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KEY WORDS: Effectiveness Of Antimicrobial Agents-continuous Monitoring Of Bacterial Antibiotic Sensitivity.

# DIABETIC FOOT ULCER : A STUDY IN A TERTIARY HOSPITAL IN PUDUCHERY (SOUTH INDIA)

**Dr.C.Meenakshi sundaram*** Sri Venkateswara Medical College Hospital & Research Institute, Puduchery, India. *Corresponding Author.

**Dr.G.Jayalakshmi** Sri Venkateswara Medical College Hospital & Research Institute, Puduchery, India.

**Dr. P.Selvaraj** Sri Venkateswara Medical College Hospital & Research Institute, Puduchery, India.

ABSTRACT

A total of 40 patients (30 males, and 10 females) were taking treatment for diabetic foot infections in a tertiary hospital situated in a peri-urban locality in Puduchery (South India), during a period of 9-months from October 2015 to July 2016. The data on bacterial culture and antibiotic sensitivity patterns were analysed for evaluating the effectiveness of various antimicrobial agents in offering treatment to diabetic foot ulcer patients.

In total, 67 bacterial organisms were isolated, amounting to 1.675 organisms per patient. The Gram-negative organisms were 56.7%, and Gram-positive organisms were 43.3%. The most predominant among the Gram-positive organismswere Staphylococcus aureus (14.9%), plus MRSA (3.0%). The most predominant Gram-negative organisms were Pseudomonas species (10.4%) plus Pseudomonas aeruginosa (6.0%).The Enterobacteriaceae species were 40.3%, including the ESBL-producing Escherichia coli (3.0%).

Patients infected with one pathogen were 45.0 % (18/40). Another 42.5 % (17/40) were infected with two pathogens. The remaining 12.5 % (5/40) of patients were infected with three pathogens. Nobody had more than 3 pathogens.The ages of patients varied from 36 to 84, showing 55.0% of infection in patients above 50 years of age.

The 9-months' data revealed that Amikacin was the most effective drug against all Gram-negative pathogens, and a few Gram-positive organisms excepting Enterococcus and Streptococcus species (to which Penicillin, or Ampicillin was effective). Vancomycin and Linezolid were effective, in cases wherever they were tested against Gram-positive organisms. Clindamycin was effective against Gram-positive organisms, excepting in the case of MRSA and Beta-hemolytic Streptococcus strains. Imipenem was sparingly used against Gram-negative organisms. Gentamicin or Ciprofloxacin or Cephalosporins were effective only in a few (limited) cases of infections involving Gram-negative organisms.

Conclusion : Continuous monitoring of bacterial antibiotic sensitivity is recommended for strengthening the baseline data at the local centre, aimed at enhancing a better treatment approach for diabetic foot ulcer.

## Introduction

In most cases, a small bruise in the skin of the foot initiates the foot infection. Once the bacteria enters inside the bruise, it multiplies in large numbers and proves to be pathogenic. In this stage, it could be termed as a mild-infection.Bowler, J.H., et.al (2001) reported that an infection in the foot would remain superficial, to begin with, and would spread to the uninfected subcutaneous tissues, with the prospects of penetrating deeper to reach the bone (1). One can visualize the progress of the wound to accommodate a polymicrobial flora, in the absence of any appropriate treatment, in which case, the status of mild infection process could slowly progress to become a moderate infection when the flora becomes polymicrobial. Progressing further, steadily, it could grow as a severe infection, in which case,the aerobic bacteria, obligate anaerobic bacteria, and fungal species would start breeding to make the characteristics of infection still worse.This kind of development could lead to a life-threatening situation. However, Cavanagh, P.R., et.al (2005) indicated that there could be an increasing cause for optimism in the treatment of diabetic and chronic wounds, due to the availability of enhanced knowledge related to pathogenic-factors, corrective steps, availability of newer biological agents, preparedness in adhering to stricter standards in healthcare, etc., if careful attention could be paid to these factors, thus, earning new hopes for tackling the problem of impaired healing (2). Perhaps, early diagnosis and prompt antibiotic treatment when the infection remains monobacterial, could prove to be helpful, to obtain a cure.

