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Identifying Predictors and Its Relationship with Developing of Diabetic Foot Ulcer (DFU) among People with 2 Diabetes Mellitus: A Scoping Review

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ABSTRACT Diabetic Foot Ulcer (DFU) is a serious complication of type 2 diabetes mellitus, often leading to amputation, prolonged hospitalization, and increased mortality. Early identification of contributing predictors is essential to prevent these outcomes. This study aimed to synthesize current evidence on predictors of DFU and their relationship with DFU development among individuals with type 2 diabetes mellitus. A scoping review design was employed, involving a systematic search of four major databases PubMed, ScienceDirect, ProQuest, and Google Scholar using keywords such as "predictors," "diabetic foot ulcer," and "type 2 diabetic patients." A total of 170 articles were screened using PRISMA guidelines, with 17 studies meeting the inclusion criteria. These comprised eight cross-sectional studies, seven retrospective studies, and two systematic reviews. Findings revealed that the incidence of DFU exceeded 11.6%, with the majority of cases presenting as grade 1 or 2 ulcers. The identified predictors were categorized into three main domains: diabetes-related complications, demographic characteristics, and self-care behaviors. Peripheral arterial disease (PAD) emerged as the dominant predictor within the complication category; diabetes duration over 10 years was the most frequent demographic risk factor; and inadequate foot-care practices were the leading behavioral predictor. These findings suggest that enhancing patient education, particularly regarding foot-care behaviors tailored to individual risk profiles and clinical complications, may significantly reduce the incidence and severity of DFU. Strengthening preventative strategies based on these predictors is crucial for improving diabetes management and clinical outcomes in type 2 diabetic populations.

INDEX TERMS diabetic foot ulcer, predictors, type 2 diabetes mellitus, peripheral arterial disease, foot-care behavior

I. INTRODUCTION

Diabetic foot ulcer (DFU) is recognized as one of the most serious and prevalent complications of diabetes mellitus (DM), contributing to a high risk of lower-extremity amputation, prolonged hospitalization, reduced quality of life, and increased mortality among patients [1]–[3]. DFU is typically characterized by full-thickness wounds penetrating through the dermis, often resulting from a combination of peripheral neuropathy, vascular insufficiency, and infection [4]–[6]. Globally, the annual incidence of DFU is estimated to range from 1.9 to 26.1 million cases [7], with 6.3% of patients with diabetes developing DFU during their lifetime, and 42% of those progressing within five years of onset [8], [9]. The annual rate of amputation among individuals with DFU is reported to reach 5.1%, while mortality may range between 2.8% and 14.4% within the first year of diagnosis [10], [11].

A growing body of literature highlights multiple predictors associated with DFU development, including diabetes-related complications, demographic characteristics, and self-care behaviors [12]–[14]. For instance, inadequate foot self-care, poor glycemic control, and the presence of comorbidities such as peripheral arterial disease (PAD) and neuropathy have all been identified as contributing factors [15]–[17]. Demographic attributes such as older age, low education level, rural residence, and longer diabetes duration have also been found to increase DFU risk [18]–[20]. Meanwhile, behavioral factors including poor adherence to diabetic foot-care practices, low health literacy, and limited access to healthcare exacerbate the likelihood of DFU formation [21]–[23].

Recent scoping and systematic reviews have investigated categories of predictors related to DFU incidence, such as body mass index (BMI), smoking, insulin use, and socioeconomic factors [24]–[26]. However, these reviews often lacked a clear classification of predictors or failed to explore the strength of the relationship between predictors and DFU development. In addition, there is limited synthesis of dominant or high-risk predictors across multiple populations, particularly in low-

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resource settings where the prevalence of DFU remains high [27]–[30]. Therefore, a comprehensive analysis is required to identify the key predictors of DFU and their relational impact on ulcer development.

This study aims to identify the most significant predictors and their association with the development of DFU among individuals with type 2 diabetes mellitus through a structured scoping review. The results are expected to inform early screening, preventive measures, and personalized interventions based on patient-specific risk factors. The contributions of this study are as follows:

1. It provides an up-to-date synthesis of evidence on DFU predictors using recent global studies published between 2014 and 2024.
2. It classifies the predictors into three main domains: diabetes complications, demographic characteristics, and self-care behaviors, offering a structured perspective for clinical application.
3. It identifies the dominant predictors within each category and assesses their relevance to DFU development, supporting targeted screening and prevention strategies.

