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Staphylococcus aureus in two municipal abattoirs in Nigeria: Risk perception, spread and public health implications

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ABSTRACT

Staphylococcus aureus is a zoonotic pathogen of significant public health concern. Information on the prevalence and risk factors facilitating bacterial colonization and spread under abattoir settings in Nigeria are scarce. This cross-sectional study was designed to determine prevalence of *S. aureus* as well as risk factors on knowledge and practices facilitating pathogen carriage among workers and slaughter animals in two municipal abattoirs of Ilorin and Ibadan, Nigeria. Swab samples (n = 1671) from nostrils of cattle, goats, pigs and abattoir workers, and from meat tables and abattoir walls were collected for detection of *S. aureus*. A questionnaire was administered to 275 workers to elucidate risk factors of pathogen carriage applying a logistic regression model. *S. aureus* prevalence was 6.5%. In total, MSSA and MRSA were detected at a frequency of 5.4% and 1.1%. Molecular analysis of the isolates revealed 19 different *spa* types, including a novel *spa* type (t16751). Gender, marital status, occupation and abattoir location were factors influencing worker's practices in relation to pathogen carriage and spread in the abattoir setting. This present study detected not only low MSSA and MRSA prevalence, in both abattoirs but also low risk perception and hygiene practices employed by abattoir workers. Good practices among workers at Nigerian abattoirs are needed to mitigate *S. aureus* carriage. Further studies expounding the antibiotic resistance and relationships of MSSA and MRSA strains detected in this study are needed to complement understanding of the spread of *S. aureus* in the abattoir food chain.

1. Introduction

Foodborne diseases (FBD) in humans are an important public health concern worldwide (Kadariya et al., 2014). Poor hygienic conditions and unfavorable handling of food, in particular animal-derived food contaminated with pathogenic zoonotic bacteria may have a great impact on the occurrence of FBD (Abunna et al., 2016). Food handlers at abattoirs applying poor personal hygiene also need to be considered to play an important role in the dissemination of zoonotic bacteria along the farm-to-fork food chain (World Health Organization (WHO), 1989). Interaction of food handlers with food-producing animals in the abattoir can also be a risk factor for the contamination of meat with zoonotic pathogens and further transmission within the food processing environment (Normanno et al., 2015). The few available studies addressing risk factors facilitating spread of zoonotic bacteria under abattoir settings in Nigeria have identified occupational exposure as a major risk factor for the development of diseases such as brucellosis (Aworh et al., 2013) and leptospirosis (Abiayi et al., 2015).

Staphylococcus aureus belongs to the normal flora including skin, nose and mucous membranes of healthy humans and animals (Lozano et al., 2016). *S. aureus* is a pathogen which frequently causes community-associated and nosocomial infections. It is also a major cause of foodborne disease worldwide due to its ability to produce different types of enterotoxins preformed in food (Doyle et al., 2012; Kadariya et al., 2014). The worldwide spread of methicillin-resistant *Staphylococcus aureus* (MRSA) and methicillin-susceptible *Staphylococcus aureus* (MSSA) strains has become a serious challenge for human infection control and antibiotic therapy (Fall et al., 2012; Pantosti, 2012). *S. aureus* causes a wide range of mild to severe human infections in hospitals and the community (Falagas et al., 2013). In the last decade an expansive spread of MRSA mainly of clonal complex (CC)398 of livestock origin along the farm-to-fork food chain has been shown around the globe (Aires-de-Sosa, 2017), including the African continent (Lozano et al., 2016). These so-called livestock-associated (LA)-MRSA

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also emerged among humans, mainly in livestock professionals such as veterinarians, butchers, livestock farmers, animal handlers and meat traders indicating a zoonotic transmission from animals to humans (van Loo et al., 2007; Goerge et al., 2017). Asymptomatic carriage of MRSA in livestock could be a risk factor not only for zoonotic transmission but also for food contamination (Doyle et al., 2012). Thus, it becomes imperative to determine the colonization of food animals and abattoir workers as well as contamination of slaughterhouse environment with. Some studies exist on the occurrence of *S. aureus* in Nigeria. The prevalence of *S. aureus* in cattle, goats and abattoir workers were 45.7%, 39.7% and 29.7% respectively at the Maiduguri abattoir, Northeast Nigeria (Gulani et al., 2016). Sampling food animals and humans within the Maiduguri metropolis (Northeast, Nigeria), Adamu et al. (2010) reported prevalence of 52.3%, 37.5% and 30.0% for healthy humans, cattle and goats respectively. The detection rate for *S. aureus* was 23% in meat sellers in Southeast, Nigeria (Nworie et al., 2013). None of these studies provided information about the molecular characteristics of the detected *S. aureus* isolates. Reports from other parts of the country are limited leading to a gap in the understanding of the epidemiology of *S. aureus* in Nigeria.