The available literature suggests that microbiological profiles of pathogenic bacteria in diabetic foot ulcer infections would change with time in each geographic location (3). Adequate management of diabetic foot infections would need an appropriate selection of antimicrobial agents, on the basis of culture and bacterial sensitivity test reports (4).

Initial empiric therapy must be based on local epidemiological data of antimicrobial susceptibility. A sound knowledge on the various microbial organisms causing the diabetic foot infections is essential in selecting an appropriate empiric therapy (5, 6, 7). Therefore, the necessity for generating local data on the susceptibility patterns of various antimicrobial agents, in case of each pathogen, cannot be overlooked.

## Aim of the study

The purpose of the retrospective study was to evaluate the effectiveness of the various antimicrobial agents (AMAs) against specific bacterial pathogens found in diabetic foot ulcers, using the bacterial culture and sensitivity data relating to 40-patients who received treatment for diabetic foot ulcers in a Tertiary Care Hospital, in Puduchery (South India), during a period of 9-months from October 2015 to July 2016.

## Scope of the study

The results of the study can be used to create a data-bank on antibacterial susceptibility patterns of the various antimicrobial agents, at the local centre, which can be used for formulating/updating a strategic policy regarding empirical treatment for diabetic foot ulcer patients.

## Materials and methods

The data on bacterial culture and sensitivity was retrieved from the hospital records, relevant to the period of study. Permission was obtained from the Ethics Committee of the Hospital to use the data for research studies. It was confirmed with the Microbiology Laboratory of the Hospital that all the clinical (pus/swab) samples were collected from the patients, processed and analysed as per standard operative procedures, and that the antibiogram was performed by Kirby-Bauer Disk Diffusion Method, and interpreted in accordance with The Clinical Laboratory Standards Institute (CLSI) Guidelines (8). Screening for MRSA and ESBL production were done as per standard procedures.

The data contained informations on the gender and age of each patient, with details of bacterial pathogens responsible for the infection, and details of antibiotic susceptibility pattern. The

antimicrobial agent (AMA) was shown against each patient, in the case of each pathogen, indicating whether the AMA experienced sensitivity, or resistance from the pathogen, or faced intermediate resistance.

The data analysis was done by counting the number of trials in which a particular antimicrobial agent (AMA) was found susceptible to a specific pathogen. If a particular AMA was found to be susceptible in more than two thirds of trials against a specific pathogen, it was selected and included in the list of effective drugs. This approach corresponded to a second scrutiny of AMAs already assessed as susceptible AMAs, in the original data. This list of selected AMAs was compared with the findings of other investigators who conducted similar studies in many other locations, in South India, in so far as the effectiveness of AMAs was concerned.

In the data analysis, a scheme of identifying each patient by a code number(instead of by name) was adopted. The code is assigned with a serial number for the patient, along with the gender and age, thus, protecting the privacy-aspects of the person concerned, and yet satisfying the statistical aspect of analysis.

The antimicrobial agents included in the annual data represented all classes of antimicrobial agents, namely, Penicillins, Aminoglycosides, Cephelosporins, Beta-lactam/beta-lactamase inhibitor combinations, Macrolides, Fluouroquinol ones, Tetracyclines, Glycopeptide (Vancomycin), Monoamine oxidase-inhibitor (Linezolid), and miscellaneous antibiotics which included Clindamycin, Cotrimoxazole, Chloremphenicol ,Polymyxins, etc.

**Results**

Details of bacterial pathogens are listed in Table-1(for Gram-Positive organisms, and in Table-2 (for Gram-negative organisms). The total number of bacterial isolates gathered from the 40-numbers of Diabetic Foot Ulcer patients (30 males and 10 females) was 67, out of which the Gram-positive organisms were 43.3% (29/67), and Gram-negative organisms were 56.7% (38/67). This pattern is shown in Figure-1.

The most predominant bacterial group among the Gram-positive organisms were Staphylococcus aureus (14.9%), followed by Enterococcus species ( 10.4%). The Methicillin-resistant Staphylococcus aureus (MRSA) was present (3.0%).

