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*Original Article*

# Trauma-related wound infections among patients admitted to emergency teaching hospital in Duhok province, Iraq

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## Abstract

Introduction: Wound infection is one of the universal challenges for patients who visit the hospital after trauma and undergo surgery and/or during their admission. Trauma could be due to Road Traffic Accidents (RTA), violence, or Falling from High (FFH). There is tangible evidence of the scope and the danger of hospital-acquired infections, which are far more common and deadly than many people comprehend.

Methodology: 280 samples were collected from 140 injured persons, who attended the Emergency Teaching Hospital in Duhok, Iraq from September 2021 to April 2022. 140 samples were collected on the patients' arrival and 140 samples after admission and treatment. The isolated bacteria were manually diagnosed, and then VITEK®2 compact system was performed for confirmation.

Results: 27 microbial species were identified. The common bacterial species detected on patients' arrival were *Staphylococcus epidermidis* 22 (19.6%), *Escherichia coli* 16 (14.3%), *Staphylococcus aureus* 14 (12.5%), *Staphylococcus lentus* 10 (8.9%) and *Stenotrophomonas maltophilia* 6(5.4%). On the 2nd samples, which were collected after patients' admission, the species were *Staphylococcus aureus* 35(31.3%), *Escherichia coli* 13(11.6%), *Pseudomonas aeruginosa* 12 (10.7%), *Staphylococcus epidermidis* 10 (8.9%), *Acinetobacter baumannii* and *Klebsiella pneumonia* were 8 (7.1%) each.

Conclusions: The bacteria that contaminate wounds at the accident time led to serious problems after the admission as they cause wound infection with inappropriate antibiotic administration. It is established that there are differences between the bacterial species detected before and after admission in this study with $p = 0.004$. Furthermore, it has been demonstrated that some species that are isolated prior to the admission of patients turn hostile afterward.

**Key words:** Trauma; infection; patients; bacteria; wound.

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## Introduction

Patients with traumatic injuries are at increased risk for infections. Wounds provide a moist, warm and nutritive environment conducive to microbial colonization, proliferation, and infection [1]. The interruption of tissue integrity, haemorrhage and frequency of invasive procedures, and impaired host defense mechanisms all have a major impact on subsequent infection [2]. It is well known that trauma patients with hospital-acquired infections are at increased risk for mortality, have a longer length of stay, and incur higher inpatient costs. The mortality rates of trauma are still very high and are increasing, according to the World Health Organization [3]. There are a few essential points that need to be taken into consideration throughout the process of wound management, like the patient's origin, the site and chronicity of the wound, and its size, as they play a role in wound colonization and infection [4,5]. On the other hand, microbial pathogenicity and virulence as well as the patient's immune status play vital roles in the development and process of wound infection. Moreover, in order to confirm the diagnosis of wound infection, various clinical signs ought to be present like pain, redness, tenderness, abscess formation, and/or pus discharge [6,7]. Hence, the process of wound healing is most likely hindered by wound infection [8]. Having said that, the aforementioned clinical signs may not all be existing in every single wound infection and therefore the caring medical team has to be conscious that symptoms and signs of infection may vary for each injury. Wound infection is considered confirmed if the diagnosis has been based on the combination, by the standardized descriptions of skin and soft tissue infections, of localized symptoms from direct clinical findings and laboratory results [9]. Therefore, the bacterial existence within the wound by itself does not suggest that a wound is infected [10]. However, it has

been speculated and supported by data that a critical microbial load would actually affect the healing process of both acute and chronic wounds and delay it [11,12]. Generally, after the clinical diagnosis of infection is made, a culture is recommended to identify the causative organisms and guide antibiotic therapy.

The chances of the wound becoming infected increase depending on a few factors, like the patient's age, other co-morbidities, duration of hospital admission, patient's immune status, and lengthy admission to the Intensive Care Unit (ICU) [13,14]. Furthermore, the mortality rate from nosocomial infection in admitted patients varies depending on a number of variables like young age, admission to ICU, large hospital, duration of hospitalization, necessity for lengthy specialized central venous access, and infection with methicillin-resistant *Staphylococcus aureus* (MRSA) or multidrug-resistant *Pseudomonas aeruginosa* [15,16]**.** Among the microorganisms that contaminate wounds, bacteria are the chief agents in wound infection development. Nearly 50% of the bacteria are gram-negative, as per the CDC, with *E. coli*, *P. aeruginosa*, *Enterobacter*, and *Klebsiella pneumoniae* being the most common species. On the other hand, *Staphylococcus aureus*, *Coagulase-negative Staphylococci* and *Enterococci* are the commonest gram-positive bacteria [17]**.** As a particular example of this, MRSA is considered to be the most controversial bacterium in traumatic and surgical wound infections, primarily based on the information that all incidence is high in these and other types of wounds [18,19]. Henceforth, researching and studying nosocomial infection is vital as the evidence shows a rise in the rate of patients' mortality and morbidity due to infection, prolonged hospitalization, and by the end, soar costs [20]**.**

