



Analysis of Infection-Causing Factors and Antibiotic Sensitivity to the Degree of Ulcers in Diabetes Mellitus Patients

Ahmad Rizqi Ramadhan^{1*}, Eva Niamuzisilawati², Tri Nugraha Susilawati³, Dhani Redhono Harioputro⁴

Universitas Sebelas Maret, Indonesia
Email: ahmadrizqi2026@outlook.co.id*

Keywords:

bacteria, diabetic foot ulcers, logistic regression, medical records, multivariate analysis

Abstract

The diabetic foot ulcer prevalence was 6.3% globally and 7.3% in Indonesia. This study analyzes the relationships between the type of germs and antimicrobial susceptibilities to the Wagner's degree of diabetic-foot-ulcers on patients with type-2 diabetes mellitus admitted to Dr. Moewardi regional hospital. The method used in this observational analysis is a cross-sectional approach. The variables used were the type-of-germs, antimicrobial susceptibilities, and the degree of diabetic-foot-ulcers with the data extracted from 149 inpatients between the period of 2021-2022 and tested with Fisher's-exact and multinomial-logistic-regressions. Data for the 4-most-frequent germs on the diabetic-foot-ulcers are *Pseudomonas aeruginosa* (17.4%; 26/149), *Escherichia coli* (12.8%; 19/149), *Klebsiella pneumoniae* ss. *Pneumoniae* (11.4%, 17/149) and *Proteus mirabilis* (10.7%; 16/149). Data for the 4-most-frequent antimicrobial susceptibilities are ampicillin (20,8%; 31/149), sulfamethoxazole (20,8%; 31/149), gentamicin (18,8%; 28/149) and amikacin (16,1%; 24/149). Data for the 3-most-frequent degree of diabetic-foot-ulcers are the 4th (39.6%; 59/149), 3rd (31.5%; 47/149) and 2nd (19.5%; 29/149) degrees. There is no relationship between the type-of-germs and the degree of diabetic-foot-ulcers ($p=0.111$). There is a relationship between antimicrobial susceptibilities and the degree of diabetic-foot-ulcers ($p=0.009$). There is a relationship between the type-of-germs and antimicrobial susceptibilities ($p=0.0001$). There is a simultaneous relationship between the type-of-germs ($p=0.029$) and antimicrobial susceptibilities ($p=0.032$) to the degree of diabetic-foot-ulcers ($p=0.005$). Therefore, it is necessary to conduct microbial culture and antimicrobial susceptibility tests on all patients with diabetic foot ulcers.

INTRODUCTION

One of the common complications of diabetes mellitus (DM) is diabetic foot ulcers, which are wounds or disruptions of the skin's protective barrier extending through the dermal layer (Powers et al., 2022). Peripheral neuropathy plays an important role in facilitating the occurrence of diabetic foot ulcers by damaging sensory fibers and reducing pain sensation (Goljan, 2019). Infection, ischemia, abnormal pressure, and contamination are the four main etiologies of diabetic foot ulcers. In recent decades, the incidence of diabetic foot ulcers has increased. It is estimated that 35% of patients with DM will experience diabetic foot ulcers during their lifetime, with a recurrence rate of 65% within 3–5 years and an amputation rate of 20% (McDermott et al., 2023). Data show that 85% of lower-limb amputations begin with diabetic foot ulcers (Schmidt et al., 2024). About half of diabetic foot ulcers become infected (Rizqiyah et al., 2020; Voelker, 2023). Patient mortality ranges from 50–70% at 5 years.

The global prevalence of diabetic foot ulcers is 6.3% among adults with DM and is higher in men (4.5%) than in women (3.5%) (Oliver & Mutluoglu, 2022; Packer et al., 2023). The global prevalence of diabetic foot ulcers is 6.3% among adults with DM and is higher in

men (4.5%) than in women (3.5%) (Boulton & Whitehouse, 2023). The epidemiology of foot ulcers indicates that they occur in 5–10% of the DM population (Sukartini et al., 2020). Patients living in rural areas have a 35% higher risk of amputation than those in urban areas. The prevalence of diabetic foot ulcers in Asia is 5.5%,⁷ and in Southeast Asia it is usually less than 15% (Soares & Santos, 2022). The prevalence of DM based on a doctor's diagnosis in Indonesia is 1.5%, while it is 1.6% in Central Java ((Balitbangkes), 2018a) and 2.97% in Surakarta City ((Balitbangkes), 2018b). The prevalence of diabetic foot ulcers in Indonesia is 7.3% among patients with type 2 DM (Yunir et al., 2021).

Previous research in Sudan found that the most common Gram-negative bacteria were *Proteus* spp. (58.8%, 147/250), while the most common Gram-positive bacteria were *Staphylococcus aureus* (41.2%, 103/250) (Suparwati et al., 2022). A literature review conducted by the researchers did not identify any studies analyzing the relationship between bacterial types and antibiotic sensitivity relative to ulcer severity in patients with type 2 DM and diabetic foot ulcers at Dr. Moewardi Regional Hospital.

