Diabetic Foot Ulcer

An Update

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Editors

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Diabetic Foot Ulcer
Diabetes mellitus (DM) is a chronic disorder (an excess of glucose levels in blood) because insulin is no longer produced in the pancreas (type I DM) or the body is unable to utilize produced insulin in the body properly (type II DM). DM is the world’s most endemic and mortality causing disease affecting more than 6% of the adult population. The growth rate of DM patients has been increasing rapidly due to different factors such as genetic, environmental, lifestyle, increased calorie intake, and less body exercise. But the development of medication is not as much as the growth rate of DM and its complications. Type I DM has no preventive medicine, but type II can be prevented and controlled by maintaining a healthy lifestyle. However, their complications can be delayed by taking insulin therapy.

The complications of DM have more impact on different metabolisms in the body and are not specific to any particular disease, because insulin is the principal hormone responsible for the uptake of glucose from blood to different cells of the body. DM mainly damages the blood vessels and leads to the preliminary complications in the eyes, kidneys, and nerves. All these complications are interlinked to each other because glucose is the principal fuel for cellular functions. The damage of nerves due to DM is known as diabetic neuropathy (DN); its main symptoms are numbness and tingling that lead to skin damage.

Skin damage due to DM is because of peripheral arterial damage, i.e., lower blood circulation. Diabetic foot ulceration/diabetic foot ulcer (DFU) is one of the foremost DM complications associated with it and sometimes may cause amputation.

The availability of information on DFU prevalence, major symptoms, pathogenesis, complications, treatments, and management was very less. This book provides updated knowledge on the prevalence of DFU around different parts of the world, its development, pathophysiology, major complications, and new methodologies in its treatment. The editors sincerely acknowledge the efforts of authors in manifesting their perspectives about DFU.

Shamina Begum et al. describe the occurrence of DM, its complications, and the current scenario about prevalence, risk factors, and different strategies and policies to control DFU around Asia and European continents.

Zulfiqarali G. Abbas explains the common causes of DFU, in relation to peripheral neuropathy, and analyzes over the last two decades conditions of DFU complications and prevention and control programs in Africa and Antarctica.
Kanakamani Jeyaraman presents the implications of DFU in relation to clinical, social, and economic problems because of endemic type II DM and the annual outlay on DM and its complications including DFU in American and Australian continents.

Ayman Faisal Foad explains the pathophysiology of wound healing with respect to different control factors and importance of proteins and vitamin C in wound healing.

Hyder O. Mirghani describes the different approaches for image (scanning) models to differentiate harm at various tissue levels for providing the remedial approaches to different foot inflammation including DFU due to DM.

Mohammad Zubair and Farha Fatima demonstrates the various complications due to DM, mainly focused on development of DFU, and explains the risk factors for DFU development and approaches for timely diagnosis to overcome complications of DFU.

Ahmad Faraz et al. explain the major healthcare challenges in the twenty-first century and how DM and its complications impact the mortality rate around the globe and also elucidate the association of diabetic neuropathy with the diabetic foot abnormalities.

Tarek Kabil describes the association of inflammation wounds with different microbes (aerobic and anaerobic) and their involvement in DFU and its complications.

Fohad Mabood Husain et al. illustrate the DFU and DN contribution for the development of different pathogenic microorganisms at infectious sites and how these microbial infections lead to tissue and bone injury.

M. Oves et al. illustrate the hidden role of fungus in infection management.

Thomas Thanyath demonstrates the risk factors for DFU, and evaluation of DFU at appropriate stages in different diabetic patients using various identification methods.

Hamid Ashraf et al. explain the management of different microbial infections associated with DFU using different antibiotics.

Vijay Viswanathan and Sai Prathiba A. explain the recent circumstances about the DFU and its treatments in the Indian subcontinent.

Zulfiqarali G. Abbas elucidates complications, its prevalence, and management strategies to control and prevent DFU in developing countries.

Deepti Singh and Hifzur R. Siddique discuss about the role of different growth factors, their usage in control and prevention, and future prospects in DFU management.

Rashid Mir et al. expound the current approaches in the control, prevention, and treatment of DFU and also explain the role of stem cell therapy in different wound healing infections including DFU management.

M. Ahmed Masaik et al. explain the importance of alternative medicine (AM) against the rising of global DM patients and the management of AM in the DM and its complications including DFU and diabetic foot infections (DFIs).

Mohamed Ali-Sayed and Ayesha Siddiqua enlighten the role of phytomedicine (traditional medicine) and herbal formulations in the treatment of DM and
DFU. They also explain the possible mechanism of action of important medicinal plants against DM and their future scope in identification of different phytocompounds against DM, DFU, and other complications.

_Sumbul Rehman_ explains the common complications including DFU due to prolonged high blood glucose levels and the management of bloodletting by leeching therapy using _Hirudo medicinalis._

_Mohammad Azam Ansari et al._ describe the prevalence of DM and DFU complications and emphasize the delayed wound healing because of DFU, possibly employing nanotechnology in the management of DM and DFU treatment using nanoformulations.