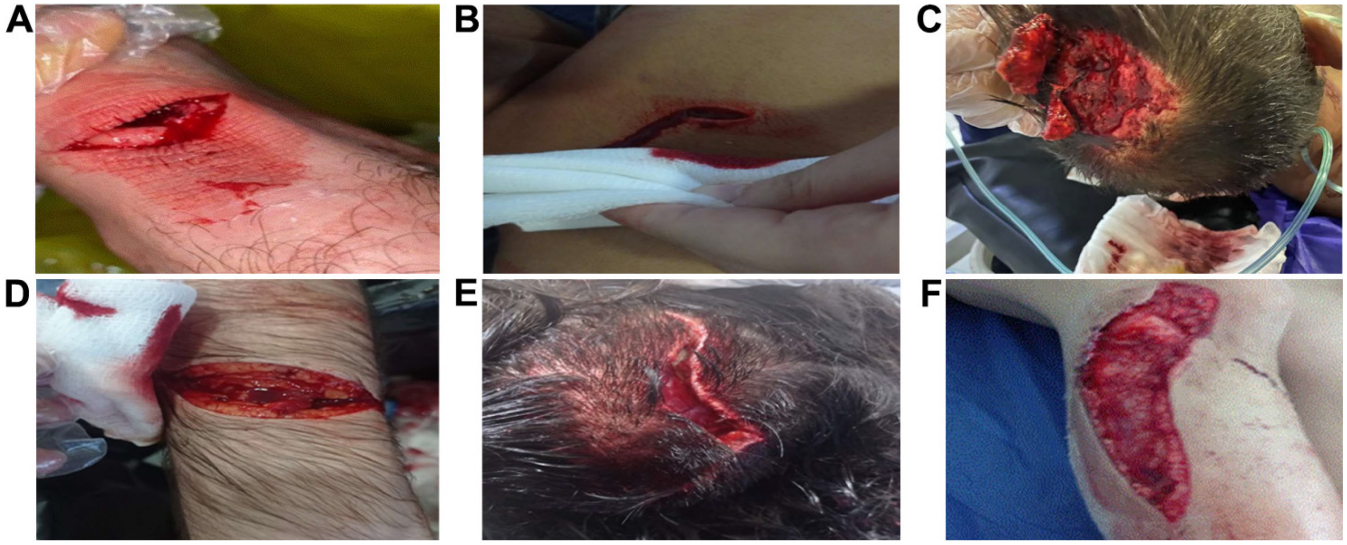
Our study targets the causes and sources of wound infection in trauma patients who attended Emergency Teaching Hospital in Duhok from September 2021 to April 2022. Multiple approaches are used for identifying the causative agents of the trauma wound infection, firstly manually [21]and then by the VITEK®2 compact system. The source of causative organism of wound infection will be the question to answer whether it is from wound contamination at the site of accident or from the hospital after admission. This study will provide insightful information of bacterial prevalence that continues to thrive in our healthcare system. Early prevention of infection in trauma patients would improve outcomes, early discharge, and decrease mortality.

