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OCCURRENCE AND OUTCOMES OF UROLITHIASIS AND OTHER URINARY TRACT CONDITIONS IN DOMESTIC CATS IN NAIROBI.

A Thesis submitted in partial fulfillment of the requirements for Master of Veterinary Surgery (MVETSurg) Degree of the University of Nairobi

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DECLARATION

This is my original work and has not been presented for a degree in any other university.

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Occurrence and outcomes of urolithiasis and other Urinary tract conditions in domestic cats in Nairobi.

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LIST OF ABBREVIATIONS

CKD	Chronic kidney disease
CT	Computed Topography
CVUC	Canadian Veterinary Urolith Center
DX	Diagnosis
EXM	Examination
FIC	Feline idiopathic cystitis
FLUTD	Feline lower urinary tract disease
FUS	Feline Urologic Syndrome
GFR	Glomerular filtration rate
GOK	Government of Kenya
HX	History
IMG	Imaging
IRIS	International Renal Interest Society
KVB	Kenya Veterinary Board
LUT	Lower urinary tract
LUTD	Lower urinary tract disease
MEMO	Multimodal environment modification
ROC	Receiver Operator Characteristic curve
SDMA	Serum symmetric dimethylarginine
UTI	Urinary tract infection

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ABSTRACT

This was a retrospective study that covered a 10-year period from January 2009 to December 2018. The objectives of this study were to determine 1) the prevalence, 2). the clinical manifestations, diagnostic approaches and diagnoses, as well as 3). the treatments and outcomes of urolithiasis and other urinary tract conditions in domestic cats in Nairobi County, Kenya. Clinical data of all cases of cats was collected from five (5) purposively selected veterinary clinics. All cases with history of urinary tract condition were isolated from the pool. For each of these cases with urinary system problems, specific data was retrieved, which included breed, sex, age, weight, neuter history, clinical signs, diagnostic methods employed and confirmed diagnosis, methods of treatment whether medical or surgical, drugs used, site of uroliths and other urinary tract conditions diagnosed, post-treatment care and the outcome of each case. Prevalence of each of the conditions was determined. Proportions were determined for categorical variables i.e. sex, breed and neuter history. Ranges, means and standard deviations were determined for continuous variables i.e. weight and age. Univariate and multivariate analysis was done to determine the actual factors that were most likely to be associated with the occurrence of urolithiasis.

The total number of domestic cat cases in the 10-year period was 4,404. The overall prevalence of urinary tract disease was 2.4% (n=104) and that of urolithiasis was 0.6% (n=28). Out of the 104 cases with urinary tract conditions, 72.1% (n=75) had definitive diagnoses indicated in the case records, while in 27.9% (n=29) the definitive diagnoses were not indicated. Among the cases with indicated definitive diagnoses, urolithiasis was 37.3% (n=28) and idiopathic FLUTD was 22.7% (n=17). The cats presented with urinary tract conditions included 64.6% (n=62) males and

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35.4% (n=34) females, while those with urolithiasis included 76.9% (n=20) males and 23.1% (n=6) females. Domestic shorthair breed was the most (77.3%, n=68) affected by various urinary tract conditions out of which 30.9% (n=21) had urolithiasis. Most (61.7%, n=50) cats with urinary tract diseases were sexually intact, while most (60.9%, n=14) cats with urolithiasis were neutered. The most common clinical manifestations of cats with urinary tract conditions were haematuria 40.4% (n=40) and dysuria 23.2% (n=24). Dysuria 37% (n=10) and haematuria 29.6% (n=8) were the commonest clinical signs of cats with urolithiasis. Diagnostic methods used in the 104 cases of urinary tract conditions were physical examination 75% (n=78), urinalysis 12.5% (n=13), imaging (including radiography and ultrasound) 38.5% (n=40) and cystotomy 11.5% (n=12).

Therapy for urinary tract conditions in this study included use of corticosteroids (37.2%, n=35), antibiotics [such as cephalosporins (21.3%, n=20), metronidazole 14.9%, n=14), tetracyclines (4.3%, n=4) and sulphonamides (2.1%, n=2). Lactated Ringer's solution was used for fluid therapy in 20.4% (n=19) of the cases, normal saline (17.0%, n=16) and 5% dextrose (5.3%, n=5). Pain therapy was achieved using non-steroidal anti-inflammatory drugs (9.6%, n=9). The records indicated that 55.7% (n=39) of the cats recovered after treatment, recurrent cases were 17.1% (n=12) and 27.1% (19) of the cases died. Dysuria (OR=0.10; CI= 0.01 to 1.17; P=0.066), distended urinary bladder (OR=20.79; CI=2.32-186.22; P=0.007) and body weight (OR=16.45; CI=1.38-196.68; P=0.027) were factors significantly associated with urolithiasis in domestic cats.

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The study concluded that urolithiasis was found to have the highest prevalence at 37.3% (n=28) among the urinary tract conditions in domestic cats in Nairobi County, Kenya, followed by idiopathic FLUTD and idiopathic cystitis each at 22.7% (n=17). There was a higher prevalence of idiopathic FLUTD, which may be due to lack of proper examination of cats with urinary tract problems. However, according to this study, most of the urinary tract conditions recovered after treatment. Further studies need to be conducted to chemically verify the type of uroliths affecting cats in Nairobi County, Kenya for proper management and prevention of occurrence of urolithiasis. There is need to also carry out a comprehensive research on the predisposing factors for urinary system conditions in domestic cats.

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CHAPTER ONE

1.0 INTRODUCTION

The urinary system is composed of the urethra, urinary bladder, kidneys and ureters. There are quite a number of urinary tract conditions in domestic cats, including urolithiasis, feline urologic syndrome (FUS), bacterial infection, cystitis, idiopathic cystitis, urethral obstruction and neoplasia (Mateescu *et al.,* 2012). Cats are presented to the veterinary clinics and hospitals mainly due to such conditions (da Rosa *et al*., 2018). A veterinarian is likely to examine a cat for feline urologic syndrome, cystitis, renal disease, and inappetence (Lund *et al.,* 1999). Clinical signs of urinary tract diseases in cats are non-specific and similar symptoms may manifest in diseases with different aetiology. Typical signs of urinary tract involvement are haematuria, dysuria, anuria, polyuria stranguria, pollakiuria and periuria, but rarely do these signs point out to a specific cause (Mateescu *et al.,* 2012).

In USA, 8% of cats presented to hospitals suffer from feline lower urinary tract disease (FLUTD) (Gerber, 2008). Urolithiasis accounted for 22% of the cats suffering from FLUTD (Gerber *et al.,* 2005) and 56.06% of cats with urinary tract diseases (Mateescu *et al.,* 2012). In USA, the estimated prevalence of LUTD is approximately 1.5% (Hostutler *et al.,* 2005). Previous studies have shown that urolithiasis accounted for 13-28% of the causes of non-obstructive urinary tract disease in referral institutions (Hostutler *et al.,* 2005). Zohaib et al. (2013) indicates that 10 to 20% of cats suffering from LUTD have uroliths or urethral plugs. Occurrence of urolithiasis is estimated to be approximately 15 to 21% in cats with clinical signs of lower urinary tract disease (LUTD) (Hunprasit *et al.,* 2019).

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Urolithiasis is one of the urinary tract conditions reported in domestic cats and is a common cause of clinical signs linked to feline urinary tract (Lulich *et al.,* 2011). By definition, urolithiasis is the occurrence and the effects of urinary calculi in the urinary tract. This condition is one of the causes of haematuria in cats (Popa *et al.,* 2017). Uroliths commonly occur in the urinary bladder and the urethra. The predisposing factors for urolithiasis are multifactorial, which include hereditary, congenital and acquired pathophysiological factors. These factors can synergistically promote precipitation of urine-excreted metabolites to form uroliths (Lulich *et al.,* 2011). Other factors that may contribute to urolithiasis are certain metabolic derangements, absence or reduction of natural crystallization inhibitors and urinary tract infections (Ling *et al.,* 1998).

Higher incidences of urinary tract conditions were found in neutered 6 to 9 months old cats, but the cause of this occurrence for the specified age category was not determined (Howe *et al.,* 2000). When urine becomes supersaturated with minerals and has conducive pH for crystallization, the minerals precipitate to form crystals that converge to form uroliths (Houston *et al.,* 2003). The supersaturation of urine may be enhanced by factors such as urine retention of crystalloids, high urine specific gravity, increased mineral excretion in urine, and decreased natural inhibitors of crystallization (Houston *et al.,* 2003).

Uroliths are composed of small amounts of organic matrix (mucoid material) and large amounts of crystalline material, which are either organic or inorganic crystalloids. They are classified based on the mineral content (Lulich *et al.,* 2011). There are four types of uroliths that occur in cats, which include struvite (magnesium ammonium phosphate), calcium oxalates, calcium phosphate and urate. Uroliths can also be of mixed composition (Norsworthy, 2011). The type of calculi formed may vary depending on breed, age, geographical location and diet (Hunprasit *et al.,* 2019). Struvites are the commonest uroliths in cats. Bacterial infections, especially *Staphylococcus* species or *Proteus* species induce a small percentage of struvite uroliths. Other types of uroliths are unrelated to bacteria, and their pathogenesis is not well known, but dietary factors are incriminated (Norsworthy, 2011). In some cases, cats with urinary cystic uroliths do not have crystals in their urine, while others may have crystals of different mineral content, which is rare (Houston *et al.,* 2003).

Diagnosis of urolithiasis in cats is dependent on clinical signs of haematuria, dysuria, pollakiuria, periuria or symptoms of urethral obstruction (Norsworthy, 2011). Palpation is done during clinical examination but it elicits pain. Confirmation is by radiography or ultrasonography (Norsworthy, 2011).

Treatment of urolithiasis includes surgical removal of the uroliths, retrograde urohydropropulsion, dietary or medical dissolution of the uroliths, and antibiotic therapy of some bacteria-induced uroliths. Prevention of urolithiasis is done by increasing water intake, urine acidifying diets or urinary acidifiers in cases of non-infection struvite uroliths and non-acidifying diets with reduced sodium and protein to prevent occurrence of calcium oxalate uroliths (Norsworthy, 2011).

Some of the other common urinary tract conditions in domestic cats include lower urinary tract disease, cystitis, urethral obstruction, pyelonephritis and neoplasia. Lower urinary tract disease (LUTD) is a urologic syndrome consisting of multiple disorders including idiopathic cystitis, urolithiasis, urethral obstructions, bacterial urinary infections and tumours. It entails dysfunction of the urethra or urinary bladder. Some of the common symptoms for this syndrome may include pollakiuria, stranguria,

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haematuria and periuria (Lew-Kojrys *et al*., 2016).

The prevalence, diagnosis, treatments and outcomes of urinary tract conditions in domestic cats in Kenya is not documented. This study therefore, is aimed at consolidating data related to these factors of urinary tract conditions; with emphasis on urolithiasis in domestic cats that have been presented for treatment in various veterinary clinics in Nairobi County, Kenya from January 2009 to December 2018. Publication of this data will give a guidance on the existing situation of domestic cat urinary tract disease, the methods of diagnosis, treatments and their outcomes in Kenya.

1.1 Hypothesis

There is a likelihood of high occurrence of varied urinary tract conditions in domestic cats in Nairobi County, Kenya.

1.2 Justification

Uroliths are responsible for about a quarter of all cases of haematuria and dysuria in domestic cats, and the second commonest cause of lower urinary tract infection (Palma *et al.,* 2009). They are the major cause of urethral obstruction in cats (George and Grauer, 2016). In Kenya, there is no study that has been conducted specifically on urinary tract conditions and urolithiasis in domestic cats. Therefore, there was need of a study to establish the status of the conditions in Kenya with emphasis on urolithiasis with respect to prevalence, clinical manifestations, diagnoses, treatments and outcomes. Publication of data from this study will facilitate veterinary practitioners in diagnosis, treatment, and judging of prognosis for domestic cats with urinary tract conditions.

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1.3 Objectives

1.3.1 General objective

To retrospectively determine the occurrence, clinical manifestations, diagnoses, treatments and outcomes of urinary tract conditions with emphasis on urolithiasis in domestic cats in Nairobi County, Kenya

1.3.2 Specific objectives

a) To determine the prevalence of urolithiasis and other urinary tract conditions in domestic cats from January 2009 to December 2018 in Nairobi County, Kenya.

b) To determine the clinical manifestations and diagnoses of urolithiasis and other urinary tract conditions in domestic cats from January 2009 to December 2018 in Nairobi County, Kenya.

c) To determine the treatments and outcomes of urolithiasis and other urinary tract conditions in domestic cats from January 2009 to December 2018 in Nairobi County, Kenya.

d) To determine the factors associated with urolithiasis in domestic cats from January 2009 to December 2018 in Nairobi County, Kenya.

