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Risk of diabetic foot ulcer and its associated factors among Bangladeshi subjects: a multicentric cross-sectional study

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ABSTRACT

Objective To assess the risk of diabetic foot ulcer (DFU) and find out its associated factors among subjects with type 2 diabetes (T2D) of Bangladesh.

Design, setting and participants This cross-sectional study recruited 1200 subjects with T2D who visited 16 centres of Health Care Development Project run by Diabetic Association of Bangladesh.

Primary and secondary outcome measures Risk of DFU was assessed using a modified version of International Working Group on the Diabetic Foot (IWGDF) Risk Classification System. The modified system was based on five parameters, namely peripheral neuropathy (PN), peripheral arterial diseases (PAD), deformity, ulcer history and amputation. The risks were categorised as group 0 (no PN, no PAD), group 1 (PN, no PAD and no deformity), group 2A (PN and deformity, no PAD), group 2B (PAD), group 3A (ulcer history) and group 3B (amputation). The associated factors of DFU risk were determined using multinomial logistic regression for each risk category separately.

Results Overall, 44.5% of the subjects were found 'at risk' of DFU. This risk was higher among men (45.6%) than women and among those who lived in rural areas (45.5%) as compared with the urban population. According to IWGDF categories, the risk was distributed as 55.5%, 4.2%, 11.6%, 0.3%, 20.6% and 7.9% for group 0, group 1, group 2A, group 2B, group 3A and group 3B, respectively. The associated factors of DFU (OR >1) were age ≥50 years, rural area, low economic status, insulin use, history of trauma, diabetic retinopathy and diabetic nephropathy.

Conclusion A significant number of the subjects with T2D under study were at risk of DFU, which demands an effective screening programme to reduce DFU-related morbidity and mortality.

INTRODUCTION

In recent years, diabetes mellitus (DM) has become a fast-growing public health problem that affects both developed and developing countries.[1] The International Diabetes Federation reports that about 415 million people globally had DM in 2015 and it is projected to affect 642 million by 2040. It was deemed possible that by the year 2040 it might even double the number.[2] Among the clinical classifications of DM, type 2 diabetes (T2D) is more common and prevalent in certain ethnic groups, with estimates up to six times more common in the people of South Asian descent, three times more common in those of African and African-Caribbean descent and is more common in people of Chinese descent compared with the white population.[3]

Like in other developed and developing countries affected by it, it is also highly prevalent in Bangladesh. Evidence suggests that 9.7% of Bangladeshi adult population (>35 years) are diabetic and 22.4% are prediabetic.[4] A trend analysis revealed an increasing prevalence of DM in Bangladesh, from 4% in 1995–2000 and 5% in 2001–2005 to 9% in 2006–2010, respectively.[5] As the prevalence of diabetes increases, the prevalence of long-term diabetes-related complications is also likely to increase. Diabetic foot ulcer (DFU) is a common and major complication of diabetes, representing a major healthcare burden with significant morbidity.[6]

Strengths and limitations of this study

► This is the first study in Bangladesh that assesses the risk of diabetic foot ulcer (DFU) using a standard tool.
► For the first time, the associated factors of DFU were explored to guide the prevention effort.
► Sex-specific and area-specific difference in the risk of DFU will help to identify the disparities and promote decentralisation of diabetes care for all.
► Because of the cross-sectional design, we could not establish any causal relationship between the contributing factors and risk of DFU.
► The risk of DFU may be overestimated or underestimated as all centres did not provide the same quality diabetes care.

Diabetic foot is defined as the presence of infection, ulceration and/or destruction of deep tissues associated with neurological abnormalities and various degrees of peripheral arterial disease (PAD) in the lower limb in patients with diabetes.[7] It is a significant cause of morbidity and can lead to prolonged hospital stays, which is evidenced by the fact that ~20% of diabetes-related hospitalisations are related to DFU.[8] The mortality rate in patients with DFU is also high and is approximately twice that of the patients without ulceration.[9] Other than morbidity and mortality, the toll of economic burden in terms of direct and indirect costs is also high for those having DFU, estimated approximately €11.6 billion per year for Europe in 2017 and €7.6–11 billion among Medicare beneficiaries of the USA from 2007 to 2014.[7] Another issue related to foot ulcers among patient with diabetes is the health-related quality of life that cannot be measured in economic terms. It has been reported that patients with foot ulcers or amputation have low health-related quality of life because of substantial depression and other physical problems like inability to do simple tasks or recreational activities.[7]

