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Bacteriological Profiles of Multidrug Resistance Bacteria Isolated from Skin and Soft Tissue Infections

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In present study thirty one of bacterial isolates were isolated from twenty six samples collected from different patients suffered with skin infections. The bacteria isolated on culture media (Mannitol salt agar, MacConkey agar and blood agar), identified and determined the antibiotic resistance by vitek 2 system. The results showed that most frequent infection were impetigo, boil and chronic folliculitis 5(19%) at age group (2-17), (18-55) and (18-38) years respectively. According to the gender the infections were more in females 15(57.6%) than males 11(42.3%), of all those infections, impetigo and boil were more common in females 4(15%), while skin cancer and chronic folliculitis were more common in males 3(12%). The results of bacterial isolation showed that 26 (83.87%) of isolates were Gram positive bacteria while 5(16.13%) were Gram negative, The high frequent genus in identified by Vitek 2 system was *Staphylococcus* sp. followed by *Acinatobacter* sp., *Aeromonas* sp., and *Sphingomonas* sp., the most dominant species was *staphylococcus aureus* 11 (35.5%) followed by *Staphylococcus. epidermidis* 8(25.8%). The results of antibiotic resistance to (48) antibiotics from different groups revealed that out of (31) isolates (23) were multi-drug resistance

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bacteria, the more resistance isolates were *Staphylococcus aureus* (R3) was resist to (12) classes of antibiotics followed by *Staphylococcus hominis* (R16) and *Staphylococcus epidermidis* (R18) (9) classes. There has been a concerning rise in the antibiotic-resistant pattern of skin infection-causing *Staphylococcus aureus*. These days, it is imperative to utilize antibiotics wisely and to put antimicrobial stewardship into practice.

Keywords: Skin infection; bacteria; drug resistance.

1. INTRODUCTION

Skin is the largest organ in human body and basic barrier, serving as the first line of defense against bacterial infections. It's not only blocking the pathogens from entry to body from the environment, but also providing a large-scale biological niche for a wide range of bacteria (Ibrahim et al., 2015). Skin and soft tissue infections (SSTIs) are a major cause of morbidity and mortality, they are characterized by a microbial invasion of the skin layers and underlying soft tissues which range in severity from mild to life threatening, the infections can occurs from the uncomplicated cellulitis, to

abscesses, deep tissue necrosis and necrotizing fasciitis (Esposito et al., 2016, Allaw et al., 2023). Bacterial SSTIs are mainly caused by Gram-positive bacteria like *Staphylococcus aureus* and β-hemolytic streptococci and many coagulase-negative *Staphylococcus*, Gram-negative Enterobacteriaceae, non-fermentative bacteria such as *Pseudomonas* spp. and *Acinetobacter bumaniin* can also cause (Allaw et al., 2023, Ramirez et al., 2020). Necrotizing fasciitis, scarlet fever, erysipelas, erythrasma, abscesses, folliculitis, furunculosis, and impetigo have all been related to a numerous of bacterial skin infections (Al-Kahfaji, 2022).

Cellulitis is an acute bacterial infection that is inflaming the subcutaneous tissue around it as well as the deep dermis (Brown et al., 2003). The bacteria that most commonly involved of cellulitis are *S. aureus* and group A streptococci, also Gram negative bacteria *Pseudomonas aeruginosa* and Enterobacteriaceae group (Sari et al., 2022, Joseph et al., 2022). Erysipelas is a severe Streptococcal infection of the skin primarily spreading through the lymphatic vessels (Jendoubi et al., 2019). It's a soft tissue infection involving the upper dermis, it has more distinct margins when compared with other soft tissue skin infections. Impetigo is a superficial soft tissue skin infection infect the epidermis. Is a most common bacterial skin infection in children two to five years of age. Is caused by *S. aureus* or *S. pyogenes* (Linz et al., 2023). Currently, folliculitis is a common skin condition, which an inflammation of the tiny pockets in the skin of hair grow (hair follicles) and the per follicular tissue that can affect healthy people of any age group or any sex. It occurs when bacteria infect hair follicles. Some of resolve spontaneously, but others progress to furuncles (boils), involve adjacent tissue. That is distinguished with red swelling, hard and painful lumps filled with pus. *S. aureus* are most common bacteria cause of these infection (Nasr, 2018, Jappa and Kutre, 2018, Lin et al., 2021).

Resistance to antibiotics is one of the crucial issues related to public health. and one of the most vital threats to the healthcare sector is the rise of antibiotic-resistant microbes. Multidrug-resistant bacteria (MDR) that are deadly pathogenic are rising day by day and pose a very serious threat to human health. Whereas earlier, such antibiotic resistance was only found in nosocomial infections, but it is now become a common phenomenon (Jubeh et al., 2020, Bharadwaj et al., 2022). The spread of "superbugs" that are now resistant to several antibiotics is a serious issue (Davies et al., 2010). These include the ESKAPE pathogens (*Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter* spp.) (Khan and Khan, 2016). The total deaths from methicillin- resistant *S. aureus* (MRSA) are now comparable to those caused by HIV, and it is predicted that by 2050, antimicrobial resistance would be responsible for at least 10 million annual deaths (De Kraker, 2016). So the present study aimed to evaluate the clinical and bacteriological profiles of bacterial isolates in skin infections, including the number and type of potential bacteriological pathogens as well

as antibiotic susceptibility and pattern of isolates because of limited data are available regarding skin and soft tissue infection, mortality rate, and antibiotic susceptibility of bacteria in our hospital settings.