The most predominant pathogens among the Gram-negative organisms were Pseudomonas species (10.4%), followed by Klebsiella pneumoniae (8.9%). The presence of Extended Beta-Lactamase- producing Escherichia coli (ESBL-E.coli) was 3.0 %.

The 40-patients included 30 males and 10 females. The median age among the males was 54.3+/- 11.5, and the median age of the female patients was 60.2 +/- 11.4. The age group of patients varied from 36 to 84, showing 55.0% of infection in patients above 50 years of age.

**Table-1 : Profile of Gram-positive Pathogens in Diabetic Foot Ulcer**

| S.No | Name of Pathogens | No. of Isolates (n=67) | % |
|---|---|---|---|
| | A. Gram Positive Organisms | 29 | 43.3 |
| 1. | Staphylococcus aureus (S.au) | 10 | 14.9 |
| 2. | Methicillin Resistant S.aureus(MRSA) | 2 | 3.0 |
| 3. | Streptococcus sp. (Strept) | 3 | 4.5 |
| 4. | Beta Hemolytic streptococcus sp. | 3 | 4.5 |
| 5. | CONS sp. | 4 | 6.0 |
| 6. | Enterococcus sp. (Enteroc.) | 7 | 10.4 |

**Table-2 : Profile of Gram-negative Pathogens in Diabetic Foot Ulcer**

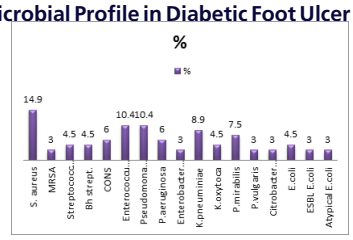
| S.No | Name of Pathogens | No. of Isolates (n=67) | % |
|---|---|---|---|
| | B. Gram Negative Organisms | 38 | 56.7 |
| 7. | Pseudomonas spp (Pseud) | 7 | 10.4 |
| 8. | Pseudomonas aeruginosa (P.ae) | 4 | 6.0 |
| 9. | Enterobacter spp (Enterob.) | 2 | 3.0 |
| 10. | Klebsiella pneumoniae (K.pn) | 6 | 8.9 |
| 11. | Klebsiella oxytoca (K.oxy) | 3 | 4.5 |
| 12. | Proteus mirabilis (P. mir) | 5 | 7.5 |
| 13. | Proteus vulgaris (P.vul) | 2 | 3.0 |
| 14. | Citrobacter spp (Citrob) | 2 | 3.0 |
| 15. | Escherichia coli (E.coli) | 3 | 4.5 |
| 16. | ESBL-producing E.Coli | 2 | 3.0 |
| 17. | Atypical E.coli* | 2 | 3.0 |

**Note :**

**(Enterobactericiae family,in this study, corresponds to 40.3%)**

*aEPEC : atypical Entero-Pathogenic Escherichia coli (34).

**Figure-1 :Microbial Profile in Diabetic Foot Ulcer**




Tables-3,4 and 5, present the cases of patients infected with a single pathogen, two pathogens and three pathogens, respectively.

Referring to Table-3,it can be seen that monobacterial infection could be caused by either by a Gram-positive organism or a Gram-negative organism.

In Table-4, details of patients infected with 2 pathogens, are shown, wherein a combination of two Gram-positive-organisms, or a combination of one Gram-positive organism with one Gram-negative organism, or a combination of two Gram-negative organisms, were prevailing, under the grouping A, B and C respectively.

In Table-5, the details of patients infected with 3 pathogens are presented. Some of the combinations of pathogens prevalent in patients become noteworthy, in the following cases: The first 3-cases represent one Gram-positive pathogen coexisting with two Gram-negative pathogens; and the fourth and fifth cases represent two Gram-positive pathogens plus one Gram-negative pathogen.

Based on analysis of data of bacterial culture and antibiotic susceptibility, the AMAs effective against each pathogen were evaluated, as described earlier. The effectiveness of the various AMAs against each Gram-positive pathogen and Gram-negative pathogen are listed in Tables-6 and 7, respectively.

