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Journal of Animal Science and Veterinary Medicine
Volume 9(1), pages 19-29, February 2024
Article Number: 5CD9D5733
ISSN: 2536-7099
https://doi.org/10.31248/JASVM2023.423
https://integrityresjournals.org/journal/JASVM

Full Length Research

Carriage of *Staphylococcus pseudintermedius* on dogs, surfaces, and personnel at University of Jos Veterinary Teaching Hospital, Plateau State, North-central Nigeria

Asinamai Athliamai BITRUS[1,2]*, Domshak Benmuwan NGUKET[1], Dishon Hurdson CHARIBU[1], Adanu Williams ADANU[3], Mayowa Peter OLABODE[4], Gaddafi Mohammed SANI[5], Faez Firdaus Abdullah JESSE[6] and Zakaria ZUNITA[7]

[1]Department of Veterinary Microbiology and Pathology, Faculty of Veterinary Medicine, University Jos, PMB 2084 Jos Plateau Nigeria.
[2]Biomedical and Vaccine Research Laboratory, Veterinary Teaching Hospital, University of Jos, PMB 2084 Jos Plateau Nigeria.
[3]Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary Medicine, University of Jos, PMB 2084 Jos Plateau Nigeria.
[4]National Veterinary Research Institute, P.M.B 01 Vom, Plateau State, Nigeria.
[5]Ministry of Animal Health Husbandry and Fisheries, Kebbi State, Nigeria.
[6]Department of Veterinary Clinical studies, Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Malaysia.
[7]Department of Veterinary Pathology and Microbiology, Faculty of Veterinary Medicine, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Malaysia.

*Corresponding author. Email: bitrusaa@unijos.edu.ng; Tel: +2348065680664.

Received 19th December 2023; Accepted 25th January 2024

ABSTRACT: *Staphylococcus pseudintermedius* is considered a primary pathogen of canine skin and soft tissue infections, which can be found in several sites of the body, including nares, perineum-rectum, and mouth. The importance of this bacteria has brought this study to determine the carriage and antimicrobial resistance profiles of *S. pseudintermedius* from dogs, personnel (Veterinarians and Animal health attendants), and surfaces (door handles, examination tables, weighing scales, thermometers, drip stands and trays, floors, and refrigerators doors) at a Veterinary Teaching Hospital. Two hundred and ten (n = 210) swab samples were collected and continued to phenotypic bacteriologic culture identification and antibiotic susceptibility testing. Fifty (50) questionnaires were collected from dog owners for demographic information and other variables. The result showed that 65.7% (138/210) of *S. pseudintermedius* phenotypes were recovered from dogs, surfaces, and personnel. Overall, male dogs had a higher carriage of 73.3% (11/15) than females of 65.7% (23/35). The total carriage per body part was 74% (37/50) in the nasal cavity, 72% (36/50) in the perineum, and 58% (29/50) in the oral cavity. A total of dogs sampled 10% (5/50) had a history of previous surgeries within the last 6 months and 64% (32/50) of antimicrobial use for either prophylaxis or therapeutic purposes. Frequency of dog baths showed 42% (21/50) at least twice a week, while the others 58% (29/50) responded that they bathed their dogs if only necessary. All personnel revealed 100% (10/10) of *S. pseudintermedius* phenotypes in their nasal cavity, while 52% (26/50) of surfaces within the Veterinary Hospital were contaminated with *S. pseudintermedius.* Seventy-one 71% of the *Staphylococcus pseudintermedius* isolates were multi-drug resistant (MDR) phenotypes, with a very high resistance to tetracycline (67.6%) and erythromycin (44.9%).

Keyword: AMR, MDR, phenotypes**,** *Staphylococcus pseudintermedius,* veterinary hospital.

INTRODUCTION

Staphylococcus pseudintermedius, alongside *Staphylococcus delphini,* and *Staphylococcus intermedius,* are members of the *Staphylococcus intermedius* group (SIG) (Bannoehr and Guardabassi, 2012). The pathogens are coagulase-positive and are found on the skin and mucous membranes of dogs, cats, and horses. Carriage rate per bodies sites including nares (16 to 64%), perineum-rectum (28 to 72%), mouth (42 to 74%), and groin (16 to 38%) have been reported (Devriese *et al*., 2005; Sasaki *et al*., 2007; Bannoehr *et al*., 2007; Bannoehr and Guardabassi, 2012; Carroll *et al*., 2021). The carriage rates in non-canine species including horses and cats appeared to be less than in dogs, with only about 6.8% of cats being colonized compared to 46.2% of dogs (Hanselman *et al*., 2009; De Martino *et al*., 2010).

The food chain has considerably been fingered as a major source of zoonotic resistant bacteria (Terzungwe *et al*., 2018). However, the scientific community has noted that this approach leads to the under-reporting of other reservoirs of pathogenic resistant zoonotic bacteria which ignores the roles of pets and companion animals as sources of resistant pathogens for humans. This fact relates to the large number of dogs (approximately 2 million) in Nigerian households, and increased level of contact between companion animals and humans (physical contact by petting, licking, and touching based on the perception that dogs are now considered as family members) offers a great opportunity for a sustained circulation of resistant bacteria between humans and animals (Terzungwe *et al*., 2018; Cuny *et al*., 2022; Moses *et al*., 2022; Gado *et al*., 2023).

