CROSS-SECTIONAL SURVEY OF THE OCCURRENCE OF AZOTAEMIA IN TRADE PIGS IN NSUKKA, ENUGU STATE, NIGERIA

OGOENYI, Echezonachukwu Ernest and IHEDIOHA, John Ikechukwu
Department of Veterinary Pathology and Microbiology, Faculty of Veterinary Medicine, University of Nigeria, Nsukka, Enugu State, Nigeria.

Corresponding Author: Ihedioha, J. I. Department of Veterinary Pathology and Microbiology, Faculty of Veterinary Medicine, University of Nigeria, Nsukka, Enugu State, Nigeria. **Email:** john.ihedioha@unn.edu.ng **Phone:** +234 8035387156

Received *November 09, 2022;* ***Revised*** *November 18, 2022;* ***Accepted*** *November 21, 2022*

ABSTRACT

This study was a cross-sectional survey that evaluated the occurrence of azotaemia in pigs slaughtered at Ikpa Abattoir, Nsukka, Nigeria. A total of 304 pigs were evaluated. The pigs were physically examined, and categorized based on sex, age and health status. Blood samples were collected from each of the pigs and assayed for biomarkers of azotaemia. Cut-off value (CoV) based on established reference limits in pigs for serum creatinine (sCr) [1.0 – 2.7 mg/dL] and serum urea (sUr) [21.4 – 64.0 mg/dL] was used to classify the pigs as azotaemic or non-azotaemic. Results showed that 18(5.9 %) out of the 304 pigs were azotaemic based on sCr CoV, 14(4.6 %) had azotaemia based on sUr CoV, and only 8(2.6 %) had both sCr and sUr above the CoV. There was no significant association (p>0.05) between sex and the occurrence of azotaemia based on sCr CoV, but significantly more (p<0.05) females had sUr levels above the CoV. Significantly more (p<0.05) adults had azotaemia based on the sCr CoV, but significantly more (p<0.05) growers and fatteners had sUr levels above the CoV. Also, significantly higher (p<0.01) number of unhealthy pigs was azotaemic when compared to the healthy ones. Significantly more (p<0.05) females and young pigs had sCr levels below the lower reference limit (LRL) of 1.0 mg/dL, but none of the pigs had sUr levels below the sUr LRL. The occurrence of azotaemia in the pigs sampled ranged from 2.6 to 5.9 %, and was strongly associated with the health status of the pigs.

Keywords: Pigs, Azotaemia, Occurrence, Serum creatinine, Serum urea, Nsukka, Nigeria

INTRODUCTION

Pig farming is one of the most profitable agricultural ventures worldwide and a common livelihood option for rural dwellers and low income populations (Njuki *et al*., 2010; Adetunji and Adeyemo, 2012; Chauhan *et al*., 2016; Aminu and Akhigbe-Ahonkhai, 2017; Bhadauria *et al*., 2019). Pigs are produced mainly for meat (pork), though the skin and hoof serve as source of raw materials for other agro-allied industries (Young, 2005; Okoli, 2006). Pork is one of the two (pork and poultry) most consumed meats in the world, and pork meat contains all the essential amino acids in enough quantity and proportion to cover corporal needs (Ribeiro *et al*., 2021). Pork meat, like other livestock-derived meats, is known to provide critical nutritional benefits, especially to vulnerable groups such as children, women of reproductive age and the elderly (Murphy and Allen, 2003; Randolph *et al*., 2007; Enahoro *et al*., 2018; Inyeinyang and Ukpong, 2019). However, pig production is hampered by various constraints, prominent among which are the occurrence of swine diseases/disorders and the associated mortality (Youssouf *et al*., 2014;

Uddin and Osasogie, 2016; Munzhelele *et al*., 2017; Majunder and Cherala, 2021).

Azotaemia is a biochemical disorder characterized by an elevation and buildup of nitrogenous products (mainly urea), creatinine and other secondary waste products in the blood, as a result of the inability of the kidney to eliminate such waste products adequately (Ihedioha and Chineme, 2005; Chew *et al*., 2010; Tyagi and Aeddula, 2022). Azotaemia is a typical feature of both acute and chronic kidney injury and may occur in three forms (pre-renal, renal and post-renal), depending on its origin (Tyagi and Aeddula, 2022). Pre-renal azotaemia arises as a result of insult/injury that leads to hypoperfusion or decreased blood flow to the kidneys consequent upon various aetiologies of volume depletion, such as the physiologic state shock, dehydration, haemorrhage, over-diuresis, burns, congestive heart failure and liver failure (Blantz, 1998). Renal azotaemia results from direct damage to the kidney structure affecting the glomeruli, renal tubules, interstitium and renal vasculature, which may be brought about by inflammatory conditions, exposure to nephrotoxins, nephrotoxic drugs, infections and damage from hypoperfusion (Chew *et al*., 2010). Post-renal azotaemia occurs as a result of disorders in the ureters, bladder and urethra that obstruct the outflow of urine, as may occur in recurrent urinary tract infections, urolithiasis, hydronephrosis, benign prostatic hyperplasia (Fischer *et al*., 2009). In all cases, azotaemia may progress to severe renal dysfunction if the inciting/underlying cause is not removed. Complications may arise from the toxic uremic effects of the waste products that built up/accumulate in the blood, which may be associated with further lesions and clinical signs/symptoms such as platelet dysfunction and bleeding, encephalopathy, peripheral neuropathy, nausea, vomiting, hypothermia, and itching (Ihedioha and Chineme, 2005; Chew *et al*., 2010; Tyagi and Aeddula, 2022).

