2023. The data obtained from the medical records include demographic data, client complaints, together with diagnostic workup and the treatment provided. Data collected from medical records was coded with the use of Excel sheets and then analysis was done via the use of SPSS. Prevalence is calculated as the proportions of dogs diagnosed with diabetes mellitus among the total number of dogs visited the selected veterinary clinics. Trends of disease prevalence were recorded. Descriptive statistics for categorical data were summarized into frequency and percentage. Pearson's Chi-square test was used to determine the association between diabetes mellitus development and the potential risk factors. In this study, it was found that the overall prevalence of diabetes mellitus from 2021 to 2023 was 1.04%, and there is a significant association of disease development with demographic variables such as physiological status, breed and age. The result of this study provided some information which was previously unavailable.

Keywords: diabetes mellitus, hyperglycemia, glycosuria, insulin, prevalence, risk factors

1.0 INTRODUCTION

Diabetes mellitus is an endocrine disease that is characterized by persistent hyperglycemia and glycosuria, due to insufficient or no insulin production from the pancreas (Ihedioha and Enahoro, 2019). It is classified into two main types, Type I and Type II. Type I is characterized by permanent deficient to no insulin production from pancreatic cells which necessarily relies on exogenous insulin for glycemic control (Nelson and Reusch, 2014), while Type II is characterized by insulin resistance, with some but not enough insulin production due to beta-cells dysfunction, hence affect glycemic control and lead to hyperglycemia (Rand, 2020). The causes of diabetes mellitus in dogs can be on a genetic basis, immune-mediated, pancreatitis, environmental factors (such as drug use) and others (Nelson and Reusch, 2014). In cats, diabetes mellitus development can be due to genetic, immune-mediated and drug use (Nelson and Reusch, 2014).

When there is destruction of pancreatic beta-cells leading to reduced or loss of function, it causes deficient to no insulin production. Hence glycemic control is dysregulated. (Guptill, Glickman, and Glickman, 2003). In case of poorly regulated blood glucose levels due to endogenous insulin insufficiency or no production from beta-cells, or lack of proper exogenous insulin therapy, it impairs circulating glucose uptake by body cells, thereby leading to subsequent development of hyperglycemia and glycosuria (Nelson and Reusch, 2014) which results in characteristic clinical signs of diabetes mellitus being observed, including polyuria, polydipsia, polyphagia with weight loss (Behrend and et.al., 2018; Moshref and et.al., 2019). According to several studies, the complications that can follow include weight loss, cataracts, retinopathy, urinary tract infection and diabetic ketoacidosis (Moshref and et.al., 2019; George, 2020; Rand, 2020).

2.0 RESEARCH PROBLEM STATEMENT

Diabetes mellitus refers to abnormally high blood glucose levels due to inadequate to no endogenous insulin production and would lead to glycosuria (Behrend and et.al., 2018). Some studies have been carried out in countries such as Australia, the UK, the USA and Nigeria, and the prevalence of diabetes mellitus has been recorded. In the USA, there was an increasing trend of diabetes mellitus development in dogs being identified over the years. Yet, there is limited information regarding the prevalence of diabetes mellitus in dogs in Selangor, Malaysia.

3.0 RESEARCH QUESTIONS

a. What is the prevalence of diabetes mellitus among dogs in Selangor, Malaysia?
a. Is there any association of diabetes mellitus with demographic variables in dogs?

4.0 RESEARCH HYPOTHESIS

a. There is a low prevalence of diabetes mellitus among dogs in Selangor, Malaysia
a. There is a significant association between diabetes mellitus and demographic variables which include age, sex, physiological status, breed, body weight, diet and animal management.

5.0 RESEARCH OBJECTIVES

a. To determine the prevalence of diabetes mellitus among dogs in Selangor, Malaysia.
a. To determine the association of demographic variables, which include age, sex, physiological status, breed, body weight, diet and animal management with the prevalence of diabetes mellitus in dogs.

6.0 LITERATURE REVIEW

Diabetes mellitus

Diabetes mellitus is mainly divided into two types. Type I diabetes appears to be the most common form of diabetes in dogs and is characterized by pancreatic beta-cell loss that leads to absolute insulin deficiency (Nelson and Reusch, 2014). The etiology of such beta-cell loss can be multifactorial, which includes genetic factors, pancreatitis, or autoimmune-induced beta-cell destruction, with clinical signs being exacerbated if concurrent with factors that can induce insulin resistance, such as obesity or glucocorticoid usage (Rand, 2020). In type I diabetes mellitus since there is a permanent deficiency to absolute no insulin production from beta-cells, regulation is dependent on the exogenous insulin administration (Guptill, Glickman, and Glickman, 2003). While for type II, is the most common type in cats and is characterized by inadequate insulin production by beta cells and/or impaired insulin action, which can be caused by genetic or environmental factors (Nelson and Reusch, 2014). Risk factors such as obesity, physical inactivity, sex, and glucocorticoid usage were reported to contribute to the disease development (Nelson and Reusch, 2014; Rand, 2020).