Antimicrobial use in humans and pets is essentially the same, given that antimicrobial preparations for human use and active ingredients of interest in the treatment of human infections are identical to those used in dogs (Guardabassi *et al*., 2004; Dickson *et al*., 2019; Cuny *et al*., 2022). In Nigeria, antimicrobial use in pets and companion animals has not been strictly regulated, thus, pets, particularly dogs constituted a major hub for the spread of antimicrobial resistance (AMR) (Palma *et al*., 2020). Most often, the prolonged use of antimicrobial human preparations with broad-spectrum activities such as cephalosporins, fluoroquinolones, and aminopenicillins and clavulanic acid contributes to the spread of antimicrobial resistance within the veterinary setting (Kadlec and Schwarz, 2012; Little *et al*., 2019). Studies has found that veterinarians that were colonized with *S. pseudintermedius* may point towards animal to human transmission (Feßler *et al*., 2018). Nienhoff *et al*. (2009) reported a case of human to animal transmission where dogs were colonized by Methicillin-Resistant Staphylococci (MRS) species that originated from their owners. Other studies also reported the roles of veterinarians in the dissemination of *S. pseudintermedius* within the veterinary clinical environment (Walter *et al*., 2016; Feßler *et al*., 2018). *S. pseudintermedius* and other members of the non-aureus staphylococci species often show multiple drug resistance characteristics, they can thrive within the hospital environment where pet dogs are brought in for treatment. Due to the sustained exchange of these pathogens between pet dogs and humans with the involvement of the environment, it is pertinent to screen the hospital environment, animal health attendants, and veterinarians who had contacts with these facilities for these pathogens. Because this close interactions help to maintain the circulation of resistant microbes between pet dogs, their owners, and individuals considered as at-risk groups (Veterinarians, animal health workers, veterinary students etc). Thus, this study aimed to determine the carriage of *Staphylococcus pseudintermedius* on dogs, surfaces, and personnel at the University of Jos Veterinary Teaching Hospital.

MATERIALS AND METHODS

Ethical statement

All sampling procedures involving animals was performed according to the relevant guidelines for the care and use of animals approved by the Institutional Animal Care and Use Committee of the University of Jos, Plateau Nigeria, with Ref. No. UJ/FPS/F17-00379.

Study area

The Veterinary Teaching Hospital (VTH), University of Jos is located near the Jos Polo Club within the Jos metropolis, Plateau State, Nigeria (Figure 1). The facility was the former Plateau State Veterinary Hospital, owned by the Plateau State Government until the year 2015, when it signed a Memorandum of Understanding with the Faculty of Veterinary Medicine, University of Jos to train undergraduate veterinary students and providing clinical services. All dogs sampled were registered with the VTH for the purpose of treatment (medical and surgical), vaccination or for routine prophylaxis. The roles played by canine pet in the dissemination of resistant bacteria and resistance genotypes informed the decision to carry out this study.

Sampling

A cross-sectional study using convenience sampling method was conducted between August to October 2023. Swab samples from client-owned dogs, personnel (Veterinarians and animal health technologist), and surfaces (door handles, examination tables, weighing scales, medical equipment (thermometers, drip stand and