The occurrence of azotaemia is common in humans and animals. In humans, it has been reported to be responsible for 8 to 16 % of hospital admissions, and more so, it is associated with a significantly higher risk of mortality (Chertow *et al*., 2005; Sawhney *et a*l., 2017; Sawhney and Fraser, 2017; Tyagi and Aeddula, 2022). In dogs presented for veterinary care at animal hospitals, the occurrence of azotaemia has been reported to range from 8.9 – 17 % and has been noted to be a predictor of mortality (Harison *et al*., 2012; Babyak *et al*., 2017; Defauw *et al*., 2018; Nabi *et al*., 2018; Eze *et al*., 2019). In cattle, Ihedioha *et al*. (2019) reported a 7.5 % occurrence of azotaemia, though Mahouz *et al.* (2015) reported a 17.55 % occurrence of renal diseases in general, based on histopathological examination. A 2.1 – 6.9 % occurrence of azotaemia has been reported in goats, depending on the biochemical parameters used for the evaluation (Udeh *et al*., 2021), while a 22.66 % occurrence of renal lesions based on histopathology has been reported in sheep (Mahouz *et al*., 2015). There is no information in the available literature on the occurrence of azotaemia and renal dysfunction in pigs generally, particularly in Nigeria. This present study evaluated the occurrence of azotaemia in trade pigs slaughtered at the Ikpa Abattoir, Nsukka Local Government Area, Enugu State Nigeria.

MATERIALS AND METHODS

Study Design, Location and Animals for the Study: The study was a cross-sectional survey of pigs reared in Nsukka and its environs that were presented for slaughter at the Ikpa Abattoir, Nsukka. Nsukka is located within the derived savannah belt of Eastern Nigeria between latitude 5°50° and 7°60° north and longitude 6°52° and 7° 54° east at an average elevation of approximately 500 metres above sea level (FMANR, 2009; Ihedioha *et al.,* 2019).

The study populations were pigs slaughtered at the Ikpa Abattoir, Nsukka during the study period, from September 2019 to February 2020. A sample size of 292 was calculated using the Taro Yamane formula (Adam, 2020). Research visits to the abattoir were done once a week and all pigs slaughtered on each day of the research visit were sampled. A total of 304 pigs slaughtered during the days of the research visit within the 6-month study period constituted the sample population. Each of the pigs was physically examined before slaughter, noting the sex, age and health status. The sex (female or male) of each pig sampled was determined by visual examination of the external genitalia, while the age of the sampled pigs were estimated using the tooth eruption and wear method (Silver, 1969; Clarke *et al*., 1992), with the sampled pigs categorized into age groups: Growers, 2 – 3 months of age; Fatteners, older than 3 months of age but less or equal to 6 months of age; Adults, older than 6 months of age, but less that 3 years of age; and Seniors, older than 3 years. The health status was determined by a standard physical and clinical examination (Ugochukwu, 2011), and each pig was classified as healthy or unhealthy. The study design and procedures were approved by the Institutional Animal Care and Use Committee (IACUC), Faculty of Veterinary Medicine, University of Nigeria, Nsukka.

Blood Sample Collection and Laboratory Analysis: Blood samples were collected from the jugular vein outflow at the point of the slaughter of each of the pigs (Coles, 1986). The blood samples were dispensed into labelled plain glass tubes and allowed to stand at room temperature for 45 minutes to clot (Coles, 1986). The clotted blood sample was centrifuged at 3000 revolutions per minute for 10 minutes to separate the serum from the clot. The clear serum was used to determine the serum levels of creatinine and urea, within three hours of separation of serum from clot. Serum creatinine levels were determined based on the modified Jaffe reaction, while serum urea levels were determined based on the modified Berthelot-Searcy enzymatic reaction (Fawcett and Scott, 1960; Blass *et al*., 1974; Lamb and Price, 2008). The biochemical determinations were done using commercially available serum creatinine and urea test kits manufactured by Quimica Clinica Aplicada (QCA), Spain and Dialab Neudorf, Austria respectively, on a Diatek® Semi-automated Blood Biochemistry Analyzer (Wuxi Hiwell Diatek Instruments Company Limited., Wuxi, China). Serum creatinine levels above 2.7 mg/dL and serum urea levels above 64 mg/dL were considered positive for azotaemia in the sampled pigs, based on the established reference intervals for serum creatinine (1.0 – 2.7 mg/dL) and serum urea (21.4 – 64.0 mg/dL) in pigs (Radostitis *et al.,* 2000; Jackson and Cockcroft, 2002).

Data Analysis: Data obtained in the study were subjected to appropriate statistics using SPSS statistical package version 16. Data on the proportion of pigs with serum creatinine and urea levels above or below the reference limits were subjected to descriptive statistics and the occurrence of azotaemia was presented as percentages. Chi-square or Fisher's exact test (as appropriate) was used to analyze the association between the occurrence of azotaemia and age, sex, and health status of the pigs.

RESULTS

Demographic Characteristics of Sampled Pigs: The demographic characteristics of the sample population of pigs evaluated are presented in Table 1. Out of the 304 pigs sampled, 160(52.6 %) were females, while 144(47.4 %) were males. Thirty (9.9 %) out of 304 pigs were growers, 118(38.8 %) were fatteners and 156(51.3 %) were adults. Two hundred and sixty-four (86.8 %) out of 304 pigs were adjudged as healthy following a physical examination, while 40(13.2 %) were unhealthy with grossly observable signs/evidence of diseases/disorders (Table 1).

Azotaemia in Sampled Pigs: Eighteen pigs (5.9 %) had serum creatinine levels of > 2.7 mg/dL, while 14(4.6 %) had serum urea levels of > 64.0 mg/dL (Table 2). Only 8 pigs (2.6 %) had both their serum creatinine and urea levels above the upper reference limits of 2.7 mg/dL and 64.0 mg/dL, respectively (Table 2). The serum creatinine levels of 272 (89.5%) out of the 304 pigs were within the serum creatinine reference interval (1.0 – 2.7 mg/dL), while the serum urea levels of 282 out of the 304 pigs (92.8 %) were within the serum urea reference interval (21.4 – 64.0 mg/dL) (Table 2).