Pathogenesis leading to clinical signs and complications

Diabetes mellitus is an endocrine disease in which the glucose level in the bloodstream is abnormally high due to absolutely no or insufficient insulin production, or impairs insulin action on the body cells to uptake glucose for use, hence the resultant hyperglycemia (Rand, 2020). According to Liman and Jialal (2020), in a normal situation when blood passes through the glomerulus, blood glucose will be passively filtered through and then enter the renal tubules, where it will later be resorbed back. hence there is hyperglycemia and the blood glucose level exceeds the renal threshold, the excessive glucose will remain in renal tubules and result in osmosis diuresis, in which water are not reabsorbed back into the bloodstream, instead retained in the renal tubules due to high osmolarity of renal filtrate (Liman and Jialal, 2020). It then leads to clinical signs of polyuria and so compensatory polydipsia (Rand, 2020). In addition, the presence of glucose in urine would promote bacterial growth and so lead to the complication of bacterial urinary tract infection (George, 2020). The inability of cells to uptake glucose, fat and protein will undergo catabolism for energy production, which leads to weight loss. Clinical signs of increased appetite will be noted in the affected animals due to poor glucose uptake by cells and nutrient loss (Rand, 2020). With hyperglycemia, excessive glucose diffusing into the lens would be converted into sorbitol and cause an increase in lens osmolarity, hence drawing water in and disrupting the lens structure, leading to potential cataract formation (Miller and Brines, 2018).

Epidemiology of diabetes mellitus in dogs

Studies had been carried out in different countries and the prevalence had been recorded. In Australia, the prevalence of diabetic dogs was recorded as 0.36% of overall dogs that attended a primary-care setting (Yoon and et.al, 2020). In the UK, the estimated prevalence was within the range of 0.32–0.36% (Davison, Herrtage and Catchpole, 2005; Mattin and et.al., 2014); Heeley and et.al., 2020), while in Nigeria, the recorded prevalence was 0.22% (Ihedioha, J.I. and Enahoro, G., 2019). In the US, there was an increasing trend of diabetes mellitus-diagnosed dogs over decades, which within 30 years from the same veterinary hospital, there was a rise of prevalence of canine diabetes mellitus from 0.19% in 1799 to 0.64% in 1999. (Guptill and et.al., 2003; Rand and et. al., 2004; Kumar and et.al., 2014). A report from Banfield Pet Hospital by Aja (2016) showed that there was also a steady increase in the prevalence of the disease by 79.7% from 2006 to 2015 in the US.

Potential risk factors associated with diabetes mellitus

One of the risk factors possibly associated with diabetes mellitus is age. The risk of developing diabetes mellitus in dogs increases with age (Salgado, Reuschand Spiess, 2000). According to Rand (2020) and Rand and et.al. (2004), diabetes mellitus mainly occurs in middle-aged to old aged dogs, with prevalence peaks at a range of seven to 12 years old. The other potential predisposed factors include sex and the physiological status of the animals. Females are reported to be more commonly affected by diabetes mellitus than males (Donzel, Arti and Chahory, 2017; Guptill and et.al., 2003; Salgado, Reusch, and Spiess, 2000). According to study by Pöppl and et.al. (2024), females are generally more predisposed to diabetes mellitus in compared to males due to hormones fluctuation in estrus cycle, mainly relating to the progesterone. In the diestrus stage where the dominant hormone is progesterone, its concentration remains high in the bloodstream. Progesterone can reduce insulin binding to the insulin receptor, causing reduced ability of cells for glucose uptake, leading to hyperglycemia due to reduced insulin sensitivity. It would also enhance hepatic gluconeogenesis to promote glucose production, thereby exacerbating the glucose availability in bloodstream and resultant hyperglycemia, which predisposed the animal to diabetes mellitus. Besides, progesterone can act on the mammary gland and stimulate growth hormone production (Catchpole and Davison, 2005). Growth hormone is an insulin counterregulatory hormone which antagonizes insulin action by reducing insulin receptor on cell membrane, enhancing the insulin insensitivity, so results in reduced glucose uptake by cells resulting in hyperglycemia (Pöppl and et.al., 2024). This might be contributed to why more females were affected in this study.

To compare physiological status, neutered ones generally have greater risk than the intact ones (Oberbauer, Belanger and Famula, 2019; Guptill and et.al., 2003). Another potential predisposed factor is breed. Pöppl and et.al. (2017) carried out their study in Brazil and reported that Poodles are the most frequently affected breed. A study from France shows that Yorkshire terrier is the most commonly affected breed (Donzel, Arti and Chahory, 2017), Another study by Mattin and et.al. (2014) in the UK, showed that Yorkshire terrier also appeared to have the highest occurrence of canine diabetes mellitus, while Samoyed and Poodles are also reported to be predisposed to diabetes mellitus, with German shepherds, Golden retrievers and Boxers reported as having lower risk for the disease development (Mattin and et.al, 2014). Studies do show that there is an increased genetic risk of disease development in some breeds. According to Short and et.al. (2007), a single-nucleotide polymorphism (SNP) - based analysis for certain genes was carried out to identify the association of alleles of these genes with canine diabetes mellitus. A single nucleotide polymorphism is a genomic variant with single base variation at a single base position in the DNA. From the analysis, they identified a total of 37 SNP allele associations with canine diabetes, of which 24 of them are associated with an increased susceptibility towards the disease. The breeds involved in this significant susceptibility association between SNP alleles in certain genes and disease development includes Dachshund, Poodle, Schnauzer and West Highland White Terrier, Cavalier King Charles Spaniel, Cocker Spaniel, Border Terrier, Jack Russell Terrier and Yorkshire terrier.