2. MATERIALS AND METHODS

2.1 Samples Collection

A total of 26 samples were collected from patients undergoing skin infections includes cellulitis, erysipelas, impetigo, folliculitis, furuncles and acne (it's a very common skin infection that causes pimples) in Al-Sadr Teaching Hospital, Al-Fyhaa Teaching Hospital, AL-Mauana Teaching Hospital and Tumor center in Basrah province south of Iraq at the period from the beginning of October 2022 to the end of December 2022. The age of patients ranged between 3 - 70 years old. It should be mentioned that all patients in this study were selected depending on their history and clinical examination by specialist doctors. Samples that taken were collected from deep parts of the infection (pus) by a cotton sterile media swab. Then all samples were collected in sterilized containers and transported to a laboratory for isolation.

2.2 Culturing of Bacteria

All swabs were streaking on the media of blood agar, MacConkey agar and Mannitol salt agar the plates incubated at 37 ˚C for 24 hrs. Then observed for the presence of isolated colonies. re-cultured on nutrient agar plates for purification and subsequent experiments.

2.3 Identification of Bacterial Isolates

The vitek 2 system was performed at Al-Bayan laboratory in Basra city by using Vitek 2 kit (NG REF 21 341) (Pincus, 2006).

2.4 Antibiotic Sensitivity Test

The sensitivity and resistance of isolates were tested by using VITEK 2 system (Piddok, 1991).

3. RESULTS

3.1 Skin Infection Frequency

The result of skin infection frequency showed that impetigo was the most frequent infection with percentage 5(19%) followed by chronic folliculitis and boils (furuncles) 5(19%), while folliculitis infection recorded the lowest frequent 1(4%) Fig. 1.

3.2 Skin Infection Percent According to the Age

Table (1) revealed the results of skin infection according to the age. Where the percentage of impetigo, boils (furuncles) and chronic folliculitis was 5(19%) at (2-17), (18-55) and (18-38) years respectively. Folliculitis infection showed the lowest percentage 1(4%) at the age of 73 years old.

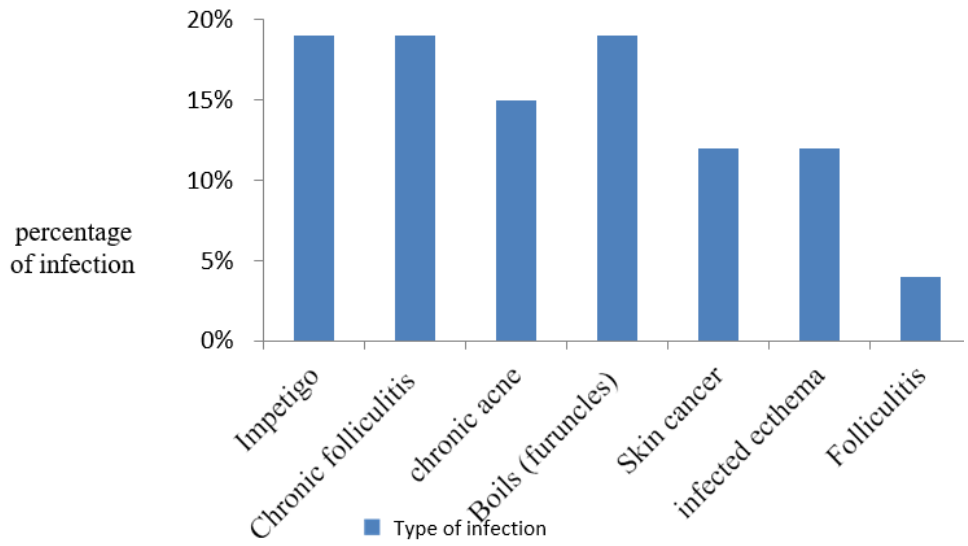

Fig. 1. Percentage of skin infection

Table 1. Percentage of skin infections according to the age

Type of infection	No. of infections per (%)	Age of patients
Impetigo	5 (19%)	2-17
Chronic folliculitis	5 (19%)	18-38
Skin cancer	3 (12%)	25-35
Boils (furuncles)	5 (15%)	18-55
Folliculitis	1 (4%)	73
infected ecthema	3 (12%)	9-50
chronic acne	4 (15%)	27-25
Total	26	