The novelty of this study lies in several aspects. First, it specifically focuses on Dr. Moewardi Regional Hospital, providing local data that can guide empirical antibiotic therapy in this institution. Second, it employs multivariate analysis (multinomial logistic regression) to examine the simultaneous relationship between bacterial type and antibiotic sensitivity in relation to ulcer severity, which has not been previously conducted at this hospital. Third, it calculates odds ratios for specific bacteria (*Pseudomonas aeruginosa*) and specific antibiotic sensitivities (gentamicin, meropenem, amikacin, piperacillin, ampicillin) across different Wagner ulcer grades (2, 3, and 4), thereby providing quantitative risk estimates for clinicians. Fourth, it includes a 2-year data period (2021–2022), capturing recent bacterial patterns. The research objectives are: (1) to analyze the relationship between bacterial type and ulcer severity; (2) to analyze the relationship between antibiotic sensitivity and ulcer severity; (3) to analyze the relationship between bacterial type and antibiotic sensitivity; and (4) to analyze the simultaneous relationship between bacterial type and antibiotic sensitivity in relation to ulcer severity in patients with type 2 DM and diabetic foot ulcers at Dr. Moewardi Regional Hospital. The benefits of this research are both clinical (providing evidence for empirical antibiotic therapy selection) and academic (contributing to the understanding of diabetic foot ulcer bacteriology in Central Java, Indonesia).

MATERIALS AND METHODS

The study was conducted in the inpatient ward of Internal Medicine, Dr. Moewardi Hospital, then continued with data collection at the Microbiology Laboratory Installation of Dr. Moewardi Hospital. The inclusion criteria were patients with a diagnosis of diabetic foot ulcers and had pus culture and antibiotic sensitivity test results in 2021-2022. The exclusion criteria were non-growing cultures, culture results stating fungi and anaerobic bacteria (limitations of equipment, materials). The sampling technique used was total population sampling with a total of 149 samples.

This study used an observational analysis method with a cross-sectional approach in type 2 DM patients with diabetic foot ulcers. Data were analyzed with IBM SPSS Statistics 27 using Fisher's exact test and multinomial logistic regression with a significance threshold or α

= 0.05. Data collected from medical records include medical record number, type of bacteria according to pus culture results, antibiotic sensitivity test results, and Wagner ulcer grade.

RESULTS AND DISCUSSION

Patients who met the inclusion criteria of the study with data on bacterial types and antibiotic sensitivity amounted to 149 samples. 31 types of bacteria and 12 antibiotic sensitivities were obtained at various degrees of ulcer. The distribution of bacterial types and gram types is as follows.

Table 1. Distribution of bacterial types

Types of Bacteria	N=149
Gram positive, n (%)	21 (14,1)
<i>Staphylococcus aureus</i>	11 (7,3)
<i>Enterobacter cloacae</i>	3 (2)
<i>Enterobacter aerogenes</i>	1 (0,7)
<i>Enterococcus faecalis</i>	1 (0,7)
<i>Staphylococcus cohnii</i> ss. <i>Cohnii</i>	1 (0,7)
<i>Staphylococcus haemolyticus</i>	1 (0,7)
<i>Streptococcus agalactiae</i>	1 (0,7)
<i>Streptococcus anginosus</i>	1 (0,7)
Gram-negative, n (%)	128 (85,9)
<i>Pseudomonas aeruginosa</i>	26 (17)
<i>Escherichia coli</i>	19 (12,8)
<i>Klebsiella pneumoniae</i> ss. <i>Pneumoniae</i>	17 (11,4)
<i>Proteus mirabilis</i>	16 (10,7)
<i>Proteus hauseri</i>	9 (6)
<i>Providencia stuartii</i>	9 (6)
<i>Acinetobacter baumannii</i>	6 (4)
<i>Morganella morganii</i> ss. <i>Morganii</i>	4 (2,7)
<i>Providencia rettgeri</i>	4 (2,7)
<i>Citrobacter freundii</i>	2 (1,3)
<i>Pseudomonas putida</i>	2 (1,3)
<i>Serratia fonticola</i>	2 (1,3)
<i>Serratia marcescens</i>	2 (1,3)
<i>Acinetobacter nosocomialis</i>	1 (0,7)
<i>Aeromonas hydrophila</i>	1 (0,7)
<i>Alcaligenes faecalis</i>	1 (0,7)
<i>Escherichia hermannii</i>	1 (0,7)
<i>Klebsiella oxytoca</i>	1 (0,7)
<i>Morganella morganii</i> ss. <i>Sibonii</i>	1 (0,7)
<i>Myroides spp</i>	1 (0,7)
<i>Raoultella planticola</i>	1 (0,7)
<i>Serratia liquefaciens</i>	1 (0,7)
<i>Vibrio mimicus</i>	1 (0,7)

As seen in Table 1, there are 8 gram-positive bacteria (14.1% 21/149) with the largest number being *S. aureus* (7.3%; 11/149) and there are 23 gram-negative bacteria (85.9%; 128) with the largest number being *P. aeruginosa* 17.4% (26/149). The number of gram-negative bacteria is much greater than gram-positive. The four most bacteria (52.3%; 78/149) are *P. aeruginosa*, *E. coli* 12.8% (19/149), *K. pneumoniae* ss. *Pneumoniae* 11.4% (17/149), and *P.*

mirabilis 10.7% (16/149). As many as 74.5% (111/149) of cases were extended spectrum beta lactamase (ESBL) producing bacteria and 25.5% (38/149) were non-ESBL bacteria.