II. METHODS

A. STUDY DESIGN AND SEARCHING STRATEGY

This study employed a scoping review design, which is particularly useful for mapping existing literature, identifying key concepts, and examining research gaps within a given field [31]. The review followed the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) guidelines to ensure methodological rigor and transparency in the review process [32]. A systematic literature search was conducted across four reputable academic databases: PubMed, ScienceDirect, ProQuest, and Google Scholar. The search strategy used Boolean operators and relevant keywords: “predictors,” “diabetic foot ulcer,” “DFU,” and “type 2 diabetes mellitus.” The search was limited to English-language articles published between 2014 and 2024, focusing on predictors of DFU in patients with type 2 diabetes mellitus. Manual searching of reference lists from selected articles was also performed to ensure comprehensive coverage.

B. INCLUSION AND EXCLUSION CRITERIA

Studies were included if they met the following criteria:
Focused on predictors of diabetic foot ulcers in type 2 diabetic patients, Employed-primary designs (cross-sectional, retrospective, cohort, case-control), or systematic reviews, Published in peer-reviewed journals between 2014 and 2024, Written in English. Articles were excluded if they: Focused on type 1 diabetes, Were editorials, conference abstracts, letters to the editor, or non-peer-reviewed, Did not directly assess DFU predictors.

C. SCREENING AND SELECTION PROCESS

All identified records were imported into a citation manager and screened in two phases. First, titles and abstracts were reviewed for relevance. Second, full-text articles were assessed against inclusion criteria. The review process was conducted independently by two reviewers, with any disagreements resolved through discussion or by consulting a third reviewer. From an initial 170 articles, 17 articles met the inclusion criteria and were analyzed. The PRISMA 2020 flow diagram was used to report the selection process.

D. QUALITY ASSESSMENT AND DATA EXTRACTION

The methodological quality of each included study was evaluated using the Joanna Briggs Institute (JBI) critical appraisal checklist. The studies were assessed based on design type: observational, retrospective, or systematic review. In addition, the AMSTAR 2 tool was applied to assess the quality of review studies. Each study was scored and classified into high, moderate, low, or critically low-quality categories based on item completeness. A structured data extraction form was developed and used to collect essential information from the included studies. The extracted data included: Author and year, Country of study, Study design, Sample size and population, Identified-predictors, Type and grade of DFU, Odds ratio (OR), 95% Confidence Interval (CI), and p-value (when available).

E. OUTCOME MEASURES

The dominant predictors in each category were evaluated based on reported OR, CI, and p-values, where available. This review aimed to extract two primary outcomes:

1. Prevalence or incidence of diabetic foot ulcer among type 2 diabetic patients, expressed either as a percentage or per 100 person-years,
2. Predictors of DFU, categorized into three domains: (a) diabetes-related complications (e.g., peripheral arterial disease, retinopathy), (b) demographic characteristics (e.g., age, duration of diabetes, BMI), and (c) self-care behaviors (e.g., foot hygiene, physical activity).

F. ETHICAL CONSIDERATIONS AND LIMITATIONS OF METHODOLOGY

As this study was based on publicly available data from previously published studies, no ethical approval was required. Nevertheless, all sources included in the review were cited appropriately to ensure academic integrity and proper acknowledgment of original authorship. While a scoping review provides comprehensive mapping of literature, it does not assess effect sizes or conduct meta-analysis. Furthermore, the use of different terminologies across studies may have led to variability in data synthesis. Nonetheless, the strict inclusion criteria and use of structured appraisal tools improved the reliability of findings.

III. RESULTS

17 articles included from 170 articles, from which 8 articles are cross-sectional studies, 7 articles are retro-spective studies, as well as 2 articles are systematic review. The quality of articles review was all articles (17 articles) in a high category.

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A. INCIDENCE OF DIABETIC FOOT ULCER (DFU) AMONG TYPE 2 DIABETIC PATIENTS

The result shows the incidence of DFU among type 2 diabetic patients was 11,6% or more, it indicates that there is 1,51 cases of DFU per 100 person per year. Majority of DFU patients are in grade 1 and grade 2 (67,5%), or in superficial ulcer (62,84%). It could enhance in grade 2 or grade 3 when having diabetes complications or other. using wagner scale, diabetic foot ulcer was classified into 0 up-to 5 level, namely 0=no open lesion in skin, 1=partial or full thickness ulcer, 2=depp ulcer into fascia without abscess, 3=deep abscess, 4=gangrene in the outside of foot, 5=gangrene has spread into the entire foot.