Table 2. Percentage of skin infection according to the gender

Type of infection	Male	Female
Impetigo	1 (4%)	4(15%)
Boils (furuncles)	1(4%)	4(15%)
Skin cancer	3(12%)	0
Chronic folliculitis	3(12%)	2(8%)
Folliculitis	1(4%)	0
infected ecthema	1(4%)	2 (8%)
chronic acne	1(4%)	3(12%)
Total	11 (42.3%)	15(57.6%)

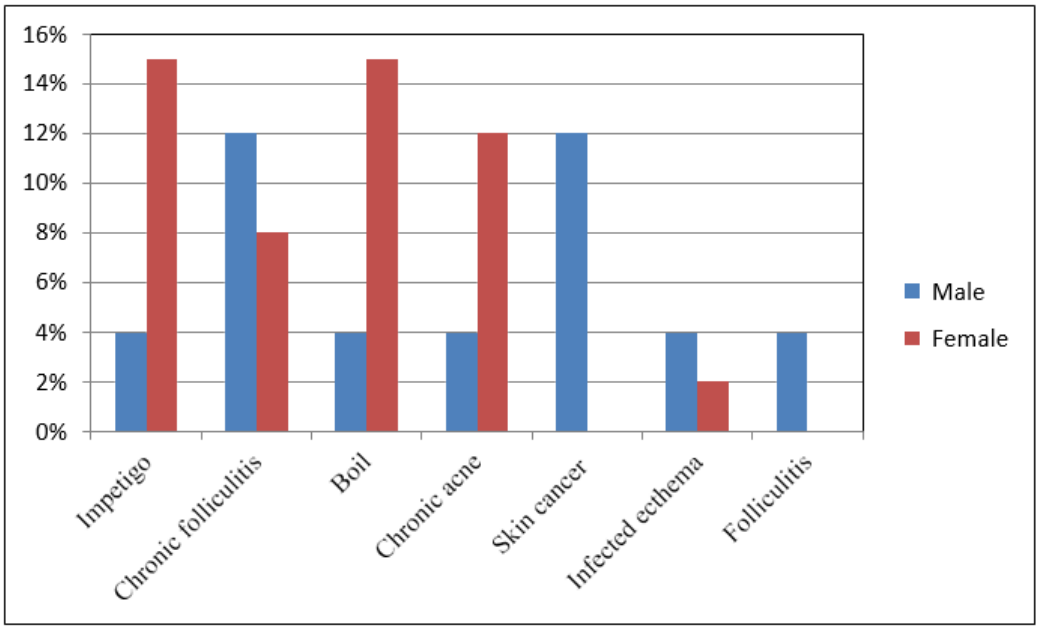

Fig. 2. percentage of infections according to the gender

3.3 Skin Infection Percent According to the Gender

The results showed, that the frequent of skin infection in female (15) was more than male (11), the impetigo and boils (furuncles) showed the highest percentage 4(15%) in female compared to the male where the skin cancer and chronic folliculitis recorded 3(12%) Table (2) and Fig. 2.

3.4 Culturing of Samples and Isolated of Bacteria

All samples were cultured on blood base agar, Mannitol salt agar, and MacConcy agar

media with duplicate. Out of 26 samples, 25 samples showed bacterial growth while one sample showed no. The total of isolates that obtained were 31 and depending on Gram staining, the percentage of Gram positive was high 26 (83.87%) compared to Gram negative 5 (16.13%) Fig. 3.

3.5 Identification of Bacterial Isolates

Thirty-one isolates were identified by Vitek 2 system analysis. The results showed identified 4 genera and 10 species with identity percent about (99-86%) Table (3).

The species of *S. aureus* showed significantly superior percentage 11(35.5%) followed by *S. epidermidis* 8(25.8%), *S. hominis* and *A. baumannii* were 3(9.7%) Table 4 and Fig. 4.

3.6 Antibiotic Susceptibility Test by Vitek 2 System Analysis

Antibiotic Susceptibility of all bacterial isolates was determined by using Vitek 2 Compact System analysis. Bacterial isolates were tested for susceptibility to different antibiotics from different groups. Out of 31 bacterial isolates 23 were shown to be multiple drug resistant (MDR), were resistant to more than three classes of antibiotics and were classified as MDR as shown in Table (5). The isolate of R3 (*S. aureus*) was resistance for 12 classes of antibiotics followed by R16 (*S. hominis*) and R18 (*S. epidermidis*) resist for 9 classes of antibiotic, Table (5).

