Incidence of Chronic Wounds Infections in Kaduna, Nigeria

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ABSTRACT

Wound infection is a common complication affecting wound healing with a variety of organisms co-existing thereby predisposing affected individuals to different degrees of morbidity, severe pain, prolonged hospitalizations, increased cost of healthcare, loss of limbs and mortality. This study determined the incidence and types of bacteria infecting chronic wounds in Kaduna, Nigeria. A total of 150 wound samples were collected from December 2020-November 2021. Bacterial isolation and identification were carried out using standard culturing methods. Demographic data of patients, causes and age of wounds were obtained from medical records. Gender distribution showed male 103 (68.7%) and female 47 (31.3%) giving a male to female ratio of 2.19:1. An isolation rate of 137 (91.3%) obtained showed *Staphylococcus* species as most predominant 102 (60.7%) and *Escherichia coli* 24 (14.3%) as most frequent of Gram-negative species. Others were *Proteus* spp. 22 (13.1%), *Klebsiella* spp. 10 (5.9%), and *Pseudomonas* spp. 10 (5.9%). Age group 30-45 years were most affected by chronic wound infections. Wounds aged 6-24 weeks were most frequently infected. Accident wounds were the most common (37.2%) followed by diabetic foot ulcers (20.0%). Chronic wounds consist of a huge diversity of microorganisms thus requiring constant and appropriate diagnosis for quality of care.

Keywords: chronic wounds, bacteria, age, gender, Kaduna.

INTRODUCTION

The intact skin acts as a protective barrier for the body preventing underlying tissues from becoming colonized and infected by potential pathogens (Mama *et al*., 2014). This protective barrier can be broken following an accident, a pathological condition, or post-surgical thus resulting in wounds. Chronic wounds are wounds that do not heal within a timely and orderly fashion. They show a slowed or interrupted progression through the healing processes due to factors that impact on the individual and their wounds (IIWI, 2016). Exposed subcutaneous tissue provides a favourable environment for invading microorganisms to contaminate and colonise the wounds. Microbial growth becomes optimal where the host immune response is compromised and the tissues hypoxic or necrotic (Bowler *et al*., 2001).

From the moment of skin breakage, all open wounds are generally contaminated with microorganisms and chronic wounds become contaminated with exogenous and endogenous microbial sources (Sibbald *et al*., 2003). Infection is a common complication of wounds and it leads to delay in wound healing, increases the risk of loss of limbs, and life

(IIWI, 2016). Contaminating microbes move into the wound's deeper tissue and proliferate to the extent to invoke a host response which may present as subtle signs that may develop into classic signs of infection particularly in chronic wounds (Siddiqui and Bernstein, 2010).

Chronic wounds are polymicrobial in nature and a wide variety of aerobic and anaerobic microorganisms have been reported (Parajuli *et al.*, 2014). Bacteria, fungi, viruses and protozoa have been found to coexist in communities especially in wound margins and in chronic wounds (Parajuli *et al.*, 2014; Akinkumi *et al.*, 2014). Most bacteriological findings in human chronic wounds have been reported to also be present on the skin, in faeces and water, or individual's endogenous flora (Trostrup *et al.*, 2013). They include *Staphylococcus aureus*, Coagulase negative staphylococci (CoNS), *Enterococcus faecalis*, *Proteus* species, anaerobic bacteria and *Pseudomonas aeruginosa* (Gjobsbol et al., 2006). Other reports have implicated *Streptococcus* and *Peptostreptococcus* species, *Corynebacterium* spp., *Enterobacteriaceae*, *Prevotella* spp., *Prophyromonas*, *Bacteroides fragilis* (Trivedi *et al.*, 2014), *Klebsiella* spp., and *Escherichia coli* (Mama *et al.*, 2014).