Table 1: Demographic characteristics of the sampled population of pigs evaluated for azotaemia

Demographic Characteristic	Categories	Number out of the total sample population of 304	Percentage occurrence (%)
Sex	Females	160	52.6
	Males	144	47.4
	Total	304	
Age	Growers	30	9.9
	Fatteners	118	38.8
	Adults	156	51.3
	Total	304	
Health status	Healthy	264	86.8
	Unhealthy	40	13.2
	Total	304	

Table 2: Distribution of the pigs sampled based on established creatinine and urea cut-off points*

Categories	Number out of the 304 pigs sampled	Percentage occurrence (%)
Pigs with serum creatinine levels > 2.70 mg/dL	18	5.9
Pigs with serum urea levels > 64.0 mg/dL	14	4.6
Pigs with both serum creatinine > 2.70 mg/dL and serum Urea > 64 mg/dL	8	2.6
Pigs with serum creatinine levels between 1.0 and 2.70 mg/dL	272	89.5
Pigs with serum urea levels between 21.4 and 64.0 mg/dL	282	92.8
Pigs with serum creatinine levels < 1.0 mg/dL	6	2.0
Pigs with serum urea levels < 21.4 mg/dL	0	0.0

** Radostitis et al., 2000; Jackson and Cockroft, 2002*

Six (2.0 %) pigs out of the 304 had serum creatinine levels below the lower reference limit of serum creatinine (< 1.0 mg/dL), but none of the pigs (0.0 %) had serum urea levels below the 21.4 mg/dL lower reference limits for serum urea (Table 2).

Distribution of Azotaemic Pigs Based on Sex: Out of the 18 pigs that were classified azotaemic based on their serum creatinine values, 6 were females and 12 were males and there was no significant association (p=0.091) between sex and occurrence of azotaemia based on serum creatinine reference limits (Table 3). The 14 pigs that were azotaemic based on their serum urea reference limits were made up of 12 females and 2 males, with a significantly higher (p=0.013) number of females being azotaemic based on the serum urea reference limits (Table 3). The 8 pigs that were azotaemic based on a combination of serum creatinine and urea reference limits were composed of 6 females and 2 males, and there was no significant association (p=0.288) between sex and occurrence of azotemia based on the two combined parameters (Table 3).

Distribution of Azotaemic Pigs Based on Age: The 18 pigs considered azotaemic based on serum creatinine reference limits were made up of 2 fatteners and 16 adults, with a significantly more (p=0.004) adults being azotaemic when compared to other age groups (Table 4). Based on serum urea reference limits, the 14 azotaemic pigs were made up of 4 growers, 6 fatteners and 4 adults, and statistics showed that significantly more (p=0.041) growers were azotaemic based on serum urea reference limits (Table 4). The 8 pigs with their combined serum creatinine and urea above upper reference limits (azotaemic based on both parameters) were made of 4 fatteners and 4 adults and there was no significant association (p=0.768) between age and occurrence of azotaemia based on the combined parameters (Table 4).

Table 3: Sex differences in the occurrence of azotaemia in the pigs sampled

Categories	Sex		Totals	P-value
	Female (n = 160)	Male (n = 144)		
Pigs with serum creatinine levels > 2.70 mg/dL	6 (3.8 %)	12 (8.3 %)	18	0.091
Pigs with serum urea levels > 64.0 mg/dL*	12 (7.5 %)	2 (1.4 %)	14	0.013
Pigs with both serum creatinine > 2.70 mg/dL and serum urea > 64 mg/dL	6 (3.8 %)	2 (1.4 %)	8	0.288

** Asterisks on a category indicates significant (p<0.05) association between sex and occurrence of azotaemia. Percentages of the total for each sex are in brackets*

Table 4: Age variations in the occurrence of azotaemia in the pigs sampled

Categories	Age groups			Totals	P-value
	Growers (n = 30)	Fatteners (n = 118)	Adults (n = 156)		
Pigs with serum creatinine levels > 2.70 mg/dL*	0 (0.0 %)	2 (1.7 %)	16 (10.3 %)	18	0.004
Pigs with serum urea levels > 64.0 mg/dL*	4 (13.3 %)	6 (5.1 %)	4 (2.6 %)	14	0.041
Pigs with both serum creatinine > 2.70 mg/dL and serum urea > 64 mg/dL	0 (0.0 %)	4 (3.4 %)	4 (2.6 %)	8	0.768

**Asterisks on a category indicates significant association (p<0.05) between age groupings and occurrence of azotaemia. Percentages of the total for each age group are in brackets*

Association between Health Status and Occurrence of Azotaemia: Sixteen out of the 18 pigs considered azotaemic based on serum creatinine reference limits were unhealthy while 2 were judged healthy (Table 5). There was a significant association (p=0.000) between health status and the occurrence of azotaemia based on serum creatinine levels, with significantly higher (p=0.000) proportion of the azotaemic pigs being unhealthy (Table 5). Using serum urea as a basis also, significantly more (p=0.000) azotaemic pigs (10 out of 14) were unhealthy while only 4 were adjudged to be healthy (Table 5). Six out of the eight pigs considered azotaemic based on having both serum creatinine and urea above the upper reference limits were unhealthy and only 2 were judged healthy (Table 5). Also, there was a significant association (p=0.000) between the occurrence of azotaemia (based on both parameters combined) and health status (Table 5).

Distribution of Pigs with Serum Creatinine Levels below the Lower Reference Limits: Six out of the 160 female pigs evaluated (3.8 %) had their serum creatinine levels below 1.0 mg/dL but no male (0%) had their serum creatinine level below 1.0 mg/dL (Table 6). Significantly more (p=0.031) females had their serum creatinine below 1.0 mg/dL than males (Table 6). When categorized based on age, the six pigs with serum creatinine below 1.0 mg/dL comprised two growers (6.7 %) and 4 fatteners (3.4 %) and no adult (0.0 %) (Table 6). The occurrence of serum creatinine levels below 1.0 mg/dL was significantly associated (p=0.011) with age, with the growers and fatteners (younger ones) being the ones with serum creatinine less than 1.0 mg/dL. There was no significant association (p=0.180) between the occurrence of serum creatinine levels < 1.0 mg/dL and the health status of the pigs sampled (Table 6). Four out of the 264 healthy pigs had serum creatinine < 1.0 mg/dL, while 2 out of the 40 unhealthy pigs had serum creatinine values below 1.0 mg/dL (Table 6).

