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Prevalence and interrelationships of foot ulcer, risk-factors and antibiotic resistance in foot ulcers in diabetic populations: A systematic review and meta-analysis

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Abstract

BACKGROUND

Diabetic foot ulceration (DFU) is the prime health concern globally. It accounts for the major burden related to disease mortality and morbidity and economic cost. The timely and early recognition of the DFU can help present its occurrence and improve clinical outcomes.

AIM

To evaluate interrelationships between foot ulcers, risk factors, and antibiotic resistance among diabetic patients having ulcers in their foot.

METHODS

The databases such as PubMed, ERIC, Medline, and Google Scholar were extensively used for the extraction of studies. The selected studies were published within the time-period of 2014-2018. Ten studies were selected, which were found to be completely relevant to the current study.

RESULTS

The prevalence of diabetic foot ulcers among the population was evaluated, and the associated risk factors with its prevalence. Moreover, few studies also reported on the bacteria that are found to be most prevailing among diabetic patients. A narrative discussion was drawn through this analysis, which was used to highlight the specific area of research through selected studies, extraction of the significant information that matched with the topic of research, and analysis of problem through the findings of the selected articles. The results helped in assessing significant knowledge regarding the risk factors of diabetic foot ulcers and the role of antimicrobial resistant in its treatment.

CONCLUSION

The gram-negative bacteria were found to be the most common reason for diabetic foot ulcers. The study only included 10 studies that are not sufficient to

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produce generalized results, and no information was reported on the tests required to analyze antimicrobial susceptibility that can guide clinicians to propose better and sound treatment plans. It is evident that most study results depicted that the most common risk factors were found to be hypertension and neuropathy.

Key words: Amputation; Diabetes mellitus; Drug resistance; Foot ulcer; Gram-negative bacteria

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Core tip: The study has investigated relationship between foot ulcer, risk factors and antibiotic resistance among diabetic patients having ulcers in their foot. The results demonstrated that gram-negative bacteria are more responsible for the occurrence of diabetic foot ulcers. Antimicrobial sensitivity needs to be controlled by prescribing effective treatment plans to patients. Whereas, the overuse of antibiotics can negatively influence the health of patients.

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INTRODUCTION

With the prevalence of diabetes, a number of new complications related to the health of patients have been witnessed in the recent decades. On top of it, diabetic foot infection is a severe complication being faced by a large number of diabetic patients consisting of lesions in the deep tissues^[1,2]. Foot complications are the major cause of mortality and morbidity among diabetic patients leading to increased health care cost^[3,4]. Moreover, foot wounds are the most common diabetes-related complication often leading to hospitalization. Around 15% of diabetic patients experience foot ulcer once in their lifetime^[5,6].

The pathophysiology of the diabetic foot is complex; however, the infection is generally caused by the disturbance in the host such as; neuropathy, immunopathy and arteriopathy and other factors related to pathogen^[7]. The development of ulcer on the foot is related to the trauma that disrupts the protective skin envelope on the foot, leading to the bacterial colonization of the underlying subcutaneous tissues^[8]. However, infection is caused by the overgrowth of microorganisms in these areas leading to the destruction of tissues. Therefore, a foot ulcer might result in the amputation of the lower limb due to healing failure^[9].

The most common type of risks that leads to foot ulcers are diabetic neuropathy and peripheral vascular disorders. The most common type of neuropathy is diabetic neuropathy, developing in around 50% of Type 1 and Type 2 diabetic patients^[9,10]. The risk factors of diabetic foot ulcer include age^[10], duration of diabetes^[10,11], male gender^[11,12], poor glycemic control^[13], peripheral vascular disease^[12,14], diabetic retinopathy^[11,12], and nephropathy^[7,15].