The major risk factors of DFU are a loss of protective sensation due to diabetic peripheral neuropathy (DPN), PAD and trauma. However, the first two are not independently responsible for DFU; it is the combination neuropathy and PAD with trauma that leads to foot problems. It has been reported that trauma and PAD are major contributors to foot ulceration and diabetic neuropathy is the common denominator in almost 90% of DFU cases. There are some other risk factors namely male gender, previous foot ulceration or amputation, foot deformities, calluses, Charcot arthropathy and high plantar pressures which have been associated with an increased risk for foot ulceration. There are some diabetes-related risk factors also that influence the risk of foot ulcers such as the duration of diabetes, poor glycaemic control, diabetic retinopathy or nephropathy, poor compliance with medical instructions and neglectful behaviour. Some societal and behavioural risk factors also show significant association with DFU including low socioeconomic condition, poor access to healthcare services, poor educational status, living alone and smoking.[7 10] Previous studies have reported that the risk of diabetic foot or amputation is significantly lower among the Asians compared with the Europeans in the UK.[11 12] This reduced risk is probably due to a low prevalence of DPN and PAD among Asians, but the exact reason is not fully understood. However, a previous study has reported prevalence of DPN among Bangladeshi subjects at 19.7% and found it significantly as well as independently associated with age, mode of treatment, income, duration of diabetes and glycaemic status.[13]

It is estimated that the lifetime risk of foot ulcers among diabetic population is 19%–34%.[7] To overcome this burden of DFU, it is recommended that clinicians estimate the risk of and the response to associated factors that increase the risk.[10] However, studies related to diabetic foot risk assessment and associated factors among Bangladeshi subjects are absolutely lacking. Hence, we were prompted to assess the risk of foot ulcers and sought to determine the factors that influence the risk among patients with T2D of Bangladesh.

METHODS
Study design
This cross-sectional study was conducted among 1200 subjects with T2D who visited several centres of Health Care Development Project run by the Diabetic Association of Bangladesh (DAB). A total of 16 centres were selected: 7 from Dhaka and 9 from the northern part of Bangladesh. We purposefully selected the centres and followed convenient sampling technique to collect data from subjects with diabetes. Our exclusion criteria included presence of DFU during the interview (active ulcer), acute illness of the subject, unwillingness to participate and mental instability. To meet the eligibility criteria, all subjects were screened for DFU, based on their self-reported statement, their clinical history, foot examination and medical records review.

Data collection and measurement
The data collection comprised two phases and was conducted from July 2011 to June 2012. In the first phase, a face-to-face interview was conducted using a pretested questionnaire adapted from the STEP-wise approach to Surveillance (STEPS) of non-communicable diseases risk factors of WHO.[14] The questionnaire collected sociodemographic and behavioural risk factors (tobacco use, physical inactivity), status of diabetes (duration, medication) and its complications (retinopathy, nephropathy) and foot problem-related information (neuropathy, PAD, trauma, foot hygiene) of the participants. The blood glucose levels (fasting/2-hours post meal) and information about diabetic nephropathy or retinopathy in the participants were extracted from their diabetes records book. The last record within one month was used to assess their glycaemic status. In the second phase, physical measurements (anthropometric and blood pressure) and foot examination were carried out by trained physicians. The anthropometric and blood pressure measurement followed the methods described in 'Noncommunicable disease risk factors survey Bangladesh 2010'.[15] The anthropometric measurements included height, weight, waist circumference, hip circumference and derivatives like body mass index and waist–hip ratio.

Assessment of DFU
The risk of DFU was assessed using a modified version of International Working Group on the Diabetic Foot (IWGDF) Risk Classification System proposed by Lavery *et al*.[16] We screened each patient to identify lower extremity complications and presence of any risk factors, like ulcerations, amputation, peripheral neuropathy (PN), PAD, foot deformities and limited joint mobility using

the methods followed by Lavery *et al.*[16 17] We used a 10 g Semmes–Weinstein monofilament and vibration perception threshold tester to assess PN, palpation of the pulses and Ankle Brachial Index (ABI) to detect PAD, goniometer to identify foot deformity and clinical examinations to evaluate joint mobility. The risks were categorised according to the modified IWGDF risk classification system: group 0 (no PN, no PAD), group 1 (PN, no PAD, no deformity), group 2A (PN and deformity, no PAD), group 2B (PAD), group 3A (ulcer history) and group 3B (amputation). Here, group 0 indicated 'no risk' and rest of the groups (1, 2A, 2B, 3A, 3B) classified the study population 'at risk' of in varying degrees.