**Monobacterial infection case:**

In Table-3, four patients (P10,P18,P27 and P7) are shown to be infected with Staphylococcus aureus, for which the effective AMAs are shown inTable-6, namely, Amikacin,or, Clindamycin, or Linezolid, or Doxycycline, or Ciprofloxacin, or Vancomycin. By way of comparison, the reports of other investigators of South India have been shown in column (v) of Table-6, in which Amikacin, Clindamycin, Linezolid and Vancomycin are agreeable to the results of the present study.

Similarly, in the case of MRSA, the AMAs evaluated to be effective in the present study are Amikacin, Astreonam, and Vancomycin. The findings of other investigators agree with the two AMAs, namely, Amikacin and Vancomycin.

**Table – 3 : Patients infected with one pathogen**

| Monobacterial | |
|---|---|
| A.Gram-positive cases:<br>(a)S.au : P10(1)M50; P18M70; P27(1)M52; P7(1)M55;<br>(b)MRSA :<br>P20(1)M65;P31(1)M45;<br>(c) CONS :<br>P9(1)M81;P35(1)M50;<br>(d) Enterococ.sp. : P36(1)M36;<br>(e) Streptococci sp. : P12(1)F84; | B. Gram-negative cases :<br>(i) Pseud. sp. : P30(1)M36; P32(1)M60;<br>(ii)E.coli :P16(1)M37;<br>(iii) Atypical E.coli :P1(1)M58;<br>(iv) K.oxy :P17(1)F65;<br>(v) P.mir : P39(1)F50;<br>(vi) P.vul : P40(1)M52;<br>(vii) P.ae. : P25(1)M49; |

Note : P10(1)M50=Patient code 10, Male, age 50, pathogen (1).

**Table - 4 : Patients infected with 2 pathogens**

| Infection with 2-pathogens | |
|---|---|
| A.Two Gram-positive pathogens<br>(a)S.au + Enterococ. sp :<br>P8(1,2)F55;<br>(b)S.au + Bhstcsp : P29(1,2)M75;<br>(c)CONS sp. + Bhstc. sp. :<br>P2(1)M55;<br>P21(1,2)M75;<br>B. One Gram-positive + One Gram-Negative:<br>(a)S.au + P.mir: P15(1,2)M58;<br>(b) S.au + P.ae : P33(1,2)M44;<br>(c)S.au + Citrob.sp : P28(1,2)F60;<br>(d)S.au + K.pn. : P26(1,2)F45;<br>(e) Enterococ.sp + Pseud. sp :<br>P22(1,2)M66;<br>(f) Enterococ. sp +K.pn :<br>P37(1,2)M45; | C. Two Gram-negative pathogens:<br>(i)Pseud.sp + K.pn :P23(1,2)F65;<br>(ii)K.pn + P.mir : P3(1,2)M36;<br>(iii)P.mir + P.vul : P5(1,2)M38;<br>(iv)Pseud. sp + Citrob. sp :<br>P4(1,2) M68;<br>(v)P.ae + K.oxy : P38(1,2)M47;<br>(vi)P.ae. + Enterob. sp :<br>P24(1,2) M65;<br>(vii)P.mir. + ESBL.E.coli :<br>P14(1,2)M50; |

Note : P8(1,2)F55= Patient code 8, Female, age 55, pathogens (1 & 2).

**Infection with two pathogens :**

In Table-4 listing the infections with two pathogens, the infection with Staphylococcus aureus and Pseudomonas aeruginosa, were seen in patient P33(1,2)M44, a male patient of age 44. By refering to Table-6, the appropriate AMAs were Amikacin, or Clindamycin, or Linezolid, or Doxycycline, or Vancomycin, or Ciprofloxacin would be the choice for Staphylococcus aureus. For working against Pseudomonas aeruginosa, the effective AMAs are shown in Table-7, namely, Gentamicin, or Amoxicillin/clavulanic acid, or Piperacillin/tazobactam or Ceftriaxone/sulbactam.There is a considerable agreement with the findings of other investigators of South India, in this respect.