Most superficial wounds have been observed to be colonized by endogenous bacterial flora (commensals) or pathogens, of which *S. aureus* is the most frequent (Parajuli *et al.*, 2014). The age of the wound has also been observed to affect the type or species of micro-organisms present (Johnson *et al.*, 2018). Gram-positive bacteria such as *S. aureus* and CoNS decreased dramatically as the wound aged. Thus, older wounds are colonized more by Gram negative bacilli (Patil *et al.*, 2016).

In an otherwise healthy population, chronic wound is not a problem (Sen, 2019). However,

increase in lifestyle diseases and pathological conditions such as diabetes, obesity and cardiovascular diseases have been reported to predispose individuals to non-healing wounds (Sen, 2019; Trostrup *et al.*, 2013).

There are varying aetiologies of chronic wounds, all of which burden the healthcare system and also markedly affect the individuals (Sen, 2019). The condition presents with different degrees of morbidity, severe pain, septicaemia, prolonged hospitalizations, increased healthcare costs, amputation and mortality (Patil *et al.*, 2016). Effective management of chronic wounds can have an outstanding impact on population health, morbidity, improved function and quality of life. Chronic leg ulcers, such as venous ulcers, diabetic and pressure ulcers affect 1-2% of the general population (Serra *et al.*, 2015).

An estimated 400 million people are living with diabetes worldwide (Amin and Doupis, 2016) and it is predicted that by 2030, developing countries will have more people living with diabetes than developed countries (Sen, 2019). A rough prevalence of non-healing wounds in developed countries is estimated between 1-2% of the general population (Nussbaum *et al.*, 2018; Guest *et al.*, 2015), approximately 2% in the US (Jarbrink *et al.*, 2017) and Germany 1% (Heyer *et al.*, 2016). However, in most developing countries, there is limited chronic wounds data (Lotz, 2019), despite substantial economic and quality of life impacts (Danmusa *et al.*, 2016). This study was therefore designed to determine the incidence of chronic wounds in Kaduna, Northwest-Nigeria.

MATERIALS AND METHODS

Study Area

This study was conducted in Kaduna, capital city of Kaduna State. Nigeria. The city is

located on the north-western region of the country, along the Kaduna River at latitude 10.52^0 and longitude 7.43^0. It is a trade centre and major transportation hub for the surrounding agricultural areas due to its rail and road junction. The population of Kaduna city was 760,084 according to the 2006 National Population Census report.

Study Population

This study population comprises in-and out-patients attending four selected health facilities within the city metropolis. Three of these are secondary health facilities namely; Sabo General Hospital (SGH), Rigasa General Hospital (RGH) and, Yusuf Dantsoho Memorial Hospital (YDMH) while the fourth is a tertiary hospital; Barau Dikko Teaching Hospital (BDTH).

Ethical Consideration

Ethical clearance to carry out the study in these hospitals was obtained from the Ministry of Health, Kaduna State for the named secondary health facilities and BDTH Health Research Ethic Committee (BDTH-HREC).

Inclusion/Exclusion Criteria

All in-patients or out-patients attending the hospitals during the period of the study with open, cutaneous wounds lasting beyond 6 weeks who gave consent to participate, were enrolled in the study.

Wound Sample Collection and Processing

Sample collection was done by the attending nursing officer. Wounds swabs were collected with sterile swab sticks using the Levine technique after carefully cleaning the wounds with physiologic saline. Sterile swab stick was rotated over $1cm^2$ while applying sufficient pressure to express fluid within the wound and avoiding the edge or peri-wound skin (Angel et al., 2011).

The wound swab samples were immediately transported to the microbiology laboratory in sterile airtight vials. Samples were cultured in MacConkey, Blood and Chocolate agar media and incubated aerobically for 18-24 hours. The bacterial colonies obtained were further sub-cultured in differential and enriched media to obtain pure, discrete cultures. Gram staining was conducted as a preliminary test. Biochemical tests were carried out for proper identification and classifications.