Ascertainment of key variables

Peripheral neuropathy
PN was defined as lack of feeling/protective sensation (at 4 or more of 10 sites)[18] and vibration perception threshold value in either foot >25 V using an electromechanical instrument.[17]

Peripheral arterial disease
We defined PAD as non-palpable dorsalis pedis or posterior tibial arterial pulse and ABI in either foot as <0.80.[16]

Limited joint mobility
Limited joint mobility was defined based on three averaged measurements of the first metatarsophalangeal joint, the subtalar joint and ankle joint range of motion of the forefoot, rear foot and ankle. From these measurements, we determined the presence of ankle joint equinus (<0° dorsiflexion), limited subtalar joint motion (<20° total joint motion) and hallux rigidus (<50° hallux dorsiflexion).[18] It was measured using a goniometer and a detailed technique was described elsewhere (see online supplementary file 1)

Foot deformity
Deformity was defined as any contracture that could not be fully corrected manually, such as hallux valgus, hammer toes or claw toes, hallux rigidus and ankle equines.[16] It was measured using a goniometer and a detailed technique was described elsewhere (see online supplementary file 1).

Foot ulcer
Foot ulcers were defined as full thickness wounds involving the foot or the ankle.[19]

Quality assurance
To ensure standard quality control, a panel of senior researchers and survey investigators visited the data collection sites to monitor the research activities. To prevent bias, monitoring panel was anonymised for the data collectors. All team members including investigators, supervisor and data collectors participated in intensive three consecutive training programmes (lasting two and a half days) in Dhaka before the survey. The first training program was conducted for the physicians (doctors) who

were involved in foot examination. This training program focused on 'Detection of Diabetic Foot Problem at the Early Stage' through screening using a standard instrument. A certified neurologist from a reputed postgraduate training institution was appointed as a resource person to conduct the sessions. Second and third training programmes were conducted for the volunteering data collectors selected from undergraduate physiotherapy students, who interviewed the respondents to fill up the questionnaire. The purpose of this training was to inform the data collectors about potential difficulties associated with data collection. During this intensive training, data collectors got practical training about self-administration of a questionnaire, physical measurement and maintenances of data collection environment. Other than these, we also followed specific protocols to assure quality of the study that included: (1) pretesting of the questionnaire and data collection procedure, (2) standard method of measurement as per STEPS survey 2010 of Bangladesh, (3) used show cards for a better understanding of different forms of tobacco use and intensity of physical activities, (4) adequate privacy during physical measurements and clinical examinations, and (5) robust equipment for physical measurement and clinical examination. None of the quality control observer reported any violation of physical measurement and data collection.

Patient and public involvement
We collected data from the patients who visited the selected diabetes care centres of DAB. However, they were not involved directly in the setting of the research question or outcome measures. They did not have any role in designing or implementing this work or interpretation of the results.

Ethical consideration
The purpose of the study, rights of the respondents and data safety issues were explained to each participant. All subjects gave their informed written consent for inclusion before they participated in the study (see online supplementary file 2). The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethical Review Committee of Bangladesh Diabetic Association (Identification number: BADAS/ BIO/EA/11/033) on 17 January 2011 (see online supplementary file 3).

Data processing and analysis
Data (see online supplementary file 4) were analysed using the Statistical Package for Social Science (SPSS) V.20.0 for Windows (SPSS). All estimates of precision were presented at 95% CI in the tables. Descriptive analysis included mean, SD, median and IQR, frequencies and percentages where appropriate. In this study, the p value (two-sided) was considered statistically significant at the threshold of $p < 0.05$. In our study, there were only three respondents with PAD. Hence, we had to merge

group 2B with group 2A and make a new group 2-A/B that was used in multinomial logistic regression analysis.