The distribution of antibiotic sensitivity and ulcer grade is shown in the figure below.

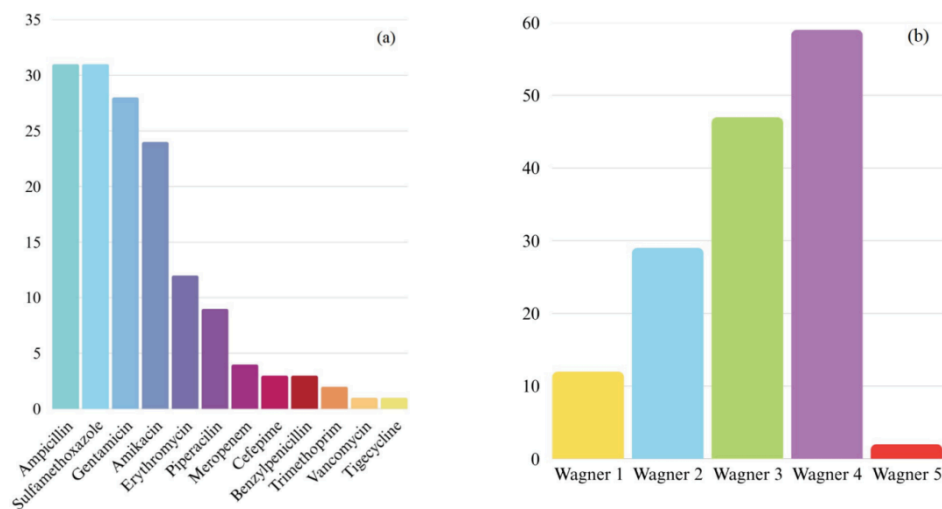


Figure 1. Distribution of (a) antibiotic sensitivity and (b) ulcer grades

As seen from Figure 1.a, there are 12 antibiotic sensitivities from the highest to the

lowest, namely ampicillin (20.8%; 31/149), sulfamethoxazole (20.8%; 31/149), gentamicin (18.8%; 28/149), amikacin (16.1%; 24/149), erythromycin (8.1%; 12/149), piperacillin (6%; 9/149), meropenem (2.7%; 4/149), cefepime (2%; 3/149), benzylpenicillin (2%; 3/149), trimethoprim (1.3%; 2/149), vancomycin (0.7%; 1/149) and tigecycline (0.7%; 1/149).

As seen from Figure 1.b, there are 5 degrees of ulcers from the largest to the smallest, namely Wagner 4 (39.6%; 59/149), Wagner 3 (31.5%; 47/149), and Wagner 2 (19.5%; 29/149), Wagner 1 (8.1%; 12/149), and Wagner 5 (1.3%; 2/149). The degree of ulcer has a mean value = 3.07; minimum = 1; maximum = 5; and standard deviation = 0.984.

The distribution of ulcer grades grouped according to bacterial type is shown in Figure 2.a. The 4 most cases of diabetic foot ulcers in each type of bacteria are grade 3 in *P. aeruginosa* followed by *E. coli*, then grade 2 in *K. pneumoniae* ss. *Pneumoniae* and grade 4 in *P. aeruginosa*. Grade 1 in *S. aureus* is included in the 11 most cases, while grade 5 in *A. baumannii* and *P. rettgerii* is the least.

The distribution of ulcer grades grouped according to antibiotic sensitivity is shown in Figure 2.b. The 3 most cases of diabetic foot ulcers in each antibiotic sensitivity are grade 3 in sulfamethoxazole, then grade 4 in ampicillin followed by gentamicin. Grade 2 in sulfamethoxazole is included in the 7 most cases, while grade 1 in erythromycin is included in the 12 most cases. Grade 5 in ampicillin and sulfamethoxazole is the least.