Statistical Analysis

Data obtained were analysed using Microsoft Excel and SPSS 22.0. Descriptive statistics and Chi-square were employed to interpret results of demographic data, frequency distribution of wounds, wound types, age of wounds, bacterial isolation, and degree of associations. P-value of $p<0.05$ was considered as statistically significant.

RESULTS

A total of 150 wound samples were collected from patients with chronic wounds attending the four selected hospitals from December 2020 to November 2021. Study participants included 103 (68.7%) males and 47(31.3%) females, with ages ranging from 4 months to 85 years with a mean age of 37.7±18.7 (Table 1).

Table 1: Sociodemographic characteristics of patients with chronic wounds in selected health facilities in Kaduna, Nigeria

Sex	Age range in years					
	0-15	16-30	31-45	46-60	Above 60	Total
Male	15(10.0)	28(18.7)	37(24.7)	14(9.3)	9(6.0)	103(68.7)
Female	3(2.0)	10(6.7)	17(11.3)	9(6.0)	8(5.3)	47(31.3)
Total	18(12.0)	38(25.4)	54(36.0)	23(15.3)	17(11.3)	150(100.0)

The rate of infection was highest among the males (67.9%) and age group 31-45 years among both males and females (Table 2).

Table 2: Frequency of bacterial infections based on age and sex of chronic wound patients attending selected health facilities in Kaduna, Nigeria

Age of patients (in years)	Male infected wounds (n/%)	Female infected wounds (n/%)	Total infected wounds (n/%)
0-15	14 (10.2)	3 (2.2)	17 (12.4)
16-30	24 (17.5)	9 (6.6)	33 (24.1)
31-45	33 (24.1)	17 (12.4)	50 (36.5)
46-60	14 (10.2)	7 (5.1)	21 (15.3)
Above 60	8 (5.8)	8 (5.8)	16 (11.7)
Total	**93 (67.9)**	**44 (32.1)**	**137 (100.0)**

Among the four facilities in which this study was carried out, BDTH had the highest number of samples 117 (78.0%) as well as highest infection rate 109(72.7%), followed by YDMH with total samples 27(18.0%) and 23(15.3%) infection rate. All samples from SGH were infected (Table 3).

Table 3: Distribution of bacterial pathogens of wounds of patients based on selected hospitals in Kaduna, Nigeria

Name of hospital	Samples collected (n/%)	Bacterial growth (n/%)	No bacterial growth (n/%)
BDTH	117 (78.0)	109 (72.7)	8 (5.3)
RGH	4 (2.7)	3 (2.0)	1 (0.7)
SGH	2 (1.3)	2 (1.3)	0 (0.0)
YDMH	27 (18.0)	23 (15.3)	4 (2.7)
TOTAL	**150 (100.0)**	**137 (91.3)**	**13 (8.7)**

The 137 samples that yielded bacterial growth (isolation rate of 91.3%) comprised single and polymicrobial infections from which a total of 168 isolates were obtained (Table 4). *Staphylococcus* species was the predominant infecting bacteria as single and polymicrobial infections. *Escherichia coli* was the most predominant Gram-negative bacteria species among the single infections while *Proteus* species was the most prevalent of the Gram-negative species in polymicrobial infections.

Table 4: Distribution of isolates recovered from chronic wound samples of patients attending selected health facilities in Kaduna, Nigeria

Isolates	Single isolates (n/%)	Polymicrobial isolates (n/%)	Total (n/%)
Staphylococcus spp.	83 (49.4)	19 (11.3)	102 (60.7)
Escherichia coli	14 (8.3)	10 (5.9)	24 (14.3)
Klebsiella spp.	2 (1.2)	8 (4.8)	10 (5.9)
Proteus spp.	10 (5.9)	12 (7.1)	22 (13.1)
Pseudomonas aeruginosa	7 (4.2)	3 (1.8)	10 (5.9)
Total	**108 (69.0)**	**50 (30.9)**	**168 (100.0)**

Table 5 shows the distribution of infected wounds based on the age of the wounds. Wounds aged 6-24 weeks were found to be most infected while the least proportion of infected wounds was among the older wounds, one year and above.