To find the factors that influenced the risk of DFU, first we run χ^2 test considering modified IWGDF risk classification as a dependent variable. Variables that showed significant association ($p < 0.05$) with the dependent variable in the χ^2 were identified. Then, statistically significant variables were examined as independent variable against the dependent variable in the multinomial logistic regression analysis. For multinomial logistic regression analysis, we calculated OR, and 95% CI for each independent variable. In the regression table, predictors that had OR >1 were presented for each risk category. We ensured the presence of no multicollinearity using variance inflation factor to run the regression analysis. We used the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for reporting the results of cross-sectional observational study (see online supplementary file 5).

RESULTS
Sociodemographic characteristics and diabetes-related information
The mean age of the participants was 51.6 ±11.9 years and most of them (33.1%) were in the 50–59 year age group. More than half of the participants were women (62.9%) and predominantly urban residents (67.3%). Most of them had completed primary-level education (36.7%), 99% were married, 57.8% were housewives and 44.5% came from middle-income background. However, urban participants were more literate (88.2%) and economically stable (60.3% >lower-middle-income range) than their rural counterparts. The mean duration of diabetes was 6.9 ±5.9 years and a majority of them had uncontrolled glycaemic status (89.3%). Among the diabetes-related complications, retinopathy (14.3%) was much higher than nephropathy (5.6%). No mentionable urban–rural difference was observed for the glycaemic status and diabetic nephropathy (table 1).

Risk of DFU among the study population
Table 2 shows the sex-specific and area-specific distributions of the DFU risk according to the modified version of IWGDF classification. Overall, 44.5% of the study population was diagnosed as 'at risk' of DFU and the burden was higher among men (45.6%) and those who lived in rural areas (45.5%). The risk of DFU according to the modified version of IWGDF was 55.5%, 4.2%, 11.6%, 0.3%, 20.6% and 7.9% for group 0, group 1, group 2A, group 2B, group 3A and group 3B, respectively. Among the six groups of risk classification, group 3A (ulcer history) showed maximum risk (20.6%) compared with other groups. For sex and area variables, 21.8% of men and one-fourth of the rural residents (25.7%) had a history of foot ulceration.

Factors associated with the risk of DFU among the study subjects
Table 3 shows the associated factors of DFU risk among the study population. Total six factors were identified

which showed high odds (>1) for different groups at risk: age (group 2-A/B, OR 1.212; group 3B, OR 1.173), area of residence (group 1, OR 1.188; group 3A, OR 1.461), monthly income (group 2-A/B, OR 1.491; group 3A, OR 1.415; group 3B, OR 1.768), medication (group 2-A/B, OR 1.014), history of trauma (group 1, OR 2.015; group 2-A/B, OR 1.032; group 3A, OR 2.998; group 3B, OR 3.104), diabetic retinopathy (group 1, OR 1.104; group 3B, OR 1.933) and diabetic nephropathy (group 1, OR 2.174; group 3A, OR 1.260; group 3B, OR 2.389).

Overall, the odds for risk of DFU was higher among those who were ≥50 years old, lived in rural areas, had a monthly income ≤19 488 BDT, had a history of foot ulcer, were insulin user and had diabetic complications as retinopathy or nephropathy.

DISCUSSION
The results show that nearly half (45%) of the subjects with T2D were at the risk of DFU and rural population was mostly affected. This is significant as there is no straightforward evidence on the risk of DFU among T2D population of Bangladesh. Moreover, the contributing factors are not yet explored in Bangladesh to take an effective initiative to reduce the burden of associated morbidity and mortality.

In our modified DFU risk classification as per IWGDF, the higher burden was observed in those who had a history of foot ulcer (20.6%). This proportion is much higher than an Iranian study that reported only 7% of the study subjects to have a history of foot ulceration.[20] The percentage of our finding is also higher than Portugal, where a study reported a history of DFU among 16% of study subjects using modified IWGDF risk classification.[21] Although it has been estimated that the annual risk of DFU is approximately 2%, this risk in patients with a history of foot ulcer is expected to increase to 17%–60% over the next 3 years.[22]

Several studies have reported the cumulative burden of a history of foot ulcer and amputation as a part of their diabetic foot risk assessment. In our study, the cumulative proportion of a history of foot ulcer and amputation was 14.3%, which is twice that of studies conducted in India[23 24] and in a half of Portugal.[21] A follow-up study from the USA reported nearly three times higher proportion of foot ulcer or amputation compared with our study.[25] In this regard, a systematic review comprising 41 documents by Hunt[26] found that a person with a history of DFU has a 66% chance of ulcer recurrence and 12% chance of amputation over 5 years.