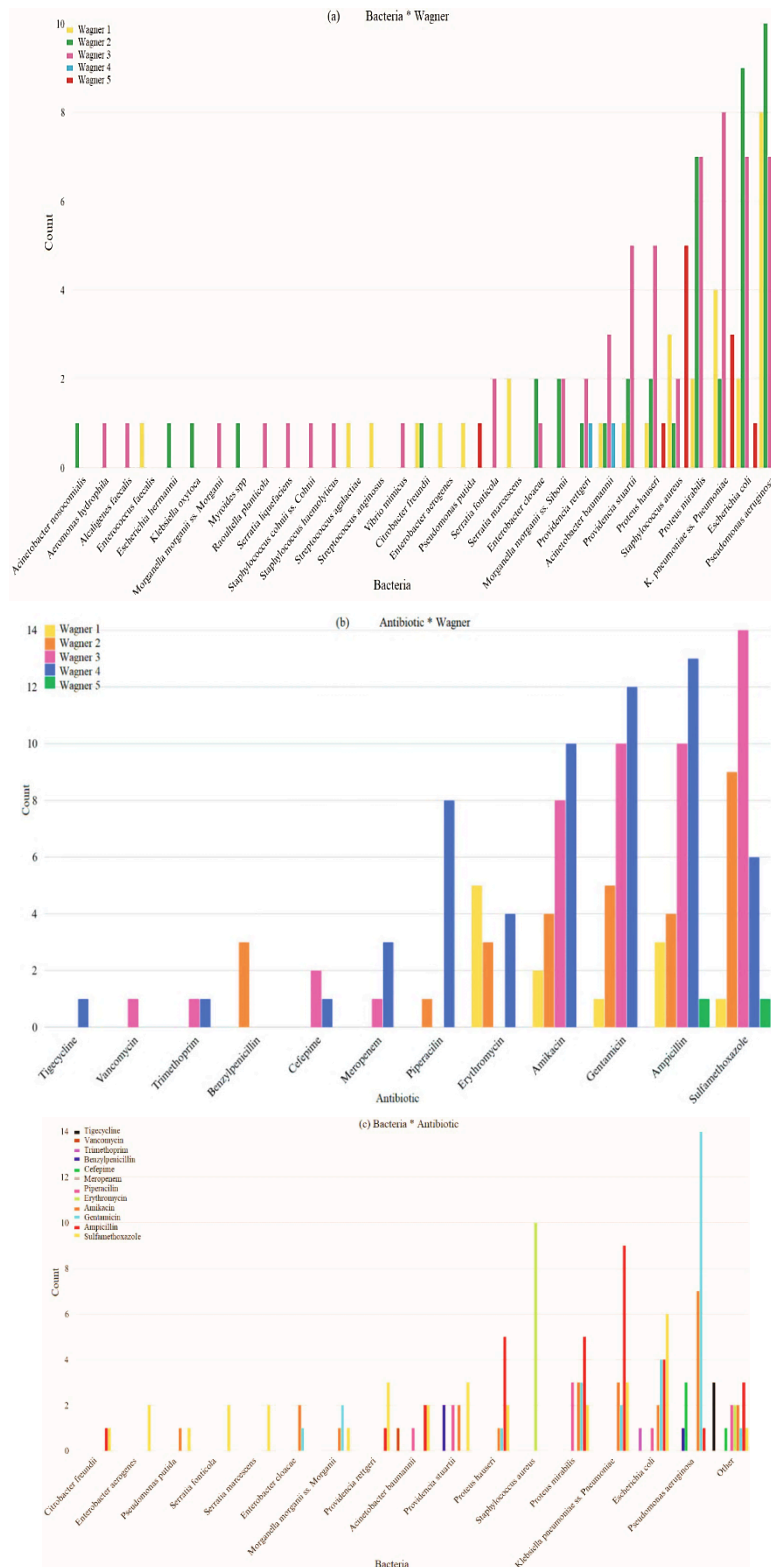


Figure 2. Distribution of (a) ulcer grade based on bacterial type (b) ulcer grade based on antibiotic sensitivity, (c) antibiotic sensitivity based on bacterial type

The distribution of antibiotic sensitivity grouped according to bacterial type is shown in Figure 2.c. The data shows the 5 most antibiotic sensitivities in each type of bacteria, namely gentamicin in *P. aeruginosa*, erythromycin in *S. aureus*, ampicillin in *K. pneumoniae*

ss. Pneumoniae, amikacin in *P. aeruginosa*, and sulfamethoxazole in *E. coli*. While the least is vancomycin in *S. aureus* and tigecycline in *A. baumannii*.

Then a bivariate test was conducted using the Fisher's exact test. The results obtained were that there was no relationship between the type of bacteria and the degree of ulcer ($p = 0.111$), there was a relationship between antibiotic sensitivity and the degree of ulcer ($p = 0.009$), and there was a relationship between the type of bacteria and antibiotic sensitivity ($p = 0.0001$).

The distribution of bacterial types, antibiotic sensitivity, and the highest ulcer grades are presented in Table 2.

Table 2. Distribution of bacterial types, antibiotic sensitivity and highest ulcer grades

Types of Bacteria	Antibiotic Sensitivity	Ulcer Degree	n
<i>S. aureus</i>	Erythromycin	1	5
<i>K. pneumonia</i>	Ampicillin		3
<i>P. aeruginosa</i>	Gentamicin	2	8
<i>K. pneumonia</i>	Ampicillin		4
<i>P. aeruginosa</i>	Gentamicin	3	10
<i>E. coli</i>	Sulfamethoxazole		9
<i>K. pneumonia</i>	Ampicillin	4	8
<i>P. aeruginosa</i>	Gentamicin		7
<i>A. baumannii</i>	Ampicillin	5	1
<i>P. rettgeri</i>	Sulfamethoxazole		1

Table 2 shows that the 2 most cases in ulcer grade 3 are *P. aeruginosa* — gentamicin with 10 cases and *E. coli* — sulfamethoxazole with 9 cases. Then followed by *K. pneumoniae* — ampicillin in ulcer grade 4 and *P. aeruginosa* — gentamicin in ulcer grade 2 with 8 cases each.