## Methodology

*Sample collection*

Samples were collected from patients who attended at Emergency Teaching Hospital in Duhok City, Iraq, with a history of trauma, like Road Traffic Accident (RTA), Falling From Height (FFH), occupational injury and violence (Figure 1). Full details of the patient were documented, including age and sex, cause of trauma, wound site, type of exudates, size, and depth of the wound. The date and time the specimens were collected

**Figure 1.** Photos of trauma cases on their arrival at the Emergency Teaching Hospital. (**A**) Arrival Date: 25/09/2021, Occupational injury of dorsum of the foot (Lower limb) by a metallic object (shish kebab); (**B**) Arrival Date: 24/9/2021, Shoulder (Upper limb) injury by a knife in a violent attack; (**C**) Arrival Date: 25/09/2021, Falling from Height (FFH) causing injury to the back of the head; (**D**) Arrival Date: 2/10/2021, Forearm (Upper limb) injury by a knife in a violent attack; (**E**) Arrival Date: 24/12/2021, Injury of the back of head as a result of a Road Traffic Accident (RTA); (**F**) Arrival Date: 10/04/2022, Leg (Lower limb) injury from a Road Traffic Accident (RTA).



and any past medical history of chronic diseases (Questionnaire form) were also noted down. The specimens were collected from wounds on various body parts, like the head, lower limb, upper limb, abdomen, back, face and chest. Basically, two samples were collected from the patient, the first sample when the patient arrived at the hospital, and the other sample was taken after surgery or during the hospital admission within a duration of three to twenty days. Targeted surveillance including the admission specimen was collected by sterile pre-moistened cotton swab with Normal Saline (NaCl) in a zig-zag motion from center to the periphery [22] without touching the edges of the wound. The swab was then immersed in a container containing a sterilized nutrient broth as a transport medium and transported to the laboratory for bacterial identification [23].

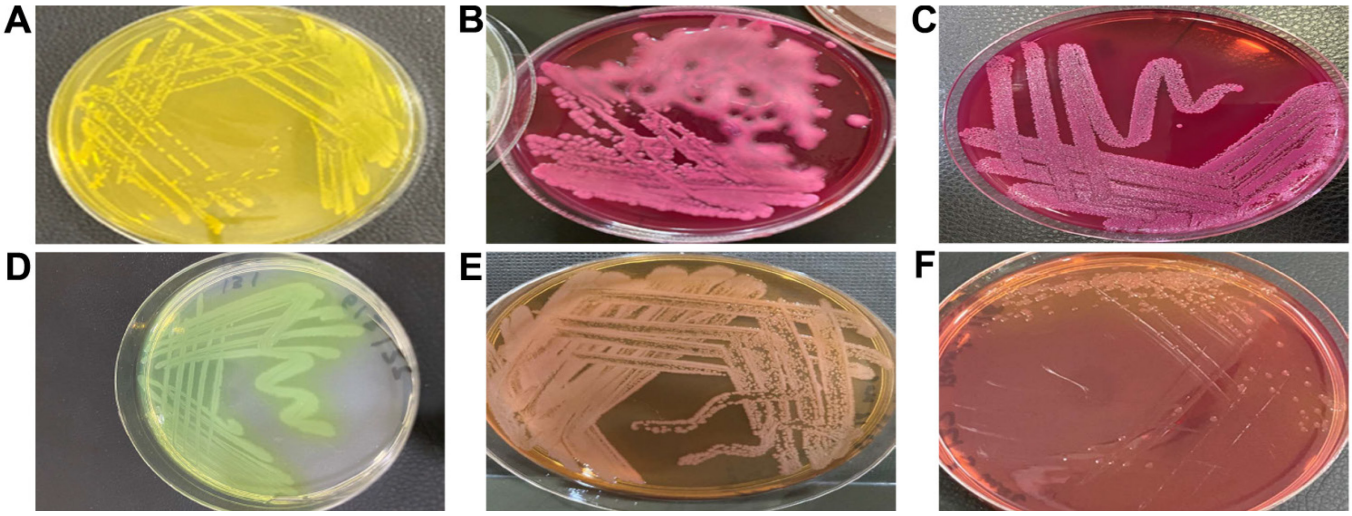
*Microbiology Analysis*

The specimens were directly transferred to the laboratory for incubation at 37 °C for 24 hours then they were examined by eye and under the microscope for bacterial growth in the nutrient broth. If there was no growth, the samples were incubated further for up to three days.