B. THE PREDICTORS OF DIABETIC FOOT ULCER (DFU) AMONG PEOPLE WITH TYPE 2 DIABETES MELLITUS IS CLASSIFIED INTO 3 CATEGORIES INCLUDING:

1) DIABETES COMPLICATIONS

TABLE 1 shows that predictors of diabetic foot ulcer among people with type 2 diabetes based on diabetes complications including peripheral neuropathy, peripheral arterial disease (PAD), diabetic nephropathy and retinopathy, hypertension, hyperglycemia, callus on the feet. It proved from OR, CI 95%, as well as p-value. The participants who have diabetes complication have more high value of OR, CI, and p-value than participants who do not have diabetes complication, so it means that patients with diabetes complication have more high risk experiencing severe diabetic foot ulcer. The dominant predictors of DFU from this result is different. Some studies proved that peripheral arterial disease (PAD) as the dominant predictor of DFU [29,37,39,8], other studies reported that diabetic retinopathy is the dominant predictor followed by diabetic nephropathy [30], the other is callus on the feet [28,43].

2) DEMOGRAPHIC CHARACTERISTIC

TABLE 1 shows predictors of diabetic foot ulcer according to demographic characteristics including age, gender, BMI, location of living, smoking, alcohol consumption, and duration of diabetes. It is known through the value of OR, CI 95%, and p-value. Most studies show that p-value <0,001 as well as higher value of OR dan CI- value in cases group than control group. It also indicates that diabetic patients with positive predictors of DFU have a higher risk experiencing DFU.

There are different findings about the dominant predictor of DFU, some studies proved that heavy smoking [31], the other studies is duration of diabetes [32,36,40,41], patient with duration diabetes>10 years have more high risk experiencing DFU. Other studies is female [33,35], the other is age >50 years old [34], majority of studies prove that age more than 50 years old are high risk experiencing DFU. Other study is alcohol consumption [38], other study is obesity [42].

3) SELF-CARE BEHAVIOR

TABLE 1 shows that self-care behavior has correlation with incident of diabetic foot ulcer among type 2 diabetes mellitus. It means that self-care behavior including diabetic-care or diabetic foot-care practice is significant as predictor of DFU [33,38,8,39,40]. The participants with low foot-care practice, physical inactivity, and using combined diabetes medication have more higher value of OR, CI, and p-value than participants who do not have that predictor, so it means that patients with low foot-care practice, physical inactivity, and using combined medication have more high risk experiencing severe diabetic foot ulcer. There are different findings about the dominant factor of DFU based on self-care behavior. Some studies prove that using combined medication (insulin with metformin) is the dominant predictor of DFU [34,42], whereas other studies prove that physical inactivity is the dominant predictor [38,40], and other studies also prove that low foot-care practice [31,33,43].

TABLE 1
Data Extraction

Author	Country	Purpose	Study design	Result
Abdissa et al. (2020) [28]	Ethiopia	Identify of diabetic foot ulcer and its associated factors	Cross-sectional study	✓ The prevalence of DFU was 11,6% ✓ The dominant predictor of DFU was previous ulceration history, followed by peripheral neuropathy
Abuhay et al. (2022) [29]	Ethiopia	Determine DFU incidence and its predictors	Retrospective study	✓ The prevalence of DFU is 12,1% ✓ The dominant predictor of DFU was Peripheral Arterial Disease (PAD), followed by neuropathy and rural residence
Adem et al. (2020) [30]	Ethiopia	Investigate the incidence of DFU and its predictors	Retrospective-follow up study	✓ The incidence of DFU was 17,05% ✓ The dominant predictor was diabetic retinopathy, followed by diabetic nephropathy, and body mass index
Alhassan (2022) [31]	Egypt	Assess DFU severity and its predictors	Cross-sectional study	✓ Majority of participants have been experiencing on grade 2 DFU (42,9%), followed by Grade 3 (28,6%). ✓ The dominant predictor of high ulcer severity was heavy smoking, followed by treatment with insulin, elevated glycated hemoglobin, unsatisfactory foot care practice and long duration of diabetes
Almobarak et al. (2017) [32]	Sudan	Determine the prevalence of DFU and its associated risk factors	Cross-sectional study	✓ The prevalence of diabetic foot ulcer was 18.1 % ✓ The dominant predictor of diabetic foot ulcer was duration of diabetes. Living with diabetes>10 years has significant effect on increasing DFU, whereas living with diabetes >20 years has significant effect on increasing diabetic foot complication.