Adding to the challenges faced by the clinicians in treating diabetic foot ulcers is the antibiotic resistance, which restricts the choice of antibiotics for the treatment process. In this regard, a study conducted by Xie *et al*^[16] explained the bacterial profile and antibiotic resistance in patients with diabetic foot ulcers. The main focus of the study was on the differences among different Wagner's Grades, ulcer types and Infectious Diseases Society of America/International Working Group on the Diabetic Foot Grades. To support this, McArdle *et al*^[17] also conducted a study to evaluate the antibiotic resistance in foot ulceration. A cohort of literature has been dedicated to evaluate the antibiotic resistance in patients with diabetic foot ulcers. The studies have also suggested various recommendations including; clinicians must pay significant attention to the antibiotic resistance patterns of common pathogens in their areas^[18], reconsidering antibiotic choice^[19,20] and curtailing the prevention of the development of drug resistant strains^[21,22]. Based on the literature present on the topic of research,

the current meta-analysis is aimed at discussing the prevalence of foot diseases, risk factors and antibiotic resistance among patients with diabetic foot ulcers. Moreover, the current study will help in providing recommendations to address the issues related to antibiotic resistance among patients with diabetic foot ulcers.

The present review aims to discuss the prevalence and the interrelationship between the risk factors, foot diseases and antibiotic resistance among patients with diabetic foot ulcer. The following meta-analysis highlights the recommendations and methods discussed in the previous studies to cure diabetic foot ulcer. Moreover, the current study also analyzes the prevalence of risk factors leading to diabetic foot ulcer. The research questions for this study are as follows: (1) Is diabetic foot ulcer more prevalent among the population below the poverty line and those living in developing countries? (2) What are the risk factors which contribute to the development of foot ulcer among diabetic patients? (3) Is antibiotic resistance a major factor causing increase in diabetic foot ulcer? and (4) What are the possible recommendations to address the prevalence of diabetic foot ulcer and antibiotic resistance?

MATERIALS AND METHODS

To retrieve the qualitative and most authentic studies, the databases such as: PubMed, ERIC, Medline, and Google Scholar were extensively used for the extraction of studies. The inclusion and exclusion criteria were strictly applied to all the selected studies. The inclusion criteria were based on the complete relevance of the selected studies to the topic of research, time-period of the selected studies (2014-2018) and the limitation that selected studies must be a review article. Some common keywords used for the literature survey included; prevalence of diabetic foot ulcer, risk factors of diabetic foot ulcer, antibiotic resistance of diabetic foot ulcer, nephropathy and diabetic foot ulcer, and diabetic foot ulcer. The studies which did not meet the inclusion criteria were excluded from the study. Moreover, essays, reports, and blogs were also excluded due to reduced reliability and authenticity.

Meta-analysis was conducted to review the studies that were found relevant with the topic of research. A narrative discussion was drawn through this analysis, which was used to highlight the specific area of research through selected studies, extraction of the significant information that matched with the topic of research and analysis of problem through the findings of the selected articles.

Based on the keywords, the aforementioned platforms were extensively researched, and 2150 abstracts were extracted for the study. A two-stage investigation of the selected abstracts was carried out with the help of a professional and an investigator. With regards to this, the older version of the studies was excluded due to reduced reliability and authenticity and cross-sectional, prospective and retrospective studies were included in the study. The abstracts chosen for the study discussed the prevalence, risk factors and antibiotic resistance in foot ulcers among diabetic patients.

After the first application of inclusion criteria, the number of abstracts reduced to 725 with the elimination of 1425 abstracts. The inclusion criteria were again applied which reduced the number of articles to 125 after the exclusion of 1300 abstracts that were found irrelevant with the topic of study. The remaining 125 articles were again passed through a phase of strict scrutiny and were evaluated on the basis of conceptual framework to assure the direction and significance of the study. In the next step, only 10 studies were selected which were found to be completely relevant with the current study. Pictorial depiction of literature survey has been demonstrated in [Figure 1](#).