DISCUSSION

The fact that relatively more female pigs were recorded to have been presented for slaughter than males in this study is worthy of note, and it is thought that more males are bought off from

Table 5: Distribution of the azotaemic pigs sampled based on their health status

Categories	Health status		Totals	P-value
	Healthy (n = 264)	Unhealthy (n = 40)		
Pigs with serum creatinine levels > 2.70 mg/dL*	2 (0.8 %)	16 (40.0 %)	18	0.000
Pigs with serum urea levels > 64.0 mg/dL*	4 (1.5 %)	10 (25.0 %)	14	0.000
Pigs with both serum creatinine > 2.70 mg/dL and serum urea > 64 mg/dL*	2 (0.8 %)	6 (15.0 %)	8	0.000

**Asterisks on a category indicates significant association (p<0.01) between the health status and occurrence of azotaemia. Percentages of the total for each health status are in brackets*

Table 6: Sex, age and health status distribution of pigs with serum creatinine levels below the lower reference limit (< 1.0 mg/dL)

Characteristic	Categories	Number with serum creatinine levels < 1.0 mg/dL	Number out of the total sample population of 304	Percentages occurrence (%)	P-value
Sex*	**Females**	6	160	3.8	0.031
	Males	0	144	0.0	
	Total	6	304		
Age*	**Growers**	2	30	6.7	0.011
	Fatteners	4	118	3.4	
	Adults	0	156	0.0	
	Total	6	304		
Health status	**Healthy**	4	264	1.5	0.180
	Unhealthy	2	40	5.0	
	Total	6	304		

** Asterisks on a category indicates significant association (p<0.05) between the characteristic and occurrence of serum creatinine levels below the lower reference limit*

farms for ceremonies that may require males specifically before selling out the remaining for routine slaughter (Berhanu *et al.*, 2012), or there were relatively more females than males produced in a litter. There had been earlier concurring reports of more female goats being presented for slaughter at abattoirs than males (Okorie-Kanu *et al.*, 2018; Udeh *et al.*, 2021), and also a contrasting report in cattle where more males than females had been reported to be presented for slaughter at Ikpa Abattoir, Nsukka (Ihedioha *et al.*, 2019). Fatteners and adults were higher in number than growers; this is most likely because they are the ones that may have reached the market weight desired by most buyers. The higher number of healthy pigs slaughtered may be attributed to market forces, as buyers will commonly prefer healthy and robust pigs to unhealthy, weak and emaciated ones.

The 5.9 % occurrence of azotaemia in the pigs sampled based on serum creatinine reference limit of > 2.7 mg/dL is considered to be relatively low, and this low occurrence may probably be a result of the fact that the dominant age group of pigs encountered in the study were young (growers and fatteners) and adult pigs; higher occurrences of azotaemia /renal dysfunction have been associated with old age in all species (Weinstein and Anderson, 2010; Chao *et al.,* 2013; Toyama *et al.,* 2013; Brown *et al.,* 2016; O'Sullivan *et al.,* 2017; Ravani *et al.,* 2020). The 5.9 % recorded in this present study is lower than the 7.5 % reported by Ihedioha *et al.* (2019) for trade cattle at the same Ikpa Abattoir, Nsukka, and also lower than the 8.9 % reported by Eze *et al.* (2019) for dogs in Nsukka. It is however higher than the 2.1 % reported for goats slaughtered at Ahiaeke abattoir in Umuahia, Abia State, Nigeria (Udeh *et al.*, 2021).

The 4.6 % occurrence of azotaemia recorded in this study based on the serum urea levels criteria is because serum urea is a less specific biomarker of azotaemia/ kidney dysfunction (Defauw *et al.,* 2018; Eze *et al.*, 2019; Udeh *et al.* 2021). This occurrence is close to the 4.2 % reported by Monaghan and Hannan (1983) for the prevalence of renal disease in cattle. However, the 4.6 % obtained based on the serum urea criteria in pigs in this study was higher than 1.5 % occurrence reported by Ihedioha *et al*. (2019) for urea levels above the reference limits in cattle slaughtered at Ikpa Abattoir Nsukka, and lower than the 6.9 % reported by Udeh *et al*. (2021), for goats slaughtered at Ahiaeke abattoir, Umuahia.

The finding in this study of 2.6 % occurrence of azotaemia in pigs based on combined serum creatinine and urea levels cut-off values is worthy of note; it suggests that increases in serum creatinine above the upper reference limit in the pigs sampled did not completely concur with increases in their urea levels above the upper limit; that is, some pigs that have serum creatinine level above the cut of values do not at the same time have their serum urea levels elevated above cut-off values and vice versa. This finding brings to question the continued extrapolation of the idea from human nephrology to animals that creatinine and urea values are concurrently elevated in renal failure. Further experimental work specifically on pigs to compare the concurrence of elevations in serum creatinine and urea in conditions of renal dysfunction may be needful to clarify this in future.

The non-significant association (p=0.091) recorded in this study between the occurrence of azotaemia based on serum creatinine cut-off value and sex was in agreement with reports by Ihedioha *et al*. (2019), Eze *et al*. (2019) and Udeh *et al*, (2021), all of whom reported no significant association between sex and occurrence of azotaemia based on serum creatinine cut-off values in cattle, dogs and goats, respectively. The significant association (p=0.013) recorded between azotaemia based on serum urea cut-off values and sex implied that azotaemia occurred significantly more in females than in males, and this may be because of frequent occurrence of urinary tract infections in females than in males (Harrington and Hooton, 2000; Ani and Mgbechi, 2008; Dielubanza and Schaeffer, 2010). Also, males have been reported to have 17 % higher nephron capacity than females (Hoy *et al*., 2005). The significantly higher proportion of females with azotaemia based on serum urea cut-off values recorded in this study agreed with the reports of Maric (2009), Ingsathit *et al*. (2010), Tufani *et al*. (2015) and Mimura (2019), of whom reported a significantly higher occurrence of azotaemia and renal dysfunction in females but contrasts with the reports of Iseki (2008) and Fanelli *et al*. (2017), who documented a higher occurrence of chronic kidney disease in males than in females. Udeh *et al*. (2021) reported no significant association between sex and occurrence of serum urea levels above the cut-off values for goats.