We have mentioned earlier that PN is one of the major risk factors for DFU. In our study, 4.2% of the subjects with T2D had only PN and 11.6% had PN with deformity, represented as group 1 and group 2A, respectively. This finding has much lower percentages compared with similar studies conducted among subjects of India[23 27 28] and Iran.[20 28] However, this burden is still higher than Portugal.[21] Our study classified very low proportion of

Table 1 Sociodemographic and diabetes-related information of the study subjects, n=1200

	Urban		Rural		Total	
Variables	N (%)	95% CI	N (%)	95% CI	N (%)	95% CI
Age (years)*	52.3±11.9		50.2±11.8		51.6±11.9	
Age categories (years)						
<30	52 (4)	2.6 to 5.4	22 (5.6)	3.3 to 7.9	54 (4.5)	3.3 to 5.7
30–39	63 (7.8)	5.9 to 9.7	39 (9.9)	14.6 to 18	102 (8.5)	6.9 to 10.1
40–49	212 (26.3)	23.3 to 29.3	109 (27.7)	23.3 to 32.1	321 (26.8)	24.3 to 29.3
50–59	270 (33.5)	30.2 to 36.8	127 (32.3)	27.7 to 36.9	397 (33.1)	30.4 to 35.8
≥60	230 (28.5)	25.4 to 31.6	96 (24.4)	20.2 to 28.6	326 (27.2)	24.7 to 29.7
Sex						
Men	302 (37.4)	34.1 to 40.7	143 (36.4)	31.6 to 41.2	445 (37.1)	34.4 to 39.8
Women	505 (62.6)	59.3 to 65.9	250 (63.6)	58.8 to 68.4	755 (62.9)	60.2 to 65.6
Educational status						
Illiterate	95 (11.8)	9.6 to 14	107 (27.2)	22.8 to 31.6	202 (16.8)	14.7 to 18.9
Primary	288 (35.7)	32.4 to 39	152 (38.7)	33.9 to 43.5	440 (36.7)	34 to 39.4
Secondary	265 (32.8)	29.6 to 36	98 (24.9)	20.6 to 29.2	363 (30.3)	27.7 to 32.9
Higher education	159 (19.7)	17 to 22.4	36 (9.2)	6.3 to 12.1	195 (16.3)	14.2 to 18.4
Marital status						
Married	797 (98.8)	98 to 99.6	391 (99.5)	98.8 to 100.2	1188 (99)	98.4 to 99.6
Others	10 (1.2)	0.4 to 2	2 (0.5)	–0.2 to 1.2	12 (1)	0.4 to 1.6
Occupational status						
Service	184 (22.8)	19.9 to 25.7	49 (12.5)	9.2 to 15.8	233 (19.4)	17.2 to 21.6
Business	89 (11)	8.8 to 13.2	38 (9.7)	6.8 to 12.6	127 (10.6)	8.9 to 12.3
Housewife	462 (57.2)	53.8 to 60.6	231 (58.8)	53.9 to 63.7	693 (57.8)	55 to 60.6
Others	72 (8.9)	6.9 to 10.9	75 (15.2)	11.7 to 18.7	147 (12.3)	10.4 to 14.2
Monthly household income (BDT)†	20 000 (10 000–40 000)		10 000 (6000–20 000)		20 000 (10 000–30 000)	
Monthly household income groups						
<4907 (low)	21 (2.6)	1.5 to 3.7	41 (10.4)	7.4 to 13.4	62 (5.2)	3.9 to 6.5
4907–19 488 (lower-middle)	299 (37.1)	33.8 to 40.4	238 (60.6)	55.8 to 65.4	537 (44.8)	42 to 47.6
19 489–60 252 (upper-middle)	422 (52.3)	48.9 to 55.7	108 (27.5)	23.1 to 31.9	530 (44.2)	41.4 to 47
>60 252 (high)	65 (8.1)	6.2 to 10	6 (1.5)	0.3 to 2.7	71 (5.9)	4.6 to 7.2
Duration of diabetes (years)*	7.3±6		6.3±5.8		6.9±5.9	
Glycaemic status‡						
Controlled	87 (10.8)	8.7 to 12.9	42 (10.7)	7.6 to 13.8	129 (10.8)	9 to 12.6
Uncontrolled	720 (89.2)	87.1 to 91.3	351 (89.3)	86.2 to 92.4	1071 (89.3)	87.6 to 91
Diabetic retinopathy	134 (16.6)	14 to 19.2	38 (9.7)	6.8 to 12.6	172 (14.3)	12.3 to 16.3
Diabetic nephropathy	46 (5.7)	4.1 to 7.3	21 (5.3)	3.1 to 7.5	67 (5.6)	4.3 to 6.9