RESULTS

A total of 10 studies were selected for the systematic literature survey which included information regarding the topic of research. The prevalence of diabetic foot ulcers among the population was evaluated and the associated risk factors with its prevalence. Moreover, few studies also reported on the bacteria that are found to be most prevailing among diabetic patients. Furthermore, data regarding the antimicrobial resistance offered by these bacteria was also mentioned in the study. Different types of approaches used in the selected studies were summarized in the graphical form ([Figure 2](#)); whereas, [Table 1](#) has illustrated the characteristics of included studies that include; study type, mean age, male and female ratio, diabetes duration, Hemoglobin A1c percentage, ulcer description, and follow-up months. In

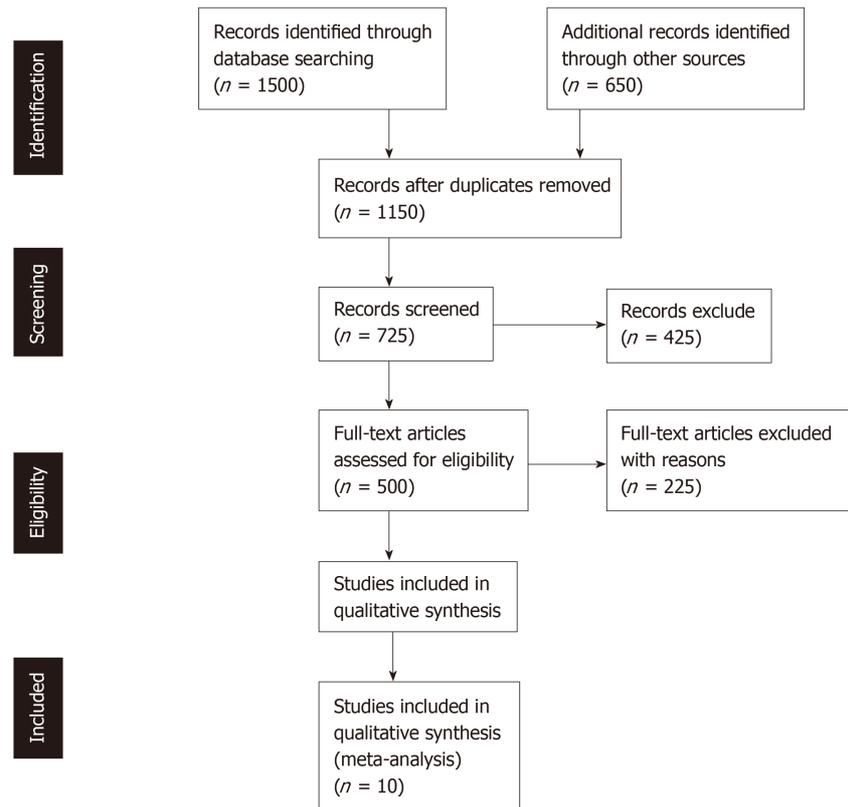


Figure 1 Literature survey process.

Hemoglobin A1c, A1c percentage measures the quantity of the sugar present in the blood's hemoglobin protein. It measures how well the sugar in the blood is controlled. Table 2 has summarized the study objective, methodology used, and study outcomes of the included studies. Whereas, Table 3 has provided description of the included studies related to the causative agents from diabetic foot ulceration (DFU).

DISCUSSION

Quilici *et al*^[21] measure the risk factors that are involved in the amputation process for diabetic patients hospitalized due to foot infections. One hundred patients were selected who were suffering complications related to diabetes infections in their lower limbs. Multiple Cox regression analysis was used to analyze the data collected from the patients. The prevalence of several factors was evaluated, among which, hypertension and neuropathy were found to be the prevalent risk factors. The results conducted from Morisky test showed that 42% of patients were on the risk of progression to amputation due to the previous use of microbials. Also, the results suggested that those patients who did not comply with diabetes treatment were on 26% more risk of amputation. Such that, it can be concluded that these risk factors can significantly increase the risk of amputation among patients. The knowledge of these risk factors will help practitioners to develop treatment plans that can effectively reduce the risk of amputation among diabetic patients. Another study conducted by Pickwell *et al*^[23] reported a 28% ratio of patients that underwent amputation.