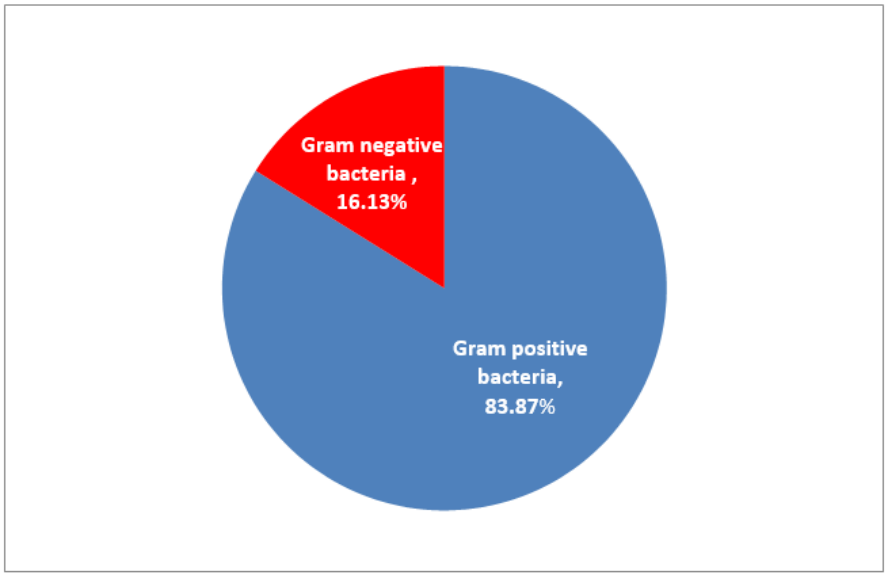

Fig. 3. Percentage of Gram positive and Gram negative bacteria isolated from skin infections

Table 3. Identification of bacterial isolates by vitek 2 system

Sample No	Type of bacteria	Identity
R1	*S. hominis ssp hominis*	94%
R2	*A. baumannii complex*	99%
R3	*S. aureus*	86%
R4	*S. aureus*	95%
R5	*S. aureus*	91%
R6	*S. aureus*	92%
R7	*S. aureus*	87%
R8	*S. epidermidis*	96%
R9	*S. aureus*	92%
R10	*S. aureus*	99%
R11	*S. aureus*	95%
R12	*S. aureus*	92%

Sample No	Type of bacteria	Identity
R13	*S. aureus*	99%
R14	*S. aureus*	99%
R15	*S. epidermidis*	92%
R16	*S. hominis ssp hominis*	95%
R17	*S. epidermidis*	92%
R18	*S. epidermidis*	99%
R19	*A. baumannii complex*	99%
R20	*A. baumannii complex*	99%
R21	*S. warneri*	87%
R22	*S. lentus*	94%
R23	*S. epidermidis*	95%
R24	*S. epidermidis*	95%
R25	*S. epidermidis*	99%
R26	*S. epidermidis*	99%
R27	*S. hominis ssp hominis*	92%
R28	*S. xylosus*	99%
R29	*Sphingomonas paucimobilis*	97%
R30	*S. lugdunensis*	ND
R31	*A. hydrophila/ Punctate (caviae)*	98%

**ND = note done*

Table 4. frequency and percentage of bacterial species identified by vitek 2 system

Vitek 2 system	NO	Per(%)
Staphylococcus aureus	11	35.5 %
S. epidermidis	8	25.8 %
S. hominis ssp hominis	3	9.7 %
S. lugdunensis	1	3.2 %
S. lentus	1	3.2 %
S. warneri	1	3.2 %
S. xylosus	1	3.2 %
Acinetobacter baumannii complex	3	9.7 %
Aeromonas hydrophila/punctate (caviae)	1	3.2 %
Sphingomonas paucimobilis	1	3.2 %

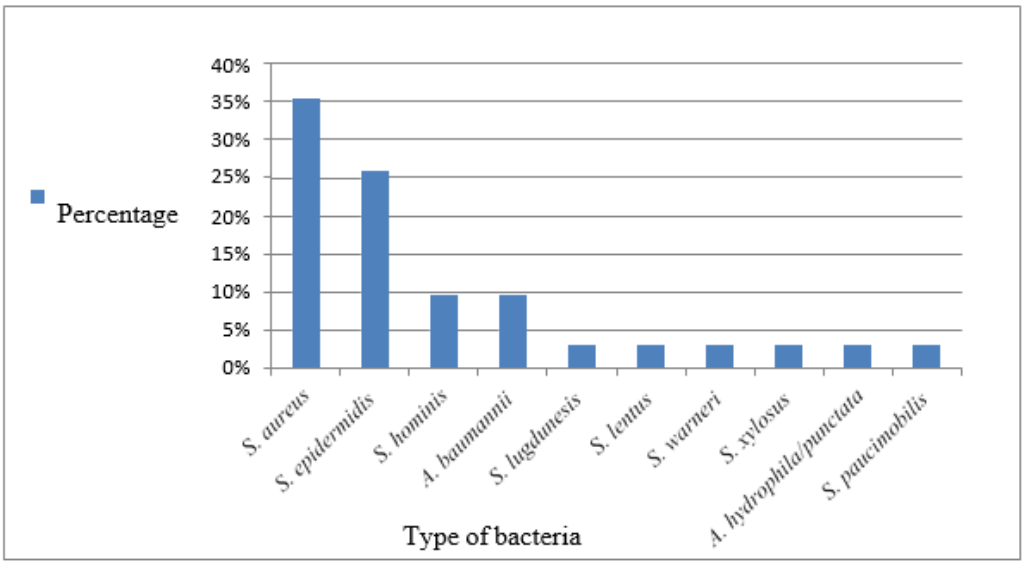

Fig. 4. Percentage of bacterial species identified by vitek 2 system

Table 5. Number of antibiotics classes that resistance by bacteria isolated from skin infections