Table 5: Distribution of infections and age of chronic wounds of patients attending selected facilities in Kaduna, Nigeria

Age of wounds (weeks)	Infected (n/%)
6-24	109 (79.6)
25-40	18 (13.1)
41-52	6 (4.4)
Above 52	4 (2.9)
Total	**137 (100.0)**

The most predominant cause of wounds was as a result of accident (37.2%), followed by diabetic foot ulcers (DFUs) (20.4%). Table 6.

Table 6: Distribution of infection based on causes of chronic wounds in patients attending selected hospitals in Kaduna, Nigeria

Causes of wounds	Infected wounds (n/%)
Accident	51 (37.2)
Diabetes	28 (20.4)
Surgery	20 (14.6)
Sickle cell disease	4 (2.9)
Carbuncles/abscesses	4 (2.9)
Malignancy	3 (2.2)
Burns	2 (1.5)
Others	25 (18.3)
Total	**137 (100.0)**

DISCUSSION

Previous studies done in Nigeria have considered wounds of varying aetiologies thereby creating a gap in knowledge particularly on bacteriology of chronic wounds. This study shows that male patients within 30-45 years age group were most affected by chronic wounds. This is comparable to studies by Motayo *et al.,* (2013) and Tom *et al.,* (2019). Male gender has been reported to be a dependent factor for both acute and chronic wounds (Agwunglefah *et al*, 2014; Builders and Bassi, 2019; Builders and Oseni-Momodu, 2018), which may be attributable also to their traditional roles, and occupational exposures.

The age bracket most affected regardless of gender, encompasses the most active and productive phase of their lives. This could be explained to reflect the historically prevalent male dominance and their propensity to greater risk-taking, wider participation in physical and social activities thereby exposing them to higher possibilities of experiencing trauma. It also followed that the proportion of infected wounds was highest in the same age group as those having the highest prevalence of chronic wounds, both for the male and female groups. Omole *et al.,* (2014) had earlier suggested that age has a significant effect of development and prevalence of wound infections. Persons in the active age group, and particularly adolescents may not pay much attention to hygiene as they are busy with other physical activities, hence resulting chronic wound infections.

It was observed in this study that BDTH, a tertiary health facility, exhibited the most prevalence of chronic and infected wounds. This may not be unconnected with the facility being a referral and specialty centre. Thus, a greater population of patients compared to the other hospitals in the metropolis, overstretched facility and possibly inadequate infection prevention and control measures to meet the huge demand. Mohammed *et al.,* (2013), Akinkunmi *et al.,* (2014) and Tom *et al.,* (2019) had similar findings in their studies from other tertiary hospitals in Nigeria, so also did Patil *et al.,* (2016) in India.

A high culture positivity rate observed in this study is in agreement with other studies such as Schaumburg *et al.,* (2022), Omoyibo *et al.,* (2018) and Mama *et al.,* (2014). Infection is a major contributor to non-healing wounds and in many cases of chronic wounds, the presence of bacterial biofilms further complicates chronicity because bacteria exist in aggregates of microcolonies embedded in an extracellular matrix making penetration of

antibiotics difficult (IIWI, 2016; Omoyibo *et al*., 2018). We did not find any study with a moderate or less than 50% isolation rate in all cases, be it chronic or acute wounds.

Overall, Gram-positive bacteria were most prevalent and the most frequently isolated organism in this research was *Staphylococcus* species, occurring one-and-a half times more than all the Gram-negative isolates put together. This is in agreement with similar studies from others parts of Nigeria; Abdulfatai *et al.,* (2017), and from other African countries Ghana, Sierra Leone, Ethiopia (Vicar *et al*, 2021; Schaumburg *et al*, 2021; Mohammed *et al*, 2017). Also, from other parts of the world; Hawaii, Bulgaria (Nahid *et al*, 2021; Tzaneva *et al*, 2016) reported predominance of *Staphylococcus* species.