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Alrub et al. (2019) [33]	Jordan	Determine impact of DFU on diabetic patient's QOL and its associated factors	Cross-sectional study	✓ There was positive correlation between DFU with low foot-care practice. ✓ The dominant predictor of DFU was female, followed by obesity and peripheral vascular disease (PVD).
Banik et al. (2020) [34]	Bangladesh	Identify of DFU and its associated factors	Cross-sectional study	✓ The incidence of DFU was 44.5% ✓ The stronger predictor of DFU was age ≥50 years, followed by living in rural area, low economic status, insulin use, history of trauma, and diabetes comlications (retinopathy, nephropathy).
Dee et al. (2020) [35]	Indonesia	Assess incidence of DFU and its predictors	Cross-sectional study	✓ women, aged 56-65 years, duration of diabetes >10 years, peripheral neuropathy as well as peripheral arterial disease (PAD) were significant predictor of DFU
Fawzy et al. (2019) [36]	Saudi arabia	Determine the associated factors of DFU among diabetic patients	Prospective study	✓ the dominant predictor of DFU was long duration of diabetes, followed by older age and poor glycemic control (high level of HbA1c).
Galal et al. (2021) [37]	Egypt	Investigate the predictors of DFU	Case-control study	✓ The dominant predictor of DFU was diabetes complications, followed by callus deformity, flatfoot, and three or more comorbidities.
Jalilian et al. (2020) [8]	Iran	Summarize evidence related to DFU among diabetic patients	Systematic review	✓ The majority of participants are in G1 and G2 stages (67.5%; basis of Wagner) or in superficial ulcer (62.84%). ✓ The primary factors associated with DFU including high BMI, smoking, lack of diabetes control, type of diabetes treatment and older age. ✓ The secondary factors including vascular complications, bacteria isolated, marital status, gender, high levels of cholesterol and triglycerides. ✓ The tertiary factors including life location, type 2 diabetes, genotype, long-time DFU and delay to refer patients
Mohebi et al. (2018) [38]	India	Assess the risk factors affecting to DFU	Cross-sectional comparative study	✓ The dominant factor of DFU was alcohol consumption, followed by physical activity outside home, low foot care practices, irregularity of diabetic medication, and family history of diabetes among mothers
Negussie et al. (2024) [39]	Ethiopia	Identify incidence and predictors of DFU	Retro-spective follow-up study	✓ Incidence of diabetic foot ulcer was 1.51 cases. ✓ The dominant factor was peripheral arterial disease, followed by combined medication and diastolic blood pressure on 90 mm Hg or above.
Piran et al. (2024) [40]	UK	Assess of DFU predictors	Retrospective cohort study	✓ The dominant factor was duration of diabetes > 10 years, followed by insulin therapy, male sex, older age, smoking, addiction to other drugs, family history of diabetes, higher body mass index, physical inactivity, and diabetes complications (retinopathy and nephropathy)
Salawu et al. (2022) [41]	Nigeria	Determine the proportion of DFU and its associated factors	Cross-sectional study	✓ The prevalence of DFU was 18.7%. ✓ The dominant predictor of DFU was duration of diabetes ≥10 years, followed by fasting blood glucose (FBG) of ≥ 7.2 mmol/L and male gender.
Tola et al. (2021) [42]	Ethiopia	Determine the prevalence of DFU and its associated factors	Retrospective study	✓ The prevalence of DFU was 21.1%. ✓ The dominant predictor of DFU was obesity, followed by treatment with insulin, hypertension, history of infection, physical inactivity, and delay to start follow-up
Tolossa et al (2020) [43]	Ethiopia	Identify factors associated with DFU	Systematic review	✓ The prevalence of DFU was 12,98% ✓ The dominant predictor of DFU was callus on the feet, followed by rural residence, BMI >24,5, and poor self-care practice