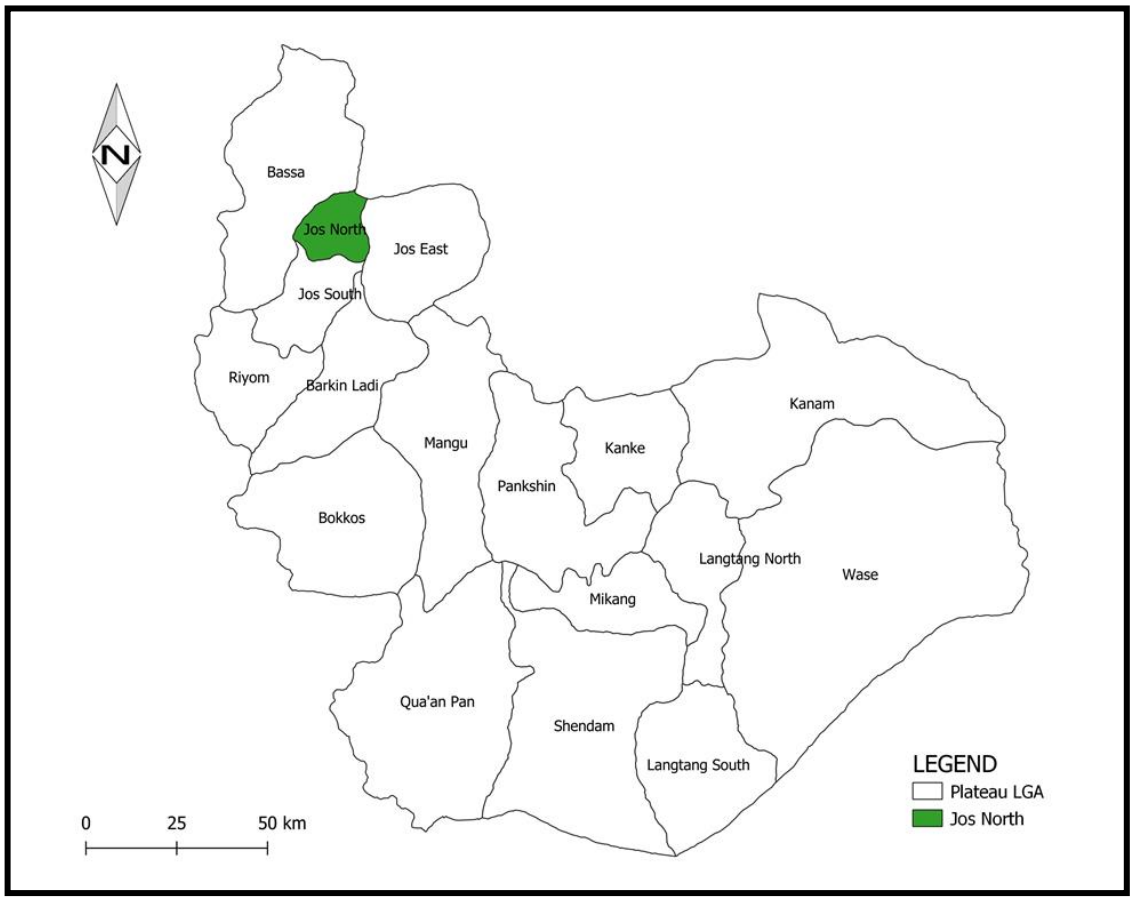

Figure 1. Map of Plateau State showing Jos North the host Local Government Area where the Veterinary Teaching Hospital is located.

trays, floors and refrigerators doors) of the Veterinary Teaching Hospital were collected and used. The VTH has over 30,000 clientele and patients cutting across different animal species, with canines constituting over 70%. On average, more than 30 dogs of different breeds pass through the Veterinary Teaching Hospital daily. A total of 210 samples from fifty dogs (50 swab samples each from the nares, oral cavity and perineum), ten nasal swabs from personnel (based on willingness to participate in the study, and fifty surface swabs were aseptically collected and used for this study. Immediately upon admission, swab samples were taken from the oral cavity, nares, and perineum of each apparently healthy dog having obtained informed consent from the dog owners. Briefly, a sterile cotton swab (Recombigen Laboratories Private Limited) was inserted and rotated severally against the surfaces of the perineal area to collect a sample. The same method was repeated with a different swab in the nares and oral cavity. Surface swabs were collected from different surfaces across the hospital. On the floor, surface swab sampling was performed at 1 cm^2 per site, whereas on tables and equipment, surface swab sampling was performed by rolling a cotton bud around the surface as described by Dancer (2004). Samples were carefully packaged in ice and transported in a sealed box to the Veterinary Microbiology Laboratory for processing.

To establish factors linked with the carriage of *S. pseudintermedius* in dogs, information on the following variables animal demographic data, history of previous hospitalization within the last six months, history of antimicrobial use, and for what purpose, presence or absences of dermatitis, otitis, or oral lesions, and frequency of bath were obtained by an administration of 50 questionnaires. The questionnaires were administered to dog owners who agreed to participate in the study.

Isolation and Identification of *S. pseudintermedius*

Swab samples were each directly cultured on Mannitol Salt Agar (MSA) (HiMedia Laboratories Private Limited, Maharashtra, India) and incubated aerobically at 35 ±2°C for 18 hours as described by Holmstrom *et al*. (2020) with modifications (direct culture on MSA instead of Blood agar). Presumptive golden yellow colonies (maximum of three) from each sample were sub-cultured on nutrient

agar and identified using routine bacteriological culture and identification via colony morphology, Gram-staining, catalase test, fermentation of mannitol and susceptibility to Polymyxin B to differentiate between *S. pseudintermedius* from other staphylococci species (Markey *et al*., 2013). Two to three colonies of *S. pseudintermedius* were stored on nutrient agar slant until used for antibiotic susceptibility testing.

Polymyxin B susceptibility test

Susceptibility to Polymyxin B test was performed as described by Holmstrom *et al*. (2020). Briefly, a direct inoculum of McFarland 0.5 (1.5 x 10^8 CFU/mL) was streaked on the entire surface of a freshly prepared Mueller Hinton Agar (HiMedia Laboratories Private Limited, Maharashtra, India). The media was allowed to dry and a 300 µg Polymyxin disc (Oxoid, Basingstoke UK) was carefully placed on the prepared lawn containing the inoculum with the aid of a forceps. The plates were then incubated at 35 ± 2°C overnight, after which the diameter of zone of inhibition were measured using a Vernier caliper and interpreted per the report of Markey *et al*. (2013) where a zone diameter greater than 10 mm represents susceptibility to Polymyxin by *S. pseudintermedius*.

Antimicrobial susceptibility test

Antibiotic susceptibility of *S. pseudintermedius* was tested against eight (8) antibiotics (MASTDISCs ® AST) representing different classes (beta-lactams, phenicol, aminoglycosides, fluoroquinolones, macrolides, tetracyclines, and nitrofurans) using disk diffusion method as described according to the guidelines of Clinical and Laboratory Standard Institute (CLSI, 2013). The antibiotics used included cefoxitin, FOX (30 µg), chloramphenicol, C (30 µg), ciprofloxacin, CIP (5µg); gentamicin, CN (10 µg); tetracycline, TE (30 µg), nitrofurantoin, F/M (300 µg), vancomycin, VA (5 µg) and erythromycin, E (15 µg). Briefly, a standardized inoculum was prepared using overnight fresh cultures of *S. pseudintermedius* suspended in a 4 mL of normal saline solution. The inoculum was adjusted to 0.5 McFarland that contained between 1-1.5 x 10^8 CFU/mL. Using a sterile swab stick, the standardized inoculum of *S. pseudintermedius* was then cultured on a freshly prepared Mueller Hinton Agar (MHA), it was allowed to dry and then antibiotics were placed at equidistant (25 mm) to each other on the surface of the plate. The plates were then incubated at 35 ±1°C for 16 to 18hours. After incubation, the diameter of zone of inhibition was then measured using a digital caliper and interpreted according to CLSI guidelines 2013. Multidrug-resistant *S. pseudintermedius* was defined as resistance to at least one agent in three or more antimicrobial classes (Mohd Asri *et al*., 2021).