This cross-sectional study aimed to determine the prevalence and characteristics of *S. aureus* among abattoir workers, slaughtered animals and the abattoir environment of two municipal slaughterhouses in Nigeria. In addition, we investigated the risk perception of abattoir workers and association between demographic characteristics and knowledge regarding pathogen carriage and spread among abattoir workers. Finally, practices employed during abattoir operations influencing pathogen carriage among workers were elucidated. Our results will help to establish risk mitigation strategies to prevent further spread of zoonotic pathogens along the farm-to-fork food chain in Nigeria, thus filling the information deficits in this regard.

2. Materials and methods

2.1. Study areas

The research was conducted in two large municipal abattoirs (Ibadan and Ilorin) of two states (Oyo and Kwara, respectively) (Fig. 1). The choice of these states is due to high number of food animals slaughtered on daily basis as well as the high human population density. Ibadan is located at the Southwestern geo-political zone of Nigeria and currently ranked as the 3rd densely populated city with about 3,565,108 inhabitants (see: http://worldpopulationreview.com/countries/nigeria-population/). On average, 342 cattle are usually slaughtered daily at Ibadan abattoir (Ogunbodede and Oladele, 2016). In contrary, Ilorin is found at the Northcentral geo-political zone. Ilorin is ranked as 11th most inhabited city in Nigeria with a population of 814,192 inhabitants.

2.2. Study design

A cross-sectional survey was carried out from March to December 2016 and included a questionnaire survey among abattoir personnel and sampling (from humans, food animals and the environment). Targeted populations were veterinarians, para-veterinarians, butchers, meat traders (workers who buy, process and sell products from food animals slaughtered at the abattoir), other abattoir workers (workers providing services to butchers and meat traders within the abattoir), and non-meat workers (workers not handling slaughtered animals and/or meat but working within the vicinity of an abattoir, such as administrative personnel) employed at the two municipal abattoirs. Targeted food animals include cattle, goats and pigs destined for slaughter.

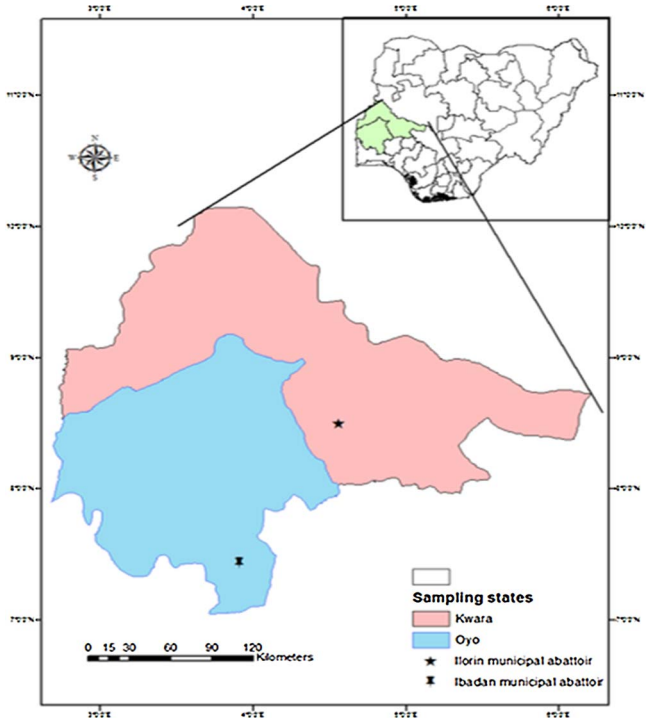

Fig. 1. Map of the study areas showing the location of two abattoirs in Kwara and Oyo states.

2.3. Questionnaire design, implementation and data collection

The questionnaire consisted of structured questions divided into two major sections (Supplementary file 1), the first of which comprised questions regarding the demographic characteristics of participants (age, gender, marital status, having children under the age of 5 years, level of formal education, occupation and abattoir location) and the second part covering questions regarding the knowledge levels and practices related to the risk of bacterial (including *S. aureus*) colonization and spread in the abattoir among surveyed workers. The questions to ascertain the participants level of knowledge related to bacterial colonization included the following: the prominent symptoms of bacterial infection and the association of pathogens with livestock, companion animals, community, hospitals and healthcare facilities. Questions were also asked on bacterial contamination of food during processing and zoonosis. Among respondents, practices related to substance use, infection control, animal contact, and hospital exposure-related practices were also examined (see Supplementary file 1 for further details).

The questionnaire was pretested on a group of butchers at the Ilorin abattoir and improved based on feedbacks before final administration. The questionnaire was randomly administered to members of the target population who had spent at least one year working in either of the two abattoirs. Six enumerators (3 for each study area) were trained in the administration of the questionnaire. Respondents provided informed consent orally and were allowed to voluntarily withdraw from the study at any time. The Ethical Review Committees of the Ministry of Health, Oyo State (AD13/479/1079) and University of Ibadan Animal Care and Use Committee (UI-ACUREC/App/2016/018) approved the study.

2.4. Sampling and sample collection

At each visit, samples were obtained using dry and sterile swabs – polyester tipped applicator (Puritan®, USA) – from both nostrils/anterior nares of cattle, goat and pigs destined for slaughter, the abattoir workers and abattoir walls and meat processing/display tables for each