Bacterial species		NO. of antibiotics classes	Classes of antibiotics
S. hominis ssp hominis R1		7	Cephalosporins, Penicillins, Carbapenems, Quinolones, Macrolides, Lincosamides, and Tetracyclines
A. baumannii complex R2		6	Penicillins, Cephalosporins, Carbapenems, Tetracyclines, polymyxine and Antifolate
S. aureus	R3	12	Cephalosporins, Penicillins, Carbapenems, Aminoglycosides, Quinolones, Macrolides, Lincosamides, Tetracyclines, Antifolate, Rifamycins, Fusidane and Sulphonamides
S. aureus	R4	5	Cephalosporins, Penicillins, Carbapenems, Macrolides and Lincosamides
S. aureus	R5	7	Cephalosporins, Penicillins, Carbapenems, Macrolides, Tetracyclines Fusidane and Lincosamides
S. epidermidis	R8	7	Cephalosporins, Penicillins, Carbapenems, Aminoglycosides, Macrolides, Tetracyclines and Fusidane
S. aureus	R9	3	Cephalosporins, Penicillins, and Carbapenems
S. aureus	R10	3	Cephalosporins, Penicillins, and Carbapenems,
S. aureus	R11	6	Cephalosporins, Penicillins, Carbapenems, , Aminoglycosides, Quinolones, and Macrolides
S. aureus	R12	3	Cephalosporins, Penicillins, and Carbapenems
S. aureus	R13	3	Cephalosporins, Penicillins, and Carbapenems
S. aureus	R14	3	Cephalosporins, Penicillins, and Carbapenems
S. epidermidis R15		7	Cephalosporins, Penicillins, Carbapenems,, Aminoglycosides, Lincosamides, Glycopeptides and Fusidane
S. hominis ssp hominis R16		9	Cephalosporins, Penicillins, Carbapenems, Glycopeptides , Quinolones, Lincosamides, Fusidane, Rifamycins, and Macrolides
S. epidermidis	R17	7	Cephalosporins, Penicillins, Carbapenems, Macrolides, Lincosamides, Tetracyclines and Fusidane
S. epidermidis R18		9	Cephalosporins, Penicillins, Carbapenems, Quinolones, Macrolides,, Tetracyclines, Antifolate, Sulphonamides and Fusidane
S. warneri R21		5	Cephalosporins, Penicillins, Carbapenems, Macrolides, and Fusidane
S. lentus	R22	6	Cephalosporins, Penicillins, Quinolones, Macrolides, Sulphonamides and Fusidane
S. epidermidis	R23	7	Cephalosporins, Penicillins, Carbapenems,, Aminoglycosides, Lincosamides, Glycopeptides and Fusidane
S. epidermidis	R24	6	Cephalosporins, Penicillins, Macrolides, Lincosamides Glycopeptides and Fusidane
S. epidermidis	R25	4	Cephalosporins, Penicillins, Lincosamides, and Glycopeptides
S. epidermidis	R26	3	Cephalosporins, Penicillins, and Carbapenems
S. hominis ssp hominis R27		6	Cephalosporins, Penicillins, Lincosamides, Macrolides, Glycopeptides and Fusidane

4. DISCUSSION

In the current study, Out of twenty six samples collected from various skin infections, Impetigo and chronic folliculitis were the most frequent infection 5(19%) Fig. 1, according to the age the results showed that most of impetigo infections were between 2-17 years, Table 1 this was agreed with previous studies that showed impetigo common in children under 18 years (Loadsman et al., 2019, Bowen et al., 2015). Children between the ages of two and five are typically affected by impetigo, a highly contagious superficial skin illness that comes in two varieties: nonbullous impetigo and bullous impetigo (Bowen, et al. 2015, Manje et al., 2023).

Skin infection is a prevalent illness that affects children. Geographical location, climate and season, social status, and personal hygiene all have an impact (Kelbore et al., 2019, García et al., 2020). Alkubaisi *et al*. (2020) suggests that because this age group of "schoolchildren" has access to the same healthcare services, and practices almost identical personal hygiene, they are more likely to be exposed to infectious skin diseases. In a developing country like Iraq, it is a complicated big health issue. Temperature, humidity, poor personal hygiene, a lack of good water sources, and low levels of education allow the disease to spread among children in the community. One of the contributing reasons to skin infections and infectious diseases is personal cleanliness (Gauchan et al., 2015, Aggarwal et al., 2021). For chronic folliculitis the infection was between (18-38) years Table 1, this was compatible with Srinivas and KA, (2020) that observed most commonly in the age group of (21-40) years.