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Jamal Ahmad is a former Professor of Endocrinology; ex Dean of the Faculty of Medicine, J.N. Medical College; and ex Director of the Rajiv Gandhi Centre for Diabetes & Endocrinology, Faculty of Medicine, Aligarh Muslim University, India. He has made a significant contribution toward determining the role of protein glycation in diabetes and its associated complications. He has published more than 240 research articles in various international and national journals, was Principal Investigator or Co-Investigator in a number of research projects, and has completed 9 phase III international, multi-centre, multicounty new drug trials in diabetes mellitus. He is a former President of the Endocrine Society of India, and the recipient of the prestigious RSSDI fellowship-2015 and a Lifetime Achievement Award by Diabetes India 2019.

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Part I

World Preview
Diabetic Foot Complications in Asia and European Continents

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1.1 Introduction

Diabetic Foot Ulcer (DFU) is a major global concern accounting for costly complications. Its prevalence is gaining momentum particularly in Asia and European Continents. The intent of this chapter is to provide an overview of diabetic foot ulcer both globally and regionally. It also provides insights on the social and economic burden along with the factors that cause it. Different ways of diagnosis of DFU are also described followed by the management strategy which can be implemented for achieving improved health outcomes. This chapter focuses on the regional wise
comparison of Asia and European Continents concerning the adequate treatment and prevention of DFU. As per the International Diabetes Federation [1], the annual estimation of the foot ulcer ranged from 9.1 million to 26.1 million people, globally. The diabetic proportion and the foot ulcer history are understandably higher as compared to the individual ratio of an active ulcer, i.e., 3.1–11.8%. This percentage accounts for the global population of about 12.9 million to 49 million [2]. The foot ulcer lifetime incidence is predicted to be 15–25% among diabetes. The complication of diabetic foot includes Charcot neuroarthropathy (CN), amputation, and ulceration. The complications of the foot are substantially increasing, which is predicted to be more than 5% of the diabetic patients will have foot ulcer history, while the overall lifetime concerning the risk of foot ulceration might exceed 25%. Given that the overall amputation ratio is preceded by foot ulcers, it can be safely presumed that the success in the mitigation of the incidence concerning foot ulcers would reduce the occurrence of amputation.

1.1.1 Foot Ulceration Pathogenesis

The ulcer of the foot occurs rarely due to a single pathology, instead, its major occurrence is due to its interaction with either two or more contributory causes that cause a high-risk foot breakdown. For instance, the neuropathic foot ulceration does not lead to spontaneous ulceration. It occurs due to insensitivity combination including in either extrinsic (such as barefoot walking, step on the sharp object, and inadequate fit of the shoes) or intrinsic factors (such as insensitivity and callus among the patients, who walks and which leads to the ulcer development), leading to ulceration [3]. The most significant contributory cause in the ulceration pathway is neuropathy.

1.1.2 Neuropathy

For the past many years, the link between the autonomic and somatic neuropathy as well as foot ulceration has been identified. The prospective follow-up researches in the previous decades have confirmed the somatic neuropathy causative role. The risk is sevenfold among the patients that suffer from a loss in the sensory ability, leading to the development of the ulcer in the foot in contrast to the patients with non-neuropathic diabetes. The inadequate balance, as well as instability, are substantially recognized as the challenging peripheral neuropathy, which is presumably secondary for the proprioceptive loss [4].

The dysfunction of the peripheral autonomic (sympathetic) makes the skin dry along. It, in the peripheral vascular disease, results in a warm foot with distended dorsal foot veins. This increases the difficulties concerning the education of the patient given the recognized fact that each foot problem develops as a result of vascular disease. This makes it challenging for the patients to identify that their warm feet, which is pain-free are at an increasing unperceived trauma risk, which subsequently results in foot ulceration [5]. In case, the preventive programs concerning the
education of being planned, it is necessary to dedicate substantial attention to the effective and careful neuropathy development, leading to understandable terms.

Practically, the simple clinical examination can lead to easy documentation of the peripheral neuropathy for obtaining the neuropathy evidence. In it, the most significant process is to remove the socks and shoes of the patients and examine the feet closely. The tools, for instance, the neuropathy disability scorecard or the monofilament can be used to assists in the identification of the neuropathic foot [3] that can be used for the neuropathic evidence. Also, to identify the increased risk of the foot, there is no need to conduct comprehensive testing through a survey or using electrophysiology.

### 1.1.3 Peripheral Vascular Disease

The peripheral ischemia, which occurs from the disease of proximal arterial, is identified as a component that occurs in the pathway for the foot ulceration, accounts for the third in all patients [3]. Whereas, the details concerning the ischemic foot are that the feet are dry, red, as well as neuropathic. These characteristics further increase its susceptibility to its pressure resulting from the footwear type.