*Sample cultivation and manually identification*

After that, the bacteria were cultured on blood, chocolate, MacConkey, Cetrimide, and Mannitol salt agars. The samples cultured on blood and chocolate agar plates were incubated in both aerobical and microaerophilic conditions. All aerobic plates were initially examined for growth after 24 hours, and those without growth were further incubated for up to 48 hours at 37 °C. On the other hand, the blood and chocolate plates, which were put in the microaerophilic conditions, were incubated in a candle jar with humid 5% $CO_2$ atmosphere for 48 hours at 35–37 °C. After obtaining pure colonies, further identifications were performed by using the standard microbiological techniques like Gram staining, colony morphology and biochemical tests. MacConkey agar, Mannitol salt agar and Cetrimide agar were also used to identify cultural characteristics for the bacterial growth and they were incubated at 37 °C for 18–24 hours. Species identification of the isolates carried out from pure cultures using classical biochemical tests according to the standard guidelines [24]. The process of diagnosis of bacterial species, which were isolated from the wounds, commenced manually and then by automated VITEK®2 technology to confirm the diagnosis. The manual approach was based on the characteristic growth pattern of each bacterium on each agar and culture such as colour changing of the media after bacterial growth, type of haemolysis of the blood agar and size, shape of colonies, Gram stain and classical biochemical test. The type of media was also used as a tool in manual diagnosis, for example Mannitol Salt Agar (MSA) was used as a selective and differential medium for the isolation and identification of *S. aureus* from clinical and non-clinical specimens. In addition, MSA was prepared according to the recommendations of Chapman for the isolation of presumptive pathogenic staphylococci. *S. aureus* gives yellow colour on the MSA (Figure 2A) and causes beta haemolysis on the blood agar when incubated aerobically and

**Figure 2.** Bacterial growth on different types of media. (**A**) *Staphylococcus aureus* growth on Mannitol Salt agar, Mannitol fermentation (Yellow Colour); (**B**) *Klebsiella pneumonia* growth on MacConkey agar is pink colour due to lactose-fermenting and mucoid; (**C**) *E. coli* isolates produce bright pink colonies on MacConkey agar; (**D**) *Pseudomonas aeruginosa* growth on the Cetrimide agar that is used for diagnosis.; (**E**) *Acinetobacter baumannii* growth on the MacConkey agar; (**F**) *Burkholderia cepacia* growth on the MacConkey agar.



anaerobically. Moreover, *S. aureua* is catalase and coagulase positive. On the other hand, *Staphylococcus epidermidis* on the Mannitol Salt agar shows pink colour and alpha haemolysis on the blood agar. The colour changing of MSA media is basically due to mannitol fermentation. Microscopically, both *S. aureua* and *S. epidermidis* are Gram-positive cocci and cluster. In addition, many strains of Gram-negative bacteria were also detected in the wound samples, such as *Klebsiella pneumonia* (Figure 2B), *E. coli* (Figure 2C*, Pseudomonas aeruginosa* (Figure 2D), *Acinetobacter baumannii* (Figure 2E), and *Burkholderia cepacia* (Figure 2F).

All bacterial species were diagnosed by classical biochemical tests and then confirmed by automated VITEK®2 technologies. The most initial step in this process was to put the swap that was taken from the patient into a broth. Then, from this broth an inoculate was cultured on the appropriate agar, such as blood, chocolate, MacConkey, Cetrimide, and Mannitol salt agars according to the bacterial type which was previously identified by classical biochemical test. Secondly, 3.0 mL of sterile saline was transferred to a clear (polystyrene) tube (12 mm x 75 mm) of (aquatic 0.45% to 0.50% NaCl, pH 4.5 to 7.0%). Thirdly, a sterile stick or swab was used to transfer a sufficient number of morphologically similar colonies to the saline tube prepared in previous step. After that, a homogeneous suspension of the bacterial colony with normal saline was prepared with an optical density equivalent to a McFarland No. 0.50 to 0.6 using a calibrated VITEK®2 DensiCHEKTM Plus. It must be insured that the age of suspension must not exceed 30 minutes before VITEK®2 cards are put in the homogeneous suspension. Following which, the suspension tube and card were placed in the cassette.

**Table 1.** Number and percentage of site of wound and type of trauma in patients (n = 140) who visited the Emergency Teaching Hospital, Duhok, 7 Sept 2021 - 13 April 2022.

| Characteristics | n (%) |
|---|---|
| **Site of wound** | |
| Abdomen | 16 (11.4) |
| Back | 10 (7.1) |
| Chest | 4 (2.9) |
| Face | 8 (5.7) |
| Head | 55 (39.3) |
| Lower Limb | 30 (21.4) |
| Upper limb | 17 (12.1) |
| **Type of trauma** | |
| Falling from High | 47 (33.6) |
| Occupational | 12 (8.6) |
| Road Traffic Accidents | 50 (35.7) |
| Violence | 31 (22.1) |
| **Total** | **140** |

Lastly, according to the Instrument User Manual of the VITEK®2 tool, data entry and how to load the cassette into the instrument are followed.