The differences observed in azotaemia occurrence based on serum creatinine cut-off value of > 2.7 mg/dL between the various age groups showed that adults had a higher frequency of azotaemia than other age groups. This may partly be attributed to higher muscle mass (Hannemann *et al*., 2012; Báez Suárez *et al*., 2014) or to age-related functional and structural renal deterioration and decreased renal reserve (Weinstein and Anderson, 2010; Chao *et al.,* 2013; Brown *et al.* 2016; O'Sullivan *et al.* 2017; Ravani *et al.* 2020; Toyama *et al.* 2013). Several earlier reports had documented a substantial decrease in kidney function in animals and humans as they age (Afolabi *et al.,* 2009; O'Neill *et al.,* 2013; Tufani *et al*., 2015; Mshelbwala *et al.,* 2016; Cannon, 2016). A significantly higher (p=0.041) number of growers were azotaemic based on serum urea cut-off value of > 64 mg/dL when compared with other age groups; this may be due to other extra-renal factors that affect serum urea levels (Sanusi *et al*., 2008; Seki *et al*., 2019).

The significant association (p=0.000) between health status and occurrence of azotaemia for all cut-off values (creatinine, urea and creatinine and urea combined) as recorded in this study may be because azotaemia is commonly associated with many clinically observable signs/symptoms of the disorder (Polzin, 2011; Romagnani *et al*., 2017). The inability to eliminate waste which then accumulates in the blood in addition to the inability to retain substances that need to be reabsorbed by the kidneys in conditions of azotaemia account for this. Ultimately an animal/individual with azotaemia/renal dysfunction will physically appear ill/sick. An earlier report by Udeh *et al.* (2021) in goats also showed a strong significant association between health status and occurrence of azotaemia based on all the biochemical parameters used for evaluation.

Significantly more (p=0.031) females had their serum creatinine levels below 1.0 mg/dL than males. This is probably because females generally have less muscle mass than males, as total muscle mass is the major determinant of the creatinine pool size and creatinine production (Patel *et al*., 2013). Differences between males and females in their normal levels of serum creatinine had been severally reported (Milić *et al*., 2011; Amin *et al*., 2014; Nisha *et al*., 2017).

The occurrence of serum creatinine levels below 1.0 mg/dL was also significantly associated (p<0.011) with age, with the younger ones (growers and fatteners) being the ones with serum creatinine levels less than 1.0 mg/dL. This difference between age groups may be attributed to the fact that younger pigs generally have smaller body sizes and consequently lower muscle mass. Earlier reports in humans showed that younger individuals have lower levels of serum creatinine (Amin *et al.,* 2014; Nisha *et al*., 2017).

Conclusion: Based on the results of the study, it was concluded that the occurrence of azotaemia in the pig population sampled ranged from 2.6 to 5.9 % depending on the parameter used for assessment (creatinine, urea or combination of creatinine and urea cut-off values). Also, the occurrence of azotaemia was significantly associated with the health status of the pigs notwithstanding the parameter used for assessment. It was noted that in this survey of trade pigs, piglets and old pigs were not presented for slaughter during the survey; therefore information on them and occurrence of azotaemia in these two age groups could not be captured in the present study. Future on-farm surveys that will capture information on all age categories of pigs is proposed.

ACKNOWLEDGEMENTS

The authors acknowledge the cooperation and support of the staff of the Ikpa Abattoir, Nsukka in facilitating the survey, and the laboratory support of the Biomedical Research Support Unit of the Foundation for Education and Research on Health, Nsukka for the serum biochemical assays.

REFERENCES

ADAM, A. M. (2020). Sample size determination in survey research. *Journal of Scientific Research Reports*, 26(5): 90 – 97.

ADETUNJI, M. O. and ADEYEMO, K. E. (2012). Economic efficiency of pig production in Oyo State, Nigeria: a stochastic production frontier approach. *American Journal of Experimental Agriculture*. 2(3): 382 – 394.

AFOLABI, M. O., ABIOYE-KUTEYI, E. A., AROGUNDADE, F. A. and BELLO, I. S. (2009). Prevalence of chronic kidney disease in a Nigerian family practice population. *South African Family Practice,* 51(2): 132 – 137.

AMIN, N., MAHMOOD, R. T., ASAD, M. J., ZAFAR, M. and RAJA, A. M. (2014). Evaluating urea and creatinine levels in chronic renal failure pre and post dialysis: a prospective study. *Journal of Cardiovascular Disease*, 2(2): 1 – 4.

AMINU, F. and AKHIGBE-AHONKHAI, C. (2017). Profitability and technical efficiency of pig production in Nigeria: the case of Ekiti State. *Agricultura Tropica et Subtropica*, 50(1): 27 – 35.

ANI, O. C and MGBECHI, E. K. (2008). Prevalence of urinary tract infections (UTI) in sexually active women of Abakiliki, Ebonyi State, Nigeria. *Animal Research International,* 5(2): 876 – 879.

BABYAK, J. M., WEINER, D. E., NOUBARY, F. and SHARP, C. R. (2017). Prevalence of elevated serum creatinine concentration in dogs presenting to a veterinary academic medical center (2010-2014). *Journal of Veterinary Internal Medicine*, 31(6): 1757 – 1764.

BÁEZ SUÁREZ, P. C., CABRA MARTÍNEZ, C. A. and RUIZ, I. C. (2014). Standardization of serum creatinine levels in healthy dogs related to body weight at the South Valley of Aburra, Colombia. *Revista de Medicina Veterinaria*, 27: 33 – 40.

BERHANU, T., THIENGTHAM, J., TUDSRI, S., ABEBE, G., TERA, A. and PRASANPANICH, S. (2012). Purposes of keeping goats, breed preferences and selection criteria in pastoral and agro-pastoral districts of South Omo Zone. *Livestock Research and Rural Development,* 24(12): 213. https://lrrd.cipav.org.co/lrrd24/12/berh2412cit.htm

BHADAURIA, P., SHARMA, A., VERMA, H. K., SINGH, I. and SINGH, R. (2019). *Pig Farming: Promising Agri-Business in Punjab*. ICAR-ATARI, Ludhiana, Punjab, India.