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CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Urolithiasis

Urolithiasis is the formation of precipitates consisting of poorly soluble uroliths in any part of the urinary tract. Calculi form when urine happens to be supersaturated with crystalloid substances, which consist of one or more mineral types (Tion *et al.*, 2015). The factors that predispose to the formation of urinary calculi include mineral excretion by kidneys, urine pH, presence of mineral crystallization promoters, and absence of inhibitors of mineral crystallization and infection or inflammation of the urinary tract (Palma *et al.*, 2009). Nephroliths and ureteroliths are uncommon in cats (Tion *et al.* (2015). Most of the uroliths are found in the urethra and urinary bladder (Hesse and Sanders, 1985, Tion *et al.*, 2015). Urolithiasis accounted for 13% of the overall cases of feline urologic syndrome (FUS) in Polish cats (Lew-Kojrys *et al.*, 2016) and 7% in German cat population (Dorsch *et al.*, 2014). The disease has an incidence of 0.6% (Hesse and Sanders, 1985). According to Tion et al. (2015), causes of feline urologic syndrome are related to infection in 46% of the cases and to concurrent infection and calculi in 17% of the cases. In 59% of feline urethral obstruction, the cause is mainly urethral plugs followed by urolithiasis in 12%. In non-obstructed cats, urolithiasis was found in 13% of the cases (Tion *et al.*, 2015). Urethral plugs are accumulations of small component of crystals, largely being a matrix of inflammatory materials. Other urethral plugs may consist of blood, sloughed tissue, and/or inflammatory reactants. Few of the plugs consist of concretions of crystalline minerals (Cari *et al.*, 1996; Tilley and Smith, 2008).

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Presence of uroliths is one of the factors that predisposes cats to urinary tract infections (Srivastava and Syed, 2012). Uroliths can cause urethral blockage in the male cat and is associated with pollakiuria, dysuria and urinary bladder distension. In cats suffering from FUS, 58% were diagnosed to be suffering from obstruction of urethra (Gerber *et al.,* 2005). Apart from urethral calculi and plugs, urethral obstruction can also be caused by neoplasms, stricture, and idiopathic factors (George and Grauer, 2016). Urinary bladder rupture may occur in cases of severe distension (Tion *et al.,* 2015). Common clinical finding in cats with feline urologic syndrome is crystalluria. Calcium oxalate and Struvite (magnesium ammonium phosphate) are the most common cystoliths in cats (Kamiloglu and Kilicoglu, 2017). Struvite uroliths accounts for 6% to 9% of feline uroliths (McCue *et al.,* 2009). Between 89 to 96 % of uroliths submitted to urolith centers are struvites (Langston *et al.,* 2008). However, calcium phosphate, urate, cysteine, silicate, xanthine and mixed stones are infrequent uroliths in cats (Kamiloglu and Kilicoglu, 2017).

2.1.1 Occurrence and risk factors of urolithiasis in domestic cats

Factors predisposing cats to urolithiasis are age, anatomical and functional anomalies of the urinary system, breed, sex, urinary tract infections, metabolic derangements, urine pH and diet (Kamiloglu and Kilicoglu, 2017). A study on the occurrence of urate uroliths, incriminated neutered purebred cats and age of 4 to 7 years as risk factors for cystoliths or urethroliths (Albasan *et al.,* 2012). The predisposing factors related to calcium oxalate uroliths are obesity, old age and neutering of cats (Gisselman *et al.,* 2009). Urolithiasis was reported to occur more frequently in male than female cats (Hesse and Sanders, 1985, Gerber *et al.,* 2005, Hesse *et al.,* 2012, Hunprasit *et al.,* 2019). Castrated cats accounted for 85% of the uroliths analyzed with 8.3 times greater risk of developing uroliths than intact cats (Picavet *et al.,* 2007). Two studies found neutered cats with higher proportion of cases of urolithiasis than intact cats (Picavet *et al.,* 2007, Hesse *et al.,* 2012). A higher percentage of occurrence of urolithiasis was found in neutered male cats, and intact female cats (Hunprasit *et al.,* 2019).

Urate urolithiasis was more frequent in cats with an average age of 6.3 years as well as male cats. Cats aged between 4 and 7 years had high occurrence of feline struvite urolithiasis (Palma *et al.,* 2009). These authors reported that cats older than 10 years or younger than 1 year were more commonly affected by non-sterile uroliths. Generally, occurrence of feline urolithiasis increases with age (Lew-Kojrys *et al.,* 2016). Alkaline urine predisposes cats to develop struvite uroliths. This type of calculi is usually seen in urine with a pH above 6.8. They are easier to form in presence of bacterial infection because bacteria increase with urine pH, thus reducing the solubility of struvite. Calcium oxalates form in acidic urine and also in cats suffering from hypercalciuria and hypercalcaemia (Kamiloglu and Kilicoglu, 2017).

Breed predilection for struvite urolith formation include domestic shorthair, Chartreux, ragdoll, foreign shorthair, oriental shorthair and Himalayan, while those breeds predisposed to urate urolithiasis are Birman, Siamese and Egyptian Mau breeds (McCue *et al.*, 2009). Female cats are predisposed to struvite uroliths, while male cats are susceptible to calcium oxalate uroliths (Lekcharoensuk *et al.*, 2000; Houston *et al.*, 2003; Appel *et al.*, 2010; Kamiloglu and Kilicoglu, 2017). Neutered cats are susceptible to calcium oxalates and struvites (Lekcharoensuk *et al.*, 2000). Studies have shown that most urethral plugs are diagnosed in longhair and shorthair domestic

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cats. In another study, domestic longhair and shorthair cats were commonly affected by nephroliths (Ling *et al.,* 1998). Urate urolithiasis affects both male and female cats with equal frequency (McCue *et al.,* 2009). Crossbreed cats are less predisposed to nephroliths than other breeds (Ling *et al.,* 1998).

Factors that predispose cats to formation of struvites are increased magnesium, phosphorous, calcium, chloride, and variety of fiber concentrations. Cats fed on liver or other organ meats are predisposed to urate urolithiasis due to the resulting high ammonia (McCue *et al.,* 2009, Tion *et al.,* 2015). Cats fed diets low in proteins and moisture are predisposed to calcium oxalate urolithiasis. Calcium oxalate urolithiasis increases with age. In-door cats are predisposed to calcium oxalate urolithiasis (Tion *et al.,* 2015).

2. 1.2 Diagnosis of urolithiasis

Uroliths may be composed of different mineral components but for all types, the related clinical signs and diagnostics are the same. History and presenting clinical signs are of importance in the diagnosis (Langston *et al.,* 2008). Urinary bladder uroliths present clinical signs of stranguria, haematuria, dysuria and pollakiuria. Small uroliths might cause urethral obstruction, leading to urinary bladder distension, stranguria, paradoxical incontinence, abdominal pain, and signs of post-renal azotaemia, which include vomiting, depression and anorexia. In severe cases, the bladder might rupture causing uro-abdomen. Clinical history vary, signs may be sporadic and sometimes asymptomatic in cases of nephrolithiasis and ureteroliths. Macroscopic and microscopic haematuria may be present. Clinical signs related to ureteroliths are mainly due to kidney dysfunction from obstructive uropathy or

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concurrent pyelonephritis (Langston *et al.,* 2008).

Uroliths may not be palpable, but pain is elicited on the urinary bladder on palpation (Norsworthy, 2011). With cystoliths, there might be thickened urinary bladder wall and the calculi may be palpable on abdominal palpation. Urethral calculi may be palpable per rectal (Langston *et al.,* 2008). Urinalysis is an important diagnostic method in urolithiasis especially determination of urine pH, which normally influences crystal formation and solubility (Tion *et al.,* 2015). Calcium phosphate form in neutral to alkaline urine, struvite uroliths in alkaline urine, silica and calcium oxalates in acidic to neutral urine and brushite, urate, xanthine and cystine in acidic urine (Langston *et al.,* 2008; Tion *et al.,* 2015).

Biochemical profile may be normal. Azotemia may be present in cases of lower or upper urinary tract obstruction. Calculi of both lower and upper urinary tract may cause secondary urinary tract infection; and high white blood cell count may be seen in some cases of pyelonephritis (Langston *et al.*, 2008).

Other important diagnostic tests include urine sediment examination and urine culture (Tion *et al.,* 2015). Urolithiasis can be associated with urinary tract infection and urine sediment examination may show pyuria or bacteriuria. Due to this fact, urine culture should be done for all cases of urolithiasis (Langston *et al.,* 2008).

Radiography or ultrasound are able to identify most uroliths including struvite calculi, which are radiopaque (Norsworthy, 2011). Diagnosis of urolithiasis in cats was achieved by urine analysis, ultrasonography and direct and indirect radiography (Kamiloglu and Kilicoglu, 2017). However, at first presentation, not all cat patients with symptoms of urinary disease require imaging. It is indicated in cases of persistent and frequently recurring signs and if the particular breed of cat is predisposed to urolithiasis (Langston *et al.,* 2008). Most radiopacity in the urinary bladder are due to calculi, or rarely mucosal wall mineralization or mineralized neoplasia (Langston *et al.,* 2008; Tion *et al.,* 2015). Calcium oxalates and struvites are usually radiopaque, cysteine, urate and calcium phosphate uroliths are variably radiopaque. Kidney mineral opacity may be due to renal calculi, calcified neoplasia, nephrocalcinosis, or mineralized cysts (Langston *et al.,* 2008; Tion *et al.,* 2015). Majority of mineral radiopacities in area of the ureter are calculi (Tion *et al.,* 2015). Ultrasonography or double-contrast cystography are better for detection of ≤3mm calculi than plain radiography (Tion *et al.,* 2015). In ten cats with uroliths, direct radiography could not determine the presence of calculi in four cats but contrast radiography and ultrasonographic examination was able to diagnose their presence (Kamiloglu and Kilicoglu, 2017).

Pneumocystography also called double-contrast cystography is superior compared to plain radiography in detecting uroliths (Langston *et al.,* 2008; Tion *et al.,* 2015). Intravenous urogram helps in the diagnosis of upper urinary tract uroliths (Langston *et al.,* 2008; Tion *et al.,* 2015). A sudden end of contrast medium within the ureters and dilatation of the renal pelvis predicts obstructive uropathy. Antegrade pyelography provides a more superior image of the renal collecting system and ureters than excretory urography (Langston *et al.,* 2008).

Radiopaque and non-radiopaque uroliths are both identifiable with ultrasonography (Langston *et al.,* 2008; Tion *et al.,* 2015). Uroliths create hyperechoic lesions in ultrasonography (Langston *et al.,* 2008; Kamiloglu and Kilicoglu, 2017). Combining survey radiography and ultrasonography improves the detection of ureteral calculi (Tion *et al.,* 2015). Computed tomography (CT) can easily detect uroliths. It has been shown in humans that non-contrast CT can be used to project the composition of calculi based on differences in radiodensity (Langston *et al.,* 2008; Tion *et al.,* 2015).

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A study in dogs showed 75% to 88% accuracy for pure calculi but mixed calculi could not be assessed precisely (Langston *et al.,* 2008). Chemical analysis of calculi is necessary for a definitive diagnosis to be made of the actual composition of the calculi (Langston *et al.,* 2008).

2.1.3 Treatment and prevention of urolithiasis

Treatment of urolithiasis in cats as well as dogs for the past century has been done majorly by the surgeon. However, there are advanced endoscopic and lithotripsy technologies that have been developed for management of urolithiasis (Lulich *et al.,* 2016). Treatment of this condition includes dissolution therapy and cystotomy to remove the uroliths (Palma *et al.,* 2009; Tion *et al.,* 2015). Dissolution therapy is effective in managing sterile uroliths. It has advantages of avoiding surgery, general anesthesia and perioperative complications. However, it has disadvantages of treatment failure, relying on the patient and owner compliance and high cost when monitoring the effectiveness through radiographic evaluation. Special diets are used to achieve dissolution of certain uroliths. These diets aim at reducing dietary magnesium and urine pH to ≤6.3. However, this method is ineffective without antibiotic therapy if infection is present (Palma *et al.,* 2009). Therapy failure has been reported for calculi of mixed-composition, due to owner non-compliance, and the patient not taking the special diet. (Tion *et al.,* 2015). Dissolution therapy is not ideal for male cats due to the likelihood of urethral obstruction (Palma *et al.,* 2009).

During treatment of urate uroliths, their dissolution is best achieved through combination of urine alkalization, dietary modification and controlling of secondary infection (McCue *et al*, 2009). Physical removal by surgical or non-surgical methods

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is the effective treatment for calcium oxalate uroliths. Extracorporeal shock wave lithotripsy is a procedure that can be used to fragment calcium oxalate uroliths (Gisselman *et al.,* 2009).

Prevention of urolithiasis include increased water intake, which enhances diuresis, hence reducing time for aggregation and crystallization. Other preventative measures include using urine acidifying diets in cases of non-infection struvite uroliths and non-acidifying diets with reduced sodium and protein to prevent occurrence of calcium oxalate uroliths (Norsworthy, 2011). Therapy using diets may help to reduce calculi recurrence. Consumption of low-magnesium diets with urine pH of 6.0 to 6.3 reduces the chances of recurrence of naturally occurring sterile struvites urocystoliths. Control of urinary tract infections can also help to prevent urolithiasis in cats. For all prevention recommendations, periodic monitoring by doing follow-up urinalysis, serum biochemical profiles and radiography may be useful (Tion *et al.,* 2015).