*Statistical analysis*

Excel spreadsheet and Statistical Package for Social Studies, SPSS (IBM V 23) software used to calculate the proportion of univariant variables, to summarize the descriptive data, and the relation of the proportion of gender and Bacterial growth before and after admission, bacterial growth before and after admission tested through using Chi-square statistic (Yates' continuity correction when the minimum expected count is 6.0), and Fisher's Exact Test (when more than 20% of cells in sub-tables have expected cell counts less than 5, or the minimum expected cell count in sub-table is less than one), and McNemar test used to test the statistical significance of changes of two paired proportions of bacteria groups. The $p$ value of $< 0.5$ is considered statistically significant to show the differences in the bacteria before and after admission.

*Ethical Clearance*

Ethical clearance was obtained from the ethical committee in the local Directory of Health (DOH), Duhok, Iraq. The assent of children (< 18 years old) was obtained from their family or guardian. All the information obtained from each study participant was kept confidential.

## Results

In total, 280 samples were collected from 140 different types of wounds, 140 samples on the patient's arrival to the hospital, and 140 after admission between September 2021 and April 2022. Of those, 224 (80%) were positive, and 56 (20%) were negative. The negative samples have shown either no growth at all or growth from contamination. These samples were taken from people who arrived at Emergency Teaching Hospital in Duhok with a history of trauma and wounds. These trauma patients had a history of Road Traffic Accident (RTA) in 50 cases (35.7%), Fall from height (FFH) in 47 cases (33.6%), violence in 31 cases (22.1%), and occupational injury in 12 cases (8.6%) (Table 1). The majority (110, 78.6%) of the patients were male and the remaining 30 (21.4%) were female, and their ages ranged from 1 to 80 years (mean age = 29.339). The specimens were collected by sterile wound swabs from different body parts like the head 55 (39.3%), lower limbs 30 (21.4%), upper limbs 17 (12.1%), abdomen 16 (11.4%), back 10 (7.1%), face 8 (5.7%) and chest 4 (2.9%). The patients, who were

**Table 2.** Number and percent of traumatic patients (n = 140) who visited the Emergency Teaching Hospital, according to Wound discharge before and after admission (n = 138).

| Characteristics | n (%) | $\chi^2$ | *p* |
|---|---|---|---|
| **Wound Discharge Before Admission** | | | |
| Blood | 102 (72.9) | | |
| Dry | 10 (7.1) | 154.9421 | 0.00001 |
| Pus | 28 (20.0) | | |
| **Total** | 140 | | |
| **Type exudates After Admission** | | | |
| Dry | 101 (73.2) | | |
| Plasma | 8 (5.8) | 154.9421 | 0.00001 |
| Pus | 29 (21.0) | | |
| **Total** | 138 | | |

admitted to the hospital until recovery, were followed up by taking a second sample from their wounds.

Totally 27 different microbial species were isolated before and after admission. The wounds that were sampled before the patient's admission to the hospital at the reception, polybacterial saprophytic flora were found contaminating the patients wound. From these polybacterial saprophytic flora that contaminate the traumatic wound, only the bacteria species that relate to wound infection were isolated. About 18 bacterial species were isolated from the wounds on patients' arrival. The most predominant species were

**Table 3.** Number and percent of traumatic patients (n = 112) who visited the Emergency Teaching Hospital, according to Bacteria groups before and after admission.

| Characteristics | n (%) | $\chi^2$ | *p* |
|---|---|---|---|
| **Bacteria structurally divided two groups (before admission)** | | | |
| Gr (-) | 30 (26.8) | 4.5101 | 0.033 |
| Gr (+) | 82 (73.2) | | |
| **Bacteria structurally divided two groups (after admission)** | | | |
| Gr (-) | 45 (40.2) | 4.5101 | 0.033 |
| Gr (+) | 67 (59.8) | | |
| **Total** | **112** | | |