The infections were significantly higher in female 15(57.6%) compared to male 11(42.3%), Table 2, this finding is consistent with previous studies conducted in Brazil and Egypt (Ferreira et al., 2011, Abdel-Hafez et al., 2003) and disagreement with other study conducted in Iraq by Alkubaisi *et al*. (2020). According to the gender the results showed that prevalence of impetigo infections were significantly higher among female (Little girls (4(15%) than male (Little boy) Table 2 and Fig. 2, while in chronic folliculitis the results showed that the infections were high in male 3(12%) compared to the female 2(8%) this was in agreement with Srinivas and KA, (2020). Immune modulation is influenced by progesterone, testosterone, and estradiol. They impact a wide range of cells, such as lymphocytes, macrophages, and dendritics (Muenchhoff et al., 2014). It is well known that testosterone suppresses the immune system, which may lower interferon-γ levels (IFN-γ), Conversely, estradiol has the ability to increase T-helper 1 (Th1) immunity (Jacobsen and Klein, 2021). So, the difference in the level of estradiol and testosterone between males and femalescould effected.

Depending on Gram staining, 26 (83.87%) were Gram positive, whereas 5 (16.13%) Gram negative. The result come in agreement with Ahmed *et al*. (2020) where Gram positive cocci recorded (65.4%) while 68 (34.5%) was Gram negative bacilli. The bacteria was identified biochemically by an automated microbiology vitek 2 system, it's used for microbial identification provide highly accurate and reproducible results that approved by multiple independent studies. The result revealed that isolated bacteria with probability range between (99-86%) the frequency showed high percentage of *S. aureus* 11(35.5). This outcome is consistent with research conducted by previous studies (Matiny et al., 2012, Marko et al., 2012, Sanaa, 2017), which used the Vitek 2 method to identify a variety of bacterial species.

The result showed that *Staphylococcus* genus was the most frequent with high percent (35.5%) of *S. aureus* this compatible with previous studies (Manje et al., 2023, Mohanty, et al., 2018, Zhao et al., 2021). Major Gram-positive bacterial pathogen *S. aureus* is responsible for a broad range of clinical illnesses, from endocarditis and localized soft-tissue infections to potentially fatal bacteremia (Mohanty et al., 2018). Human skin is frequently home to the commensal bacteria *S. epidermidis*. In the present study this species showed the percent of (25.8%). This bacteria viewed as a key member of the healthy skin microbiota, involved in the fight against pathogens, influencing the immune system, and implicated in wound repair. Concurrently, it is the second source of nosocomial infections, and skin conditions including atopic dermatitis have been linked to an overgrowth of this bacteria (Landemaine et al., 2023).

Antibiotic susceptibility testing was performed using the Vitek- 2 Compact system analysis,

(48) antibiotics were used. the results revealed that bacterial isolates had different patterns of resistance to antibiotics Table 5. (23) isolates of bacteria were MDR out of (31) isolates. Widest spectrum of resistance was observed of *S. aureus* (R3) among the Gram positive bacterial isolates, this isolate showed more resistance to antibiotics than any other where resist (12) classes of antibiotics such as aminoglycosides, penicillins, macrolides, quinolones, lincosamides, tetracyclines, antifolate and sulphonamides the result was compatible with previous studies in Botswana (Truong et al., 2011, Alter et al., 2019). The bacteria of *S. epidermidis* (R18) was resist for (9) classes of antibiotics include penicillins, cephalosporins, tetracyclines, macrolides, antifolate and sulphonamides this result agreed with previous studies (Chabi and Momtaz, 2019, Siciliano et al., 2023, Leili et al, 2024).

5. CONCLUSION

According to the current investigation, *S. aureus* and *S. epidermidis* are the two Gram-positive bacteria isolates most frequently associated with skin infections. The concerning increase in Gram-positive bacterial infections that are resistant to many drugs highlights the critical need to determine the sensitivity pattern and epidemiology of the bacteria causing infections of the skin and soft tissues. Adhering to antibiotic stewardship can assist in preventing the development of drug resistance and minimizing the use of ineffective antibiotics.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Abdel-Hafez, K., Abdel-Aty, M. A., & Hofny, E. R. (2003). Prevalence of skin diseases in rural areas of Assiut Governorate, Upper Egypt. *International Journal of Dermatology, 42*(11), 887-892.

Aggarwal, P., Muddasani, S., & Fleischer Jr, A. B. (2021). Sanitation, obesity, and low body mass index as risk factors for bacterial skin infections. *Journal of Cutaneous Medicine and Surgery, 25*(3), 293-297.

Ahmed, F., Bassyouni, R., & Zedan, Y. (2020). Bacteriological profile of bacteria isolated from skin and soft tissue infections. *Fayoum University Medical Journal, 7*(1), 41-51.

Al-Kahfaji, M. H. A. M. (2022). Human skin infection: A review study. *Biomedicine and Chemical Sciences, 1*(4), 254-258.

Alkubaisi, T. A., Al-Mashhadani, J. I. S., Alhayani, N. N. A., & Al-Kubaisy, J. S. O. (2020). Socio-epidemiological study of infectious skin diseases among school children in Heet District, Iraq. *Medico-legal Update, 20*(4), 1057.