Roth-Albin *et al*^[24] assess the advanced wound care for diabetic foot ulcers. A retrospective cohort design was followed which included adult patients suffering from diabetic foot ulcers. The delayed risks of diabetic foot ulcers were evaluated in the study. The results showed that, only 35 out of 40 patients were able to heal through all diabetic foot ulcers in the period of 52 wk. The factors influencing the healing process of diabetic foot ulcers include peripheral vascular disease, chronic ulcers, multiple ulcers, and ulcer sizes. Furthermore, the results showed that the rate of unadjusted healing rate of recurrent ulcers was more than other factors. Such that, the study concluded that continued self-care, advanced wound care and outpatient has significant influence on the healing of diabetic foot infections. Jeffcoate *et al*^[25] also

Table 1 Characteristics of the included studies

Ref.	Study type	Male: Female ratio	Type 2 diabetes mellitus/Type 1 diabetes	Duration of Diabetes	HbA1c%	Ulcer description	Follow-up months
Quilici <i>et al</i> ^[21]	Cross-sectional study	68 males and 32 females	T2DM	22% had for less than five yr; 24% had from 5-10 yr; 17% had from 10-15 yr; 16% had from 15-20 yr; 21% had for >20 yr	-	75% patients had Grade 4 ulcers; 20% had Grade 3 ulcers; 5% had Grade 2 ulcers	-
Commons <i>et al</i> ^[26]	Prospective study	60% male and 40% females	All patients had T1DM, except of 7 patients	-	Median value was 8.8%	Diabetic patients with ulcers or foot infections were referred	14 mo
Barwell <i>et al</i> ^[28]	Combination of literature review	-	T1DM and T2DM	-	-	Standardized using validated classifications schemes such as the University of Texas rating, SINBAD or IWGDF PEDIS	-
Roth-Albin <i>et al</i> ^[24]	Retrospective cohort study	67.9% were males	-	-	-	Ulcer sizes > 1 cm ²	52 wk
Fitzgerald <i>et al</i> ^[30]	Retrospective study	4:4	-	Average disease duration 22 yr	-	Active foot-ulcer with a wound swab taken	15 mo
Kathirvel <i>et al</i> ^[22]	Retrospective study	74.6% males and 25.33% females	T2DM	< 5 yr - 40%; 5-10 yr - 34%; 10-15 yr - 17%; 15-20 yr - 7.3%; > 20 yr - 1.3%	6%-7%	Categorized into necrotic/non-necrotic; ulcers based on signs of infection	-
Xie <i>et al</i> ^[16]	Hospital-based retrospect study	230 males and 158 females	T2DM	-	-	Severity of ulcer was assessed by Wagner-Meggitt classification system	-
Dwedat <i>et al</i> ^[41]	Observational prospective study	48 males (57%) and 32 females (43%)	-	5-32 yr	-	Graded according to Wagner's grade	-
Abbas <i>et al</i> ^[45]	Literature review	-	T2DM	-	-	Classified on the basis of wound debridement, pressure off-loading, glycemic control, surgical interventions, and occasionally other adjunctive measures	-
Oliveira <i>et al</i> ^[46]	Epidemiological, retrospective and descriptive study	27 males and 30 females	-	-	-	Infected ulceration was associated with germs present in the community	-

International Working Group on the Diabetic Foot provides guideline for preventing and managing diabetic foot disease. Type 2 diabetes mellitus is a chronic medical condition, which occurs when the cell of the body resist effect of insulin for driving glucose to the blood cells. Type 1 diabetes mellitus is a condition when pancreas produce low or lack of insulin as required by the body. IWGDF: International Working Group on the Diabetic Foot; T2DM: Type 2 diabetes mellitus; T1DM: Type 1 diabetes mellitus; HbA1c: Hemoglobin A1c.

emphasized on improving self-care among patients to enhance the outcomes of diabetic health infections.