Recurrence of urolithiasis may occur in some cases despite a final diagnosis being made and treatment administered accordingly. Out of the ten cats with urolithiasis, one cat died and one case suffered recurrence. Diet and medical treatment should be applied with or without surgery to hinder recurrence of urolithiasis in cats (Kamiloglu and Kilicoglu, 2017).

2.2 Feline urologic syndrome (FUS)

Feline urologic syndrome (FUS) also known as feline lower urinary tract disease (FLUTD) (Pusoonthornthum *et al.*, 2012) is an important clinical condition in domestic cats covering many disorders that include bacterial infections, idiopathic cystitis, urolithiasis, tumours and urethral obstruction caused by calculi and mucus

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plugs (Lew-Kojrys *et al.,* 2016). According to Eggertsdottir et al. (2007), FUS is considered to be the most commonly diagnosed condition in feline patients. This syndrome accounted for a mean of 8% of the proportional morbidity rate of cats presented in Canada and the United States of America (Segev *et al*., 2011). It affects the bladder and urethra and is often associated with feline uroliths and urethral plugs (George and Grauer, 2016). The disease commonly originates from bacteria such as *Escherichia coli, Enterococcus* species, *Staphylococcus felis* and *Corynebacterium urealyticum* (George and Grauer, 2016). This condition is characterized by inflammation in presence or absence of lower urinary tract (LUT) obstruction (Lew-Kojrys *et al*., 2016). In an earlier study of 134 cats presented with lower urinary tract disease, 37% had obstructive syndrome, while 63% had non-obstructive syndrome (Eggertsdottir *et al.,* 2007).

Clinical signs of feline urologic syndrome include: anorexia, fever, stranguria, periuria, dysuria, pollakiuria, haematuria and in severe cases anuria (Lew-Kojrys *et al*., 2016). The last stage of feline urologic syndrome is urethral obstruction commonly seen in male cats (Roger *et al.*, 2005).

2.2.1 Diagnosis, predisposing factors and prognosis of feline urologic syndrome

Lower urinary tract infections are diagnosed basing on the clinical symptoms alone (Lew-Kojrys *et al*., 2016). Different causes of LUTD have similar clinical signs and this makes it necessary for laboratory tests and diagnostic imaging to be done in each case in order to establish the diagnosis. Urinalysis is particularly important and should be done prior to therapy (Gerber, 2018). Predisposing factors associated with feline urologic syndrome include obesity, neutering, inactivity, in-door housing, and use of

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litter trays (Jones *et al.,* 1997). Dry food tend to alkalize the urine therefore leading to struvite uroliths formation. FLUTD occur more often in indoor cats and multicat households; due to environmental stress that is highly associated with the onset of FLUTD clinical signs (Gama *et al.,* 2009). From the previous studies, the disease is commonest in male cats as compared to female cats (Gama *et al.,* 2009; Pusoonthornthum *et al.,* 2012; Dorsch *et al.,* 2014). Male cats are more likely to have urinary disorders than female cats (Mateescu *et al.,* 2012; Yamazaki *et al.,* 2016).

Diet and feeding patterns can have an impact on the aetiology, therapy or prevention of the causes of feline urologic syndrome because it influences urine volume, solute concentration and pH (Markwell *et al.,* 1998). Cats with conditions such as chronic kidney disease, diabetes mellitus and hyperthyroidism are likely to develop urinary tract infections (Mayer-Roenne *et al.,* 2007). Further, Cleroux et al. (2017) reported that there was an association between urolithiasis and chronic kidney disease. The occurrence of urinary tract infections is directly proportional to the age of the cat (Lew-Kojrys *et al*., 2016).

In one study on lower urinary tract disease (LUTD) in cats, urolithiasis occurred in 22% of the cats, urethral plugs in 10% and urinary tract infection in 8% of the cats. A specific cause of the disease was not found in 57% of the cats and were classified to be suffering from idiopathic LUTD. Pain was less associated with cats suffering from urolithiasis, while haematuria was common in cats suffering from urinary tract infection (UTI) (Gerber *et al.,* 2005).

Treatment of FUS is based on the specific cause and condition. Prognosis for non-obstructive form of the disease is unknown. However, for obstructive FLUTD, the prognosis is guarded as recurrent signs of LUTD including obstruction are

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common in cats with urethral obstruction. About half of the cats had recurrent signs of LUTD, one third had recurrent obstruction and one fifth was euthanized because of poor prognosis (Gerber, 2008).

2.3 Feline urethral obstruction

Urethral obstruction is a urologic crisis in cats (Hostutler *et al.,* 2005; Francis *et al.,* 2010; Hall *et al.,* 2015), with an estimated incidence between 1.5% and 9% (George and Grauer, 2016). Due to their long and narrow urethra, males are more predisposed to this condition compared to female cats. In addition, blockages occur commonly in the distal penile urethra behind the os penis (Bernard, 1984). Cats that develop urethral obstruction are likely to be overweight, have been fed solely on dry food and have been living in-doors. It is common in young cats with a mean age of 51.7 ± 37.7 months (George and Grauer, 2016).

The cause of feline urethral obstruction in approximately 60% of the cases was urethral plugs (Hostutler *et al.,* 2005; Segev *et al.,* 2011). Urethral plugs are semi-solid and composed of matrix and crystals, which are mainly struvite (Adams, 2013). They are different from the least commonly diagnosed uroliths (Wightman *et al.,* 2016). Uroliths and idiopathic causes accounted for 10% and 30% respectively of the causes of urethral obstruction in cats (Segev *et al.,* 2011). Other causes include stricture, extraluminal masses or neoplasia, prostatic gland lesions and muscle spasms (Hostutler *et al.,* 2005). Feline idiopathic cystitis is among the common causes of urethral obstruction (Hall *et al.,* 2015).

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2.3.1 Clinical signs

Clinical findings include turgid, overdistended urinary bladder that cannot be easily emptied, stranguria, dysuria, haematuria (George and Grauer, 2016); and various degrees of systemic signs, which correlate to the severity of the obstruction (Segev *et al.*, 2011). The signs depend on the duration and whether the obstruction is partial or complete (George and Grauer, 2016).

2.3.2 Diagnosis, treatments and outcomes

Diagnosis is made based on the history, physical examination (Cooper, 2015), urinalysis and abdominal radiography (George and Grauer, 2016). Laboratory evaluation through complete serum biochemistry, blood count, urine culture and urinalysis should be done in all obstructed cats (Hostutler *et al.*, 2005).

Treatment of this condition entails medical management, which consists of reversing electrolyte imbalances, reducing visceral pain, maintaining adequate tissue perfusion, and alleviating urethral obstruction (Drobatz, 2009; Cooper *et al.*, 2010; Hall *et al.*, 2015). Cats that are obstructed may have fatal hyperkalaemia, dehydration, hypocalcaemia or acidosis that need to be corrected. Acidosis and hyperkalaemia resolve well with volume expansion using a balanced electrolyte intravenous solution such as plasmalyte or lactated Ringer's solution. The mentioned solutions are also often adequate for rehydration and stabilizing the patient (Hostutler *et al.*, 2005). After stabilizing the patient and an indwelling catheter is still in place, butorphanol (0.2–0.4 mg/kg every 6–8 hours) and acepromazine (0.02–0.05 mg/kg every 4–6 hours) or buprenorphine (5–20 mg/kg) can be administered to relax the urethral sphincter and for analgesia. Patients with urinary bladder atony due to prolonged

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severe distension of the bladder should be given parasympathomimetic drugs, such as bethanecol once urethral patency has been established (Hostutler *et al.,* 2005).

Cystocentesis should be performed immediately in cases of obstruction and prior to anaesthesia for urethral catheterization to aid in stabilizing the patient (George and Grauer, 2016). The benefits of doing this includes immediate relief of discomfort and reduction of harmful renal backpressure. Additionally, cystocentesis lowers intraluminal urinary bladder pressure, thus facilitating retropulsion of urethral plugs or urethroliths and this eases catheterization. However, this procedure is discouraged by some authors because of a potential risk of urinary bladder rupture and consequent uro-peritoneum (Hall *et al.,* 2015). Complications of urethral catheterization includes iatrogenic injury to the urinary bladder and urethra. An indwelling catheter is paramount to keep the bladder empty, facilitate quick return of urinary bladder tone and reduce trauma from repeated manual expressions (Bernard, 1984). An indwelling urinary catheter is difficult to use in cats but may be indicated in those with urethral obstruction in moribund state, have severe azotaemia or other metabolic derangements, as well as those with severely distended urinary bladder (Hostutler *et al.,* 2005). A combination of pharmaco-therapies such as administration of acepromazine, buprenorphine and medetomidine, decompression cystocentesis, and an environment with little stress (quiet and dark), may allow relief of urethral obstruction (Cooper, 2015). Perineal urethrostomy may be indicated in cases of failure of medical treatment or recurrent severe bouts of urethral obstruction (Hostutler *et al.,* 2005).

It was reported that in cats with urethral obstruction, 43% with urethral plugs, 36% with idiopathic urethral obstruction and 30% with urolithiasis had recurrence. Of the

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cats with recurrent urethral obstruction, 21% were euthanized (Gerber *et al.,* 2008). Repeated urethral obstruction in spite of dietary management and long-term medication warrants perineal urethrostomy (Bernard, 1984). There is a risk of iatrogenic urethral trauma after urethral catheterization (Hall *et al.*, 2015). The most frequent complication after urethral catheterization is urinary tract infection (Corgozinho *et al.,* 2007).

2.4 Feline idiopathic cystitis

Feline idiopathic cystitis (FIC) is defined as pain, inflammation and damage of the urinary bladder wall without an obvious external cause. It is a frequently occurring disease, with unknown aetiology (Sparkes, 2018), in spite of thorough diagnostic evaluation (Grauer, 2012). It is the commonest cause of feline lower urinary tract disease (Hostutler *et al.*, 2005; Eggertsdottir *et al.,* 2007; Grauer, 2012).

2.4.1 Aetiology and risk factors of FIC

The pathogenesis of FIC is not known but appears to be related to multiple abnormalities of the urinary bladder, adrenal glands and the nervous system (Hostutler *et al.,* 2005; Grauer, 2012). It has been reported that cats with FIC have abnormal function and size of adrenal glands. They have high catecholamine levels that get back to normal levels after enrichment of the environment (Adams, 2013). The disease occurs mostly in cats that are obese, do less exercise, use indoor litter box, live indoors, are young to middle-aged, fed on dry food and those that live in households with other animals. Genetic and/or developmental factors are the likely primary causes of this condition (Gunn-Moore, 2001). The disease is common in middle-aged cats and uncommon in those older than 10 years (Hostutler *et al.,* 2005).

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Stress has been incriminated in the pathogenesis of FIC (Adams, 2013). Stress is caused by environmental and husbandry factors such as indoor housing (Gerber, 2018).

2.4.2 Clinical presentation

Feline idiopathic cystitis has three complexes. The first complex is acute episodes of cystitis characterized by dysuria, pollakiuria, haematuria, stranguria and periuria. This complex resolves with or without treatment within 7 days, but 50% of the cases recur within 1 year (Grauer, 2012; Adams, 2013). There is no clinical sign that is specific to FIC but most owners complain of periuria. Some cases may show stranguria, pollakiuria and haematuria (Hostutler *et al.,* 2005). The second complex is multiple recurrent episodes of cystitis and the third form is urethral obstruction seen almost exclusively in male cats (Grauer, 2012; Adams, 2013). Urethral obstruction is caused by urethral plugs, which are semi-solid and composed of matrix and crystals that are mostly struvite (Adams, 2013). The disease is commonly diagnosed in young cats (Lew-Kojrys *et al.,* 2016; Sparkes, 2018) with a mean age of 5 to 6 years (Sparkes, 2018). It was the most diagnosed condition comprising 55% to 65% of the cases (Gunn-Moore, 2001; Sparkes, 2018). Predisposing factors for FIC are neuter, male cats, overweight and middle age (2 to 7 years) (Gerber, 2018).

2.4.3 Diagnosis

Diagnosis of FIC is assigned to a case if no other cause of urinary tract condition can be concluded (Gunn-Moore, 2001; Buffington, 2011). This is done by using the exclusion criteria (Hostutler *et al.,* 2005; Grauer, 2012), after routine diagnostic tests such as urine culture and sensitivity, urinalysis, ultrasonography, radiography and contrast radiography have failed to identify the aetiology of urinary tract disease

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(Hostutler *et al.,* 2005). Cats with this condition have sterile urine, which is concentrated. In addition, there is insignificant finding in double-contrast bladder radiographs and urethral studies (Gunn-Moore, 2001). Ultrasonography and radiography help to rule out anatomical abnormalities such as polyps, urolithiasis, urachal remnants and tumours. Urinalysis is an important diagnostic test, which entails sediment examination, urine culture and sensitivity to rule out bacterial infection. The best method to collect urine for this, is by cystocentesis. These diagnostic tests should be used in all cases of recurrent cystitis (Grauer, 2012). A diagnosis of FIC is made when uroendoscopy shows submucosal petechial haemorrhages (Hostutler *et al.,* 2005).