This particular combination of two pathogens, namely, Staphylococcus aureus and Pseudomonas aeruginosa would be responsible for causing a delay in the healing process, as reported by Frank, et.al (2009), who have added an observation that the two pathogens being present together in the same wound could be a common occurrence (9) . Referring to this particular combination of the two pathogens, Townsend,E.M., et.al(2017) predicted that this combination would promote the development of biofilm in the wound, posing a complication in the case, and warranting a higher dosage of antimicrobial agents to work against the biofilm, and in such cases, the author suggested the administration of an antifungal agent for reducing the effect of the biofilm, in addition to the drugs needed for combating against Staphylococcus aureus and Pseudomonas aeruginosa (10).

**Infection with Three Pathogens :**

Referring to Table-5, the combination of Enterococcus plus Pseudomonas species plus Escherichia coli, in the patient P6(1,2,3)M54 ( a male patient of age 54), is to be read in Tables-6 & 7, for choosing the effective AMAs, in which case, Penicillin,or, Ampicillin, or Vancomycin, or Linezolid has to be chosen for combating against Enterococcus species, plus Amikacin,or Gentamicin, or Piperacillin/tazobactam to fight against Pseudomonas species, plus Amikacin to fight against Escherichia coli. The choice of all these AMAs, in this case, agree with the findngs of other Investigators of South India.

**Table – 5 : Patients infected with 3 - pathogens**

| Infection by 3-pathogens |
|---|
| (i) Enterococ. sp. + Pseud. sp +E.coli : P6(1,2,3)M54;<br>(ii) Enterococ. sp +E.coli + K.oxy :P13(1,2,3)F70;<br>(iii) Enterococ. sp + ESBL-E.coli + Atypical E.coli : P19(1,2,3)M50;<br>(iv) Streptococcus sp +S.au.+K.pn. : P11(1,2,3)M49;<br>(v) Streptococcus sp. + Enterococcus sp. +K.pn. : P34(1,2,3)M60; |

Note : P6(1,2,3)M54 = Patient code 6, Male, age 54, pathogens (1,2 & 3).

**Table 6 : AMAs effective against Gram- positive athogens**

| SL. No. (i) | Pathogen (no. of patients) (ii) | Effective AMAs (susceptible %) (iii) | Moderate AMA (iv) | Comparison with Others ** (Reference numbers) (v) |
|---|---|---|---|---|
| 1 | S.aureus ssp.(9) | Ak(100.0), Cd (88.8), Lin (100.0), Dox(85.7),V(87.5 ), Cip(66.7) | Cot,Cfxtn | Ak,V(23);Ak,V(24)V(25);Ak,V,Cd(26);V,Cd(27);Ak(28);Ak(15);Lin,V(18); Cd, Lin,V(16); Cd,Lin,V(17); |
| 2 | MRSA(2) | Ak(100.0),At (100.0), V(100.0) | …. | Ak,V(24); V(13); Ak,V(33) |
| 3. | Beta. Hemolytic Strepto-coccus sp.(3) | P(66.7),Amp(100.0),Cd(66.7), E(100.0),V(100.0),Lin(100.0),Ak(100.0)Dox(100.0), B(100.0) | Azm | P,Amp(29) |
| 5 | CONS (4) | Ak(75.0),Cd(100.0), V(100.0), Dox(100.0) | P,Cot,B | Ak,V(23); V(13);Ak,V,Cd(26); Ak,Cd, V (17); |
| 6 | Entercocc us.sp. (7) | P(87.5),Amp(83.3), V(100.0), Lin(100,0) | Azm,Cip | V,Lin(30); V,Lin(33); V(26);V(28); Lin,V(17); |
| 7 | Streptoco c.sp. (3) | P(100,0),Amp(100.0), Cd(100.0),E(100.0), B(100.0),At(100.0), Ctr(100.0),V(100.0), | Cot, | P,Amp(29); V,Cd,E(26); P,Cd(13); Cd,E,V(17); |

Note**: results of other investigators from various other locations in South India.