*Staphylococcus epidermidis* 22 (19.6%), *Escherichia coli* 16 (14.3%), *Staphylococcus aureus* 14 (12.5%), *Staphylococcus lentus* 10 (8.9%), *Staphylococcus vitulinus* 8 (7.1%) and *Stenotrophomonas maltophilia* 6 (5.4%). Moreover, a couple of species have appeared to dominate the polybacterial saprophytic flora in the first samples and have represented 2.7% of the total samples collected. These species were *Burkholderia gladioli and Pseudomonas stutzeri,* both of which are Gram-negative. On the other hand, for the admitted patients the second sample was obtained from their wounds that have yield also 18 types of isolates. On follow-up of these cases, 101 (73.2%) of the wounds have shown no signs of infection (dry) and the samples from these

**Table 4.** Number, percent, and percent change of pathogenic causative bacteria before and after admission of traumatic patients (n = 112).

| Bacteria | Bacterial diagnosis before admission | | Bacterial diagnosis after admission | | Growth Before and After Admission (Yes, No) | Percentage Change |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | | |
| *Staphylococcus aureus* | 14 | 12.5 | 35 | 31.3 | Yes | 150.0% |
| *Escherichia coli* | 16 | 14.3 | 13 | 11.6 | Yes | -18.8% |
| *Pseudomonas aeruginosa* | 5 | 4.5 | 12 | 10.7 | Yes | 140.0% |
| *Staphylococcus epidermidis* | 22 | 19.6 | 10 | 8.9 | Yes | -54.5% |
| *Acinetobacter baumannii* | 0 | 0.0 | 8 | 7.1 | No | |
| *Klebsiella pneumoniae* | 0 | 0.0 | 8 | 7.1 | No | |
| *Staphylococcus hominis* | 5 | 4.5 | 5 | 4.5 | Yes | 0.0% |
| *Salmonella enterica diarizonae* | 0 | 0.0 | 4 | 3.6 | No | |
| *Staphylococcus sciuri* | 0 | 0.0 | 3 | 2.7 | No | |
| *Kocuria kristinae* | 6 | 5.4 | 2 | 1.8 | Yes | -66.7% |
| *Kocuria rhizophila* | 2 | 1.8 | 2 | 1.8 | Yes | 0.0% |
| *B Streptococcus* | 0 | 0.0 | 2 | 1.8 | No | |
| *Burkholderia cepacian* | 0 | 0.0 | 2 | 1.8 | No | |
| *Staphylococcus lugdunensis* | 0 | 0.0 | 2 | 1.8 | No | |
| *Enterobacter cloacaea* | 4 | 3.6 | 1 | 0.9 | Yes | -75.0% |
| *Staphylococcus haemolyticus* | 2 | 1.8 | 1 | 0.9 | Yes | -50.0% |
| *Bacillus subtilis* | 0 | 0.0 | 1 | 0.9 | No | |
| *Providencia rettgeri* | 0 | 0.0 | 1 | 0.9 | No | |
| *Staphylococcus lentus* | 10 | 8.9 | 0 | 0.0 | No | |
| *Staphylococcus vitulinus* | 8 | 7.1 | 0 | 0.0 | No | |
| *Stenotrophomonas maltophilia* | 6 | 5.4 | 0 | 0.0 | No | |
| *Burkholderia gladioli and Pseudomonas stutzeri* | 3 | 2.7 | 0 | 0.0 | No | |
| *Listeria monocytogenes* | 2 | 1.8 | 0 | 0.0 | No | |
| *Pantoea sp.* | 2 | 1.8 | 0 | 0.0 | No | |
| *Staphylococcus sp.* | 2 | 1.8 | 0 | 0.0 | No | |
| *Streptococcus viridans* | 2 | 1.8 | 0 | 0.0 | No | |
| *Staphylococcus warneri* | 1 | 0.9 | 0 | 0.0 | No | |
| **Grand Total** | **112** | **100.0** | **112** | **100.0** | | |