Other potential predisposed factors include diet, animal management and body weight. Dogs who are not fed with an exclusive commercial diet were found to have greater risk of developing diabetes mellitus than those fed exclusively with commercial feed (Pöppl and et. al., 2017). In a study by Klinkenberg, Sallander and Hedhammar (2006), it was reported that dogs that are given more treats would have a higher risk of the disease, while dogs that are given more exercises are of lesser risk. Dogs being managed indoor or outdoor, feeding management such as if feeding pattern is by ad libitum or restricted feeding, and the frequency of feeding per day, may also contribute to diabetes mellitus development (Klinkenberg, Sallander and Hedhammar, 2006). Body weight can be categorized into underweight, normal, and overweight. Overweight dogs were found to be more associated with diabetes mellitus due to potential obesity, and the weight gain can be contributed by frequent treats feeding and ingestion of more homemade diet and table scraps, rather than commercial feed (Klinkenberg, Sallander and Hedhammar, 2006; Pöppl and et. al., 2017).

According to Ahmed, Sultana and Greene (2021), obesity is a condition with excessive body fat accumulation to an extent that can lead to adverse health effects, which is due to excessive nutrient intake than the body requires, resulting in these nutrients being stored as triglycerides in adipocytes as energy storage. In case of obesity, there is overnutrition, the present adipocytes would undergo hypertrophy due to increase uptake of triglycerides, while when the present adipocytes cannot further uptake the excessive triglycerides, there would be adipogenesis which is the synthesis of new adipocytes for triglyceride storage, further increase the fat mass. The increased size of adipose tissue due to increased adipocytes size and number can create a hypoxic condition, causing adipocyte cell death and this would recruit macrophages causing inflammation. Besides, these obese adipocytes hypertrophy, hypoxia, and inflammatory process would affect the adipose tissue function, such as impairing lipid metabolism and causing altered adipokine secretion towards pro-inflammatory types such as interleukin, tumor necrosis factor, leptin and resistin, with a reduced in adiponectin production which is an anti-inflammatory type. According to Castro and et.al. (2014), these dysfunctional adipose tissues are highly lipolytic, promoting the release of free fatty acids (FFA) into the circulation. This would elevate the delivery of FFA to the liver via hepatic portal vein and cause abnormal lipid accumulation in organs. Other than this, it was also proposed that when the adipose tissue reaches its limit of expansion, with continuous overnutrition it can cause a spillover of free fatty acids to non-adipose tissue such as liver, muscle, kidney and pancreas. With their limited ability to oxidize the FFA for utilization, the excess FFA abnormally accumulated in these organs as ectopic fat, can cause inflammation, lipotoxicity and so apoptosis of the cells, hence deteriorating the organ function. As pancreas functions to produce insulin, obesity can so result in pancreatitis and hence predisposes the animal to diabetes mellitus (Rand and et.al., 2004).

According to Castro and et.al. (2014), another mechanism proposed on insulin resistance is hyperinsulinemia due to reduced clearance from circulation. Insulin clearance occurs by the uptake and the degradation of insulin in many tissues, which include the liver. In cases of obesity, overproduction of insulin can occur due to induction by excessive glucose and fatty acid in the body. Yet the liver may have reduced functions due to a consequence from ectopic fat deposition, leading to a reduced insulin clearance. The imbalance between insulin production and clearance causes hyperinsulinemia. With hyperinsulinemia, it promotes downregulation of insulin receptors, hence reduced insulin sensitivity and so the ability of cells for glucose uptake, causing insulin resistance.

Diagnosis of diabetes mellitus

The diagnosis of diabetes mellitus is based on a combination of characteristic clinical signs, persistent hyperglycemia and glycosuria (Davison, Herrtage and Catchpole, 2005; Pöppl and et. al., 2017; Greco, 2018; Behrend and et.al., 2018; Rand, 2020). According to Nelson and Reusch (2014), clinical signs will typically develop when hyperglycemia reaches a concentration that breaches the renal threshold of approximately 180–220 mg/dl, and results in glycosuria.

In situations when there is elevated blood glucose level, being measured as between the upper reference level and the renal threshold values, yet without a clinical sign, it can be potentially a stress-induced hyperglycemia or that the animal is at risk for developing diabetes mellitus (Behrend and et.al., 2018). The latter can be referred to as pre-diabetes, which is defined as a condition where there is the presence of hyperglycemia but without meeting the criteria for diabetes mellitus (Gilor and et.al., 2016), which they do not have clinical signs of diabetes mellitus (Behrend and et.al., 2018). According to Rand (2020), dogs with blood glucose levels measured above the renal threshold of 200 mg/dL (11 mmol/L) are considered diabetic.

In the study by Suchowersky and et.al. (2021), biochemical analyzer usage is the gold standard for determining blood glucose concentration. While because of the disadvantages such as that it requires a bigger sample size, greater turn-around time, and higher cost compared to the use of blood glucometer, glucometers are being preferred to be used instead for their convenience, being a small hand-held device that allow rapid and easy measurement of blood glucose concentration in diabetic patients, and is comparatively more cost-effective. When measuring for blood glucose level in dogs, recommended reference range of euglycemia is set at 76 to 116 mg/dL (4.2–6.4 mmol/L), while any values lower than 76 mg/dL (<4.2 mmol/L) is considered as hypoglycemia, and any value greater than 116 mg/dL (>6.4 mmol/L) is considered hyperglycemia (Suchowersky and et.al., 2021).

7.0 METHODOLOGY

7.1 Study area

This study will be conducted in three selected veterinary clinics in Selangor, Malaysia.