Next, a collinearity test was conducted on the relationship between bacterial type and antibiotic sensitivity to ulcer grade. The variance inflation factor (VIF) value was obtained = 1.049 for bacterial type and VIF = 1.049 antibiotic sensitivity, which is <10 , so it meets the requirements for multivariate analysis with multinomial logistic regression. The goodness of fit test produced a Pearson chi-square value = 58.8 (df = 68; $p = 0.779$) and a chi-square deviance = 51.7 (df = 68; $p = 0.930$). The pseudo-R² value for Cox and Snell (0.493), Nagelkerke (0.532), and Mcfadden (0.260). The simultaneous test value (model fitting information) with chi-square results = 101.3 (df = 68, and $p = 0.005$).

The partial test value (likelihood ratio tests) produced a chi-square value = 38.8 (df = 24; $p = 0.029$) for the type of bacteria and chi-square = 62.8 for antibiotic sensitivity (df = 44; $p = 0.032$). The following is significant odds ratio data on the simultaneous relationship between the type of bacteria, antibiotic sensitivity, and ulcer grade.

Table 3. Significant odds ratios for bacterial type, antibiotic sensitivity and ulcer grade

Parameter	Wagner 2	Wagner 3
<i>P. aeruginosa</i>	33,16 ($p=0,002$)	5,83 ($p=0,025$)
Meropenem	-	0,05 ($p=0,035$)
Piperacillin	0,07 ($p=0,035$)	-
Amikacin	0,06 ($p=0,009$)	0,22 ($p=0,043$)
Gentamicin	0,03 ($p=0,003$)	0,16 ($p=0,020$)
Ampicillin	0,13 ($p=0,017$)	-

Wagner ulcer grade 4 is used as the reference category Odds ratio (OR) of exposure to grade 2 and 3 diabetic foot ulcers was associated with positive *P. aeruginosa* results, respectively, which were 33.16 times and 5.83 times compared to grade 4. Meanwhile, OR of exposure to grade 2 diabetic foot ulcers was associated with sensitive gentamicin results, which was 0.03 times compared to the reference. Then OR of exposure to grade 3 diabetic foot ulcers was associated with sensitive meropenem results, which was 0.05 times compared to the reference.

The accuracy value of the classification model (classification) with Wagner results 1 - 41.7%; 2 - 24.1%; 3 - 66.0%, 4 - 69.5%, and 5 - 0%. The value of $p = 0.005$ was obtained in the Fitting Model and $p = 0.779$ in Goodness-of-fit, meaning that there is a relationship between the type of bacteria and antibiotic sensitivity to the degree of ulcer. The value of $p = 0.029$ was obtained for the type of bacteria and $p = 0.032$ for antibiotic sensitivity in the likelihood ratio so that the relationship between the type of bacteria and the degree of ulcer is more dominant than the relationship between antibiotic sensitivity and the degree of ulcer.

The results of this study found that the most gram-negative bacteria were *P. aeruginosa* with 26 cases (17.4%), *E. coli* — 19 cases (12.8%), *K. pneumoniae* ss. *Pneumoniae* — 17 cases (11.4%) and *P. mirabilis* — 16 cases (10.7%) and the most gram-positive bacteria were *S. aureus* — 11 cases (7.4%). This is in accordance with research by Yani at Ulin Hospital, Banjarmasin using data with a 2-year period which explains that diabetic foot ulcer infections caused by gram-negative bacteria (57.4%) are more than gram-positive (42.6%) with the most bacteria being *S. aureus* (26.6%), *K. pneumoniae* (19.1%), *E. coli* (12.8%), *P. aeruginosa* (5.3%) and *P. mirabilis* (5.3%).¹⁸ Another study conducted at Abdul Moeloek Hospital, Bandar Lampung showed that the most dominant bacteria in diabetic foot ulcer infections were gram-negative including *Proteus* spp., *P. aeruginosa*, *K. pneumoniae* and *E. coli*.³ The results of other studies conducted at the Khyber Teaching Hospital, Pakistan obtained results that gram-negative bacteria (96 cases, 66.2%) were more numerous than gram-positive (49 cases, 33.8%) with a percentage of *E. coli* (20.7%), *Pseudomonas* spp. (15.9%), *P. mirabilis* (5.5%) and *S. aureus* (10.3%) (Ogba et al., 2019).