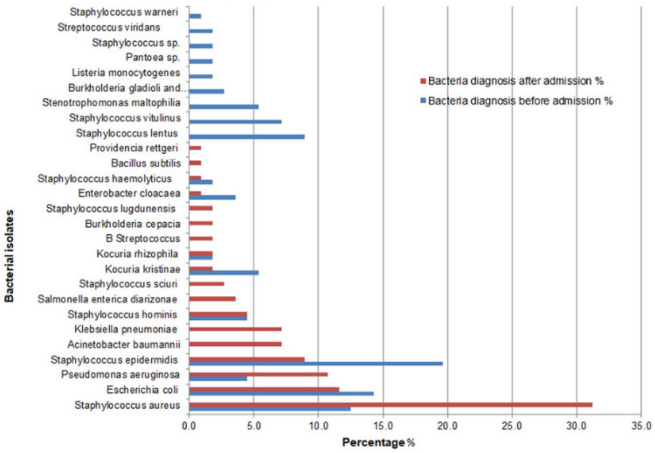
wounds detected bacterial species related to wound infection on the culture plates. The remaining 29 (21.0%) wounds were regarded as infected with (pus) exudates and at least one bacterial species with clinical importance was isolated from them. Only 8 (5.8%) of the wound were oozing plasma exudates (Table 2). There is a statistically significant difference between bacterial isolated Gram-positive and Gram-negative before and after admission in this study with $p = 0.004$ as shown in (Table 3).

The main species that were isolated from the 2nd samples were *Staphylococcus aureus* 35 (31.3%), *Escherichia coli* 13 (11.6%), *Pseudomonas aeruginosa* 12 (10.7%) *Staphylococcus epidermidis* 10 (8.9%), *Acinetobacter baumannii and Klebsiella pneumonia* isolated at same rate 8 (7.1%) (Table 4). Moreover, *Salmonella enterica* 4 (3.6%), *B streptococcus* 2 (1.8%), *Staphylococcus lugdunensis, Burkholderia cepacia, Kocuria kristinae, Kocuria rhizophila* isolated at same percentage 1.8% finally 0.9% of *Bacillus subtilis, Enterobacter cloacaea, Providencia rettgeri, Staphylococcus haemolyticus* also detected in the second swab taken from patents after admission.

## Discussion

Figure 3 shows the differences between bacterial species on the patient's arrival at the hospital and after their admission following trauma. The species of pathogenic bacteria that are related to wound infection increased significantly after admission to the hospital. On the other hand, opportunistic bacteria were completely eliminated from wounds after admissions such as *Staphylococcus epidermidis, Listeria monocytogenes, Pantoea sp., Staphylococcus sp., Staphylococcus vitulinus,* and *Staphylococcus warneri*. Moreover, the percentage of bacterial isolation altered noticeably before and after admission of traumatic patients, such as *Staphylococcus aureus* which was detected in 14 cases (12.5%) on arrival vs. 35 (31.3%) after hospitalization, the percentage change is 150.0%. However, the percentage of *Escherichia coli* detection decreased after admission from 14.3% to 11.6% with the percentage change (-18.8%).

**Figure 3.** Percentage of causative bacterial isolates before and after admission of traumatic patients (n = 112) who visited the Emergency Teaching Hospital, Duhok, between 7 Sept 2021 and 13 April 2022.




Some species that are related to the wound infection like *Staphylococcus aureus, Pseudomonas aeruginosa,* and *Escherichia coli* were detected in both samples, before and after admission. They, however, were more prevalent in the 2nd samples, i.e., after admission. *Staphylococcus aureus* is the main bacteria that are found to contaminate traumatic injuries and cause serious health problems to patients even after surgery and treatment. Its frequency has more than doubled in the collected samples after hospitalization. It is well known that *Staphylococcus aureus* is the most problematic bacteria in wound infection and hospital-acquired infections [16,24]. In contrast, *Staphylococcus epidermidis* presence has nearly halved from 22 cases (19.2%) in the first samples to 10 cases (8.9%) after admission. The predominant isolates from traumatic injuries are *S. aureus, Klebsiella spp*., *Citrobacter spp., Enterobacter spp., P. aeruginosa,* and *E. coli* [26]. Recently, *Acinetobacter baumannii* and *Burkholderia cepacia* have been detected at Emergency Hospital in Duhok. *Acinetobacter baumannii* is becoming epidemic in the hospital. The source of these microorganisms is soil and green grass and they become very aggressive with the overuse of broad-spectrum antibiotics and consequently causing serious wound infections that show drug resistance to various types of antibiotic [27].