7.2 Study design

The study design involved was a retrospective-cohort study.

7.3 Study population

The study population involves dogs presented to the selected veterinary clinics.

7.4 Selection criteria

7.4.1 Inclusion criteria

● All dogs presenting to the selected veterinary clinics for a disease diagnosis

7.4.2 Exclusion criteria

● Dogs without a definitive diagnosis of diabetes mellitus from the selected veterinary clinics

7.5 Sampling method and procedure

Convenience sampling method is used for identifying the veterinary clinics to be involved in the study.

7.6 Data collection tools

Data was collected by reviewing the available electronic or physical files of medical records of all dogs presenting to the selected clinics between Year 2021 to Year 2023. The data obtained from the medical records include demographic data, client complaints, together with diagnostic workup and the treatment provided.

7.7 Plan for data analysis

Data collected from medical records were coded with the use of Excel sheets and then analysis was done via the use of SPSS version 29.0.1.0 (171). Body weight was categorized into underweight, normal, and overweight, with the weight of each dog being categorized according to ideal weight ranges proposed by Association for Pet Obesity Prevention. Age of dogs were categorized into three life stages, which are puppy (up to 12 months old), adult (one to six years old) and senior (greater than seven years old) according to Harvey (2021). Prevalence was calculated as the proportions of dogs diagnosed with diabetes mellitus among the total number of dogs visited the selected veterinary clinics. Descriptive statistics for categorical data will be summarized into frequency and percentage. Pearson's Chi-square test will be used to determine the association between diabetes mellitus development and the potential risk factors. A p-value of 0.05 was considered statistically significant.

7.8 Ethical considerations

This paper refers to a retrospective-cohort study with no animals involved in the process, so no consent of ethics is needed for this study. Yet, the data collected will be confidentially maintained as anonymous.

8.0 RESULTS

Clinical information was collected from a total of 3355 dogs (192 puppies, 2305 adults, 858 seniors) as shown in Figure 1. In this study, a total of 1267 dogs (51 puppies, 916 adults and 300 seniors) were presented in 2021, 890 (63 puppies, 619 adults and 208 seniors) in 2022 and 1198 (78 puppies, 770 adults and 350 seniors) in 2023 (Figure 2). There were an overall of 1776 males and 1579 females (Figure 3), with 799 males and 268 females in the year 2021, 430 males and 460 females in the year 2022, with 547 males and 651 females in the year 2023 (Figure 4).