*Representing mean and SD.
†Presented as median with IQR.
‡Based on plasma glucose level premeal (fasting) <6.1 mmol/L and/or 2 hours post meal <7.8 mmol/L.
§According to the 2006 per-capita gross national income and the World Bank calculation.
BDT, Bangladesh taka.

subjects with T2D as having PAD compared with aforementioned studies.[20–23 27–29] A possible reason for the ABI being above 0.80 in the majority of patients is the presence of medial arterial calcification artefactually raising the ankle pressure. Another reason might be due to the cut-off value applied to define PAD. The compared studies used ABI 0.9 or less as the cut-off, which included more participants as PAD compared with current study. The

Table 2 Sex-specific and area-specific distribution of diabetic foot ulcer (DFU) risk among the study subjects, n = 1200

IWGDF DFU risk classification	Sex		Area of residence		
	Men	Women	Urban	Rural	Overall
	N (%)	N (%)	N (%)	N (%)	N (%)
Group 0 (no PN, no PAD)	242 (54.4)	430 (57)	452 (56)	214 (54.5)	666 (55.5)
Group 1 (PN, no PAD, no deformity)	18 (4)	32 (4.2)	32 (4)	18 (4.6)	50 (4.2)
Group 2A (PN and deformity, no PAD)	49 (11)	90 (11.9)	103 (12.8)	36 (9.2)	139 (11.6)
Group 2B (PAD)	1 (0.2)	2 (0.3)	3 (0.4)	0	3 (0.3)
Group 3A (ulcer history)	97 (21.8)	150 (19.9)	146 (18.1)	101 (25.7)	247 (20.6)
Group 3B (amputation)	38 (8.5)	57 (7.5)	71 (8.8)	24 (6.1)	95 (7.9)

IWGDF, International Working Group on the Diabetic Foot; PAD, peripheral arterial disease; PN, peripheral neuropathy.

overall burden of 'at risk' (other than group 0) subjects with T2D of this study was also lower than the findings from India[27 28] and Portugal.[21] However, the proportion of 'at risk' subjects is more than twice that of aforementioned Indian[23] and Iranian[20] studies. The reasons for the risk difference in different countries are still unclear.

A study by Abbott et al explored this risk difference among different ethnic population including South-Asians, African-Caribbeans and Europeans of the UK.[11] They reported that such difference might be due to the methods applied to detect neuropathy, provisions of primary healthcare services, such as diabetes miniclinics, podiatric care and referrals for special footwear for the healthcare districts and a variable quality of healthcare. Regarding the burden of risk factors of DFU, Abbott et al added that lower level of PN and PAD also contributes to the less percentage of South-Asian population 'at risk' compared with Europeans. Another reason behind this difference is the application of various risk classification systems in different countries. We used modified IWGDF risk classification, similar to the studies from Iran[20] and Portugal,[21] whereas one of the two Indian[23] studies used semistructured pretested questionnaire and another[27] applied American Diabetic Association task force report for comprehensive foot examination risk classification.

Our study reports a sex-specific and area-specific difference in risk of DFU among T2D population of Bangladesh. The overall proportion of DFU risk was higher among men than women. Previous studies[7 20 23 30] have also reported similar findings. However, a community-based study from India reported that DFU risk was high in women,[24] which is contradictory to our finding.