**Table-7 : AMAs effective against Gram-Negative Pathogens**

| S. No. (i) | Pathogen (no. of patients) (ii) | Effective AMA (susceptible%) (iii) | AMA (moderate) (iv) | Comparison with Others** (Reference numbers) (v) |
|---|---|---|---|---|
| 1 | Pseud. sp.(7) | Ak(85.7), G(66.7), Pit(71.4), | At,Cip, Caz,Cfs | Ak,G(23);Ak,Pit(31); Ak,Pit,Cfs (13); Ak,G,Pit(17); |

| | | | | |
|---|---|---|---|---|
| 2 | P.aeruginosa (4) | G(100.0), Pit(100.0), Amc(100.0), Ctr/s(100), | Ak, Cip,I | Ak,I(24);Ak(18); Amc,G,I(32); Amc,I,Pit(26); Ak,(15):I,(28); Amc,Pit(16); G, Pit, I, (17); |
| 3 | Enterobacter sp.(2) | Ak(100.0), I(100.0) | G,Cip, Pit,Cpm | Ak(24); Ak,I,Cpm,G,Pit(13); Ak,Pit(28);Ak(18); Ak,Cip,G,Pit(17); |
| 4 | E.coli(3) | Ak (100.0), | I,Amc,G, Cip, | Ak,I(24);Ak,I(23); Ak,I,G(13); Ak,Amc, Cip,I(BS): I(28);Ak,I,Amc(16); Ak,G,I(17); |
| 5 | ESBL-E.coli(2) | Ak(100.0), | I,G,Cip, Cpm, Ctr,Pit | Ak,I,G(13); |
| 6 | Atypical.E.coli(2)*** | Ak(100.0), G(100.0), | I,Pit, | ..... |
| 7 | K.pnemoniae (7) | Ak(100.0), I(83.7), G(66.7), Pit(66.7) | Cpm,Cip, Amc, | I(28); Ak,I,Pit(13); Ak,Amc,Pit(26); Ak, I,Pit,Amc(16); G,I,Pit(17); |
| 8 | K.oxytoca(3) | Ak(100.0), | I,G, | Ak,I(13);Ak(29); I(31);Ak,G,I(17); |
| 9 | P.mirabilis(5) | Ak(66.7), Pit(75.0), | I,Cip,G, Amc, | G,I(24); Pit,I(13): Ak,Amc,I(26); Ak,Pit,I, Amc(16); Cip,I(31); I,Pit,Amc(28); Ak,Cip,G,I,Pit(17); |
| 10 | P.vulgaris(2) | I(100.0), Lev(100.0), | Amc, Caz, Cpm, G,Pit | I(13); Amc,I,Pit(26); I(31); I(28); I,Amc,Pit(16); Ak,G,I,Pit(17); |
| 12 2 | Citrobacter sp.(2) | Ak(100.0), G(100.0) | Cip,I, Amc,Pit, | I(13); I, Ak(31); Ak,G,I,Pit(17); |

**Legend :**
Ak=Amikacin; Amp= Ampicillin; Amc = Amoxicillin-clavulanic acid;
At=Astreonam; Azm=Azithromycin;
B=Bacitracin ; Cd=Clindamycin; Ci=Colistin; Cip=Ciprofloxacin;
Cfxtn = Cefoxitin; Cfxtm =Cefotaxime; Cfs-Cefoperazone/sulbactam;
Cflxn = Cefalexin; Caz=Ceftazidime; Clrmp=Chloramphenicol?;
Cpm=Cefepime; Cprm=Cefiprome;Ctr=Ceftriaxone;
Ctr/s=Ceftriaxone/sulbactam;
Cot=Cotrimoxazole;
Dox=Doxycycline; Dap – Daptomycin; E = Erythromycin; G= Gentamicin;
HLG = High Level Gentamycin; I = Imipenem; Lev = Levofloxacin;
Lin= Linezolid. ; P=Penicillin; Pi=Piperacillin; Pit= Piperacillin/tazobactam;
PmB=Polymixin-B; T/S = Trimethoprim-sulfamethoxazole;
V=Vancomycin;

(Another point to be mentioned in this regard is that Imipenem was facing a moderate resistance from Escherichia coli, as it can be seen in Table-7, perhaps due to the production of carbapenemase enzyme, similar to some of the members of Enterobacteriaceae family, namely, Klebsiellaoxytoca, Proteus mirabilis, Citrobacter species and atypical E.coli, as listed in Table-7. This trend is to be verirfied).