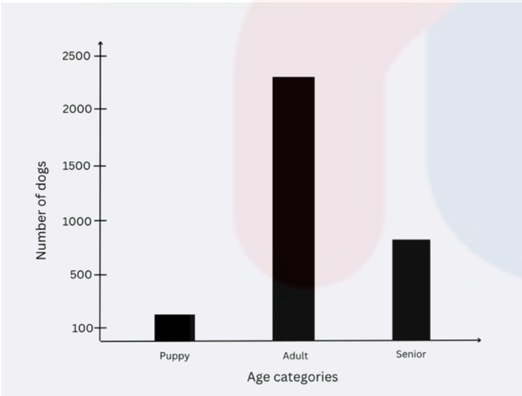

Figure 1: General dog numbers in each age category

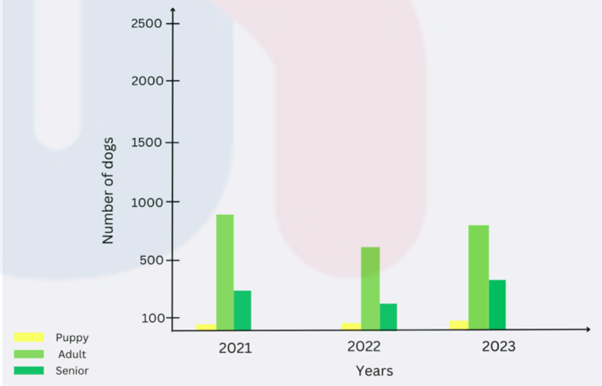

Figure 2: Numbers of puppies, adults, seniors each year

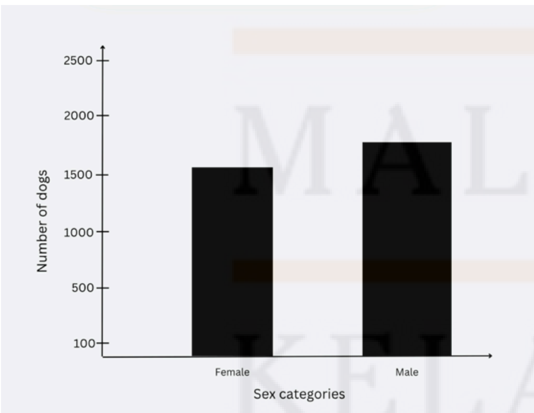

Figure 3: General dog numbers in each sex category

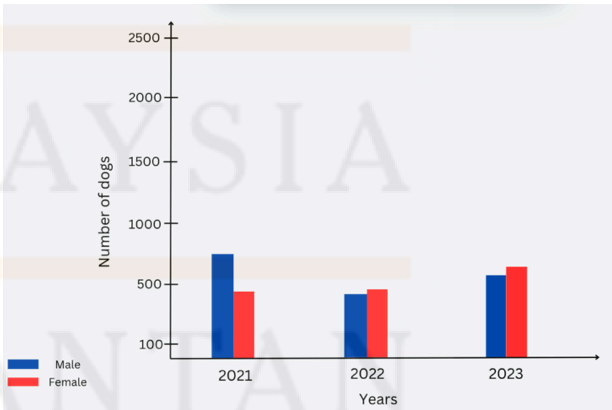

Figure 4: Number of male and female dogs each year

Among these 3355 dogs, 1052 of them were neutered (Figure 5), with 326 of them presented in the year 2021, 341 in the year 2022 while 385 in the year 2023 (Figure 6). There were a total of 596 dogs categorised as underweight, 2126 and 633 dogs categorised as normal weight and overweight respectively, as shown in Figure 7. Among them, 213 underweight, 696 normal weight and 245 overweight dogs were presented in the year 2021, with 128 underweight, 600 normal weight and 151 overweight dogs in the year 2022, with lastly 255 underweight, 830 normal weight and 237 overweight dogs in the year 2023 (Figure 8).

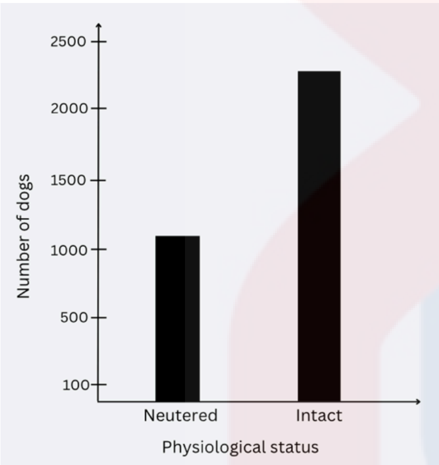

Figure 5: General numbers of neutered and intact dogs

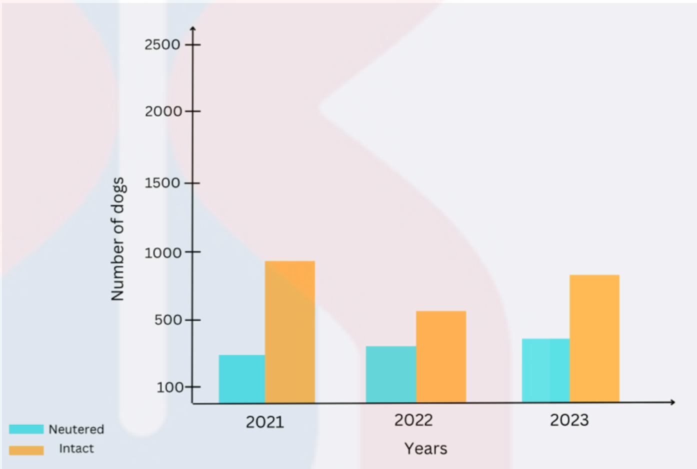

Figure 6: Number of neutered and intact dogs each year

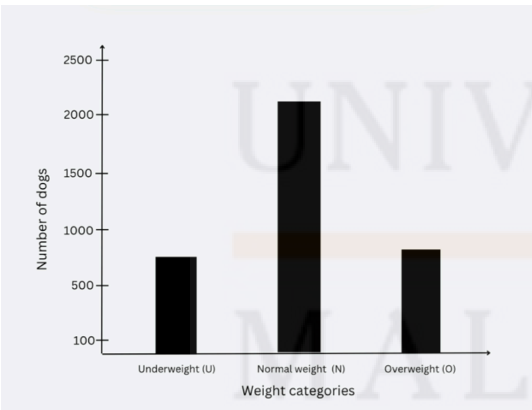

Figure 7: General dog numbers in each weight category

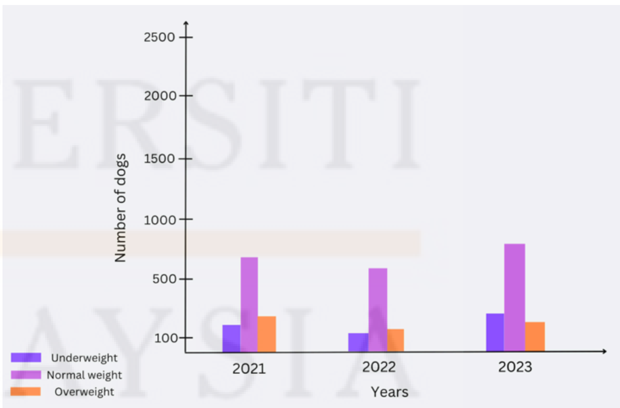

Figure 8: Number of dogs in each weight category each year

In this study, the overall prevalence of diabetes mellitus in dogs from 2021 to 2023 was reported to be 1.04% (35 diabetic patients out of 3355 dogs). Disease prevalence in the year 2023 was reported as 1.17% (14 cases out of 1198), 0.9% in the year 2022 (8 cases out of 890), lastly 1.02% in the year 2021 (13 cases out of 1267), as shown in Figure 9.