BLANTZ, R. C. (1998). Pathophysiology of pre-renal azotemia. *Kidney International*, 53(2): 512 – 523.

BLASS, K. G., THIEBERT, R. J. and LAM, L. K. (1974). A study of the mechanism of the Jaffé reaction. *Journal of Clinical Chemistry and Clinical Biochemistry* 12(7): 336 – 343.

BROWN, C. A., ELLIOTT, J., SCHMIEDT, C. W. and BROWN, S. A. (2016). Chronic kidney disease in aged cats: clinical features, morphology, and proposed pathogeneses. *Veterinary Pathology*, 53(2): 309 – 326.

CANNON, M. (2016). Diagnosis and investigation of chronic kidney disease in cats. *British Veterinary Association: InPractice Focus,* 38(S3): 2 – 9.

CHAO, C. T., TSAI, H. B., LIN, Y. F. and KO, W. J. (2013). Acute kidney injury in the elderly: only the tip of the iceberg. *Journal of Clinical Gerontology and Geriatrics,* 5(1): 7 – 12.

CHAUHAN, A., PATEL, B. H. M., MAURYA, R., KUMAR, S., SHUKLA, S. and KUMAR, S. (2016). Pig production system as a source of livelihood in Indian scenario: an overview. *International Journal of Science and Environmental Technology*, 5(4): 2089 – 2096.

CHERTOW, G. M., BURDICK, E., HONOUR, M., BONVENTRE, J. V. and BATES, D. W. (2005). Acute kidney injury, mortality, length of stay, and costs in hospitalized patients. *Journal of the American Society of Nephrology,* 16(11): 3365 – 3370.

CHEW, D. J., DIBARTOLA, S. P. and SCHENCK, P. A. (2010). *Canine and Feline Nephrology and Urology*. 2nd Edition, Elsevier Saunders, USA.

CLARKE, C. M. H., DZIECIOLOWSKI, R. M., BATCHELER, D. and FRAMPTON, C. M. (1992). A comparison of tooth eruption and wear and dental cementum techniques in age determination of New Zealand feral pigs. *Wildlife Research*, 19(6): 769 – 777.

COLES, E. H. (1986). *Veterinary Clinical Pathology.* 4th Edition, W. B. Saunders, Philadelphia, USA.

DEFAUW, P., DAMINET, S., LEISEWITZ, A. L., GODDARD, A., PAEPE, D., DUCHATEAU, L. and SCHOEMAN, J. P. (2018). Renal azotemia and associated clinical and laboratory findings in dogs with *Babesia rossi* infection. *Veterinary Parasitology*, 260: 22 – 29.

DIELUBANZA, E. J. and SCHAEFFER, A. J. (2010). Urinary tract infections in women. *The Medical Clinics of North America,* 95(1): 27 – 41.

ENAHORO, D., LANNERSTAD, M., PFEIFER, C. and DOMINGUEZ-SALAS, P. (2018). Contributions of livestock-derived foods to nutrient supply under changing demand in low- and middle-income countries. *Global Food Security*, 19: 1 – 10.

EZE, U. U., EZEH, I. O., EKE, I. G., AGINA, O. A., EGWUONWU, A., EZENDUKA, E. V. and ANENE, B. M. (2019). Prevalence of increased serum urea and creatinine levels in dogs. *Notulae Scientia Biologicae*, 11(3): 340 – 346.

FANELLI, C., DELLÊ, H., CAVAGLIERI, R. C., DOMINGUEZ, W. V. and NORONHA, I. L. (2017). Gender differences in the progression of experimental chronic kidney disease induced by chronic nitric oxide inhibition. *BioMed Research International*, 2017: 2159739. [https://doi.org/10.1155/2017/ 2159739](https://doi.org/10.1155/2017/2159739)

FAWCETT, J. K. and SCOTT, J. E. (1960). A rapid and precise method for the determination of urea. *Journal of Clinical Pathology*, 13(2): 156 – 159.

FISCHER, J., LANE, I. and STOKES, J. (2009). Acute postrenal azotemia: etiology, clinicopathology, and pathophysiology. *Compendium (Yardley, PA)*, 31(11): 520 – 530.

FMANR (2009). *Geographic Data*. Federal Ministry of Agriculture and Natural Resources (FMANR). Enugu, Nigeria.

HANNEMANN, A., FRIEDRICH, N., DITTMANN, K., SPIELHAGEN, C., WALLASCHOFSKI, H., VOLZKE, H., RETTIG. R., ENDLICH, K., LENDECKEL, U., STRACKE, S. and NAUCK, M. (2012). Age- and sex-specific reference limits for creatinine, cystatin C and the estimated GFR. *Clinical Chemistry Laboratory,* 50(5): 919 – 926.

HARISON, E., LANGSTON, C., PALMA, D. and LAMB, K. (2012). Acute azotemia as a predictor of mortality in dogs and cats. *Journal of Veterinary Internal Medicine*, 26(5): 1093 – 1098.

HARRINGTON, R. D. and HOOTON, T. M. (2000). Urinary tract infection risk factors and gender. *The Journal of Gender-Specific Medicine,* 3(8): 27 – 34.

HOY, W. E., HUGHSON, M. D., BERTRAM, J. F., DOUGLAS-DENTON, R. and AMANN, K. (2005). Nephron number, hypertension, renal disease, and renal failure. *Journal of the American Society of Nephrology*, 16(9): 2557 – 2564.

IHEDIOHA, J. I. and CHINEME, C. N. (2005). Urinary system. Pages 267 – 292. *In*: IHEDIOHA, J. I. and CHINEME C. N. (Eds.). *Fundamentals of Systemic Veterinary Pathology*. Volume II, Great AP Express Publishers Limited, Nsukka, Nigeria.