Determination of multiple antibiotic resistance index

The multiple antibiotic resistance (MAR) index for each recovered *S. pseudintermedius* isolates was determined by dividing the number of antibiotics to which the isolate was resistant, by the total number of antibiotics evaluated (Krumperman, 1983).

$$\text{MAR Index} = \frac{\text{No. of antibiotics to which the isolate is resistant}}{\text{Total No. of antibiotics tested}}$$

Data analysis

Data were entered into and analysed using SPSS software. The data were analysed using chi-square analysis descriptive statistic to show the occurrence of *S. pseudintermedius* in dogs, personnel, and surfaces and resistance phenotypes. Values with $p \leq 0.05$ are considered statistically significant.

RESULTS

Occurrence of *S. pseudintermedius*

The occurrence of *S. pseudintermedius* phenotypes recovered from dogs, surfaces and personnel at the Veterinary Teaching Hospital is 65.7% (138/210) (Table 1). Carriage rates based on body sites in dogs showed higher rate of colonization of the nasal cavity 74% (37/50) and perineum 72% (36/50) than the oral cavity 58% (29/50) (Figure 2) and the result was statistically significant [$p<0.05$; CI: 0.009-0.13]. Higher carriage rates of *S. pseudintermedius* was observed in dogs on admission 69.2% (9/13) than those brought in for routine pre-mating evaluation 66.7% (24/36). Similarly, male dogs 73.3% (11/15) had higher carriage rate of *S. pseudintermedius* than females 65.7% (23/35). However, this was statistically insignificant ($p>0.05$). According to the breeds of dogs sampled, high rate of colonization by *S. pseudintermedius* was observed in German shepherd dogs 100% (12/12), followed by mixed breeds 60% (6/10), and Caucasians 57.1% (12/21) respectively. In the study, only one sample each were collected from Lhasa, Saint Bernard, Boer bull, and Bull mastiff and all were positive for *S. pseudintermedius*.

Colonization of surfaces showed that 52% (26/50) of the sampled surfaces within the Veterinary Hospital were contaminated by *S. pseudintermedius.* Similarly, *S. pseudintermedius* isolates were recovered in all nasal swabs collected from personnel working at the Veterinary Teaching Hospital. The findings of this study also revealed that higher carriage rates of *S. pseudintermedius* were observed in dogs 68% (34/50) than on surfaces 52% (26/50) and the result is statistically significant [$p<0.05$]. Similar findings were also observed between carriage in dogs and on personnel.

Table 1. Occurrence *S. pseudintermedius* in dogs, surfaces, and personnel (n = 210).

Sample source	No. of *S. pseudintermedius*	Occurrence (%)
Oral cavity (n = 50)	29	29/50(58%)[a]
Nasal cavity (n = 50)	37	37/50(74%)[a]
Perineum (n =50)	36	36/50(72%)[a]
Surfaces (n =50)	26	26/50(52%)[b]
Personnel (n =10)	10	10/10(100%)[b]
Total No. of samples (210)	138	138/210(65.7%)

(a)X^2 = 13.112; P = 0.011; 95% CI: [0.009-0.13]. (b) X^2 = 9.739; P =0.009; 95% CI: [0.007-0.11].