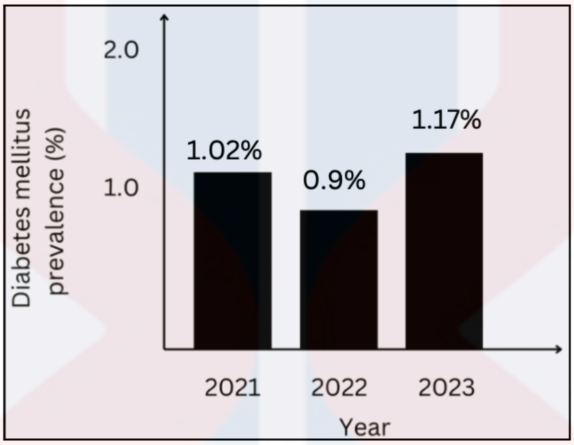

Figure 9: Prevalence of diabetes mellitus from Year 2021 to 2023

There are a total 19 out of 1579 (1.2%) females and 16 of 1776 males (0.9%) being diagnosed with diabetes mellitus. There was no significant association (P=0.390) between diabetes mellitus development and sex in dogs being studied (Table 1). In the diabetic patient population, 22 of them were neutered, which occupied 2.1% of the total neutered population, while the rest were the intact ones, occupying 0.6% of the total intact population. Results showed there was a significant association (P<0.001) between the disease development and physiological status of the dogs (Table 1).

Within Year 2021 to 2023, a total of 35 breeds were represented in this study, while 12 of them contributed to the diabetic population. The 35 diabetic dogs were made up of nine Miniature poodle (25.7%), eight Mongrel dogs (22.85%), six Miniature schnauzer (17.1%), three Toy poodle (8.6%), two Pom (5.71%) and one of each (2.85%) from the breed Beagle, Bichon, Dachshund, Labrador retriever, Pitbull, Shiba inu, and lastly West highland white terrier. Regarding disease development within specific breed, diabetes mellitus was diagnosed in one out of two (50%) West highland white terrier, one out of 17 (5.9%) Bichon, one out of 18 (5.6%) Dachshund and six out of 146 (4.1%) Miniature schnauzer, followed by one out of 35 Labrador retriever (2.9%), one out of 47 of each breed Beagle, Pitbull and Shiba inu (2.1%), three out of 169 (1.8%) Toy poodle, nine out of 525 (1.7%) Miniature poodle, eight out of 714 (1.1%) Mongrel dog and lastly two out of 450 (0.4%) Pom being diagnosed. Results showed that there was significant association (P<0.001) between the disease development and dog breed.

Table 1.

Risk factor		With diabetes mellitus	Without diabetes mellitus	P-value
Sex	Female	19	1560	0.390
	Male	16	1760	
Physiological status	Intact	13	2290	<0.001
	Neutered	22	1030	
Age	Puppy	0	192	<0.001
	Adult	10	2295	
	Senior	25	833	
Weight	Underweight	5	591	0.329
	Normal	20	2106	
	Overweight	10	623	

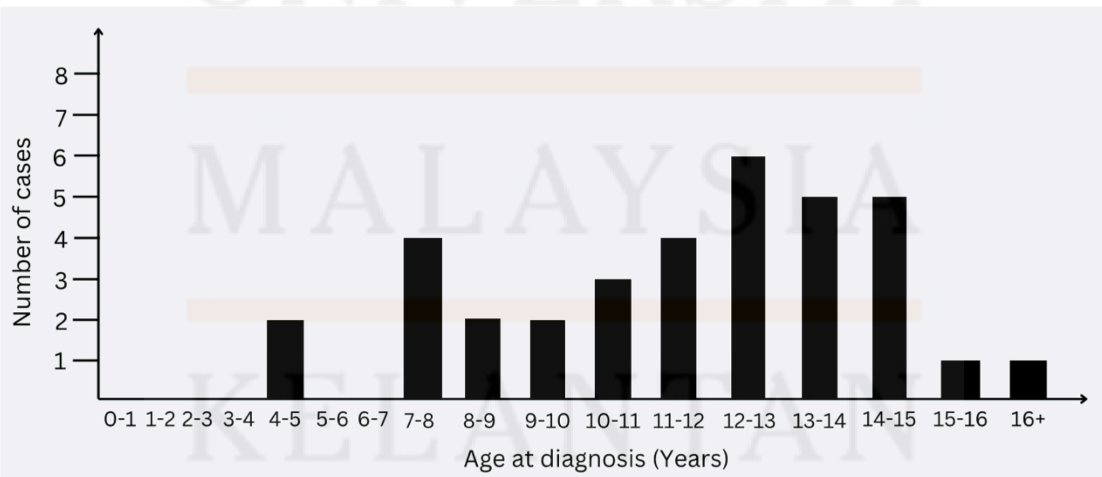

Figure 10: Number of cases presented at different age

Figure 10 showed the age of 35 diabetic dogs when the disease was identified. The mean age at which diabetes mellitus had been diagnosed was at 10 to 11 years old, which was considered as a senior stage of life in dogs, while the disease occurrence ranging from four to 16 years old in them (adult to senior stage of life). There was significant association (P<0.001) between the disease development and age of dogs studied, which had been classified into three life stages (Table 1).

Out of 3355 dogs that visited the clinics, the 35 diabetic patients were made up of five out of 596 (0.8%) underweight dogs, 10 out of 633 (1.6%) overweight dogs and 20 out of 2126 (0.9%) of normal weight dogs. There was no significant association (P=0.329) between the disease development and weight of dogs in this study (Table 1).