Gupta, V. (2007) reported that Enterobacteriaceae were generally resistant to all Cephalosporins, and Extended Spectrum Penicillins, including Monobactam(Astreonam), and that many ESBL-producing organisms also express AmpC-beta-lactamase which are clinically significant as they exerted to certain Cephalosporins (Oxyimino group , such as Ceftazidime, and 7-alpha-methoxy Cephalosporins, such as Cefoxitin), in addition to making the performance of Clavulanic acid poorer (11). Hu and Chen, et.al (2012) elaborated on the emergence of carbapenemase-resistant Enterobacteriaceae and its impact on the antibiotic treatment outcomes (12)..

**Discussion**
A similar trend of monobacterial infection being caused by either Gram-positive organism, or by a Gram-negative organism was reported in Kelambakkam Town, near Chennai City, in Tamilnadu (South India), by Priyadarshini, S., et.al (2013), in which case, there were 50.0% of monobacterial infection cases, and more than 3-pathogens in the polymicrobial infection were reported (13), whereas in the present study, the monobacterial infection was 45.0%, and the maximum number of pathogens was limited to 3.

Saraswathy, K.M., et.al(2017) reported from a different location of Puduchery City (South India), at about 20.0 kilometre distance from the site of the present study, that the monobacterial infection in diabetic foot ulcer was recorded as 77.9% (14).Suganthi,P., et.al (2014), from Salem city, in Tamilnadu State (South India), reported that the monobacterial infection in diabetic foot ulcer recorded was around 56.0% (15).

Kandati, J., et.al (2015), from Nellore in Andhra Pradesh State (South India) reported 81.16% of monobacterial infection, with a maximum of 3 pathogens in the polymicrobial infection (16).Mukkanath, S.N.,et.al (2015) reported from Bengaluru, in Karnataka State (South India) that monobacterial infection in diabetic foot ulcer was 59.% (17).Murali, T.S., et.al (2014) reported from Mangalore, in Karnataka State (South India) that the monobacterial infection was 42.0%, and that Gram-positive and Gram-negative organisms co-existed in 31.0% of the polymicrobial samples (18).

Banu,et.al (2015) reported that monobacterial infection could depend on the duration of the ulcer and the prior history of antimicrobial treatment, and that it could become polymicrobial when infection progresses further (19).

An inference can be drawn from this logic that treatment to monobacterial infections could become feasible, if proper treatment could be given to the patient, before monobacterial infection could make further progress to become polymicrobial.
The two main challenges in this regard are the probability of biofilm forming bacteria involved in the monobacterial infection, and so also, the ESBL-producing bacteria, Metallo-beta-lactamase producing bacteria.

In this study, as can be seen in Table-3, the 10-cases of monobacterialinfections by Gram-positive pathogens and 8-cases of monobacterial infection by Gram-negative pathogens, would deserve a careful attention to be considered under the scope described above.

**Comparisons with other reports :**
Referring to Tables-6&7, it can be seen that the various antimicrobial agents effective against the various pathogens have been evaluated as effective AMAs, based on the antibiotic susceptibility data of the year 2015-'16, as applicable to Gram-positive and Gram-negative organisms, respectively, in column (iii). The AMAs which faced moderate resistance from the specific pathogens have been listed in column (iv) of Tables-6&7. In column (v), the findings of other investigators in respect of appropriate AMAs, as evaluated in various locations in South India, have been quoted, for the purpose of comparison. Their findings mostly agree with the AMAs evaluated as the most effective in the present study. It can be noted that some of the AMAs shown as moderate (intermediate) AMAs in the present study, happen to appear in the findings of other investigators as effective AMAs. This reflects a reality of the situation, due to the fact that the bacterial resistance, normally, has got the likelihood of varying with respect to time and geographical locations (20, 21).Also, the bacterial resistance

in rural area might be lesser compared to the bacterial resistance to antibiotic treatment in urban locations(22).

## Conclusion :

The bacterial response to antimicrobial agents must be continuously monitored and documented, for the purpose of selecting an effective empirical therapy, in order to ensure a favourable outcome to the patient.

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