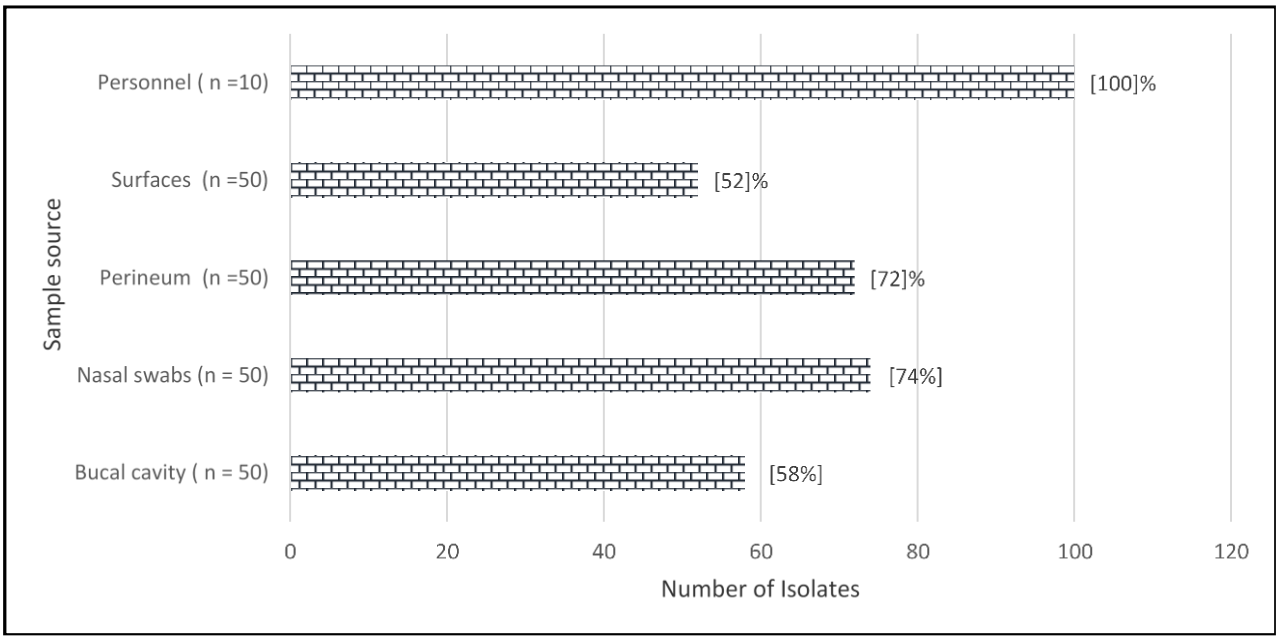

Figure 2. Occurrence of *S. pseudintermedius* species based on different body-sites, surfaces, and personnel (n = 138).

Antimicrobial resistance profiles of *S. pseudintermedius*

Results of antimicrobial susceptibility testing of *S. pseudintermedius* isolates to a panel of eight of antibiotics is shown in Figure 3. The susceptibility profiles evaluated using disk diffusion revealed highest resistance to tetracycline (67.6%) and erythromycin (44.9%) by *S. pseudintermedius*. This was followed by resistance to chloramphenicol (36%), ciprofloxacin (33.8%), vancomycin (28.9%), gentamicin (23.5%), nitrofurantoin (22.1%) and cefoxitin (17.6%). Resistance profiles based on sample sources showed that *S. pseudintermedius* phenotypes collected from dogs were resistant to all tested antimicrobials, whereas isolates from personnel and surfaces were resistant to six antibiotics (Table 2). Based on sample sources, 18.5%, 18.9% and 27.7% of the isolates from the oral cavity, nares and perineum were resistant to cefoxitin. However, only two isolates from personnel (20%) and none from surfaces were resistant to cefoxitin. Isolates from the oral cavity (44.4%), nares (35.1%), perineum (47.2%), personnel (20%) and surfaces (19.2%) were also resistant to chloramphenicol. Highest level of resistance to tetracycline was observed in isolates recovered from oral cavity (72.0%), nares (67.6%), perineum (63.9%), 90% (personnel) and surfaces (69.2%) (Table 2). Variable resistance to ciprofloxacin, erythromycin, gentamicin, nitrofurantoin, and vancomycin were observed in isolates from different sources.

Seventy-one percent (71%) of the isolates showed resistance to more than one class of antimicrobial tested with a multiple antimicrobial resistance index of ≥0.2 (Figure 4). This comprised of 27.5% (27/98), 26.5% (26/98), and 25.5% (25/98) isolates showing resistance to at least two, three and four different classes of antimicrobials, respectively. Furthermore, 11.2% (11/98), 4.08% (4/98) and 2.04% (2/98) isolates each showed resistance to five, six, seven and eight antimicrobials tested (Table 3). The most predominant MDR patterns were C-E-TE, CIP-FOX-TE, C-CIP-E-TE, and CN-CIP-E-TE.

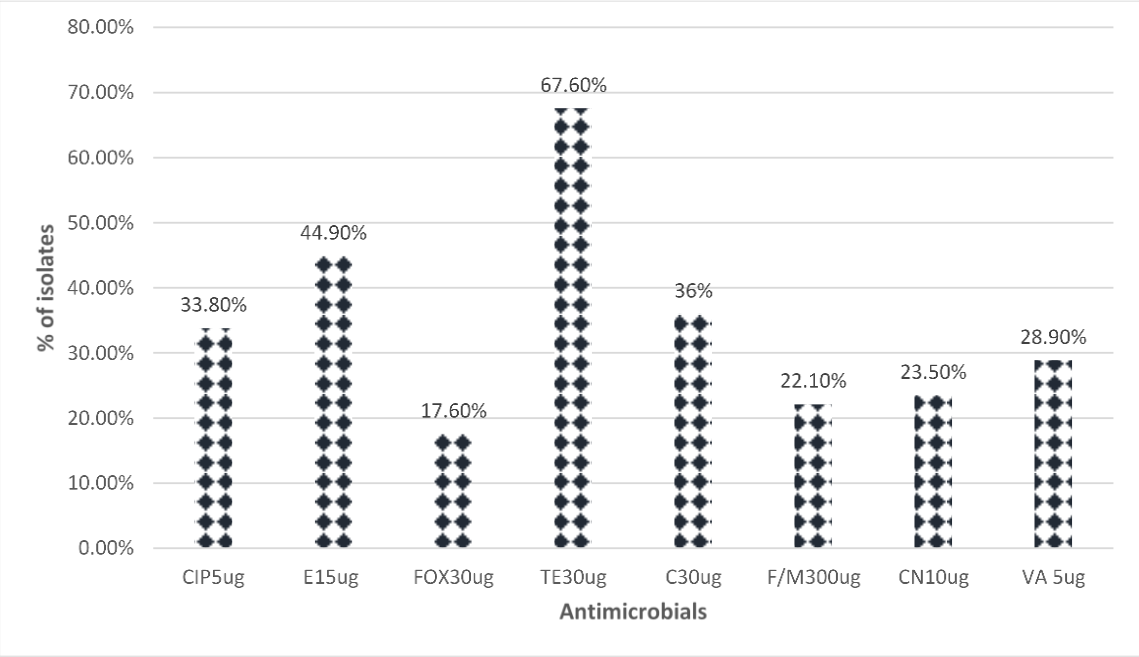

Figure 3. Antimicrobial resistance profiles of *S. pseudintermedius* isolated from dogs, surfaces and personnel working at the Veterinary Teaching Hospital, Polo (n= 138).