The proportion of Gram-negative bacteria was reportedly higher from the studies by Guan *et al.,* (2021) in China and that of Tzaneva *et al.,* (2016) in Bulgaria. Our result also differs from those of Omoyibo *et al.,* (2018) and Motayo *et al.,* (2013) in Southwestern Nigeria and Patil *et al.,* (2014) from India where there was emergence of Gram-negative bacilli as the predominant organisms.

 The predominance of *Staphylococcus* species may be associated with the fact that the organism is part of the endogenous microflora of the skin. Its prevalence could also be attributable to environmental source of infection. Bacterial aetiology can show geographical variations and may even vary over time within a population (Nahid *et al*, 2021).

Among the Gram-negative bacteria, *E.coli* was the most common infecting organism. This result is similar to that reported by Guan *et al.,* (2021), Tom *et al.,* (2019) and Hailu *et al.,* (2016) but differs from those of Motayo *et al.,* (2013). *Escherichia coli* is a natural flora

of the gastrointestinal tract and may be implicated as infecting agent for patients undergoing procedures involving regions around the rectum. It is also common in unhygienic conditions and a major contributor in nosocomial infections (Mama et al, 2014; Trostrup et al, 2013).

In this study, one-third of the wound samples were polymicrobial and consisted of between 2-4 bacterial species per wound. Patil and colleagues also found a lower degree of polymicrobial distribution in their study. A large-scale retrospective study by Wolcott *et al.,* (2016) revealed that most non-healing wounds are polymicrobial in nature. Our result differs also from James *et al.,* (2008) who reported that 60% of chronic wounds are polymicrobial in nature. The lower percentage obtained from this study may be as a result of the fact that anaerobes were not cultured and chronic wounds have been found to consist also of anaerobes and other microorganisms such as fungi and viruses (Johnson *et al*., 2018; Rhoads *et al*., 2012). Also, surface swabbing and standard culture method may underestimate the extent of microbial nature of non-healing wounds particularly because of the presence of biofilms (Percival, 2017).

The wounds in their first six months were the most infected with majority occurring as a result of accidents. This does not agree with Iyun *et al.,* (2016) who reported diabetic wounds as the most frequent. However, Omoyibo *et al.,* (2018) reported post-traumatic wounds as the most frequent in southwestern, Nigeria. Road traffic incidents are the leading cause of injury among adults and children. Falls are six times more prevalent among children than for adults (Thanni, 2011). It is no wonder that the age-group most affected are the active and productive age which on the basis of activities involved in, could result in various forms of

accidents leading to fracture, loss of function and loss of man-hours and productivity.

The next most prevalent group were those with diabetic foot ulcers (DFUs) having diabetes as co-morbidity. According to other studies by Dorgham *et al., (*2019) and Mtchembu *et al., (*2017), there was high prevalence of bacterial infection in the wounds of diabetic patients. Diabetics are more susceptible to infections due to increased glucose levels, suppressed immune response, decreased blood flow to extremities, and neuropathy. Patients with DFUs who develop antibiotic resistant infections often require amputation of their foot or leg, leading to significant lifestyle impairment, morbidity and mortality; and a quarter of diabetic patients will develop DFU during the course of their disease (Trivedi et al, 2014). The most common cause of amputation in diabetic patients is ischaemia and infection (Dorgham et al, 2019).

CONCLUSION

This study confirms that chronic wounds are often polymicrobial in nature and their bacteriology changes over time. Commensal microorganisms particularly *Staphylococcus* species were highly abundant. Therefore, knowledge of the bacterial aetiology of chronic wounds is crucial for appropriate diagnosis and subsequently, treatment options.

Acknowledgments

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