Our study shows that the risk of DFU is greater among men with a history of ulcer or amputation. This higher risk of foot ulcer history or amputation in men was also supported by a study from Iran, which used the IWGDF risk classification system.[20] This men-to-women risk difference might be due to diabetes-related healthy behavioural practice, health-seeking behaviour and self-care. In this regard, a Brazilian study reported that sex is significantly associated with changes of lifestyle behaviour related to control of T2D, foot self-care and prevention of ulceration, and women were found to adhere more to life-style changes than men.[31] The same study also reported that men were highly reluctant to check their glycaemic status and lipid profile compared with women.[31] In this case, the fact is that women are more sensitive to health issues and more frequently seek health services than men do.[32 33]

For the urban–rural difference, we found that the risk was higher among those who lived in a rural area. This finding is also supported by other studies.[23 28 34] A possible explanation is that patients with diabetes of rural area are not aware of their PN due to illiteracy, especially their lack of knowledge about diabetic foot-related complications. They walk barefoot and this leads to an injury to the foot and subsequent complications.[35] Another explanation could be that people in rural areas often sleep in huts or farmhouses where rodents are common; rodents bite their feet and in case of patients with diabetes, this can lead to chronic ulcers.[34]

One of the major objectives of this study was to identify the factors that influenced the risk of DFU among Bangladeshi T2D population. Sociodemographic factors age ≥50 years, living in a rural area and monthly income ≤19 488 BDT showed higher odds for the risk of DFU. In diabetic research, age is widely evaluated as an associated factors of DFU. Some other studies also found age as a significant risk factors[36–38] of DFU. In our study, it was found that age below 50 years was a protective factor and age above this was associated with development of DFU. This has also been supported by the other studies that reported older age was a significant factor.[37 38]

Globally, the findings of the association of economic status and area of residence with the risk of DFU are inconsistent. Our results show that lower economic status (monthly income ≤19 488 BDT) and living in a rural area are strongly associated with the risk of DFU. These findings were consistent with the results of other studies conducted in India[24 27] and Sri Lanka.[39] It was postulated that financial status is directly related to burden of risk factors, which leads to complications of chronic diseases. This is because a lack of financial resources interferes with the access to healthcare services, options of treatments

Table 3 Associated factors of diabetic foot ulcer among subjects with type 2 diabetes of Bangladesh using multinomial logistic regression, n = 1200

Risk groups	Associated factors	B	P value	OR	95% CI for OR Lower bound	Upper bound
Group 1	Area of residence					
	Rural area	0.172	0.573	1.188	0.652	2.165
	Urban area	*Ref*.				
	History of trauma					
	Present	0.7	0.076	2.015	0.929	4.369
	Absent	*Ref*.				
	Diabetic retinopathy					
	Present	0.099	0.814	1.104	0.486	2.508
	Absent	*Ref*.				
	Diabetic nephropathy					
	Present	0.526	0.14	2.174	0.755	6.099
	Absent	*Ref*.				
Group 2-A/B*	Age					
	≥50 years	0.192	0.324	1.212	0.827	1.774
	<50 years	*Ref*.				
	Monthly income (BDT)					
	≤19 488	0.4	0.039†	1.491	1.020	2.181
	>19 488	*Ref*.				
	Medication					
	Insulin user	0.013	0.945	1.014	0.692	1.485
	Insulin non-user	*Ref*.				
	History of trauma					
	Present	0.032	0.916	1.032	0.570	1.870
	Absent	*Ref*.				
Group 3A	Area of residence					
	Rural area	0.379	0.014†	1.461	1.081	1.975
	Urban area	*Ref*.				
	Monthly income (BDT)					
	≤19 488	0.347	0.031†	1.415	1.032	1.940
	>19 488	*Ref*.				
	History of trauma					
	Present	1.098	<0.001†	2.998	2.044	4.396
	Absent	*Ref*.				
	Diabetic nephropathy					
	Present	0.231	0.504	1.260	0.640	2.482
	Absent	*Ref*.				
Group 3B	Age					
	≥50 years	0.160	0.494	1.173	0.742	1.854
	<50 years	*Ref*.				
	Monthly income (BDT)					
	≤19 488	0.570	0.016†	1.768	1.114	2.805
	>19 488	*Ref*.				