Commons *et al*^[26] appraise the high burden of diabetic foot infections in Australia. The study highlighted that the ratio of diabetic patients is increasing all over the world leading to amputations in worst cases. Foot infections were reported as the common cause of amputation among patients with foot ulcers. All the patients with diabetic foot infections enrolled in Royal Darwin Hospital were included in the study.

Table 2 Objective of the study, findings and outcome data

Ref.	Methodology/Approach	Findings	Outcome
Quilici <i>et al</i> ^[21]	Cross-sectional study	Prevalence of amputation was 42% due to the previous use of antimicrobials. Risk of amputation was 26% for patients who had less compliant with the diabetes treatment	Highlight factors for the management patients with diabetic foot infection
Commons <i>et al</i> ^[26]	Prospective study was conducted among patients with diabetic foot infections, enrolled in Royal Darwin Hospital, were selected. The relation with <i>Pseudomonas aeruginosa</i> and methicillin resistant <i>Staphylococcus aureus</i> was also determined	<i>P. aeruginosa</i> and Methicillin resistant <i>S. aureus</i> infections were cured by long-term courses of antibiotics and increased hospital stay	Prevalence of diabetic foot ulcer is directly and significantly related to the best bed days
Barwell <i>et al</i> ^[28]	A literature review was conducted	Antibiotic and antimicrobial resistance of Gram positive organisms occurred as a main challenge in the treatment of diabetic foot infection	Provides guideline as empirical evidence to support clinicians
Roth-Albin <i>et al</i> ^[24]	Retrospective cohort study	35 out of 40 patients were healed in 52 weeks. 7.1% underwent amputation and 8.9% died before receiving any kind of treatment	Healing rates significantly improved by proper and continued care
Fitzgerald <i>et al</i> ^[30]	Retrospective exploratory study	Diabetes and Cardiovascular disease/peripheral-vascular disease was identified in 2 and 6 patients, respectively. 28 patients had foot ulcers and RA. Inflicted patients were treated with antirheumatic drugs and steroids	Inaccurate diagnosis of ulcer infection leads to failure of microbiological analysis
Kathirvel <i>et al</i> ^[22]	150 patients' clinical examination, clinical history and microbiological profile were prospectively examined	99 patients were isolated from MDRO. MDRO risk factors include; previous antibiotic usage, retinopathy, polymicrobial culture, presence of ulcer, antibiotic usage, ulcer size, history of amputation, peripheral vascular disease, neuropathy, and necrotic ulcer	MDRO prevalence was high among diabetic patients with foot ulcers
Xie <i>et al</i> ^[16]	Retrospective study was conducted using 207 bacteria from diabetic foot infections. Microbial and clinical information was also collected	Gram negative bacteria were found to be more as compared to gram positive bacteria with, <i>Staphylococcus</i> and <i>Enterobacteriaceae</i> to be the most dominant	The antibiotic sensitivity and bacterial profile of diabetic foot ulcers varied with their types and grades
Dwedara <i>et al</i> ^[41]	80 patients with diabetic foot infections were prospectively studied	Gram negative bacteria were more common. Vancomycin was found to be the best against gram-positive bacteria; whereas, colistin, imipenem and amikacin were effective against gram-negative bacteria	Knowledge regarding antibiotic sensitivity is required for future treatment of diabetic foot ulcers
Abbas <i>et al</i> ^[45]	Non-systematic research	Antibiotic therapy is necessary for several clinically infected wounds	Antibiotic therapies should be used for treatment
Oliveira <i>et al</i> ^[46]	Descriptive, retrospective and epidemiological study was used	65% of cases suffered amputations. <i>Staphylococci</i> was the most common bacteria type. Three patients were found to be enterobacteria and second was, <i>Staphylococci</i>	Clindamycin and cephalexin were most resistant to bacteria

Infectious Diseases Society of America is a medical association which represents healthcare professional who are expert in treating infectious diseases. Rheumatoid Arthritis is an autoimmune disabling infection. It causes pain, swelling and inflammation in joints and other body organs. Multi-drug resistant organisms bacteria that is resistance to various antibiotics. IDSA: Infectious Diseases Society of America; RA: Rheumatoid arthritis; MDRO: Multi-drug resistant organisms.