9.0 DISCUSSION

In this study, there were a total of 35 dogs being diagnosed with diabetes mellitus, with more females affected than males. The females account for 54.3% (19 out of 35), while 45.7% by the males (16 out of 35), indicating females may have greater risk of such disease development in comparison to males. These findings correspond to previous studies carried out which they also have for females being affected with diabetes mellitus (Donzel, Arti and Chahory, 2017; Guptill and et.al., 2003; Guptill, Glickman and Glickman, 2003; Marmor and et. al., 1982). This could be due to hormone fluctuation in the female estrus cycle, mainly relating to the hormone progesterone that can result in reduced insulin sensitivity and exacerbate hyperglycemia, as stated by Pöppl and et.al. (2024), with its ability to stimulate growth hormone which is an insulin counterregulatory hormone (Catchpole and Davison, 2005). This might be contributed to why more females were affected in this study.

22 out of 35 of these diabetic patients were neutered (62.85%) while the rest remained intact (37.15%), indicating an increased risk of diabetes mellitus development in neutered patients. This result is consistent with the previous studies (Oberbauer, Belanger and Famula, 2019; Guptill and et.al., 2003) where neutered dogs were reported to have greater risk of disease development, due to them having more risk for obesity.

In this study, results showed West highland white terrier was found to be the breed with the greatest disease prevalence (50%) among the other breeds, followed by Bichon (5.9%), Dachshund (5.6%) and Miniature schnauzer (4.1%), continued with Labrador retriever (2.9%), Beagle, Pitbull and Shiba inu (2.1%), Toy poodle (1.8%), Miniature poodle (1.7%), Mongrel dog (1.1%) and lastly the lowest prevalence within the breed Pom (0.4%). The inequality in breed distribution in this study population, which ranges from as low as only two West highland white terrier to as high as 714 Mongrel dogs presented in the study, could affect the result of disease prevalence in specific breeds in this study. Yet, Miniature poodles were reported to be the most frequently affected breed, accounting for nine out of 35 diabetic dogs found in this study, which is consistent with the study result by Pöppl and et.al. (2017) that had showed Poodles being the most affected breed with the disease. Within the population of Yorkshire terrier in this study, there is no diabetes mellitus diagnosed, which is different from a study by Donzel, Arti and Chahory (2017) that had proved that Yorkshire terrier as the most commonly affected breed.

The disease occurrence increased starting at seven years old in dogs and peak incidence at 12 years old, indicating an increased risk in senior dogs. This result is consistent with the studies carried out by others, which many of them stated that the disease was commonly seen in middle aged to older dogs, with age ranges from five to 12 years old being reported (Davison, Herrtage and Catchpole, 2005).

In this study, overweight dogs were more frequently affected by diabetes mellitus, which is consistent with the previous studies that showed at least 55% of diabetic dogs in their studies were overweight (Klinkenberg, Sallander and Hedhammar, 2006; Pöppl and et. al., 2017). This might be due to the fact that overweight dogs were more predisposed to obesity due to potential overnutrition as described by Ahmed, Sultana and Greene (2021) and this can predisposed the animals to have insulin resistance (Castro and et.al., 2014). The association between diet and animal management with diabetes mellitus development were not able to be identified due to very limited information available regarding these two risk factors in this study.

The prevalence reported in this study is comparatively higher to those in other studies, which could be attributed to the fact that clinics were conveniently selected for this study, hence does not represent the general population in Selangor. It may also be due to exclusion of dog patients with missing or incomplete data. From Year 2021 to 2023, the trend of disease prevalence fluctuated, being the highest in the Year 2023 (1.17%), followed by 1.02% in the Year 2021 then 0.9% in the Year 2022. This could be due to the fact that there are more seniors and neutered dogs being presented in the year 2023, as these two factors are found to be significantly positively associated with disease development. The results showed that 40.8% of seniors (350 out of 858 dogs) were being presented in the year 2023, comparatively higher than the other two years which were 208 and 300 senior dogs respectively. Also, there were generally more neutered dogs presented in the year 2023, which accounted for 36.6% (385 out of 1052), with 341 neutered dogs presented in the year 2022 (32.4%) and 326 presented in the year 2021 (30.9%).

10.0 CONCLUSION

From this study, it can be concluded that the prevalence of diabetes mellitus among dogs in Selangor, Malaysia from the year 2021 to the year 2023 was 1.04%, and there was an increase in disease prevalence in the Year 2023 when being compared with the previous two years. This result provided some information that was previously unavailable. There was a significant association between disease development and age, breed and physiological status. The potential available breeds in Malaysia that are predisposed to canine diabetes mellitus have also been identified.

11.0 LIMITATION

Due to the limited timeframe, only three clinics were visited for data collection and these three clinics were selected by convenience sampling. This study does not include potential concurrent illness in diabetic dogs and the association between the potential concurrent disease and diabetes mellitus.

12.0 RECOMMENDATION

As a recommendation, future research and study on diabetes mellitus in the dog population within Selangor, Malaysia should be conducted by data collection from a group that is representative of the whole Selangor dog population. For future studies, it is also recommended to collect more relevant data such as the disease history of patients in order to identify the potential concurrent illness in diabetic dogs and the association between them. Lastly, the potential association between factors such as diet and physical activity load, with diabetes mellitus in dogs may be studied in order to provide more useful insights.