IHEDIOHA, J. I., UKACHUKWU, C. V., UGOCHUKWU, I. and ANYOGU, D. C. (2019). Evaluation of kidney function and urinary analytes in Nigerian trade cattle. *Tropical Animal Health and Production*, 51(7): 1867 – 1875.

INGSATHIT, A., THAKKINSTIAN, A., CHAIPRASERT, A., SANGTHAWAN, P. and GOJASENI, P. (2010). Prevalence and risk factors of chronic kidney disease in the Thai adult population: Thai SEEK study. *Nephrology Dialysis Transplantation*, 25(5): 1567 – 1575.

INYEINYANG, M. M. and UKPONG, I. G. (2019). The livestock sector and its contributions to the protein and energy needs of the Nigerian population. *Ghana Journal of Agricultural Sciences*, 54(2): 86 – 97.

ISEKI, K. (2008). Gender differences in chronic kidney disease. *Kidney International*, 74(4): 415 – 417.

JACKSON, P. G. and COCKROFT, P. D. (2002). *Clinical Examination of Farm Animals*. 6th Edition, Blackwell Science, Oxford, United Kingdom.

LAMB, E. J. and PRICE, C. P. (2008). Creatinine, urea, and uric acid. Pages 363 – 372. *In:* BURTIS, C. A., ASHWOOD, E. R. and BRUNO, D. E. (Eds.). *TIETZ Fundamentals of Clinical Chemistry*. 6th Edition, Saunders, Elsevier, St. Louis, Missouri, USA.

MAHOUZ, F., KHOUDJA, F. B. and CHIKHAOUI, M. (2015). Pathological study of renal diseases in cattle and sheep. *Journal of Animal and Veterinary Advances*, 14: 357 – 360.

MAJUNDER, K. P. and CHERALA, H. (2021). Marketing pattern and constraint analysis of swine farming in Telangana State of India. *International Journal of Livestock Research*, 11(7): 37 – 43.

MARIC, C. (2009). Sex, diabetes and the kidney. *American Journal of Physiology – Renal Physiology*, 296(4): F680 – F688.

MILIĆ, R., BANFI, G., DEL FABBRO, M. and DOPSAJ, M. (2011). Serum creatinine concentrations in male and female elite swimmers. Correlation with body mass index and evaluation of estimated glomerular filtration rate. *Clinical Chemistry and Laboratory Medicine*, 49(2): 285 – 289.

MIMURA, I. (2019). Are women more susceptible to renal dysfunction than men? *Kidney International*, 96(6): 1275 – 1277.

MONAGHAN, M. I. and HANNAN, J. (1983). Abattoir survey of bovine kidney diseases. *Veterinary Records,* 113(3): 55 – 57.

MSHELBWALA, F. M., AJAYI, O. L., ADEBIYI, A. A., ONANIYI, M. O., OMOTAINSE, S. O., OMOTAINSE, O. S., OLUWABI, M. T., OJEBIYI, O. E., AKPAVIE, S. O. and KADIRI, A. K. F. (2006). Retrospective studies on the prevalence, morphological pathology and aetiology of renal failure of dog in Lagos and Abeokuta, Nigeria. *Nigerian Veterinary Journal,* 37(4): 206 – 216.

MUNZHELELE, P., OGUTTU, J., FASANMI, O. G. and FASINA, F. O. (2017). Production constraints of smallholder pig farms in agro-ecological zones of Mpumalanga, South Africa. *Tropical Animal Health and Production*, 49(1): 63 – 69.

MURPHY, S. P. and ALLEN, L. H. (2003). Nutritional importance of animal source foods. *The Journal of Nutrition*, 133(11 Supplement 2): 3932S – 3935S.

NABI, S. U., DEY, S., SHAH, O. S., HUSSAIN, T., AMIN, U., VALA, J., JAN, A., RAMDAS, A. G., MUHEE, A., HUSSAIN, A. and BEIGH, S. A. (2018). Incidence of renal disorders in canines and its relation with age, breed and sex. *The Pharma Innovation Journal*, 7(1): 87 – 89.

NISHA, R., SRINIVASA KANNAN, S. R., THANGA MARIAPPAN, K. and JAGATHA, P. (2017). Biochemical evaluation of creatinine and urea in patients with renal failure undergoing hemodialysis. *Journal of Clinical Pathology Laboratory Medicine*, 1(2):1 – 5.

NJUKI, J., PALI, P., MBURU, S. and POOLE, J. (2010). *Pig Production, Management and Marketing in the North East Indian State of Nagaland.* International Livestock Research Institute (ILRI), Nairobi, Kenya.

O'NEILL, D. G., ELLIOTT, J., CHURCH, D. B., MCHREEN, P. D., THOMSON, P. C. and BRODBELT, D. C. (2013). Chronic kidney disease in dogs in United Kingdom. Veterinary practices, prevalence, risk factors and survival. *Journal of Veterinary Internal Medicine*, 27(4): 814 – 821.

OKOLI, C. I. (2006). *Topical Tips on Intensive Pig Production*. Animal Management and Health Issues, Technical Notes, Tapas Institute of Scientific Research and Development, Imo State, Nigeria.

OKORIE-KANU, O. J., EZENDUKA, E. V., OKORIE-KANU, C. O., ANYAOHA, C. O., ATTAH, C. A., EJIOFOR, T. E. and ONWUMERE-IDOLOH, S. O. (2018). Slaughter of pregnant goats for meat at Nsukka slaughterhouse and its economic implications: a public health concern. *Veterinary World*, 11(8): 1139 – 1144.

O'SULLIVAN, E. D., HUGHES, J. and FERENBACH, D. A. (2017). Renal aging: causes and consequences. *Journal of the American Society of Nephrology*, 28(2): 407 – 420.

PATEL, S. S., MOLNAR, M. Z., TAYEK, J. A., IX, J. H., NOORI, N., BENNER, D., HEYMSFIELD, S., KOPPLE, J. D., KOVESDY, C. P. and KALANTAR-ZADEH, K.. (2013). Serum creatinine as a marker of muscle mass in chronic kidney disease: results of a cross-sectional study and review of literature. *Journal of Cachexia, Sarcopenia and Muscle*, 4(1): 19 – 29.