Table 2. Antimicrobial resistance of *S. pseudintermedius* from different sources.

Antimicrobials/disc content	Bacteria isolated from dogs			Bacteria isolated from other sources	
	Oral cavity (*n* = 29)	Nasal cavity (*n*= 37)	Perineum (*n* = 36)	Personnel (*n* =10)	Surfaces (*n* = 26)
Cefoxitin (FOX 30 µg)	05 (18.5)	07 (18.9)	10 (27.7)	02 (20)	00 (0.0)
Ciprofloxacin (CIP 5µg)	07 (25.9)	12 (32.4)	09 (25.0)	09 (90)	09 (34.6)
Chloramphenicol (C30 µg)	12 (44.4)	13 (35.1)	17 (47.2)	02 (20))	05 (19.2)
Erythromycin (E15µg)	09 (33.3)	14 (37.8)	22 (61.1)	03 (30)	13 (50)
Gentamicin (CN 10 µg)	07 (25.9)	08 (21.6)	10 (27.7)	0 (0.0)	07 (26.9)
Nitrofurantoin (F/M 300 µg)	08 (29.6)	06 (16.2)	10 (27.7)	04 (40)	02 (7.7)
Tetracycline (TE 30 µg)	21(72.0)	25 (67.6)	23 (63.9)	09 (90)	18 (69.2)
Vancomycin (VA 5 µg)	10 (34.5)	08 (21.6)	13 (36.1)	02 (20)	07 (26.9)

Management practices and characteristics of the dogs

A total of 50 dogs were sampled and swab of the nares, oral cavity, and perineum were collected, consisting of 70% (35/50) females and 30% (15/50) males. Forty-two percent (42%; 21/50) were Caucasians, while others breeds included German shepherd 24% (12/50), mixed breed 20% (10/50), Lhasa Apso and Boer bull 8% (4/50), and one dog each for Saint Bernard and Bull mastiff respectively. Twenty-eight percent were 28% (14/50) sick. With only about 12% (6/50) showing clinical symptoms of dermatitis. Based on clinical examination, only 4% (2/50) had otitis and 2% (1/50) with oral lesions. Ten percent (10% (5/50)) had history of previous surgeries within the last six months and 64% (32/50) had history of antimicrobial use for either prophylaxis or therapeutic purpose. Frequency of dog bath showed that 42% (21/50) of owners bath their dogs at least twice a week, and 58% (29/50) responded that they bath their dogs when necessary.

DISCUSSION

In this study, the overall carriage rate of *S. pseudintermedius* in dogs, surfaces, and personnel at the Veterinary Teaching Hospital (VTH) was 65.7% (138/210). This result comprised of carriage in dogs 68% (34/50), surfaces 52% (26/50) and personnel 100% (10/10). The carriage of *S. pseudintermedius* on different body sites

showed the nares and perineum as the most frequently colonised sites carrying *Staphylococcus pseudintermedius* than the oral cavity. The carriage rate in this study is higher than those reported from nares of dogs 41(28.7%) and their handlers 6 (4.3%) in Abakiliki, South-eastern Nigeria and in Zambia (47.5%), comprising of 69.5% in companion animals and 16.7% from the hospital surfaces (Youn *et al*., 2014; Moses *et al*., 2022). Similarly, the carriage rates of *S. pseudintermedius* reported in this study is higher than the rates reported in hospitalized dogs and in dogs without history of hospitalization (0 to 7%) (Norström *et al*., 2009; Van Duijkeren *et al*., 2011; Kjellman *et al*., 2015; Grönthal *et al*., 2017). The differences in carriage rates reported in this study from other works cited, may likely be due to one of many of these variables including the criteria used for the selection of the studied population, the number, and types of body sites (nasal cavity or multiple body sites), sample type, health status of the dogs, history of hospitalization and antimicrobial use and method of sampling other body sites. Other important variables include methods of isolation (direct plating or selective enrichment), identification methods (genotypic or phenotypic), and breed predisposition. Multiple body sites, and direct plating was used, and identification in this study was based on bacteriologic methods using phenotypic characteristics, which may have accounted for the high recovery rate reported in this study. In a study conducted in Denmark where one hundred and ten (n =110) dogs were sampled. It was reported that sampling multiple body sites increases the chances of recovery of *S. pseudintermedius* in apparently healthy dogs by 90% and increases the sensitivity of carriage in oral cavity by 26% and perineum (25%) (Bannoehr and Guardabassi, 2012). Carriage of *S. pseudintermedius* in dogs is a major public health problem, due to the closeness elevation between canine pets and humans. The relationship gap between dog and their owners is narrower than what it used to be, with dogs now being considered as members of the family. This gives room for circulation of pathogenic and resistant strains between humans and animals since they are granted unfettered access to owners and their families. A major downside to this close interaction being the inability to achieve successful decontamination of the home, and hospital environment, reduction in treatment options and prolonged hospitalization due emergence of multiple drug resistant bacteria. And since dogs are not the only species colonized by *S. pseudintermedius*, their presence on dogs reported in this study also put other pets and their owners who patronises the veterinary facility at risk.