2.4.4 Treatment and management.

There is no proven and effective therapy for idiopathic cystitis. Treatment may include dietary alterations, environmental enrichment, pheromone therapy and pharmacologic intervention in nonresponsive cases (Hostutler *et al.,* 2005). In non-obstructive cases, the disease resolves in 5 to 7 days and antibiotics are unnecessary but only used if urinary infection ensues or for prophylaxis after urethral catheterization (Adams, 2013). Cats with FIC have sterile urine and therefore antibiotics are not indicated (Grauer, 2012). Acute form resolves spontaneously in 5 to 7 days. The primary objectives in treating cats with the acute form of the disease is to reduce stress and relieve pain. Numerous agents, including tranquilizers, antibiotics, glycosaminoglycans, anticholinergics, amitriptyline and anti-inflammatory drugs have been recommended in the treatment of FIC although their outcome is unproven (Grauer, 2012). Cats living in poor environmental conditions are more predisposed to FIC than cats living in good environmental conditions. Cats in multi-cat households

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have higher odds of FIC occurrence than cats that live alone (Kim *et al.,* 2017). Multimodal environmental modification (MEMO) to reduce stress has been shown to enhance management of FIC and also reduce recurrent episodes (Hostutler *et al.,* 2005; Grauer, 2012). Some aspects in multimodal environmental modification include: litter hygiene, access to several sources of fresh food and water, increased contact between owners and the cat as well as increased access to private spaces especially for cats living in multi-cat households. Environmental enrichment stimulates activities that are natural and comfortable for the cat (Hostutler *et al.,* 2005). Diet change from dry to canned food helps to increase water intake and decrease urine concentration (Grauer, 2012).

2.5 Idiopathic feline lower urinary tract disease (Idiopathic FLUTD)

Idiopathic feline lower urinary tract disease (Idiopathic FLUTD) is FLUTD with no incriminated specific cause (Gerber *et al.*, 2005). It was found to be the highest cause of LUTD in European cats accounting for 57% of cats with LUTD. It affected cats aged between 1 to 15 years with mean weight of 5.5kg. The breed most affected was domestic shorthair (Gerber *et al.,* 2005).

The cause of the disease is unknown but infectious agents such as caliciviruses are incriminated. Features of the disease are a raised activity of the sympathetic nervous system, increased permeability of the urinary bladder epithelium and neurogenic inflammation (Gerber, 2008). It has been suggested that the disease is similar to human interstitial cystitis (Gerber, 2008; Adams, 2013). Predisposing factors associated with idiopathic FLUTD are overweight, male gender, multi-cat households especially when there is conflict, pedigree cat, indoor cats and feeding on dry diet. This suggests that stress could be the trigger for the disease. This has been supported

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by the finding that urinary bladder permeability is highest under stress in cats with idiopathic FLUTD (Gerber, 2008). This disease is commonly diagnosed in male than female cats and seems to affect young to middle aged cats. Clinical picture of the disease is not different from other causes of FUS, and are haematuria, pain, pollakiuria, periuria, stranguria and anuria. Of the cats with idiopathic FLUTD, 55% had urethral obstruction (Gerber, 2008).

Diagnosis of this condition is by elimination of other possible causes of FLUTD (Gerber, 2008). Cats with urethral obstruction are emergency patients with the aim of re-establishing urine flow. If urethral patency cannot be achieved, decompressive cystocentesis can be done to evacuate urine. Many cats recover spontaneously from idiopathic FLUTD. There is no specific therapy for the disease and the efficacy of the treatments suggested is unknown. Pain is a common clinical sign in this disease and should to be managed. Antibiotic therapy is indicated if urinary catheterization is done. Other medications include glycosaminoglycan and amitriptyline. Reducing stress and changing diet from dry to canned food or adding water in the diet is beneficial in cats with idiopathic FLUTD (Gerber, 2008).

2.6. Bacterial infections of the urinary tract

Bacterial infections of the urinary tract are relatively uncommon in cats (Bailiff *et al.,* 2006; Litster *et al.,* 2011) due to a wide range of immunologic and physiologic barriers to infection (Litster *et al.,* 2011). The prevalence of feline urinary tract bacterial infections is reported to be less than 3% although other reports give prevalence of 15-43% in cats whose defense mechanisms are compromised by some treatment procedures such as perineal urethrostomy and urinary catheterization. Urine cultures positive for bacteria were found in 22% of cats with clinical symptoms of

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LUTD and no obvious predisposing factors (Litster *et al.,* 2011).

2.6.1 Clinical signs

Clinical history of urinary tract disease caused by bacterial infections includes dysuria, haematuria, pollakiuria and periuria and occasionally asymptomatic. Positive urine culture is commonly obtained from older female cats and gram-positive cocci (i.e. *Streptococcus/Enterococcus*) and *Escherichia coli* are the common bacteria appearing in the culture (Litster *et al.,* 2011). *Escherichia coli, Streptococcus* species and *Enterococcus* species were the commonest three bacteria category isolated in cats with significant bacteriuria (Teichmann-Knorrn *et al.,* 2018).

2.6.2 Risk factors

Identified risk factors that increase the feline urinary tract infections (UTIs) rate are urinary catheterization, female gender, perineal urethrostomy and age (> 10 years). Asymptomatic cases are more likely to be reported in older females. Generally older female cats are predisposed to positive urine cultures (White *et al.,* 2013). The infection usually occur secondary to another disease or drug that alter the anatomy of the urinary tract, compromises the innate urinary tract defense mechanisms, decreases urine osmolality or suppresses the immune system (Bailiff *et al.,* 2006). Infections of the urinary tract are relatively common in cats with concurrent conditions such as chronic kidney disease, diabetes mellitus and hyperthyroidism (Mayer-Roenne *et al.,* 2007; Litster *et al.,* 2011; White *et al.,* 2013), and approximately 10-15% of cats that were presented with these conditions had lower urinary tract bacterial infections (Litster *et al.,* 2011). Bacterial infections of the urinary tract is a concurrent problem in diabetic cats (Bailiff *et al.,* 2006).

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2.6.3 Diagnosis

Complete urinalysis, including assessment of urine specific gravity, urine glucose level and sediment examination for crystalluria can be used for evaluation of suspected UTI and in investigating underlying causes of infection (Weese *et al.,* 2011). Urine sediment is examined microscopically and is a good method of identifying UTIs. Increased leucocytes and erythrocytes as well as observed bacteriuria after a gram stain may suggest the need for bacterial culture of the urine. Urinalysis test of UTI positive cases mostly shows pyuria and haematuria (Litster *et al.,* 2011).

Urine culture and sensitivity is the basic test in the diagnosis of UTI and to ascertain the most appropriate antibiotic therapy to be employed (Bartges, 2004; Litster *et al.,* 2011). The test helps to ascertain presence of an infection, presence of resistant bacteria and differentiate reinfection from relapse should a UTI recur (Weese *et al.,* 2011).Urine culture is encouraged for cats suspected to be suffering from diabetes mellitus, hyperthyroidism and chronic kidney disease (Mayer-Roenne *et al.,* 2007). Low specific gravity of urine has been reported in Gram-negative UTIs (Litster *et al.,* 2011).

2.6.4 Treatment and prognosis

Treatment of feline urinary tract bacterial infection is successfully achieved using oral amoxicillin for gram-positive infection and amoxicillin/clavulanic acid for gram-negative infections administered for at least 14 days. Urine culture and sensitivity is required to ascertain the most appropriate antibiotic to be used especially in recurrent or complicated cases (Litster *et al.,* 2011). In an in vitro experiment, pradofloxacin was shown to have activity against a range of feline urinary tract bacteria, including S*taphylococcus* spp and *Escherichia coli.* Cefovecin was found to

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be active against all major anaerobic and aerobic pathogens associated with urinary tract among other body systems in cats and dogs (Litster *et al.,* 2011).

Persistent recurring infections especially with uropathogenic *Escherichia coli* has been reported in older cats with chronic renal failure, cats that have undergone perineal urethrostomy or those with concurrent medical conditions causing alterations in urine chemistry. In these cases, antibiotics are ineffective and non-antibiotic prevention strategy may be required (Litster *et al.,* 2011).

2.7 Chronic kidney disease (CKD)

Chronic kidney disease (CKD) affects about 30% of cats over 12 years of age (Cannon, 2016). Grauer (2015) states that the disease affects an estimated 1 to 3% of all cats. A study in UK found CKD to be the second most common cause of mortalities in cats that are aged 5 years or older in 12.1 % of cats (Cannon, 2016). It is an important cause of mortalities and develops over a period of months to years (Grauer, 2015). The disease prevalence increases with age and about 30-50% of cats older than 15 years of age have the disease. Male cats are mostly diagnosed at a younger age compared to female cats (Grauer, 2015). The disease was found to be common in cats that are between 1 and 15 years old (Marino *et al.,* 2014).

It is difficult to determine the cause of the disease (Grauer, 2015). The disease is secondary to a variety of disorders that cause permanent damage to nephrons, resulting in reduced glomerular filtration rate (GFR). In a few cases, the cause can be identified, such as renal amyloidosis, polycystic kidney disease, neoplasia and hypercalcaemic nephropathy. In majority of cases with non-identifiable causes, tubulointerstitial nephritis and fibrosis are the common histological findings (Cannon, 2016). Concerns have been raised on the association of CKD with feline morbillivirus

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and potential for vaccine induced renal auto-antibodies in cats under lifelong vaccinations annually. Moderate to severe dental disease and annual or frequent vaccinations were the only factors identified to predispose cats to the development of CKD (Cannon, 2016).

2.7.1 Diagnosis, therapeutic options and prognosis of CKD

Diagnosis of the disease is based on identifying a combination of clinical signs, which include persistently concentrated urine and persistent evidence of reduced GFR by measuring serum creatinine or serum symmetric dimethylarginine (SDMA) levels (Cannon, 2016). International Renal Interest Society (IRIS) developed a staging system of CKD based on the serum creatinine concentrations and is used as a guide for therapeutic strategy, as well as prognostication (Marino *et al.,* 2014). Depending on the progression of the disease, clinical signs include: polydipsia, polyuria, weight loss, poor appetite, dehydration, sometimes vomiting and halitosis. Physical examination reveals poor body condition, poor hair coat quality, muscle loss, dehydration, sometimes pale mucous membranes, changes in kidney size and shape on palpation (Cannon, 2016). Urinalysis is done to measure specific gravity using dip-stick analysis and urine sediment analysis is also done. Identification of metabolic consequences of kidney disease in cats with CKD is required in order to weigh the prognosis against decision for treatment options. They include serum phosphate/ hypophosphotaemia, calcium which may be normal, subnormal or elevated and potassium/hypokalaemia. Routine haematology shows anaemia in these cases (Cannon, 2016).

Therapeutic options depend on the stage of the disease and include use of antibiotics, chemotherapy, subcutaneous ureteral bypass, renal diets with or without intestinal

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phosphorus binders, calcium channel blockers; potassium supplementation, dietary alkalization, oral or parenteral fluid therapy, appetite stimulants, recombinant erythropoietin, dietary variety and feeding tube placement (Grauer, 2015).

Screening of older cats regularly, is strongly recommended for early diagnosis and for improvement of prognosis (Cannon, 2016). Survival rates of cats decreases as CKD stage increases (Grauer, 2015).

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CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study design

This retrospective study was based on past cases of urinary tract conditions in domestic cats in Veterinary Clinics in Nairobi County, Kenya from 2009 to December 2018.

3.2 Geographical study area

The study was carried out in Nairobi County, Kenya (Figure 3.1). Nairobi County is one of the 47 Counties of Kenya. It has a population of over 4 million people (KNBS, 2019) and is located 1°.2921S, 36.8219E. The County has an average temperature and a mean annual rainfall of 19.0 °C and 869 mm respectively.

Various companion animals including dogs, cats and horses are kept in the country and require veterinary health care. Small animal practice is common in this county as evidenced by the numerous small animal veterinary clinics.