The high infection rate by the five most common bacteria is caused by several factors, such as *P. aeruginosa*, which is widely found in nature, such as the normal flora of the skin, soil, water, plants and the body surfaces of animals (Situngkir & Sembiring, 2023). These bacteria are also found on the skin of the feet that are not injured and can be transferred to wounds. Early identification of these bacteria can help in determining the prognosis, preventing, and controlling foot ulcers (Yani et al., 2021). Next, *E. coli*, *P. mirabilis* and *K. pneumoniae* ss. *Pneumoniae* can be found in the human intestinal tract as part of the normal intestinal flora that can be excreted with feces. Then *P. mirabilis* can be found in soil and water, while *K. pneumoniae* ss. *Pneumoniae* can be found in the normal flora in the mouth and skin. *S. aureus* is often found in humans on the skin and mucous membranes, especially the nasal cavity. These five bacteria are often found in hospital health facilities (Ahmad et al., 2022).

In this study, the number of cultures with Wagner ulcer grade 1 was found to be 12 cases (8.1%), Wagner 2 — 29 cases (19.5%), Wagner 3 — 47 cases (31.5%), Wagner 4 — 59 cases (39.6%) and Wagner 5 — 2 cases (1.3%). The results of the study were similar to

looking at 2-year data at Dr. Soetomo Hospital, Surabaya, namely Wagner 1 — 25 cases (6.8%), Wagner 2 — 78 cases (21.2%), Wagner 3 — 100 cases (27.2%), Wagner 4 — 137 cases (37.3%) and Wagner 5 — 27 cases (7.5%) (Heravi et al., 2019). The two studies conducted in Indonesia had similar trends with Wagner 4, 3 and 2 including the highest ulcer grade and the lowest ulcer grade, namely 4. Other studies also conducted in India obtained different data, namely Wagner 1 — 4 cases (8%), Wagner 2 — 21 cases (42%), Wagner 3 — 17 cases (34%), Wagner 4 — 6 cases (12%) and Wagner 5 — 2 cases (4%) (Park et al., 2019).

Descriptive statistical analysis between the number of antibiotic sensitivity and ulcer grade in the four main bacteria is sulfamethoxazole in Wagner 3 and Wagner 1 and 5. Ampicillin is seen in Wagner 4 and Wagner 5. Gentamicin is seen in Wagner 4 and Wagner 1. The fourth main antibiotic, amikacin in Wagner 4 and Wagner 1.

The data from this study show that the majority of diabetic foot ulcers caused by the main bacteria have a Wagner 4 and Wagner 3 ulcer grade. This is in accordance with the etiology of diabetic foot ulcers, namely that around 60-80% of diabetics will experience neuropathy which ultimately causes diabetic foot ulcers. Wagner 3 and 4 diabetic foot ulcers are caused by difficulties such as carrying out metabolic control in the form of blood sugar control, infection control which requires antibiotic therapy, ulcer treatment which requires a minimum of one to several weeks, and removal or reduction of pressure on the ulcer area (Mazumder, 2023; Taylor & Unakal, 2023).

Diabetic foot ulcers Wagner 1 and Wagner 2 caused by the main bacteria according to the pathophysiology of ulcers, namely from the development of calluses due to neuropathy. Motoric neuropathy causes physical deformities of the feet, while sensory neuropathy causes loss of sensation resulting in ongoing trauma. Autonomic neuropathy causes drying of the skin. Meanwhile, trauma that often occurs to the callus causes subcutaneous bleeding and erosion until an ulcer is finally formed. Diabetic foot ulcers Wagner 3 and Wagner 4 caused by the main bacteria according to the next ulcer pathophysiology, namely severe atherosclerosis of the small blood vessels in the legs and feet which causes blood vessel disorders. As a result, blood cannot reach the wound so that healing is delayed and finally necrosis and gangrene occur which are other causes of diabetic foot ulcer infections (Hariftyani et al., 2021).

Descriptive statistical analysis between the number of types of bacteria and the number of antibiotic sensitivities in the four main bacteria are *P. aeruginosa* on gentamicin and on cefepime and ampicillin. *E. coli* appears on sulfamethoxazole and on piperacilin. *K. pneumoniae* appears on ampicillin and on gentamicin. The fourth main antibiotic, *P. mirabilis* on ampicillin and on sulfamethoxazole.

Pseudomonas aeruginosa is one of the main bacteria that infect diabetic foot ulcers which are commonly found in superficial wounds and in patients receiving antibiotic therapy. This bacteria is more dominant in chronic wound conditions because it can form biofilms that have the potential to cause suboptimal antibiotic use and can increase antibiotic resistance in wounds.

The results of this study indicate that *P. aeruginosa* is most sensitive to gentamicin, *E. coli* is most sensitive to sulfamethoxazole, *P. mirabilis* is most sensitive to ampicillin and *K. pneumoniae* ss. *Pneumoniae* is most sensitive to ampicillin. Another study at RSUD dr. Zainoel Abidin, namely the most common bacteria in diabetic foot ulcers are *S. aureus*, *E.*

coli, *P. aeruginosa*, *K. pneumoniae* and *P. mirabilis* which are sensitive to amikacin, erythromycin, meropenem, and ampicillin (Shah et al., 2022). This is in accordance with Hamza's research that antibiotics in empirical therapy are influenced by several factors such as the type of bacteria that causes the infection and the degree of ulcer (Committee, 2022).