According to a study conducted in Thailand, 73% of the areas sampled colonized by *S. pseudintermedius*, become proof in evaluating the colonization of new veterinary facilities after a series of decontamination (Fungwithaya *et al*., 2022), *S. pseudintermedius* were recovered from surgical tables and other equipment.

This was similar to the 26/50 (52%) of *S. pseudintermedius* recovered from various surfaces

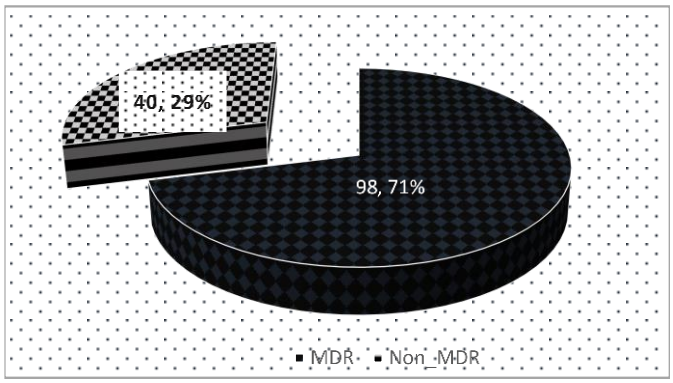

Figure 4. MDR phenotypes of *S. pseudintermedius* isolated from dogs, surfaces and personnel at Veterinary Teaching Hospital Polo (n = 138).

sampled within the VTH. This discovery is quite worrisome due to the staphylococci species's long survival ability (more than 4 months) in the environment (Gupta *et al*., 2017), resulting in transmission sources to other pets, their owners, and personnel. Besides, their survival in the environment also gives room for acquisition of resistance and virulence determinants from competent donor cells. Thus, facilitates the incessant circulation of resistant phenotypes between animals, humans, the environment (a major hub that facilitates the transmission of bacteria). In addition to contamination of surgical sites, and outbreaks of health-care related infections, especially in dogs on prolonged admission giving rise to the onset of hospital-associated infections.

Resistance profiles of *S. pseudintermedius* reported in this study showed that majority of the isolates were MDRs, that is resistant to three or more antibiotics from different classes of antimicrobials (Mohd Asri *et al*., 2021) (Figure 4 and Table 3). MDRs is a major problem in low- and middle-income countries, particularly due to weak regulations with respect to the use of antimicrobials in animals. The emergence of these MDRs negatively impacts treatment options in both animal and human health sectors, leading to reduction in treatment options, prolonged length of hospitalization and increase in the cost of treatment. The isolates were resistant to antimicrobials belonging to different antimicrobial classes including glycopeptide, macrolides, fluoroquinolones, oxytetracyclines, aminoglycosides, phenicol, nitrofurans, and beta lactams. These antimicrobials are commonly used in the small animal practice at the facility and many other veterinary settings in the region. Most *S. pseudintermedius* isolates recovered in this study were resistant to tetracycline and erythromycin. This similar with the reports of Tabatabaei *et al*. (2019), where the authors reported high levels of erythromycin and tetracycline when 49 dogs, 26 cats and 50 veterinary staff were sampled. Tetracycline resistance is associated with a decrease in intracellular accumulation of the antibiotic. In staphylococci species, resistance

Table 3. MDR patterns of *S. pseudintermedius* isolates from dogs, surface and personnel.

Resistance profile	No. of isolates	Multiple antimicrobial index ≥0.2
Double resistance (Resistance to two antimicrobials)		
C-TE	4	0.3
FM-TE	2	0.3
TE-VA	4	0.3
E-CIP	1	0.3
CIP-TE	3	0.3
CIP-C	1	0.3
E-TE	5	0.3
FOX-CN	1	0.3
TE-CN	1	0.3
C-CN	1	0.3
E-VA	2	0.3
E-C	1	0.3
FM	1	0.3
Total (n)	*27*	
Multiple resistance (Resistance to three antimicrobials)		
C-TE-FM	2	0.4
CIP-FOX-TE	4	0.4
CIP-CN-TE	1	0.4
C-CN-TE	2	0.4
CN-TE-VA	2	0.4
C-E-TE	5	0.4
CIP-TE-VA	2	0.4
C-CIP-FOX	2	0.4
CIP-FOX-TE	1	0.4
E-FM-TE	2	0.4
C-TE-FOX	1	0.4
E-TE-VA	1	0.4
FM-FOX-TE	1	0.4
Total (n)	*26*	
Multiple resistance *(Resistance to four antimicrobials)*		
C-CIP-E-TE	5	0.5
CIP-E-FM-TE	2	0.5
CN-CIP-E-TE	4	0.5
C-CIP-E-VA	1	0.5
C-E-TE-VA	2	0.5
CN-FM-FOX-TE	2	0.5
CIP-E-FOX-TE	1	0.5
C-CN-CIP-FM	1	0.5
CIP-E-FOX-VA	1	0.5
C-CIP-E-FOX	1	0.5
CIP-E-TE-VA	1	0.5
CN-E-TE-VA	1	0.5
CIP-FM-FOX-VA	1	0.5
C-CIP-FM-TE	1	0.5
CIP-E-FOX-TE	1	0.5
Total (n)	*25*	

Table 3. Contd.