The results showed that indigenous patients were found to be more subjected to amputations as compared to non-indigenous patients. Furthermore, the study highlighted *P. aeruginosa* or Methicillin resistant *S. aureus* as one of the leading infections that required longer hospital stay and antibiotic courses. Another study conducted by O'Rourke *et al*^[27] also reported that 52% of patients in Far North Queensland were indigenous who went through amputation. Such that, results concluded from these studies emphasize on increasing self-care and management of

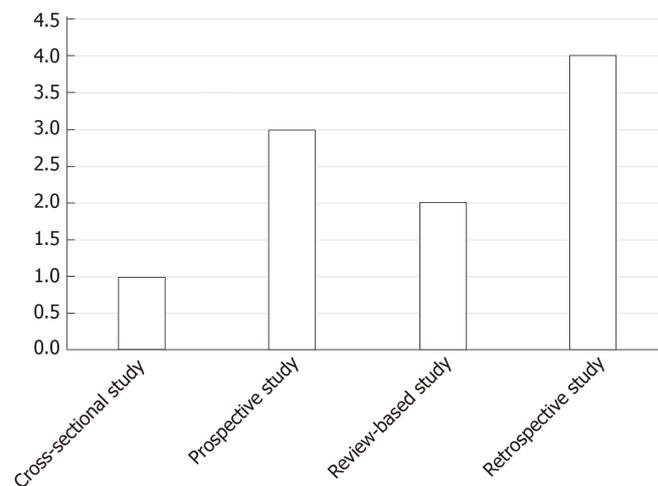


Figure 2 Type of approaches employed by included studies.

foot care, which can lead to reduction in major amputation.

Barwell *et al*^[28] reported on diabetic foot infections and recommendation related to good practice and antibiotic therapy. The study reported that diabetic foot infections can cause mortality, morbidity and a burden of economic cause on patients. According to the study, tissue sampling at the very beginning can help in overcoming the increased cost of treatment and long use of antibiotics. Long use of certain antibiotic can make the resistant toward it, thus, making the infection more complicated to treatment. A literature review was carried out to evaluate these aspects, and expert discussion was also considered. The results reported that gram positive organisms are the most common pathogens that induce foot infections. The study also reported that there are several challenges present regarding antibiotic availability and antibiotic resistance. The study concluded that the use of alternative oral agents and outpatient antibiotics can help in increasing diabetic foot care. Kang *et al*^[29] also reported that long-term use of antibiotics makes the patients with diabetic foot ulcers resistant to the antibiotics.

Fitzgerald *et al*^[30] conducted a study to evaluate the prevalence and microbiological characteristics of clinically infected foot-ulcers in patients with rheumatoid arthritis (RA). A retrospective cohort design was followed to collect data from the patients with arthritis. The patients attending a clinic aimed for the treatment of rheumatology and wound swab data was collected from the patients suffering from clinical infection. The results showed that only 28 patients were identified who were suffering from both foot infection and RA. Among these patients, only 8 had wound swabs taken and clinical infection. The study concluded that microbiological analysis has failed to isolate the pathogens. The rationale behind this failure might be due to inappropriate diagnosis or issue with tissue sampling. The study highlighted on the importance of conducting more research for infection diagnosis, processing and wound sampling. On the other hand, Grigoropoulou *et al*^[31] defined the importance of microbiological culture for the treatment of foot infections. The study emphasized that proper knowledge of the severity of infection can lead to the development of adequate treatment strategies.