IV. DISCUSSION

A. DIABETES COMPLICATIONS

The current review highlights that diabetes-related complications such as Peripheral Arterial Disease (PAD), neuropathy, retinopathy, and hyperglycemia are strongly associated with the development of Diabetic Foot Ulcer (DFU). Several studies found PAD as the most dominant predictor [29], [37], [39], [8], whereas others emphasized diabetic retinopathy and nephropathy as significant contributors [30]. This pattern aligns with findings in McDermott et al. [41] and Soyoye et al. [42], who emphasized the vascular pathophysiology of DFU. The mechanism linking these complications to DFU involves three components: neuropathic, vascular, and immune dysfunctions all aggravated by chronic hyperglycemia [43]. Hyperglycemia contributes to oxidative stress and endothelial damage, leading to impaired vasodilation and microcirculation in the lower extremities [44], [45]. Consequently, these conditions promote ischemia and poor wound healing, increasing DFU risk. Despite consistent findings, variations in the dominant predictor across studies may result from demographic or clinical differences, as well as variations in diagnostic criteria. The implication is that clinicians should adopt multifactorial screening tools for early detection. Assessment of PAD, neuropathy, and retinopathy should be standard practice in diabetic foot

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management. A limitation in this review is the lack of standardized measurements for complications across studies. Future research should quantify and compare the severity of each complication's impact on DFU incidence.

B. DEMOGRAPHIC CHARACTERISTIC

Demographic variables such as age, sex, BMI, smoking status, alcohol use, living environment, and particularly duration of diabetes >10 years emerged as consistent predictors of DFU [32], [36], [40], [41]. Smoking and older age also showed significant associations with DFU risk [31], [34], [38]. Interestingly, some studies identified female sex as a risk factor [33], [35], contradicting previous literature that suggests women are less prone to DFU due to higher foot care awareness and hormonal protection [46]. Gender differences may reflect socio-cultural dynamics, such as disparities in healthcare access and social support [47], [48]. Longer duration of diabetes was found to significantly increase DFU risk, consistent with the view that prolonged exposure to hyperglycemia leads to microvascular damage [49]. This is supported by Poledniczek et al. [50], who demonstrated that vascular inflammation intensifies with diabetes duration, promoting ulcer formation. The implication is that patients with a diabetes history exceeding 10 years should receive intensified surveillance and education regarding foot care. However, inconsistencies in demographic classifications and self-reported data are limitations that may reduce reliability.

C. SELF-CARE BEHAVIOR

Self-care behavior, including foot hygiene, physical activity, and adherence to therapy, was consistently found to correlate with DFU risk. Several studies emphasized low-quality foot-care practice and physical inactivity as dominant predictors [33], [38], [40], [43]. This is in agreement with Woo and Cui [51] and Tsai et al. [52], who linked poor diabetes self-management to elevated DFU prevalence. Key behavioral deficits include neglecting foot inspection, not using proper footwear, and poor response to early foot injury. Participants with combined insulin and metformin therapy were at higher risk, suggesting either poor glycemic control or advanced disease stage [34], [42]. Educational interventions that promote foot-care knowledge and behavioral change can significantly reduce DFU incidence [53]. From a behavioral science perspective, individuals are more likely to adopt preventive behavior if they perceive the benefit [54]. Thus, health promotion strategies should align with the Theory of Planned Behavior, targeting knowledge, attitudes, and social support. However, the review was limited by its reliance on self-reported behavior, which may suffer from bias. Objective behavioral assessments are recommended for future studies.

V. CONCLUSION

This scoping review aimed to identify the predictors of Diabetic Foot Ulcer (DFU) and their relationship to ulcer development in type 2 diabetes mellitus. Seventeen articles were analyzed, showing that the incidence of DFU exceeded 11.6%, primarily classified as grade 1 or 2 ulcers. The significant predictors were categorized into three domains: (1) diabetes complications with PAD as the most dominant; (2) demographic factors with diabetes duration over 10 years as the strongest risk; and (3) self-care behaviors, where poor foot-care practice and physical inactivity played major roles. These findings indicate that DFU is multifactorial and preventable through early screening, behavior modification, and patient-centered care strategies. Future studies should employ prospective designs with standardized tools to evaluate the influence of each predictor on DFU progression, thereby improving predictive models and tailoring interventions in diabetic populations.

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DATA AVAILABILITY

No datasets were generated or analyzed during the current study.

AUTHOR CONTRIBUTION

Yusron Amin was responsible for the conception and design of the study, data collection, literature review, and drafting of the manuscript. Haswita Haswita contributed by providing methodological guidance, critically reviewing the manuscript, and approving the final version for publication. Both authors equally participated in the overall development and completion of the research.

DECLARATIONS

ETHICAL APPROVAL

Not applicable as the study involved publicly available literature.

CONSENT FOR PUBLICATION PARTICIPANTS.

Consent for publication was given by all participants

COMPETING INTERESTS

The authors declare no competing interests.

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