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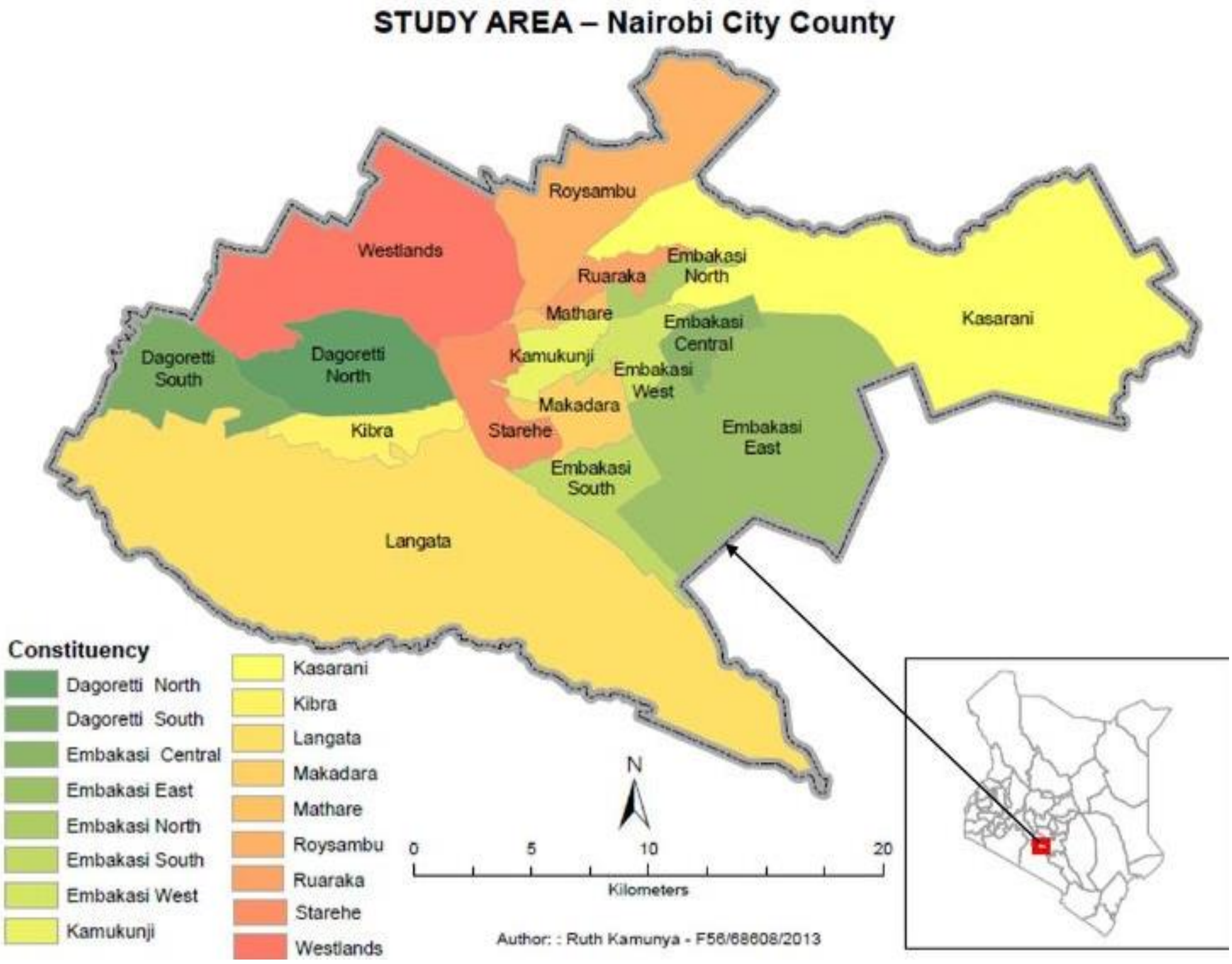

Figure 3.1: Map of Nairobi County showing the various Sub-Counties (previous Constituencies) within it. Arrow points to its location on the map of Kenya (Inset).

(https://docplayer.net/docs-images/40/14134541/images/page_5.jpg)

3.3 Selection of Veterinary Clinics

The selection of the Veterinary Clinics was purposive based willingness by the clinic owners to allow access to clinic records. The criteria for selection of the clinics was that it must have been in continuous operation for the past 10 years, be registered by the Kenya Veterinary Board (KVB), which is the regulatory professional body and have retrievable case records. The number of clinics selected was 5. The five clinics were designated as CL1, CL2, CL3, CL4 and CL5 to conceal owner identity and ensure confidentiality of the data specific to each clinic. The identity of the clinics was retained by the investigator only for anonymity to conform to owners' request.

3.4 Data collection

In each of the veterinary clinics, records of all the cases of cats presented for treatment from January 2009 to December 2018 were retrieved. Cases presented for routine vaccinations and deworming were omitted from the data collection case list. Information from retrieved cases was recorded in the data collection sheets (Appendix 1). These were further scrutinized and all the records of cases indicated to have suffered from urinary tract conditions by the characteristics of the symptoms as well as by recorded diagnoses, were isolated from the main pool. Each of these isolated records for individual cases were analyzed to identify the categories of specific urinary tract conditions that each of the cat suffered. For each case with urinary system symptoms, specific data was retrieved, which included breed, sex, age, weight, neuter history, presenting clinical symptoms, diagnostic methods employed, confirmed diagnosis, methods of treatment whether medical or surgical including specific drugs used, location of the uroliths and other problems in the urinary system, and the outcome of each case. Data for urinary conditions was recorded in data collection sheets (Appendix 2).

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3.5 Data management and analysis

Data was entered into Microsoft Office Excel 2013 (Microsoft Inc., Sacramento, California, USA). It was verified and validated as correct entries according to the data collection sheets. It was imported into Stata 15 (StataCorp LLC, College station, Texas, USA) for analysis. Descriptive statistics were analyzed. Frequencies of occurrences of each of the conditions were determined. Proportions were determined for categorical variables i.e. sex, breed and neuter history. The range, means, standard deviations and medians were determined for continuous variables i.e. weight and age.

Univariable analysis using simple logistic regression was performed to determine unconditional associations with the occurrence of urolithiasis. The predictors that were explored included sex, age, breed, weight and neuter history. Variables with a p ≤0.25 were selected for multivariable analysis. This was based on the Wald test from logistic regression and use of p value cut-off point of 0.25. Other p value levels such as 0.05 can be less sensitive in identifying significant variables (Bursac *et al.*, 2008).

Multivariable logistic regression was performed to test the variables that appeared significant from the univariable analysis. This was to determine actual factors that are most likely to be associated with the occurrence of urolithiasis and eliminate those that are most unlikely; and to control the possible confounders among model variables. The final models were built using backward and stepwise elimination of the most unlikely variables, leaving only variables which had p- ≤0.05. To investigate the sensitivity of the multivariate model, a goodness-of-fit test was done and an area under the receiver operating characteristic curve (ROC) was drawn.

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The prevalence of urolithiasis and each urinary tract condition was calculated from the total number of cases in the 5 clinics as well as for each individual clinic as follows:

i. Overall Prevalence of urolithiasis = $\frac{\textit{Total No. of cases with urolithiasis}}{\textit{Total No. of cat cases presented}} \times 100$

ii. Prevalence of urolithiasis among urinary problems = $\frac{\textit{Total No. with urolithiasis}}{\textit{Total No. with urinary conditions}} \times 100$

iii. Percentage of urolithiasis for each clinic = $\frac{\textit{No. with urolithiasis in the clinic}}{\textit{Total No. of cases presented}} \times 100$

Percentage of various animal factors under study was also calculated. This included various clinical signs of urolithiasis, various diagnostic approaches and the various outcomes.

iv. Percentage of clinical signs = $\frac{\textit{Total No. of cases with the clinical sign}}{\textit{Total No. with urolithiasis}} \times 100$

v. Percentage of various diagnostic approaches = $\frac{\textit{Total No. of the diagnostic approach}}{\textit{Total No. with urolithiasis}} \times 100$

vi. Percentage of outcomes = $\frac{\textit{Total number of the outcome}}{\textit{Total No. with urolithiasis}} \times 100$

Key

*No - Number

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CHAPTER FOUR

4.0 RESULTS

4.1 Descriptive statistics of urinary conditions and urolithiasis

A total of 104 domestic cats were recorded as having had urinary tract conditions (and among these, 28 had urolithiasis) out of an overall 4,404 cases presented in the 10-year period included in the study; thus making the prevalence of urinary tract conditions and urolithiasis in Nairobi County to be 2.4% (n=104) and 0.6% (n=28) respectively (Table 4.1). Prevalence of urolithiasis among urinary tract conditions was 26.9% (28/104). Clinic 2 had the highest recorded number of cats with urinary tract conditions (40.4%, 42/104) and the lowest was clinic 5 (6.7%, 7/104). The frequency of cases for the other clinics are presented in Table 4.1. Cases with urinary tract conditions with records for both male and female cat were 96. Male cats were 64.6% (62/96) and female cats were 35.4% (34/96). Neuter history was included in 81 case records of urinary tract conditions. Sexually intact cats were 61.7% (50/81) while neutered cats were 38.3% (31/81). Male cats were the most diagnosed with urolithiasis 76.9% (20/26) while female cats were 23.1% (6/26). Those neutered were 60.9% (14/23) and those sexually intact were 39.1% (9/23).

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The various breeds with urinary tract conditions included domestic shorthair, domestic longhair, Persian, Siamese, Sacred Birman, Cross breeds, British shorthair and Bengal. Domestic shorthair cat had the highest frequency at 77.3% (68/88), while Sacred Birman and British shorthair breeds had the lowest frequency each at 1.1% (1/88). The rest of the breeds are presented in Table 4.2. The breed mostly affected with urolithiasis was domestic shorthair at 84.0% (21/25), followed by Persian 8.0% (2/25), domestic longhair and Siamese both at 4.0% (1/25).

The mean age and weight of cats that were presented with urinary tract conditions was 5.7 years and 4.3 kg respectively. The mean age and weight of cats diagnosed with urolithiasis was 6.19 years and 4.97 kg respectively; with 78.6% (n=22) of the cats with urolithiasis weighing >4.50 kg.

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Table 4.1. Overall number of cat cases and those with urinary tract conditions presented in the five designated veterinary clinics in Nairobi County, Kenya from January 2009 to December 2018

Clinics	**Overall number of cat cases**	**Prevalence (%) of urinary tract conditions per clinic (n=*number per clinic*)**	**Number with urinary tract conditions**	**Prevalence (%) of urinary tract conditions (n=104)**	**Number with urolithiasis per clinic**	**Prevalence (%) of urolithiasis (n=28)**
CL 2	1534	2.7	42	40.4	14	50.0
CL 1	1088	2.3	25	24.0	5	17.9
CL 3	1224	1.3	16	15.4	4	14.3
CL 4	153	9.2	14	13.5	3	10.7
CL 5	405	1.7	7	6.7	2	7.0
Total	4404	2.4%	104	100	28	100

Table 4.2. Prevalence of urinary tract conditions in various breeds of cats presented to the five designated veterinary clinics in Nairobi County, Kenya from January 2009 to December 2018

Breed	**Number of cases (n=88)**	**Prevalence of breeds of cats (%)**
Domestic shorthair	68	77.3
Persian	7	8.0
Siamese	3	3.4
Cross	3	3.4
Bengal	3	3.4
Domestic longhair	2	2.3
Sacred Birman	1	1.1
British shorthair	1	1.1
Total	88	100

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4.2 Clinical history, symptoms and diagnosis of urinary tract conditions in domestic cats

The medical history found in the clinical records was narrated by the cat owners and was available in 95.2% (99/104) of the cases. It was related to the character and behaviour of urination and colour of urine. According the owners, 40.4% (40/99) of the cats with recorded history were presented with haematuria, 23.2% (23/99) with dysuria, 16.2% (16/99) and stranguria and urinary incontinence 16.2 % (16/99), 15.2% (15/99) respectively while 24.2% (24/99) had non-specific clinical history (Table 4.3). A total of 29.3% (29/99) of the cases had multiple clinical manifestations. History was available in 96.4% (27/28) cases of urolithiasis, among which dysuria was recorded in 37.0% (10/27) of the cases, haematuria 29.6% (8/27) and stranguria 22.2% (6/27) (Table 4.4).

There were a number of diagnostic methods employed in the diagnosis of various urinary tract conditions in this study, which included physical examination, urinalysis, imaging (ultrasonography and radiography) and cystotomy. From the 104 cases of urinary tract conditions, diagnostic methods used were physical examination in 75.0% (78/104) of the cases, urinalysis in 12.5% (13/104), imaging (including radiography and ultrasound) in 38.5% (40/104) and cystotomy in 11.5% (12/104) of the cases. Clinic 2 (CL2) employed all of the diagnostic methods in most cases, but CL5 relied only on physical examination (Table 4.5). Clinical examination findings in the case records were available only in 75.0% (n=78) of the cats with urinary tract conditions. The rest of the cases had no recorded description of clinical symptoms. In 7.7% (6/78) of the cases, there were more than one clinical examination findings. The clinical symptoms with highest frequencies were: distended urinary bladder at 35.9% (28/78)

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and haematuria at 21.8% (17/78). Other clinical symptoms but with much lower frequencies included: painful abdomen (6.4%, 5/78), uraemia (1.3%, 1/78) and enlarged kidneys at (1.3%, 1/78). A total of 14.0% (n=11) of the cats had symptoms that are non-specific to urinary tract conditions (Table 4.6). Medical records of clinical examination findings were available in 67.9% (19/28) of the cats with urolithiasis. Among these cases, the most frequent clinical symptoms were: distended urinary bladder at 68.4% (13/19) followed by painful abdomen at 21.1% (4/19) and haematuria at 10.5% (2/19) (Table 4.7).

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Table 4.3. Frequencies of various clinical histories given by the owners of cats presented with urinary tract conditions to the five designated veterinary clinics from January 2009 to December 2018.

History	***Number of cats**	***Percentage (%)(n=99)**
Haematuria	40	40.4
Non-specific signs	24	24.2
Dysuria	23	23.2
Stranguria	16	16.2
Urinary incontinence	15	15.2

Some (29.3% (29/99) of the cases had more than one sign recorded in the history, hence total number would exceed the actual number and the total percentage would exceed 100%.