Table 3 Continued

Risk groups	Associated factors	B	P value	OR	95% CI for OR	
					Lower bound	Upper bound
	History of trauma					
	Present	1.133	<0.001†	3.104	1.810	5.324
	Absent	*Ref.*				
	Diabetic retinopathy					
	Present	0.659	0.018†	1.933	1.122	3.329
	Absent	*Ref.*				
	Diabetic nephropathy					
	Present	0.871	0.024†	2.389	1.123	5.083
	Absent	*Ref.*				

*Group 2B was merged with 2A as the participants were very few in the group 2B.
†indicates significant.
Ref, reference; BDT, Bangladesh taka.

and hinders the adoption of preventive measures that are necessary to avoid amputations.[31] Regarding place of residence, significant urban–rural risk difference for DFU was explained by the study of Viswanathan *et al*[34] and we mentioned it in this section previously. However, one study has reported no association for the aforementioned factors.[40]

Our study found that the odds for risk of DFU were higher among insulin users, having diabetic-related complications as nephropathy and retinopathy. Previous studies also reported that use of insulin is a contribution factor of diabetic foot.[29 41] However, the exact mechanism behind this has not yet been explored and this finding is thus inconclusive. It might be possible that when patients acquiesce to start insulin, they may already have diabetes for a long time with greater associated complications.[29]

Our findings of retinopathy and nephropathy are also supported by other studies.[20 38 42 43] Regarding nephropathy, we found that about 10% of patients with diabetes had a history of amputation when they entered a dialysis program.[44] Several factors might be responsible for an increased risk of DFU among patients with nephropathy. These are PN, peripheral vascular diseases, susceptibility to infection, minimal self-care, dialysis therapy and anaemia.[45] On the other hand, one study has reported that the prevalence of diabetic retinopathy is much higher (90%) among patients with DFU than those who had no DFU.[42] Another study[43] used IWGDF risk classification to predict DFU and they found that around 67.58% of patients had diabetic retinopathy and they were included in the risk group 3, which was similar to our study. In this regard, a systematic review and a meta-analysis show that both retinopathy and nephropathy are microvascular complications. The impairment of microcirculation in T2D may lead to secondary complications in lower extremity due to dysfunctional vasodilatation. Moreover, patients of diabetic foot with retinopathy have higher level of diabetic biomarkers like ceruloplasmin.

Again, this ceruloplasmin is an independent predictor of progression of diabetic nephropathy in patients with T2D. Thus, aforementioned explanation implies a link between DFU, and retinopathy and nephropathy.[46]

History of trauma was identified as a significant contributing factor of DFU (group 3A, OR 2.998, p <0.001; group 3B, p <0.001) in our study. This finding was similar to other studies that reported a significant association between a history of trauma and DFU.[47–49] However, the exact mechanism of a previous trauma leading to DFU is not clear. As such, further research on this issue is required.

Limitations
Our study has some limitations that should be mentioned. First, the participating centres were not representative of the Bangladesh diabetes centres as a whole considering their geographical distribution as some areas were under-represented or not represented at all. Therefore, the results of our study cannot be extrapolated to the general diabetic population in Bangladesh. Second, in our study, some diabetes-related complications were under-represented, especially for diabetic retinopathy and nephropathy. These comorbidities were not based on real-time clinical examination of eyes and assessment of kidney functions, rather based on diabetic record books review. As a result, the exact cut-off value used to define both of these comorbidities was uncertain. In a similar way, glycaemic status was evaluated using the values previously recorded in the diabetic records of the subject instead of using a biochemical measurement during data collection.

Strengths
Our study is important from the public health and clinical perspective. It is the first study in Bangladesh that assessed DFU risk in a moderately large sample of T2D population. Moreover, a multicentric study recruited participants from world-renowned DAB-affiliated diabetes centres.

The other strength of this study is sex-specific and area-specific reporting of DFU risk among the study subjects. This difference will help to address the men–women and urban–rural disparities in diabetes foot care in Bangladesh and in remodelling the chain of diabetes centres where appropriate. The clinicians of Bangladesh should concentrate more on the contributing factors of DFU in the management of patients with diabetes as these are associated with morbidity and mortality resulting from DFU.

CONCLUSION

We found that a significant proportion of T2D population of Bangladesh is at a high risk of DFU. The findings indicate that each patient with diabetes must be screened for his or her foot ulcer risk factors according to IWGDF recommendation. In this regard, diabetic foot screening programme can be introduced in the primary healthcare system of Bangladesh. Based on the findings of this study, we also recommend that specialised diabetic foot care centres should be established in both urban and rural areas to stop the debilitating consequences of DFU.

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