Multiple resistance (Resistance to five antimicrobials)		
C-CIP-E-TE-VA	1	0.6
C-E-FM-TE-VA	1	0.6
C-CN-E-FOX-TE	1	0.6
CN-E-FM-FOX-VA	1	0.6
C-CN-FM-FOX-VA	1	0.6
C-E-FOX-TE-VA	1	0.6
C-CN-E-FM-FOX	1	0.6
C-CIP-E-FM-FOX	1	0.6
C-CN-CIP-E-TE	1	0.6
CIP-CN-E-TE-VA	2	0.6
Total (n)	*11*	
Multiple resistance (Resistance to six antimicrobials)		
C-E-TE-FM-FOX-VA	1	0.8
C-CIP-E-FM-TE-VA	1	0.8
C-CN-E-FM-FOX-VA	1	0.8
C-CN-E-TE-FM-VA	1	0.8
Total (n)	*4*	
Multiple resistance (Resistance to seven antimicrobials)		
C-CIP-E-FM-FOX-TE-VA	1	0.9
C-CIP-CN-E-FM-TE-VA	1	0.9
Total (n)	*2*	
Multiple resistance *(Resistance to eight antimicrobials)*		
C-CIP-CN-E-FM-FOX-TE-VA	2	1.0
Total (n)	*2*	

C: Chloramphenicol, CIP: Ciprofloxacin, CN: Gentamicin, E: Erythromycin, FM: Nitrofurantoin, FOX: Cefoxitin, TE: Tetracycline, and VA: Vancomycin.

to tetracycline was initially linked with reduced uptake. However, resistance to tetracycline may more likely be the result of a specific efflux mechanism that is like what obtains in strains of *Escherichia coli* (Bitrus *et al*., 2016a). It is important to note that these are frequently used antimicrobials in dogs and their resistance determinants (*tet*K, *tet*L, *tet*M, *tet*O, *erm*A and *erm*C) are plasmid coded (Ruzauskas *et al*., 2016) and tetracycline resistance in SP is mostly due to *tet*M. Significant levels of resistance to chloramphenicol and ciprofloxacin were also observed in this study. These two antimicrobials are considered as drug of last resort in small animal practice. There usage is mostly in situations where unsatisfactory treatment with some extended spectrum antimicrobials is encountered. More worrisome is the fact that a lot of substandard products (with little to no active ingredients of the drugs) are circulating in the markets. The high resistance rate of these antimicrobials may also be caused by selective exposure pressure to sub-optimal doses of these agents. Small animal practice is a booming business on the Plateau. Despite authorities making efforts to regulate the sector, many sharp practices by individuals parading themselves as veterinarians still exist. This includes treatment by under or overdosing the animals, and treatment without recourse to susceptibility testing. Prolonged exposure to these agents leads to resistance development. In addition, vancomycin and gentamicin resistance were also observed, while these two antimicrobials are considered critically important in veterinary practice. However, the use of vancomycin in small animal practice is banned in most countries. Resistance to vancomycin may be due to the emergence of low-level vancomycin-resistant strains that have been associated with failures in treatment options (Bitrus *et al*., 2016b). Resistance to nitrofurantoin and cefoxitin are also of clinical significance, even though phenotypic resistance to cefoxitin by *S. pseudintermedius* does not mean the isolates are methicillin resistant strains or carried the *mec* gene. The threat of resistance development to some of the very critically important antibiotics leads to a reduction in treatment options, increase in treatment cost, and prolonged hospitalization. In addition, some of the

antimicrobials used in this study, fluoroquinolones and other critically important antimicrobials for human medicine were discovered to be widely used in animals as prophylactics. Resistance to potentially harmful antimicrobials including furazolidones (nitrofurans) and chloramphenicol that have been banned for use in humans and animals were reported in this study.

This study has some limitations, only dogs registered at the Veterinary Teaching Hospital were included in the study and sampled. Additionally, due to lack of resources, detailed genotypic characterisation was not carried out. Genotypic characterisation would have been very valuable to know the sequence types and resistant genotypes circulating amongst dogs and humans at the Veterinary Hospital. Furthermore, the study reflects the occurrence of *S. pseudintermedius* within Jos metropolis and may vary according to geographical location. These limitations would be addressed in future research. In conclusion, high carriage rate of *S. pseudintermedius* was observed in dogs, personnel, and surfaces of veterinary teaching hospital. A significant proportion of which were MDRs. They were resistant to cefoxitin, gentamicin, ciprofloxacin, erythromycin, tetracycline, vancomycin, chloramphenicol, and nitrofurantoin. The fact that most of these isolates were recovered from apparently healthy animals, means that antimicrobials for veterinary use is becoming less effective, hence, imposing a serious challenge to animal health. It is recommended that emphasis be placed on active surveillance of antimicrobial resistance within the animal health sector.

CONFLICT OF INTEREST

The authors declare no conflict of interest with regards to the publication of this manuscript. All authors read and approved the final version of this manuscript.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the management of the Veterinary Teaching Hospital, University of Jos for granting access to use the facility for sample collection. We are equally grateful to the dog owners and personnel working at the facility who graciously provided the sampling permission. Many thanks to the staff of Veterinary Microbiology Laboratory for providing technical assistance during this research work.

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