Table 4.4. Frequencies of various clinical histories given by the owners of cats presented with urolithiasis to the five designated veterinary clinics from January 2009 to December 2018.

History	***Number of cats**	***Percentage (%) (n=27)**
Dysuria	10	37.0
Haematuria	8	29.6
Stranguria	6	22.2
Urinary incontinence	4	14.8
Non-specific finding	3	11.1
Polyuria	1	3.7

**Some 22.2% (6/27) of the cases had more than one sign recorded in the history, hence total number would exceed the actual number and the total percentage would exceed 100%.*

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Table 4.5. Diagnostic methods used in cats with symptoms of urinary tract conditions from the five designated veterinary clinics in Nairobi County, Kenya from January 2009 to December 2018.

Clinic	**PE (n)**	**Freq (%) (n=78)**	**Imaging (n)**	**Freq (%) (n/40)**	**Urinalysis (n)**	**Freq (%) (n/13)**	**Cystotomy (n)**	**Freq (%) (n/12)**
CL2	37	47.4	21	52.5	8	61.5	7	58.3
CL1	21	26.9	8	20	1	7.7	4	33.3
CL3	10	12.8	7	17.5	1	7.7	1	8.3
CL4	9	11.5	4	10	3	23.1	0	0
CL5	1	1.3	0	0	0	0	0	0
Total	78	75.0 (78/104)	40	38.5 (40/104)	13	12.5% (13/104)	12	11.5% (12/104)

PE= ***Physical examination***

Table 4.6. The frequencies of commonly encountered clinical findings in cats that were presented to the five designated Veterinary Clinics with urinary tract conditions from January 2009 to December 2018.

Clinical findings	**Number of cats**	**Percentage (%) (n=78)**
Distended urinary bladder	28	35.9
Haematuria	17	21.8
Non-specific findings	11	14.1
Painful abdomen	5	6.4
Enlarged kidneys	1	1.3
Uraemia	1	1.3

**Some (7.7% (6/78) of the cases had more than one sign recorded in the history, hence total number would exceed the actual number and the total percentage would exceed 100%.*

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Table 4.7. The frequencies of commonly encountered clinical findings in cases of cats that were presented to the five designated Veterinary Clinics with urolithiasis from January 2009 to December 2018.

Clinical findings	**Number of cats**	**Percentage (%) (n=19)**
Distended urinary bladder	13	68.4
Painful abdomen	4	21.1
Haematuria	2	10.5
Total	19	100

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4.3 Findings through various diagnostic methods

Urinalysis was done in 12.5% (13/104) of the cases with urinary tract conditions. Among these 13 cases, 46.2% (n=6) had more than one finding from urinalysis test. The findings were mainly the presence of erythrocytes and leucocytes in urine and only 7.7 % (n=1) were found to have uroliths in urine (Table 4.8).

Radiography and ultrasonography were the imaging modes employed to aid in diagnosis of urinary tract problems, especially for urolithiasis. This was done only in 42.3% (n=44) of the 104 cases with urinary tract conditions in which varied radiographic and ultrasonographic findings were recorded. Among these, distended urinary bladder was found in 50.0% (22/44) of the cases through radiography and uroliths were diagnosed in 6.8% (3/44) through ultrasonography. Radiographic and ultrasonographic findings not related to the urinary tract were found in 13.6% (6/44) of the cases. The remaining 29.6% (13/44) of the cats that were subjected to imaging did not show any radiographic or ultrasonographic changes (Table 4.9). Out of the 44 cases, only 45.5% (n=22) of the cats with urolithiasis underwent ultrasonographic or radiographic examination. Among these, distended urinary bladder was found in 63.6% (14/22) and urinary calculi was diagnosed in 13.6% (3/22) of the cases (Table 4.10).

Retrograde urinary catheterization as a diagnostic method was employed in 29.8% (n=31) of the 104 cases with urinary tract conditions. Among these 31 cases, 61.3% (n=19) were successfully catheterized, while catheterization failed in 38.7% (n=12) of the cases.

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Table 4.8. The findings in the 13 cases of domestic cats that urinalysis was done for diagnosis of urinary tract conditions in the five designated veterinary clinics in Nairobi County, Kenya from January 2009 to December 2018.

Findings in urine	***Number of cases**	***Percentage (%) (n=13)**
Erythrocytes	9	69.2
Leucocytes	8	61.5
Uroliths	1	7.7

***** *Some (46.2% (6/**13**) of the cases had more than one sign recorded, hence total number would exceed the actual number and the total percentage would exceed 100%.*

Table 4.9. The findings in the cases of cats that underwent diagnostic imaging with symptoms of urinary tract conditions in the five designated veterinary clinics in Nairobi County, Kenya from January 2009 to December 2019.

Findings through imaging	**Number of cases (n=44)**	**Percentage (%)**
Distended urinary bladder	22	50.0
No abnormality	13	29.6
Uroliths	3	6.8
Nonspecific finding	6	13.6
Total	44	100

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Table 4.10. The findings in the cases of cats with urolithiasis that underwent diagnostic imaging in the five designated veterinary clinics in Nairobi County, Kenya from January 2009 to December 2019.

Findings through imaging	**Number of cases (n=22)**	**Percentage (%)**
Distended urinary bladder	14	63.6
No abnormality	4	18.2
Uroliths	3	13.6
Nonspecific finding	1	4.6
Total	22	100

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4.4 Various diagnoses made for urinary tract conditions

Diagnoses of urinary tract conditions were available in the records of only 73.1% (76/104) of the cases. Among the diagnoses recorded in these 75 cases, urolithiasis had the highest frequency of 37.3% (28/75) and the lowest recorded frequency of urinary tract condition was trauma at 4.0% (3/75). There was no definitive diagnosis made in 22.7% (17/75), and these were archived as idiopathic feline urologic syndrome. The frequencies of the rest of urinary tract conditions as diagnosed are presented in Table 4.11. Urolithiasis cases as diagnosed in all the five designated veterinary clinics in Nairobi County are shown in table 4.12.

4.5 Annual cases of cats with symptoms of urinary tract conditions

The percentage of domestic cats presented to the clinics with symptoms of urinary tract conditions was highest in 2017 and 2018 at 26.9% (28/104) and 26.0% (27/104) respectively, while the lowest was in 2009 at 1.9% (2/104). From the year 2010 to 2016, the frequency of cats presented to the clinics with symptoms of urinary tract conditions ranged from 3.9% to 6.7% (Figure 4.1).

4.6 The various treatment methods used to manage urinary tract conditions

Cystotomy was the surgical intervention employed in the management of urinary tract conditions in the cases that had retrograde catheterization failure. It was done in 11.5% (n=12) of the 104 cases. Data on medications used in the treatment of various urinary tract conditions was available in 90.4% (n=94) of the cases. Among these 94 cases, the most commonly used drugs were dexamethasone and cephalosporins at 37.2% (n=35) and 21.3% (n=20) respectively. The group of drugs that had the lowest frequency of use in treatment of urinary tract conditions in domestic cats was sulphonamides at 2.1% (n=2) as shown in Table 4.13.

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Table 4.11. The frequencies of various diagnoses made in domestic cats presented with symptoms of urinary tract conditions in the five designated veterinary clinics in Nairobi County, Kenya from January 2009 to December 2018 clinical records.

Diagnoses	*Number of cases	*Percentage (%) (n=75)
Urolithiasis	28	37.3
Idiopathic Feline urologic syndrome	17	22.7
Idiopathic cystitis	17	22.7
Urinary tract infection	16	21.3
Renal failure	8	10.7
Trauma	3	4.0
Streptomycin toxicity	1	1.3
Mycoplasmosis	1	1.3

**Some (28% (21/75) of the cases had more than one tentative diagnosis made after examination, hence total number would exceed the actual number and the total percentage would exceed 100%*.

Table 4.12. The number of domestic cats presented with urolithiasis to the five designated veterinary clinics in Nairobi County, Kenya from January 2009 to December 2018

Clinic	Number of cases of urolithiasis	Percentage (%) (n=28)
CL2	14	50.0
CL1	5	17.9
CL3	4	14.3
CL4	3	10.7
CL5	2	7.1
Total	28	100

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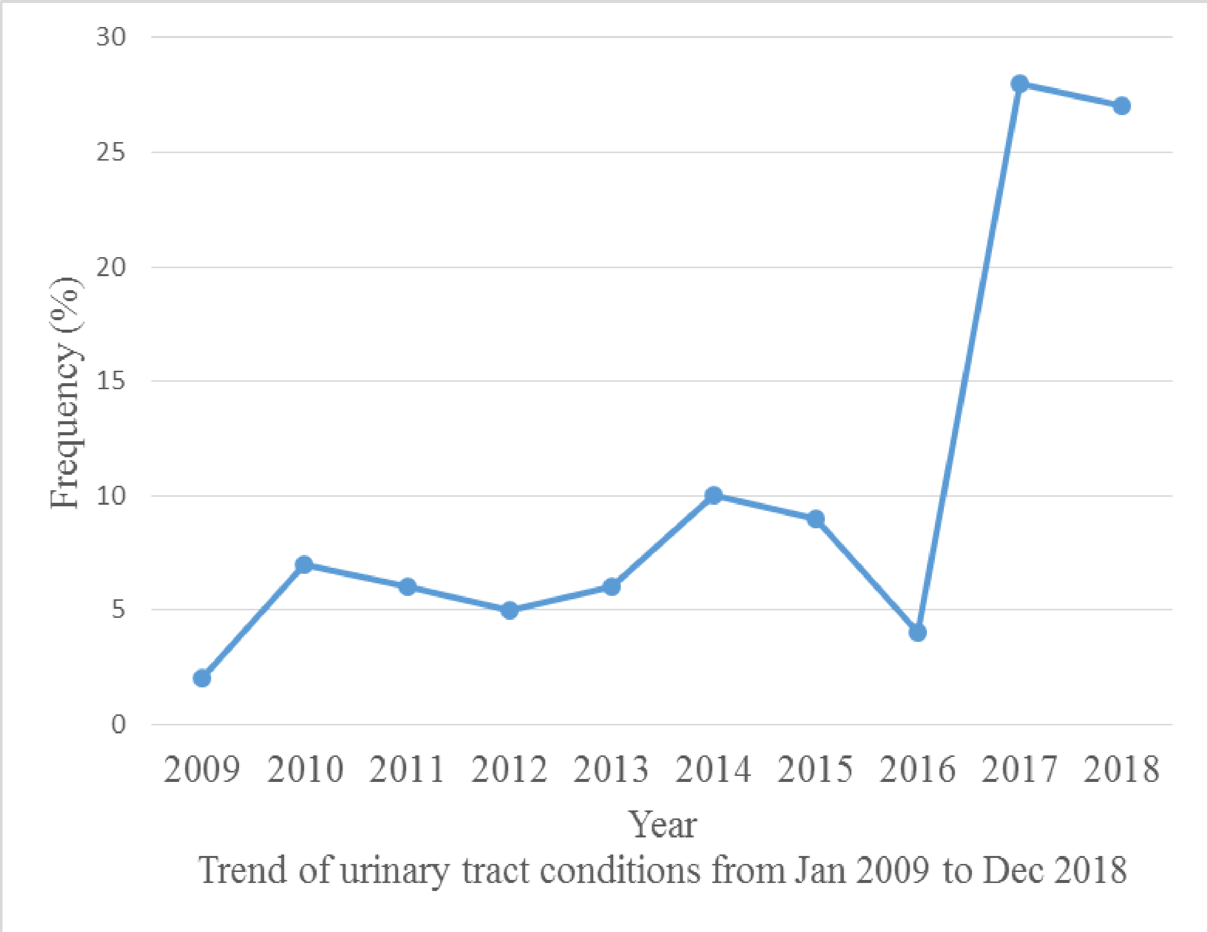

Figure 4.1: The annual trend of urinary tract conditions in domestic cats in the five designated veterinary clinics in Nairobi County, Kenya from January 2009 to December 2018.

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Table 4.13. Various drugs and solutions used in the management of urinary tract conditions in domestic cats from January 2009 to December 2018 as indicated in the clinical records of the five designated veterinary clinics in Nairobi County, Kenya.

Treatment drugs/solutions	**Number of cases**	**Percentage (%) (n=94)**
Dexamethasone	35	37.2
Cephalosporin	20	21.3
Lactated Ringers	19	20.4
Normal saline	16	17.0
Metronidazole	14	14. 9
Fluoroquinolones	13	13.8
Non-Steroidal Anti-Inflammatory	9	9.6
5% dextrose	5	5.3
Tetracycline	4	4.3
Sulphonamide	2	2.1

** Some (71.3% (67/94) of the cases had more than one medications used in the management of various urinary tract conditions, hence total number would exceed the actual number and the total percentage would exceed 100%*

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4.7 Outcomes of treatment of domestic cats that had symptoms of urinary tract conditions

The outcomes of domestic cats that were treated for symptoms or conditions of urinary tract in the five clinics were indicated in the clinical records of only 70 cats. Among these 70 cats, 55.7% (n=39) recovered after treatment, 17.1% (n=12) had recurrence, and 27.1% (n=19) died.