Allaw, F., Zakhour, J., & Kanj, S. S. (2023). Community-acquired skin and soft-tissue infections in people who inject drugs. *Current Opinion in Infectious Diseases, 36*(2), 67-73.

Alter, S. J., Sanfilippo, C. M., Asbell, P. A., & Decory, H. H. (2019). Antibiotic resistance among pediatric-sourced ocular pathogens: 8-year findings from the antibiotic resistance monitoring in ocular microorganisms (ARMOR) surveillance study. *Pediatric Infectious Disease Journal, 38*(2), 138–145.

Atia, S. S. (2017). Biological and antimicrobial activity of bacterial pigments extracted from environmental bacterial species (Master's thesis, Bacteriology, College of Science, University of Basrah).

Bharadwaj, A., Rastogi, A., Pandey, S., Gupta, S., & Sohal, J. S. (2022). Multidrug-resistant bacteria: Their mechanism of action and prophylaxis. *Bio Med Research International*.

Bowen, A. C., Mahe, A., Hay, R. J., Andrews, R. M., Steer, A. C., Tong, S. Y., & Carapetis, J. R. (2015). The global epidemiology of impetigo: A systematic review of the population prevalence of impetigo and pyoderma. *PLOS ONE, 10*(8), 0136789.

Brown, B. D., & HW, K. L. (2003). Cellulitis. *Stat Pearls*. Brown, J., Shriner, D. L., Schwartz, R. A., & Janniger, C. K. (2003). Impetigo: An update. *International Journal of Dermatology, 42*(4), 251-255.

Chabi, R., & Momtaz, H. (2019). Virulence factors and antibiotic resistance properties of the *Staphylococcus epidermidis* strains

isolated from hospital infections in Ahvaz, Iran. *Tropical Medicine and Health, 47*, 1-9.

Davies, J., & Davies, D. (2010). Origins and evolution of antibiotic resistance. *Microbiology and Molecular Biology Reviews, 74*(3), 417-433.

De Kraker, M. E., Stewardson, A. J., & Harbarth, S. (2016). Will 10 million people die a year due to antimicrobial resistance by 2050? *PLOS Medicine, 13*(11), 1002184.

Esposito, S., Bassetti, M., Bonnet, E., Bouza, E., Chan, M., De Simone, G., Dryden, M., Gould, I., Lye, D. C., Saeed, K., Segreti, J., Unal, S., & Yalcin, A. N. (2016). Hot topics in the diagnosis and management of skin and soft-tissue infections. *International Journal of Antimicrobial Agents, 48*(1), 19-26.

Ferreira, F. R., Nascimento, L. F. C., & Cirvidiu, D. C. (2011). Prevalence of pediatric dermatoses in a university hospital in southeastern Brazil. *Anais Brasileiros de Dermatologia, 86*, 477-482.

García, E., Halpert, E., Borrero, E., Ibañez, M., Chaparro, P., Molina, J., & Torres, M. (2020). Prevalence of skin diseases in children 1 to 6 years old in the city of Bogotá, Colombia. *World Allergy Organization Journal, 13*(12), 100484.

Gauchan, E., Kumar, A., Bk, G., Thapa, P., & Pun, J. (2015). Relation of sociodemographics and personal hygiene on different childhood dermatoses. *Kathmandu University Medical Journal, 13*(1), 29-33.

Ibrahim, F., Khan, T., & Pujalte, G. G. (2015). Bacterial skin infections. *Primary Care: Clinics in Office Practice, 42*(4), 485-499.

Jacobsen, H., & Klein, S. L. (2021). Sex differences in immunity to viral infections. *Frontiers in Immunology, 12*, 720952.

Jappa, L. S., & Kutre, S. R. (2018). A clinical and bacteriological study of bacterial folliculitis. *Panacea Journal of Medical Sciences, 8*(2), 54-58.

Jendoubi, F., Rohde, M., & Prinz, J. C. (2019). Intracellular streptococcal uptake and persistence: A potential cause of erysipelas recurrence. *Frontiers in Medicine, 6*, 6.

Joseph, J., Karolia, R., Sharma, S., Choudhary, H., & Naik, M. N. (2022). Microbiological profile and antibiotic susceptibility trends in orbital cellulitis in India: An analysis over 15 years. *Orbit, 41*(6), 726-732.

Jubeh, B., Breijyeh, Z., & Karaman, R. (2020). Resistance of gram-positive bacteria to current antibacterial agents and overcoming approaches. *Molecules, 25*(12), 2888.

Kelbore, A. G., Owiti, P., Reid, A. J., Bogino, E. A., Wondewosen, L., & Dessu, B. K. (2019). Pattern of skin diseases in children attending a dermatology clinic in a referral hospital in Wolaita Sodo, southern Ethiopia. *BMC Dermatology, 19*, 1-8.

Khan, S. N., & Khan, A. U. (2016). Breaking the spell: Combating multidrug resistant 'superbugs'. *Frontiers in Microbiology, 7*, 174.