The results obtained were *S. aureus* — Erythromycin and *K. pneumoniae* — ampicillin in Wagner ulcer degree 1, *P. aeruginosa* — gentamicin and *K. pneumoniae* — ampicillin in Wagner 2, *P. aeruginosa* — gentamicin and *E. coli* — sulfamethoxazole in Wagner 3, *K. pneumoniae* — ampicillin and *P. aeruginosa* — gentamicin in Wagner 4, and *A. baumannii* — ampicillin and *P. rettgeri* — sulfamethoxazole in Wagner 5.

Bacterial patterns in diabetic foot ulcers can vary from region to region and hospital, which may be related to environmental, hygiene, and cultural factors.³ Therefore, pus culture examination is prioritized to compile bacterial antibiotic sensitivity patterns as a basis for empirical antibiotic therapy in each hospital. Sensitivity testing is important in diabetic foot ulcer patients to get the right treatment (Aalaa et al., 2023; Gomas & Rehman, 2024).

CONCLUSIONS

The data collected and processed produced several findings that were discussed in more depth to produce conclusions. There is no relationship between the type of bacteria and the degree of foot ulcers in patients with type 2 DM. There is a relationship between antibiotic sensitivity and the degree of ulcers in patients with type 2 DM. There is a relationship between the type of bacteria and antibiotic sensitivity in patients with type 2 DM. There is a simultaneous relationship between the type of bacteria and antibiotic sensitivity to the degree of ulcers in patients with type 2 DM. Therefore, it is necessary to conduct culture examinations and antibiotic sensitivity tests on all patients with diabetic foot ulcers.

REFERENCES

- (Balitbangkes), B. P. dan P. K. (2018a). *Laporan nasional riskesdas 2018*. Lembaga Penerbit Badan Penelitian dan Pengembangan Kesehatan. <https://layanandata.kemkes.go.id/katalog-data/riskesdas/ketersediaan-data/riskesdas-2018>
- (Balitbangkes), B. P. dan P. K. (2018b). *Laporan provinsi Jawa Tengah riskesdas 2018*. Lembaga Penerbit Badan Penelitian dan Pengembangan Kesehatan. <https://dinkesjatengprov.go.id/v2018/storage/2019/12/CETAK-LAPORAN-RISKESDA-S-JATENG-2018-ACC-PIMRED.pdf>
- Aalaa, M., Vadhani, A. M., Tehrani, M. M., Mehrdad, N., Zohdirad, M., & Sadati, M. (2023). Epidemiological insights into diabetic foot amputation and its correlates: A provincial study. *Clinical Medicine Insights: Endocrinology and Diabetes*, *17*, 1–10. <https://doi.org/10.1177/11795514241227618>
- Ahmad, S., Khan, M. A., & Shah, M. H. (2022). Microbial profile and antimicrobial susceptibility pattern in diabetic foot ulcer patients attending a tertiary care hospital. *Cureus*, *14*(9), e29770. <https://doi.org/10.7759/cureus.29770>
- Boulton, A. J. M., & Whitehouse, R. W. (2023). The diabetic foot. In K. R. Feingold, B. Anawalt, & M. R. Blackman (Eds.), *Endotext*. MDText. <https://www.endotext.org/chapter/the-diabetic-foot>
- Committee, A. D. A. P. P. (2022). Retinopathy, neuropathy, and foot care: Standards of medical care in diabetes — 2022. *Diabetes Care*, *45*(Suppl_1), S185–S192. <https://doi.org/10.2337/dc22-S012>