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14.0 APPENDICES

3 clinics data collection

File Edit View Insert Format Data Tools Extensions Help

	A	B	C	D	E	F	G	H	I	J	K
1	Weight (kg)	Weight categon	Ideal weight range	Sex	Physiological status	Breed	Breed size	Life stage	Age	Disease status	Year
2	3.5	O	1.8-3.2	F	Neu	yorkshire terrier	toy	senior	16y 6m	no dM	2023
3	3.9	O	1.8-3.2	F	Neu	yorkshire terrier	toy	senior	13y	no dM	
4	5.3	O	3.6-4.5	F	Neu	Silky terrier	toy	senior	18y 6m	no dM	
5	9.3	O	3.6-4.5	F	Neu	Silky terrier	toy	senior	17y 6m	no dM	
6	2.38	U	3.6-4.5	F	Neu	Silky terrier	toy	senior	16y 6m	no dM	
7	3.8	N	3.6-4.5	F	Neu	Silky terrier	toy	senior	16y	no dM	
8	4.15	N	3.6-4.5	M	Neu	Silky terrier	toy	senior	15y 6m	no dM	
9	5.1	O	3.6-4.5	F	Neu	Silky terrier	toy	senior	14y 5m	no dM	
10	5	O	3.6-4.5	M	Neu	Silky terrier	toy	senior	14y	no dM	
11	4.3	N	3.6-4.5	F	Neu	Silky terrier	toy	senior	14y 2m	no dM	
12	4.9	O	3.6-4.5	M	Neu	Silky terrier	toy	senior	13y	no dM	
13	6.45	O	3.6-4.5	F	Neu	Silky terrier	toy	senior	12y 6m	no dM	
14	6.2	O	3.6-4.5	F	Neu	Silky terrier	toy	senior	11y	no dM	
15	3.7	N	3.6-4.5	F	Neu	Silky terrier	toy	senior	11y	no dM	
16	2.4	N	1.8-2.7	F	Neu	toy poodle	toy	senior	17y	no dM	
17	2.6	N	1.8-2.7	F	Neu	toy poodle	toy	senior	14y 6m	no dM	
18	3.8	O	1.8-2.7	M	Neu	toy poodle	toy	senior	14y	no dM	
19	2.9	O	1.8-2.7	F	Neu	toy poodle	toy	senior	14y7m	no dM	
20	2.2	N	1.8-2.7	F	Neu	toy poodle	toy	senior	13y	no dM	
21	3.6	O	1.8-2.7	F	Neu	toy poodle	toy	senior	13y 6m	no dM	
22	2.95	O	1.8-2.7	M	Neu	toy poodle	toy	senior	13y 6m	no dM	
23	3.9	O	1.8-2.7	M	Neu	toy poodle	toy	senior	13y	no dM	

Figure 11: Data collected were organized and coded into Excel sheets, with overweight coded as 'O', normal weight coded as 'N', underweight coded as 'U', female coded as 'F', male coded as 'M', neutered coded as 'Neu', intact coded as 'Int', non-diseased coded as 'no dM' and diseased coded as 'dM'.

Search application

1 : VAR00001

	weight..kg	weight.category	ideal.weight.range	sex	physiological .status	breed	breed.size	life.stage	age	disease.status	Year
1	3.5	O	1.8-3.2	F	Neu	yorkshire terrier	toy	senior	16y 6m	no dM	2023
2	3.9	O	1.8-3.2	F	Neu	yorkshire terrier	toy	senior	13y	no dM	
3	5.3	O	3.6-4.5	F	Neu	Silky terrier	toy	senior	18y 6m	no dM	
4	9.3	O	3.6-4.5	F	Neu	Silky terrier	toy	senior	17y 6m	no dM	
5	2.38	U	3.6-4.5	F	Neu	Silky terrier	toy	senior	16y 6m	no dM	
6	3.8	N	3.6-4.5	F	Neu	Silky terrier	toy	senior	16y	no dM	
7	4.15	N	3.6-4.5	M	Neu	Silky terrier	toy	senior	15y 6m	no dM	
8	5.1	O	3.6-4.5	F	Neu	Silky terrier	toy	senior	14y 5m	no dM	
9	5	O	3.6-4.5	M	Neu	Silky terrier	toy	senior	14y	no dM	
10	4.3	N	3.6-4.5	F	Neu	Silky terrier	toy	senior	14y 2m	no dM	
11	4.9	O	3.6-4.5	M	Neu	Silky terrier	toy	senior	13y	no dM	
12	6.45	O	3.6-4.5	F	Neu	Silky terrier	toy	senior	12y 6m	no dM	
13	6.2	O	3.6-4.5	F	Neu	Silky terrier	toy	senior	11y	no dM	
14	3.7	N	3.6-4.5	F	Neu	Silky terrier	toy	senior	11y	no dM	
15	2.4	N	1.8-2.7	F	Neu	toy poodle	toy	senior	17y	no dM	
16	2.6	N	1.8-2.7	F	Neu	toy poodle	toy	senior	14y 6m	no dM	
17	3.8	O	1.8-2.7	M	Neu	toy poodle	toy	senior	14y	no dM	
18	2.9	O	1.8-2.7	F	Neu	toy poodle	toy	senior	14y7m	no dM	
19	2.2	N	1.8-2.7	F	Neu	toy poodle	toy	senior	13y	no dM	
20	3.6	O	1.8-2.7	F	Neu	toy poodle	toy	senior	13y 6m	no dM	
21	2.95	O	1.8-2.7	M	Neu	toy poodle	toy	senior	13y 6m	no dM	
22	3.9	O	1.8-2.7	M	Neu	toy poodle	toy	senior	13y	no dM	
23	3.4	O	1.8-2.7	F	Neu	toy poodle	toy	senior	13y	no dM	

Figure 12: Data transferred to SPSS version 29.0.1.0 (171) for data analysis