Landemaine, L., Costa, G., Fissier, E., Francis, C., Morand, S., Verbeke, J., & Richard, M. L. (2023). *Staphylococcus epidermidis* isolates from atopic or healthy skin have opposite effects on skin cells: Potential implication of the AHR pathway modulation. *Frontiers in Immunology, 14*, 1098160.

Leili, M., Afrasiabi, S., Rostami, R., Khazaei, M., Roshani, M., & Tarin, Z. (2024). The evaluation of *Staphylococcus aureus* and *Staphylococcus epidermidis* in hospital air, their antibiotic resistance and sensitivity of *S. aureus* to cefoxitin. *Scientific Reports, 14*(1), 9183.

Lin, H. S., Lin, P. T., Tsai, Y. S., Wang, S. H., & Chi, C. C. (2021). Interventions for bacterial folliculitis and boils (furuncles and carbuncles). *Cochrane Database of Systematic Reviews, 2*, 013099.

Linz, M. S., Mattappallil, A., Finkel, D., & Parker, D. (2023). Clinical impact of *Staphylococcus aureus* skin and soft tissue infections. *Antibiotics, 12*(3), 557.

Loadsman, M. E., Verheij, T. J., & Van der Velden, A. W. (2019). Impetigo incidence and treatment: A retrospective study of Dutch routine primary care data. *Family Practice, 36*(4), 410-416.

Manje, N. B., AL-Rubaay, A. F., & Hasan, A. M. (2023). Isolation and diagnosis of *Staphylococcus aureus* and *Candida albicans* from impetigo, ecthyma, and bullous impetigo patients. *HIV Nursing, 23*(4), 018-023.

Marko, D. C., Saffert, R. T., Cunningham, S. A., Hyman, J., Walsh, J., Howard, W., Prusser, J., Safwat, N., Cockerill, F. R., Bossler, A. D., Patel, R., Richter, S. (2012). Evolution of Braker Biotyper and Vitek MS matrix-assisted laser desorption ionization time of flight mass spectrometry systems for identification of nonfermenting gram-negative bacilli isolated from cultures from

cystic fibrosis patients. *Journal of Clinical Microbiology, 50*, 2034-2039.

Matiny, D., Busson, L., Wybo, I., El Haj, R. A., Dediste, A., & Vandenberg, O. (2012). Comparison of the microflex LT and Vitek MS systems for routine identification of bacteria by matrix-assisted laser desorption ionization–time of flight mass spectrometry. *Journal of Clinical Microbiology, 50*, 1313-1325.

Mohanty, A., Mohapatra, K., & Pal, B. (2018). Isolation and identification of *Staphylococcus aureus* from skin and soft tissue infection in sepsis cases, Odisha. *Journal of Pure and Applied Microbiology, 12*, 419-424.

Muenchhoff, M., & Goulder, P. J. (2014). Sex differences in pediatric infectious diseases. *The Journal of Infectious Diseases, 209*(3), 120-126.

Nasr, I. (2018). Folliculitis: Pathology, presentation, management and treatment. *Dermatological Nursing, 17*(3).

Piddok, L. J. (1991). Mechanism of quinolone uptake into bacterial cells. *Journal of Antimicrobial Chemotherapy, 27*(4), 399-403.

Pincus, D. H. (2006). Microbial identification using the bioMérieux Vitek®2 system. *Encyclopedia of Rapid Microbiological Methods* (pp. 1-32). Bethesda, MD: Parenteral Drug Association.

Ramirez, M. S., Bonomo, R. A., & Tolmasky, M. E. (2020). Carbapenemases: Transforming *Acinetobacter baumannii* into a yet more dangerous menace. *Biomolecules, 10*(5), 720.

Sari, L. G. M. P., Fatmawati, N. N. D., Praharsini, I. G. A. A., & Giantoro, M. (2022). Colonization of *Citrobacter koseri* and *Streptococcus agalactiae* in a case of cellulitis cruris dextra et sinistra. *Intisari Sains Medis, 13*(2), 426-430.

Siciliano, V., Passerotto, R. A., Chiuchiarelli, M., Leanza, G. M., & Ojetti, V. (2023). Difficult-to-treat pathogens: A review on the management of multidrug-resistant *Staphylococcus epidermidis*. *Life, 13*(5), 1126.

Srinivas, S., & KA, P. R. (2020). Clinical profile and demography of patients with chronic folliculitis of the leg. *International Journal of Dermatology, Venereology and Leprosy Sciences, 3*(2), 103-106.

Truong, H., Shah, S. S., Ludmir, J., Tawanana, E. O., Bafana, M., Wood, S. M., & Steenhoff, A. P. (2011). *Staphylococcus aureus* skin and soft-tissue infections at a tertiary hospital in Botswana. *South African Medical Journal, 101*(6), 413-416.

Zhao, N., Cheng, D., Jian, Y., Liu, Y., Liu, J., Huang, Q., & Liu, Q. (2021). Molecular characteristics of *Staphylococcus aureus* isolates colonizing human nares and skin. *Medicine in Microecology, 7*, 100031.

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