- Goljan, E. F. (2019). Endocrine disorders. In *Rapid review pathology* (5th ed., pp. 698–702). Elsevier.
- Gomatos, E. L., & Rehman, A. (2024). Sensory Neuropathy. In *StatPearls*. StatPearls Publishing. <https://www.statpearls.com/point-of-care/28893>
- Hariftyani, A. S., Novida, H., & Edward, M. (2021). Profile of diabetic foot ulcer patients at tertiary care hospital in Surabaya, Indonesia. *Jurnal Berkala Epidemiologi*, 9(3), 293–302. <https://doi.org/10.20473/jbe.v9i32021.293-300>
- Heravi, F. S., Zakrzewski, M., Vickery, K., Armstrong, D. G., & Hu, H. (2019). Bacterial diversity of diabetic foot ulcers: Current status and future prospectives. *Journal of Clinical Medicine*, 8(11), 1935. <https://doi.org/10.3390/jcm8111935>
- Mazumder, S. A. (2023). Proteus infections, background, pathophysiology, epidemiology. In F. Talavera, A. E. Glatt, & M. S. Bronze (Eds.), *Medscape*. <https://emedicine.medscape.com/article/226434-overview>
- McDermott, K., Fang, M., Boulton, A. J. M., Selvin, E., & Hicks, C. W. (2023). Etiology, epidemiology, and disparities in the burden of diabetic foot ulcers. *Diabetes Care*, 46(1), 209–221. <https://doi.org/10.2337/dci22-0043>
- Ogba, O. M., Nsan, E., & Eyam, E. S. (2019). Aerobic bacteria associated with diabetic foot ulcers and their susceptibility pattern. *Biomedical Dermatology*, 3(1), 1–6. <https://doi.org/10.1186/s41702-019-0039-x>
- Oliver, T. I., & Mutluoglu, M. (2022). Diabetic foot ulcer. In *StatPearls*. StatPearls Publishing. <https://www.ncbi.nlm.nih.gov/books/NBK537328>
- Packer, C. F., Ali, S. A., & Manna, B. (2023). Diabetic Ulcer. In *StatPearls*. StatPearls Publishing. <https://www.statpearls.com/point-of-care/20448>
- Park, J. U., Oh, B., Lee, J. P., & Choi, M. H. (2019). Influence of microbiota on diabetic foot wound in comparison with adjacent normal skin based on the clinical features. *BioMed Research International*, 2019, 1–9. <https://doi.org/10.1155/2019/7459236>
- Powers, A. C., Niswender, K. D., & Molina, C. E. (2022). Diabetes mellitus: Diagnosis, classification, and pathophysiology. In J. Loscalzo, A. S. Fauci, D. L. Kasper, S. L. Hauser, D. L. Longo, & J. L. Jameson (Eds.), *Harrison's principles of internal medicine* (21st ed., pp. 3094–3128). McGraw-Hill.
- Rizqiyah, H., Soleha, T. U., Hanriko, R., & Apriliana, E. (2020). Pola bakteri ulkus diabetikum pada penderita diabetes melitus di RSUD Dr. H. Abdul Moeloek. *Majority*, 9(2), 128–133. <https://jurnalmajority.com/index.php/majority/article/view/66>
- Schmidt, B. M., Huang, Y., Banerjee, M., Hayek, S. S., & Busui, R. P. (2024). Residential address amplifies health disparities and risk of infection in individuals with diabetic foot ulcers. *Diabetes Care*, 47, 508–515. <https://doi.org/10.2337/dc23-1787>
- Shah, P., Inturi, R., Anne, D., Jadhav, D., Viswambharan, V., & Khadilkar, R. (2022). Wagner's classification as a tool for treating diabetic foot ulcers: Our observations at a suburban teaching hospital. *Cureus*, 14(1), 1–10. <https://doi.org/10.7759/cureus.21501>
- Situngkir, R. H., & Sembiring, P. (2023). Analisis regresi logistik untuk menentukan faktor-faktor yang mempengaruhi kesejahteraan masyarakat kabupaten/kota di pulau Nias. *Jurnal Matematika Dan Pendidikan Matematika*, 6(1), 25–31. <https://doi.org/10.47662/farabi.v6i1.432>
- Soares, M. M., & Santos, J. V. (2022). *IDF diabetes atlas report on diabetes foot-related complications* (D. J. Magliano, E. J. Boyko, I. Genitsaridi, L. Piemonte, P. Riley, & P. Salpea (eds.); p. 5). International Diabetes Federation. <https://diabetesatlas.org/atlas/diabetic-foot-2022>
- Sukartini, T., Dee, T. M. T., Probowati, R., & Arifin, H. (2020). Behaviour model for diabetic ulcer prevention. *Journal of Diabetes & Metabolic Disorders*, 19(1), 135–136. <https://doi.org/10.1007/s40200-019-00484-1>

- Suparwati, Sukarni, & Fradianto, I. (2022). Identifikasi bakteri pada luka kaki diabetes yang mengalami infeksi: Kajian literatur. *Berkala Ilmiah Mahasiswa Ilmu Keperawatan Indonesia*, 10(1), 35–42. <https://doi.org/10.53345/bimiki.v10i1.235>
- Taylor, T. A., & Unakal, C. G. (2023). Staphylococcus aureus infection. In *StatPearls*. StatPearls Publishing. <https://ncbi.nlm.nih.gov/books/NBK441868>
- Voelker, R. (2023). What Are Diabetic Foot Ulcers? *JAMA*, 330(23), 2314. <https://doi.org/10.1001/jama.2023.17291>
- Yani, M. R., Pratiwi, D. I. N., Rahmiati, R., Muthmainah, N., & Yasmina, A. (2021). Antibiotics susceptibility pattern in diabetic ulcer patients. *Indonesian Journal of Clinical Pathology and Medical Laboratory*, 27(2), 205–211. <https://doi.org/10.24293/ijcpml.v27i2.1652>
- Yunir, E., Tahapary, D. L., Tarigan, T. J. E., Harbuwono, D. S., Oktavianda, Y. D., & Kristanti, M. (2021). Non-vascular contributing factors of diabetic foot ulcer severity in national referral hospital of Indonesia. *Journal of Diabetes and Metabolic Disorders*, 20, 805–813. <https://doi.org/10.1007/s40200-021-00827-x>