Kathirvel *et al*^[22] discussed risk factors for diabetic foot infections with multidrug-resistant microorganisms. The study included a total of 150 patients who were diagnosed with foot ulcers. A detailed and thorough examination of the clinical history and examination of the patients with foot ulcer was carried out. Microbiological analysis of all the patients was studied. The results showed that multidrug-resistant organisms were isolated from 99 out of 150 patients. Multidrug-resistant organisms were found to be isolated organisms. On the other hand, the risk factors of diabetic foot ulcers were examined to be peripheral vascular disease, retinopathy, polymicrobial culture, and neuropathy. Moreover, the study predicted that the rate of multidrug-resistant organisms was reaching an alarming rate. Therefore, the practitioners are advised to develop proper treatment plans that reduce the rate of multidrug-resistant organisms. Other studies also emphasized on the interventions for the management of foot infection among diabetic patients^[32-35].

Xie *et al*^[16] also evaluated bacterial profile and antibiotic resistance in patients with diabetic foot ulcer. The study included a sample of 207 bacteria from a total of 117

Table 3 Description of studies causative agents from diabetic foot ulcer

Ref.	Total no of enrolled patients with multiple strains, n (%)	Number of microorganisms, n (%)											
		Gram positive					Gram negative						
		Aerobes		Ananeroberes			Aerobes		Ananeroberes				
	Methicillin-sensitive <i>Staphylococcus aureus</i> (MSSA)	Methicillin-resistant <i>Staphylococcus aureus</i> (MRSA)	Other <i>Staphylococcus</i> (Staphylococcus species)	<i>Streptococcus</i> sp	<i>Enterococcus</i> sp	Other gram positive	Ananeroberes	Enterobac-terifaceac members	<i>Pseudomonas</i> sp	Other gram negative sp	Ananeroberes	Fungus	
Quilici <i>et al.</i> ^[21]	100	-	-	-	-	-	-	-	-	-	-	-	-
Comm- ons <i>et al.</i> ^[26]	177	-	-	-	-	-	-	-	-	-	-	-	-
Bar -well <i>et al.</i> ^[28]	-	-	-	-	-	-	-	-	-	-	-	-	-
Roth -Albin <i>et al.</i> ^[23]	40	-	-	-	-	-	-	-	-	-	-	-	-
Fitze- raid <i>et al.</i> ^[30]	28	+++	-	-	-	-	++	-	-	-	-	-	-
Kathir -vel <i>et al.</i> ^[23]	150	-	-	-	-	17.90%	-	-	-	-	69.89%	-	-
Xie <i>et al.</i> ^[16]	405	43.2%, 41/95	-	65.2%, 62/95	20.0%, 19/95	45.9%, 95/207	-	73.2%, 82/112	-	54.1%, 112/207	-	10.70%	
Dwe -dar <i>et al.</i> ^[41]	80	11.40%	(10.1%)	46.80%	-	27.70%	-	10.80%	-	56.08%	8.10%	-	
Abbas <i>et al.</i> ^[45]	-	-	-	-	-	-	-	-	-	-	-	-	
Olive -ira <i>et al.</i> ^[46]	66	22.70%	-	4.50%	-	-	-	-	-	-	-	-	

-: No mention in literature; ++: The total may be over 100% this is because of mixed infections; percentage values are calculated from cases with isolated stains; +++: Approximate number. MSSA: Methicillin susceptible *Staphylococcus aureus* (bacteria that is not resistant to some antibiotics); MRSA: Methicillin resistant *Staphylococcus aureus* (Gram-positive bacteria that causes various infections in the body).

diabetic foot infections. The result stated that gram-negative bacteria were found to be in higher proportion as compared to gram-positive bacteria. Moreover, *Staphylococcus* and *Enterobacteriaceae* were found to be the most prevalent microorganisms among sample. Thus, the study recommended clinicians to examine the antibiotic resistance pattern of common pathogens. Furthermore, Perim *et al*^[36] also confirmed the high prevalence of multidrug-resistant pathogens in DFUs. Moreover, other studies focused on evaluating the antibiotic susceptibility patterns of isolates to develop effective treatment plans^[37-40].