4.8 Association between perceived risk factors and the occurrence of urolithiasis in domestic cat

4.8.1 Univariate analysis of variables against the possibility of urolithiasis

Factors associated with urolithiasis in domestic cats were determined by univariate analysis using logistic regression. Factors that were found to be significantly associated with urolithiasis included male being male (p=0.06), increase in weight (p=0.01), a history of dysuria, stranguria (p=0.12 and p=0.07 respectively) and clinical examination manifestations of haematuria, distended urinary bladder and painful abdomen (p=0.06, p=0.007 and p=0.09 respectively) (Table 4.14). Factors that had a p≤0.25 from this analysis were eligible for multivariate analysis.

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Table 4.14. Results of univariate analysis showing various factors associated with urolithiasis in domestic cats in Nairobi County, Kenya.

Variable	Category	Proportion with urinary tract conditions (%)	Proportion with Urolithiasis (%)	P value
Breed of cats	DSH	68 (77.3)	21(84.0)	0.463
	Others	22 (21.7)	4(16.0)	
Veterinary clinics	CL1	25 (24.0)	5 (17.9)	0.844
	CL2	42 (40.4)	14 (50.0)	0.550
	CL3	16 (15.4)	4 (14.3)	0.375
	CL4	14 (13.5)	3 (10.7)	0.824
	CL5	7 (6.7)	2 (7.1)	0.926
Sex of the cat	Female	34 (35.4)	6 (23.1)	0.056*
	Male	62 (64.6)	20 (76.9)	
Weight of the cat	<=4.50	42(40.4)	6(21.4)	0.011*
	>4.50	62(59.6)	22(78.6)	
Neuter history	Intact	50(61.7)	14(60.9)	0.707
	Neutered	31(38.3)	9(39.1)	
History of dysuria	No	76 (76.8)	17 (63.0)	0.117*
	Yes	23 (23.2)	10 (37.0)	
History of urinary incontinence	No	84 (84.5)	23 (85.2)	0.629
	Yes	15 (15.5)	4 (14.8)	
History of hematuria	No	59 (56.6)	19 (70.4)	0.606
	Yes	40 (40.4)	8 (29.6)	
History of polyuria	No	93 (93.9)	26 (96.3)	0.417
	Yes	6 (6.1)	1 (3.7)	
History of stranguria	No	83 (83.8)	21 (77.8)	0.067*
	Yes	16 (16.2)	6 (22.2)	
Non-specific clinical history	No	75 (75.8)	24 (88.9)	0.031*
	Yes	24 (24.2)	3 (11.1)	
Examination finding of hematuria	No	46 (73.0)	17 (89.5)	0.055*
	Yes	17 (27.0)	2 (10.5)	
Examination finding of distended urinary bladder	No	35 (55.6)	6 (31.6)	0.007*
	Yes	28 (44.4)	13 (68.4)	
Examination finding of painful abdomen	No	58 (92.1)	15 (79.0)	0.091*
	Yes	5 (7.9)	4 (21.1)	
Normal imaging findings	No	31 (70.5)	18 (81.8)	0.218*
	Yes	13 (29.6)	4 (18.2)	
Imaging finding as distended urinary bladder	No	22 (50.0)	8 (36.4)	0.021*
	Yes	22 (50.0)	14 (63.6)	
Urinalysis -Erythrocytes in urine	No	4 (30.8)	1 (16.7)	0.322
	Yes	9 (69.2)	5 (83.3)	
Urinalysis – leucocytes	No	5 (38.5)	3 (50.0)	0.888
	Yes	8 (61.5)	3 (50.0)	
Diagnosis of FUS	No	58 (77.3)	25 (89.3)	0.073*
	Yes	17 (22.7)	3 (10.7)	
Diagnosis of urinary tract infection	No	59 (78.7)	26 (96.3)	0.020*
	Yes	16 (21.3)	1 (3.7)	

Key: *Significant at p value ≤ **0.25**

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4.9 Multivariate analysis factoring significant variables from the univariate analysis for urolithiasis

The final multivariate analysis model using logistic regression was done and the results are shown in Table 4.15. The results showed that history of dysuria (OR=0.10; CI= 0.01 to 1.17; P=0.066), distended urinary bladder (OR=20.79; CI=2.32-186.22; P=0.007) and body weight (OR=16.45; CI=1.38-196.68; P=0.027) were significantly associated with urolithiasis in domestic cats.

4.10 Receiver operator characteristic curve as a test for reliability of multivariate analysis in factor prediction for urolithiasis

Receiver Operator Characteristic (ROC) curve of the test was drawn and demonstrated a 0.8607 accuracy of the multivariate analysis. This means that the occurrence of urolithiasis can be predicted by a history of dysuria, distended urinary bladder and an increased weight of a cat (Figure 4.2).

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Table 4.15. Multivariate analysis of variables associated with urolithiasis in domestic cats in Nairobi County, Kenya.

Variable	**OR**	**95% CI**		**P value**
		LCI	**UCI**	
Weight of the cat	16.45	1.38	196.68	0.027
History of dysuria	0.10	0.01	1.17	0.066
Non-specific clinical history	0.06	0.04	0.83	0.036
Imaging finding as distended urinary bladder	20.79	2.32	186.22	0.007

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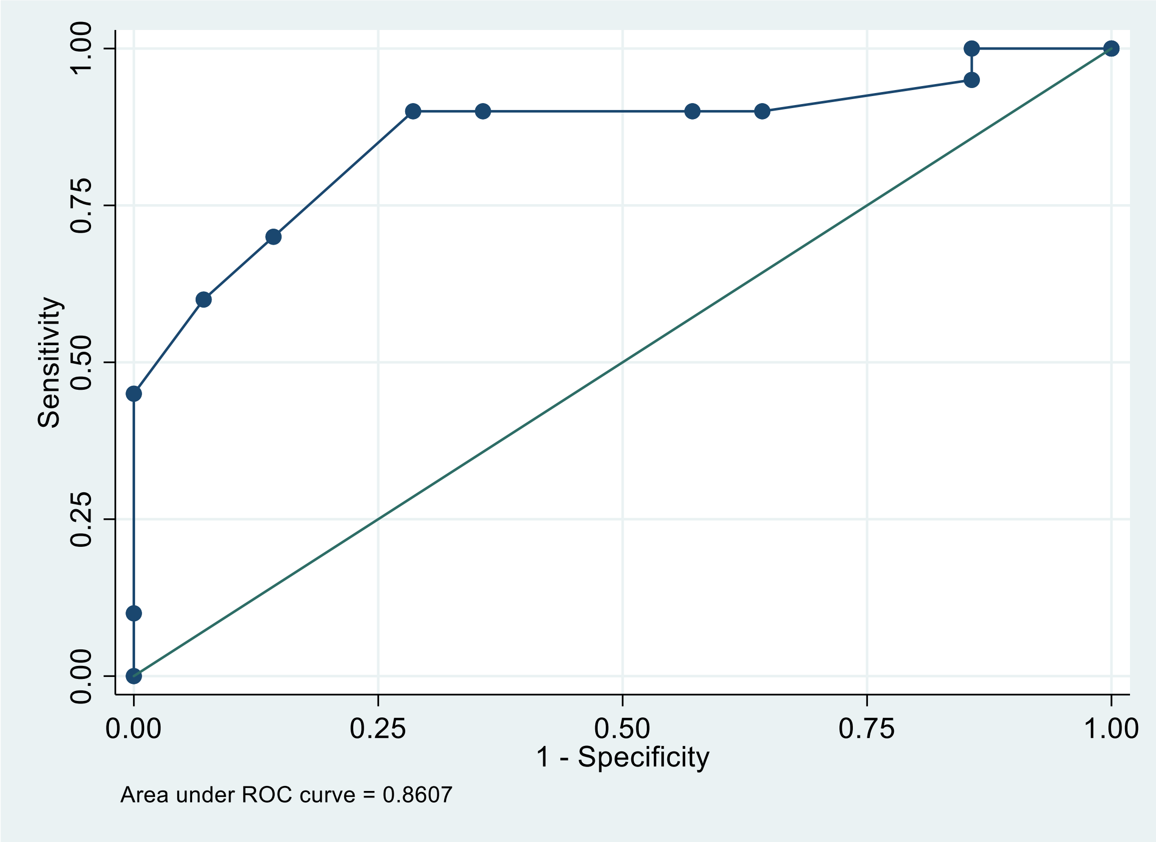

Figure 4.2: Receiver operator characteristic curve describing the predictive ability of the multivariate analysis model for urolithiasis in cats with a history of dysuria, distended urinary bladder and increased weight.

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CHAPTER FIVE

5.0 DISCUSSION

The results of this study indicate that the number of cats presented to the veterinary clinics in Nairobi County with urinary tract conditions from January 2009 to December 2018 was low. This may be attributed to the low attention and care placed on cats by their owners, hence failing to seek regular professional care for them. This is contrasted by the increased number of cases presented to the Veterinary Clinics in the years 2017 to 2018, probably due to improved understanding of the need to take care of their health.

The higher prevalence of urinary tract conditions in male (64.6%) than female (35.4%) cats recorded in this study corroborates previous findings in other parts of the world. For urinary tract disease, male and female cats constituted a prevalence of 81.8% and 17.2% respectively in Germany (Dorsch *et al.,* 2014); and 71.4% and 28.6% respectively in Thailand (Pusoonthornthum *et al.,* 2012). Other studies have stated that male cats are more likely to suffer urinary tract conditions than females (Gama *et al.,* 2009; Mateescu *et al.,* 2012; Yamazaki *et al.,* 2016). It has been suggested that sex is a risk factor for development of urinary tract diseases in cats with males having higher susceptibility for urethral obstruction and other urinary tract diseases than females (Mateescu *et al.,* 2012).

The finding that shorthair cat breed is the most commonly affected by urinary tract conditions in the current study may be due to the breed being preferred for keeping among most Nairobi County residents. However, similar results have been reported

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for urinary tract conditions with the shorthair breed in German (Dorsch *et al.,* 2014). Published reports support the finding that mixed breeds are more affected by lower urinary conditions than pure breeds (Dorsch *et al.,* 2014; Mateescu *et al.,* 2012; Lew-Kojrys *et al.,* (2016).

The mean age of 5.7 years for cats with urinary tract conditions compares closely with the mean age reported for cats with urinary tract conditions in other studies. It was 5.67 years in Poland (Lew-Kojrys *et al*., 2016), 6.74 years in Germany (Dorsch *et al.,* 2014) and 7.53 years in Romania (Mateescu *et al.,* 2012). Kaul et al. reported a mean age of 6 years of cats affected by FLUTD. It has been suggested that old cats are the most likely to suffer urinary disorders (Yamazaki *et al.,* 2016). The average reported age range of cats suffering from urolithiasis is 5.0 to 7.2 years (Gerber *et al.,* 2005; Picavet *et al.,* 2007; Hesse *et al.,* 2012; Hunprasit *et al.,* 2019). Older cats are prone to systemic diseases including diabetes mellitus, hyperthroidism and CKD. Several previous studies have shown urinary tract infections common in cats with diabetes and chronic kidney disease. Development of uroliths in cats is at times associated with urinary tract infection (Piyarungsri *et al.,* 2020).

In cats, body weight is among the predisposing factors for the occurrence of urinary tract diseases (Lew-Kojrys *et al*., 2016). It has been reported that obese cats have a high susceptibility for lower urinary tract disease (Hostutler *et al.,* 2005; Gerber, 2008; Woolf, 2012; Piyarungsri *et al.,* 2020). This is because obesity is associated with increased food intake, increased fat storage in the body and increased mineral excretion in urine (da Rosa *et al.,* 2018). This is comparable to humans where large body is incriminated as a predisposing factor for increased excretion of uric acid and oxalates in urine, which enhances the likelihood of calcium oxalate urolith formation

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(Taylor *et al.,* 2005). In addition, overweight cats may be less active, drink less water and void urine less frequently (Piyarungsri *et al.,* 2020). The three factors predispose cats to urinary tract diseases such as urolithiasis. Obesity may cause accumulation of fat around the penis and urethra which may result to urethral compression and increased urinary dysfunction (Piyarungsri *et al.,* 2020). Similar to the findings in this study, cats with urolithiasis have been reported to have an average weight of approximately ≥ 5.0 kg (Gerber *et al.,* 2005; Hesse *et al.,* 2012). This may explain the reason why urolithiasis in domestic cats was found associated with large body in the current study where most cats weighed >4.50 kg.

The current study found that most cats with various urinary tract conditions were sexually intact, which corroborates several other similar findings of higher FLUTD frequency in sexually intact than in neutered cats of both sexes (Gama *et al.,* 2009; Pusoonthornthum *et al.,* 2012). There are contrary reports to these findings, which indicate neutered cats of both sexes as being more predisposed to some urinary tract conditions (Lekcharoensuk *et al.,* 2000, Kaul *et al.,* 2020). The reason for this is that neutering is associated with weight gain, urethral growth inhibition and living sedentary lifestyle (Gama *et al*., 2009). Neutering also predisposes cats to drinking less water (Eugenio *et al.,* 2009), which could increase the probability for developing uroliths. There are other important risk factors associated with the occurrence of FLUTD such as in-door housing, use of litter trays, inactivity and diet (Jones *et al*., 1997), environmental factors (Pusoonthornthum *et al.,* 2012) and levels of physical activity (Lew-Kojrys *et al.,* 2016), all of which were not available in the case records of the current study. Other factors associated with urolithiasis in cats that were also unavailable in the case records include: diet, lifestyle, climate, infections, use of toxic and teratogenic agents, water and food source and socioeconomic status (da Rosa *et*

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al., 2018).