Many bacterial species have disappeared after admission as shown in Figure 3 such as *Burkholderia gladioli and Pseudomonas stutzeri*, *Listeria monocytogenes, Staphylococcus lentus, Staphylococcus vitulinus, Stenotrophomonas maltophilia, Staphylococcus warneri,* and *Streptococcus viridians.* On the other hand, 9 species emerged after admission in a patient with a history of hospital-acquired infection and multidrug resistance, for example, *Acinetobacter baumannii, Klebsiella pneumonia, Staphylococcus lugdunensis, B Streptococcus,* and *Burkholderia cepacia.*

Moreover, it can be observed from our results that the bacterial species, which are brought in with the patients as they contaminated their wounds, are normal-flora and opportunistic bacteria that become more aggressive with the inappropriate use of antibiotics, for

example, *Burkholderia cepaci* is detected on the second sample collected from a wound of an admitted patient with a history of gunshot injury and dirty wound, as this species is coming from soil (with soil) [27]. It is a common habit that antibiotics can be purchased in developing countries like Kurdistan and Iraq without prescription; this leads to the misuse of antibiotics by the public which contributes to the emergence and spread of multidrug resistance in bacteria. The widespread and prolonged use of antibiotics leads to the emergence of resistant bacteria pathogens in wound infections contributing to high morbidity and mortality rates [27,28].

In light of this position, it has been reasonable to predict the prevailing opinion among wound care practitioner is that aerobic such as *Staphylococcus aureus*, *Pseudomonas aeruginosa,* and beta-hemolytic streptococci are the major causes of delayed healing and infection in both acute and chronic wounds. This opinion has been formed on the basis of comments and reference studies conducted extensively over the past two decades that have investigated the role of microorganisms in wound healing [30–32]. As a particular example of this*,* MRSA is considered to be the most controversial bacterium in traumatic, surgical and burn wound infections [18,19]. Microbiological studies have also shown that MRSA is a single causative bacterium in cutaneous abscesses [33], then the same organism also has been identified as the most frequent isolate in superficial infections shown in the Accident and Emergency Departments of the hospital. MRSA have been considered multidrug-resistant in wound infection cases [34]. These extra wounds are categorized as either suspected infection or colonized by bacteria based on the presence or absence, as mentioned above, of signs and symptoms of wound infection [35]. However, a study by Rajkumari *et al.* (2014) on trauma patients undergoing investigative laparotomy following abdominal injury revealed that 13.8% experienced deep incisional and organ/intra-abdominal [36]. Knowledge of the causative agents of wound infection has proved to be helpful in the selection of empirical therapy, infection control measures in a health institution, and in formulating rationales of antibiotic policy.

A few limitations were present in our study. The first limitation is that it lacks the antibiogram test, which would have provided more useful epidemiology information; however, the main objective of our study was to isolate the causative bacterial species of wound infection and was not to determine the effectiveness of antibiotics in the management of wound infection. The other limitation is that the other micro-organisms, like fungi, were not included in this research as they also sometimes cause infections. We advocate a larger study to provide more representatives about the microorganisms that could infect the traumatic wound, especially after treatment.

## Conclusions

The source and cause of wound infection are detected; most of the causative agents are brought in with the patient's wound from the accident scene. We conclude that a lot of bacteria that contaminate the wounds at the site of accident are becoming serious problems at the hospital as they are causing infection with inappropriate use of antibiotic. Furthermore, we have established that there are differences between the bacterial species detected before and after admission in this study. Also, it is proven that some of species, which are isolated on both occasions, become more aggressive after patient's admission. Subsequently, the medical team needs to be more careful and meticulous in washing and cleaning the wound after trauma on injured person's arrival to the Emergency Department.

### Acknowledgements

All the samples were collected in Emergency Teaching Hospital, Duhok. The practical part of the research was conducted for manual identification of bacterial species at the Bacteriology Lab, Biology department, College of Science, University of Duhok, Duhok, Iraq. Then, the bacterial identification was confirmed by using VITEK®2 at the laboratories of the Department of Medical Laboratory Sciences, College of Health Sciences, University of Duhok and Emergency Teaching Hospital. We would like to thank the Director of Emergency Teaching Hospital, the Head of Bacteriology Laboratory Department in the hospital and the lab staff for their help and collaboration to conduct part of this research. Also, we would like to show appreciation to Dr Kawa Marof Salihi for his help and guidance in performing the statistical analysis.

### Authors' Contributions

The study design was agreed on and designed by both authors. The first author, Ms. Wasan Alnakshabandie, has organised the process of sample collection for the study, processed them, collected data, analyzed the results and drafted the manuscript. On the other hand, Dr. Ismaeil Mammani has supervised and guided the whole work. Finally, both authors have read and accepted the final version of the manuscript.

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