Dwedara *et al*^[41] also measure the microbiological causes of diabetic foot infections and their associated antibiotic resistance patterns. A total of 80 patients suffering from diabetic foot infections were selected as the sample of the study. The sterile swabs from the sample were collected along with thorough examination of the antimicrobial susceptibility through several susceptibility tests. The results concluded that gram-negative bacteria were more isolated as compared to gram-positive bacteria. The most common isolates were found to be *Staphylococcus aureus*, *Escherichia coli*, *Proteus mirabilis*, *Pseudomonas spp*, and Methicillin resistant *Staphylococcus aureus*. The study concluded that gram-negative bacteria are highly responsible for causing diabetic foot ulcers. Moreover, the information on the antibiotic sensitivity help clinicians to prescribe drugs that are efficient for the treatment of diabetic ulcers. Other studies also emphasized on attaining the knowledge of antibiotic sensitivity among patients with diabetic ulcers^[42-44].

Abbas *et al*^[45] evaluate the role of antibiotics in treating infection among diabetic foot ulcers, not to heal wounds. The study stated that antibiotic therapy is used for clinically infected wounds and not for uninfected ulcers. However, the study described that often clinicians fail to prescribe drugs related to such conditions. Such mistakes by clinicians can impose negative impact on the overall health of the patient. Overuse of antibiotics can make the patient more prone to the specific drug; thus, reducing its effectiveness. To this end, the study concluded that clinicians should thoroughly examine the condition of patients and should limit prescribing antibiotics for uninfected foot wounds. On the other hand, other studies also emphasized on studying the antimicrobial resistance profiles of patients^[46-49].

In conclusion, The ratio of diabetic foot infections among patients is increasing all over the world; thus, resulting in increased amputation rates. The study was aimed to evaluate the prevalence and interrelationships of foot diseases, associated risk factors and antibiotic resistance in patients with diabetic foot ulcers. The systematic review helped in assessing significant knowledge regarding the risk factors of diabetic foot ulcers and the role of antimicrobial resistant in its treatment. Thus, it can be concluded that gram-negative bacteria are more responsible for the occurrence of diabetic foot ulcers. Moreover, the risk factors were identified to be hypertension, neuropathy, etc. On the other hand, the study also reported that antimicrobial sensitivity needs to be controlled by prescribing effective treatment plans to patients. Overuse of antibiotics can negatively influence the health of patients. Therefore, clinicians are addressed to study the antimicrobial pattern among patients before prescribing any treatment plan.

Despite of the cohort of information provided in the following study, it has few limitations. The study only included 10 studies which are not sufficient to produce generalized results; therefore, the researchers should include a large number of studies in the future work. Moreover, no information was reported on the tests required to analyze antimicrobial susceptibility that can guide clinicians to propose better and sound treatment plans. To this end, the researchers were advised to include these aspects in future studies to address the issues related to the diagnosis of patients.

ARTICLE HIGHLIGHTS

Research background

Globally, the occurrence of diabetic foot ulceration (DFU) reported as a significant health concern which calls for early prevention and diagnosis.

Research motivation

This study would assist in setting out relevant guidelines for reducing the incidence of DFU and overcome the resistance among patients for its treatment.

Research objectives

The main objectives were to examine the interrelationships between foot ulcers, risk factors, and antibiotic resistance among diabetic patients having ulcers in their foot.

Research methods

A systematic and meta-analysis method is adopted for providing comprehensive insights on the

DFU prevalence, risk factors as well as its resistance.

Research results

The research findings showed an increased prevalence of gram-negative bacteria among the DFU cases.

Research conclusions

The review concludes hypertension and neuropathy as the major risk factors among DFU patients.

Research perspectives

The review highlights that antimicrobial susceptibility can be considered for attaining better treatment outcomes.

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