The clinical signs of dysuria, haematuria and stranguria were recorded in the current study as the most invariable, are reported in literature as the most consistent symptoms for various urinary tract conditions in cats (Gama *et al.,* 2009; Mateescu *et al.,* 2012). Other less frequently recorded symptoms such as periuria and pollakiuria, have also been infrequently reported previously in cats with urinary tract disease (Dorsch *et al.,* 2014; Mateescu *et al.,* 2012).

It has been observed that the clinical manifestations of urolithiasis in cats vary with the quantity, size and location of the uroliths (Grauer, 2015; da Rosa *et al.,* 2018). Thus, the clinical signs are not specific but usually show haematuria, stranguria, dysuria and periuria (da Rosa *et al.,* 2018). Nephroliths are usually asymptomatic but might be associated with macroscopic or microscopic haematuria; while ureteroliths may also be asymptomatic or associated with abdominal pain and low appetite (Grauer, 2015). Cats with cystoliths might present with signs of pollakiuria, dysuria, stranguria and haematuria (Syme, 2012; Grauer, 2015). Urethral uroliths are a common cause of complete or partial urethral blockage in male cats leading to anuria, haematuria, dysuria or stranguria (Grauer, 2015). Dorsch et al. (2014) reported haematuria as the most frequent clinical symptom in urolithiasis, followed by urethral obstruction and stranguria. Kaul *et al.,* 2020 reported haematuria and stranguria as the most frequent clinical signs of urolithiasis. In this current study, dysuria was the most frequent clinical sign in cats suffering from urolithiasis.

In the current study, the observation of urolithiasis as the major cause of urinary tract disease in cats followed by idiopathic FLUTD and idiopathic cystitis, contradicts previous reports. Previous reports indicate idiopathic cystitis is a more frequent cause

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of lower urinary tract disease in cats (Gerber *et al*. 2005; Hostutler *et al.,* 2005; Forrester, 2007; Mateescu *et al.,* 2012; Pusoonthornthum *et al.,* 2012; Dorsch *et al.,* 2014, Lew-Kojrys *et al*., 2016), then followed by urolithiasis (da Rosa *et al.,* 2018; Lew-Kojrys *et al.*, 2016). Among cats with LUTD, 10% to 20% have urinary calculi and urethral plugs (Zohaib *et al.,* 2013).

Cats with LUTD have similar clinical signs, hence the necessity to use diagnostic tools such as diagnostic imaging and laboratory tests to confirm the diagnosis (Gerber *et al.,* 2005). Diagnosis of causes of FLUTD can be achieved on the basis of clinical signs and by eliminating identifiable causes of LUTD, e.g. neoplasia and bacterial infection (Jones *et al.,* 1997), as well as urolithiasis, tumors and anatomical defects (Lew-Kojrys *et al*., 2016). Physical examination should be done keenly to include the entire urinary tract, and to supplement it with additional examinations (Mateescu *et al.*, (2012). Important diagnostic methods that may be employed to support differential diagnoses of urinary tract diseases to draw confirmatory diagnosis include: ultrasound, urine cultures, cystoscopy, contrast radiography (Lew-Kojrys *et al*., 2016) and urinary bladder biopsy (Bovens, 2011). Urinalysis is particularly important and should be done before initiating therapy (Bovens, 2011; Tion *et al.,* 2015, Gerber, 2018). Cystotomy may be used to confirm feline idiopathic cystitis (FIC) and to exclude other causes of FLUTD (Adams, 2013). Contrary to these recommendations, the case records indicate that the main mode of diagnostic method in the current study was physical examination with occasional imaging and urinalysis, which may probably imply that a number of diagnoses were not fully confirmed. Therefore, the high frequency of idiopathic FLUTD in this study could be due to failure of using proper diagnostic tools such as imaging and laboratory analysis.

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The current study found that male cats were the most affected by urolithiasis compared to females. This finding is similar to previous studies (Hesse and Sanders, 1985; Gerber *et al.,* 2005; Hesse *et al.,* 2012; Hunprasit *et al.,* 2019). Furthermore, this study found that neutered cats were also the most affected by urolithiasis than sexually intact cats. This corroborates the findings of previous researchers (Picavet *et al.,* 2007; Hesse *et al.,* 2012, Kaul *et al.,* 2020). However, urolithiasis was diagnosed more in neutered male cats but a higher proportion in intact females (Hunprasit *et al.,* 2019). In both sexes, neutering is thought to be one of the predisposing factors for the development of FUS, due to its association with suppression of urethral growth, weight gain induction and a lifestyle of inactivity (Gama *et al.,* 2009; da Rosa *et al.,* 2018). Castration in cats may be associated with obesity and sedentary lifestyle, which predisposes cats to urolithiasis (da Rosa *et al.,* 2018).

In the current study, domestic shorthair breed of cat was the most affected by urolithiasis followed by Persian. This finding is similar to most of the past studies (Gerber *et al.,* 2005; Picavet *et al.,* 2007; Houston and Moore, 2010; Hunprasit *et al.,* 2019, Kaul *et al.,* 2020). In a study on uroliths submitted at the Canadian Veterinary Urolith Center (CVUC), most submissions came from domestic shorthair, median hair, and longhair cats (Houston *et al.,* 2016). Contrary to these results, Hesse et al. (2012) found that European shorthair breed was the most commonly affected by urolithiasis (64.3%) followed by Persian (15.2%). This could be due to the breed being endemic in the countries where uroliths were submitted for analysis. The uroliths were submitted largely from Germany and partially from other European countries, which included Netherlands, Austria, Switzerland, Italy and Finland.

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Considering the cases seen in this study, different therapy methods were instituted from one case to the other, with the aim of combating and eliminating pain, treatment of infection, stimulating diuresis and obtaining hydroelectrolyte balance. Analgesia was primarily achieved using non-steroidal anti-inflammatory drugs.

Most cats with various urinary tract disorders received antibiotics as determined from this study. Because FLUTD is extremely rare due to bacterial infection, antibiotics should not be used routinely. Symptomatic treatment entails use of analgesics with opiods or NSAIDs. Lower urinary tract disease in cats is usually self-limiting and especially when the cause is FIC but the condition frequently recurs (Bovens, 2011). Clinical signs of LUTD usually resolve after 7 days and further diagnostics are indicated in cases of persistence or recurrence of the clinical signs (Hostutler *et al.,* 2005). Environmental enrichment to lessen stress especially in multicat households and indoor living are important husbandry practices in the management of LUTD in cats. Drug therapy is indicated in the management of FIC if clinical signs are not controlled after environmental enrichment combined with enhanced water turnover, dietary changes, and feline facial pheromone administration. For most severely affected cats with persistent clinical signs or those having multiple episodes of idiopathic cystitis, long-term drug therapy is indicated. A current bout of FIC is treated with systemic analgesics. For short-term pain relief, nonsteroidal anti-inflammatory drugs, such as ketoprofen and caprofen and opiods, including fentanyl, buprenorphine, and butorphanol seem to be beneficial (Hostutler *et al.,* 2005). The management of FIC aims at decreasing the severity of clinical signs and increasing the interval between bouts of LUTD (Forrester, 2007).

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Antibacterial therapy for bacterial urinary infections is based on sensitivity results. In case pyelonephritis is suspected, treatment can be done for 2 to 3 weeks or for 4 to 6 weeks (Hostutler *et al.,* 2005). Initial therapy is done using trimethoprim-sulfonamide (15 mg/kg PO q12h) or amoxicillin (11–15 mg/kg PO q8h). Amoxicillin/clavulanic acid (12.5–25 mg/kg PO q8h) can also be used. Some other antimicrobial drugs that can be used include amikacin, ampicillin, cephalexin, cephadroxil, cefovecin, chloramphenicol, ciprofloxacin, doxycycline and enrofloxacin (Weese *et al.,* 2011). Factors that determine the choice of antimicrobial agent to use include the potential adverse effects, susceptibility of the bacteria and issues regarding prudent use of certain antimicrobials (Weese *et al.,* 2011).

Definitive treatment of urolithiasis depends on the type of uroliths present (Hostutler *et al.,* 2005). It includes relief of urethral obstruction or urinary bladder decompression. This can be achieved by urethral catheterization, dislodgment through hydropropulsion, cystocentesis, or urethrotomy/urethrostomy. Fluid therapy should be started to restore hydration and electrolyte balance (Grauer, 2013). Dissolution therapy may be done for struvites and urates. Cystotomy was the surgical procedure employed in the management of urinary tract diseases including urolithiasis in this current study. Surgical intervention is indicated for large calculi or those that do not respond to dissolution therapy. For uroliths of up to 5 mm and 1 to 2 mm in diameter, voiding urohydropropulsion may be attempted (Hostutler *et al.,* 2005). Surgical intervention allows a definitive diagnosis of the type of calculi via quantitative analysis (Grauer, 2013).

From this study, uroliths recovered did not undergo mineral analysis. It is recommended that uroliths removed after cystotomy undergo quantitative analysis to determine their composition; for appropriate treatment and management of urolithiasis as well as to prevent recurrence (Bovens, 2011). This analysis is especially important in mixed calculi (Hostutler *et al.,* 2005).

Feline urinary tract disease can have an obstructive disorder or non-obstructive. Urethral obstructions may be caused by inflammatory debris from FIC, uroliths or urethral plugs. Non- obstructive causes of FLUTD include FIC, uroliths, urinary tract infections, urethral carcinoma and anatomical defects (such as urethral stricture) (Piyarungsri *et al.,* 2020). Reported recurrence rate of urethral obstruction due to FIC is 17.0% to 28.0%. Recurrence rate of some of the urinary tract conditions include; urolithiasis at 5.5% - 38.5% and FIC at 17.1% - 65.0% (Kaul *et al.,* 2020). It is important to note that different causes of separate episodes of FLUTD can be diagnosed. Therefore, a thorough examination of cats with recurrent episodes of FLUTD is emphasized (Lund and Eggertsdottir, 2019; Kaul *et al.,* 2020). The recurrence rate of FLUTD was found to be 58.1% within an observation period of 38 months. Two other studies reported a recurrence rate of 35.3% and (22.0%) within 6 months and 51.3% within 13 months (Kaul *et al.,* 2020). The mortality rate was 5.0%. (Kaul *et al.,* 2020). In this current study, 17.1% of cats with various urinary tract conditions had recurrent episodes while 27.1% of the cats died. The mortality rate is high compared to previous literature while the recurrence rate was lower. Kaul et al. (2020) study was for a period of 4 years while the current study was for a period of 10 years. This could be the reason for the observed difference in the mortality and recurrence rates.

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CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The conclusions that can be drawn from this study include:

a) Urolithiasis was found to have the highest prevalence among the urinary tract conditions in domestic cats in Nairobi County, Kenya, followed by idiopathic FLUTD and idiopathic cystitis.

b) There was a high prevalence of idiopathic FLUTD in domestic cats in Nairobi, Kenya as compared to other previous studies.

c) Male cats were more affected from the overall cases of urinary tract conditions including urolithiasis.

d) Dysuria, haematuria and stranguria were the most common clinical manifestations of cats with urinary tract diseases; while dysuria and haematuria were the commonest clinical signs of cats with urolithiasis.

e) Essential diagnostic tools such as urinalysis and survey radiography were not routinely utilized in all cases of urinary tract disease.

f) Dysuria, distended urinary bladder and increase in weight of a cat were factors found to be associated with urolithiasis.

g) Most urinary tract conditions recovered after treatment.

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6.2 RECOMMENDATIONS

The following are the recommendations made from the study:

a) Analysis of uroliths recovered from cats suffering from urolithiasis needs to be done to identify the composition of the uroliths as a guide to proper treatment and prevention of urolithiasis in domestic cats.

b) A comprehensive study on the risk factors of urinary tract conditions in domestic cats in Nairobi, Kenya need to be carried out. This will serve as a guide for management and care of cats for the owners.

c) From this study, diagnosis of some urinary tract conditions did not include use of diagnostic tools such as diagnostic imaging and laboratory tests. Veterinary practitioners should aim to utilize the mentioned diagnostic tools in order to achieve a diagnosis and plan on the treatment protocol for the specific disease.

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APPENDICES

Appendix 1: Data collection form 1

Total number of cases of cats for the past 10 years (January 2009 to December 2018) was retrieved. Data was entered in data collection forms (Appendix 1).

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Jan										
Feb										
March										
April										
May										
June										
July										
Aug										
Sep										
Oct										
Nov										
Dec										

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Appendix 2: Data collection form

Date	Name/ case No.	Breed	Sex	Age	Wgt (Kg)	Neuter Hx	Hx	Exam/clinical finding	Diagnostic method	Dx/ TDx	Rx	Outcome