POLZIN, D. J. (2011). Chronic kidney disease in small animals. *The Veterinary Clinics of North America. Small Animal Practice*, 41(1): 15 – 30.

RADOSTITIS, O. M., GAY, C. C., BLOOD, D. C. and HINCHKLIFF, K. W. (2000). *A Textbook of Veterinary Medicine*. 9th Edition, W. B. Saunders, Philadelphia, USA.

RANDOLPH, T. F., SCHELLING, E., GRACE, D., NICHOLSON, C. F., LEROY, J. L., COLE,

D. C., DEMMENT, M. W., OMORE, A., ZINSSTAG, J. and RUEL, M. (2007). Role of livestock in human nutrition and health for poverty reduction in developing countries. *Journal of Animal Science*, 85(11): 2788 – 2800.

RAVANI, P., QUINN, R., FIOCCO, M., LIU, P., AL-WAHSH, H., LAM, N., HEMMELGARN, B. R., MANNS, B. J., JAMES, M. T., JOANETTE, Y. and TONELLI, M. (2020). Association of age with risk of kidney failure in adults with stage IV chronic kidney disease in Canada. *Journal of American Medical Association Network Open*, 3(9): e2017150. https://doi.org/10.1001/jamanetworkopen. 2020.17150

RIBEIRO, D. M., MARTINS, C. F., COSTA, M., COELHO, D., PESTANA, J., ALFAIA, C., LORDELO, M., DE ALMEIDA, A. M., FREIRE, J. and PRATES, J. (2021). Quality traits and nutritional value of pork and poultry meat from animals fed with seaweeds. *Foods (Basel, Switzerland)*, 10(12): 2961. https://doi.org/10.3390/foods10122961

ROMAGNANI, P., REMUZZI, G., GLASSOCK, R., LEVIN, A., JAGER, J. K., TONELLI, M., MASSY, Z., WANNER, C. and ANDERS, H. (2017). Chronic kidney disease. *Nature Reviews Disease Primers,* 3: 17088. https://doi.org/10.1038/nrdp.2017.88

SANUSI, A. A., AROGUNDADE, F. A., EKWERE, T. G. and AKINSOLA, A. (2008). What clinical and laboratory parameters distinguish between acute and chronic renal failure. *Arab Journal of Nephrology and Transplantation*, 1(1): 21 – 24.

SAWHNEY, S. and FRASER, S. D. (2017). Epidemiology of AKI: utilizing large databases to determine the burden of AKI. *Advances in Chronic Kidney Disease*, 24(4): 194 – 204.

SAWHNEY, S., MARKS, A., FLUCK, N., LEVIN, A., PRESCOTT, G. and BLACK, C. (2017). Intermediate and long-term outcomes of survivors of acute kidney injury episodes: a large population-based cohort study. *American Journal of Kidney Diseases*, 69(1): 18 – 28.

SEKI, M., NAKAYAMA, M., SAKOH, T., YOSHITOMI, R., FIKUI, A., KATAFUCHI, E., TSUDA, S., NAKANO, T., TSURUYA, K and TAKANARI, K. (2019). Blood urea nitrogen is independently associated with renal outcomes in Japanese patients with stage 3-5 chronic kidney disease: a prospective observational study. *BMC Nephrology,* 20: 115. https://doi.org/10.1186/s12882-019-1306-1

SILVER, I. A. (1969). The ageing of domestic animals. Pages 283 – 302. *In:* BROTHWELL, D. and HIGGS, E. S. (Eds.). *Science in Archeology: A Survey of Progress and Research*. Thames and Hudson, London.

TOYAMA, T., KITAGAWA, K., OSHIMA, M., KITAJIMA, S., HARA, A., IWATA, Y., SAKAI, N., SHIMIZU, M., HASHIBA, A., FURUICHI, K. and WADA, T. (2020). Age differences in the relationships between risk factors and loss of kidney function: a general population cohort study. *BMC Nephrology*, 21: 477. https://doi.org/10.1186/s12882-020-02121-z

TUFANI, N. A., SINGH, J. L., KUMAORM, GUPTA, D., SHEKHAR, P. and ROJORA, V. S. (2015). Renal failure in Indian dogs: an epidemiological study. *Indian Journal of Veterinary Medicine*, 35(1): 7 – 11.

TYAGI, A. and AEDDULA, N. R. (2022). *Azotemia*. StatPearls Publishing, Treasure Island, Florida, USA. https://www.ncbi.nlm.nih.gov/books/NBK538145/

UDDIN, I. O. and OSASOGIE, D. I. (2016). Constraints of pig production in Nigeria: A case study of Edo Central agricultural zone in Edo State. *Asian Research Journal of Agriculture*, 2(4): 1 – 7.

UDEH, N. E., IHEDIOHA, J. I. and ORJI, E. (2021). Evaluation of the occurrence of renal dysfunction in goats using some biochemical markers. *Nigerian Veterinary Journal*, 42(2): 171 – 180.

UGOCHUKWU, E. I. (2011). Physical examination methods and general clinical examination. Pages 54 – 75. *In:* UGOCHUKWU, E. I. (Ed.). *Textbook on Equine, Porcine and*

Ruminant Medicine. Computer Edge Publishers, Enugu, Nigeria.

WEINSTEIN, J. R. and ANDERSON, S. (2010). The aging kidney: physiological changes. *Advances in Chronic Kidney Disease*, 17(4): 302 – 307.

YOUNG, M. (2005). Efficiency of pork production: a USA, Canada and Ireland comparison. Pages 124 – 129. *In:* LEMAN, A. D (Ed.). *Swine Conference Proceedings*. Swine Centre Extension Service, College of Agricultural, Food and Environmental Sciences, and College of Veterinary Medicine, University of Minnesota, Minneapolis, Minnesota, United States.

YOUSSOUF, M. L., ZEUH, V., ADOUM, I. Y. and CHANTAL-YVETTE, K. (2014). Production practices and constraints of pig farms in N'Djamena area, Chad. *International Journal of Livestock Production*, 5(12): 196 – 203.