### 1.1.4 Other Risk Factors

The deformity of the foot, primarily the claw toes and the prominent metatarsal heads, which is a well-recognized ulceration risk factor. Likewise, the accumulation of the plantar callus is linked with the sevenfold risk increase in a cross-sectional study, while the patients’ follow-up increase showed it occurrence for only callus sites for the neuropathic feet, leading to an infinite increase in the risk. The other risk factors concerning the complication of the diabetic feet include microvascular complications that increase the diabetes duration, plantar foot pressure, peripheral edema, as well as the foot ulcer history or the amputation [3].

The foot ulcer prevention for the identified risk factors is integral, in case, a decrease in the ulcer incidence is required. It is suggested that enhancement of the educational programs and provision of podiatric care on a regular basis can improve early diagnosis of the patients and helps provide the treatment at an initial level. Accordingly, different psychosocial factors are also identified to lead to ulceration incidence. The patient’s behavior concerning the ulceration and its risk factors are not based on the risk abstraction definition, but on the risk, a perception held by the patients. Thereby, in case, the patient does not believe that the foot ulcer lies in the neuropathy path to amputation, there lie low prospects concerning following their educational device, leading to an increased risk of developing a foot ulcer. This necessitates introducing different interventions for ensuring adequate care as well as preventive measures. This includes a proper examination of the patient’s feet and collecting information concerning neuropathy, vascular disease, deformities, edema, and more.
1.1.5 Ulceration Pathway

The ulceration pathway refers to the combination of one or two risk factors that lead to the development of the foot ulcer among the diabetic patients. Various studies have accounted for the commonest triad of components leading to the diabetic foot breakdown such as trauma (footwear), peripheral neuropathy (insensitivity), deformity (toes clawing, metatarsal head prominence), and more. Mechanical trauma (standing on the nail), as well as neuropathy or the thermal trauma (insensate feet of the patient who use a heating pack), are the common examples of the two-component pathway leading to the ulceration among the diabetic patients [6]. Another common example includes “corn cures” which refers to inadequate chemical use.

1.1.6 Sensory Loss Among the Patients

The neuropathy foot problems can only be reduced, when the clinicians give consideration to the fact that patients who have insensitive feet have lost their ulcer warning signs, such as pain, which requires the patient to make a visit to the doctor [6]. The sensitivity to the pain is integral for the patient to lead to various medical consultations, including the training and healthcare-oriented toward the deliverance of relief from the foot ulcer. Therefore, the training should be integrated for the clinicians to help assist in providing treatment to the patient with no pain sensation.

1.1.7 Charcot Neuroarthropathy

The occurrence of Charcot neuroarthropathy (CN) is reported for the patients who are at a loss concerning the sensation, autonomic dysfunction (i.e., increase in the blood flow as well as the dry skins) following by the trauma (unperceived by the patient) [6, 7]. The common risk factor indicated CN is the warm foot which has bounding pulses though there exists sensation loss. The patient presents with a swollen foot, unilateral warm, either with or without pain symptoms, as well as discomfort with proper circulation, is required to be assessed for Charcot neuroarthropathy. Its risk can be reduced with proper care and instigation of educational interventions.

1.2 Overview of the Diabetic Foot Ulcer (DFU)

Primarily, diabetic foot ulcer is identified as the most prevalent problem among the diabetic patients, with an annual incidence percentage of 2.2% on average [8]. Despite taking all the corrective measures for preventing the DFU, the occurrence of DFU can cause substantial complications in the form of infection, amputations, as well as death. Prompers [9] stated that the occurrence of infection among the diabetic foot ulcer is present among the 58% of the patients who present a new foot
ulcer. An earlier European study of Prompers [10] showed that about 5% of the diabetic patients had DFU, where a major amputation was required in 1 year. Another research on the European states presents that the mortality rates for the next 5 years concerning the diabetic foot ulcer, which is 45% high for the neuropathic ulcers, along with 55% high for the ischemic ulcers [8].

The predicted and actual percentage concerning the diabetic foot ulcer showed similar and at times worst statistics for various common tumor types, which include the breast, prostate, and colon [11–13]. The incidence of the diabetic foot ulcer is prevalent across the world, leading to severe economic consequences for not only patients but their families as well as the society at large. Boulton et al. [14] presented The Lancet article and wrote that the occurrence of the diabetic foot ulcer is probably of neuropathic origin. Since a major part of the occurred foot ulcer is the potential of neuropathic origin, these are extremely preventable for the developing regions, which frequently report the incidence of Type 2 diabetes for the next 20 years. Boulton et al. [14], in his paper, stated that “Individuals that are at an increasing ulceration risk could be identified easily through the instigation of careful examination, education as well as the frequent follow-up.” It is stated that the foot care problem continues to prevail for the former Soviet countries, though the development of the multidisciplinary foot clinic is becoming more commonplace. Figure 1.1 presents the pathway concerning the physical foot ulcers and the different factors associated with it.

Understanding the economic impact and burden of the diabetic foot ulcer, it is necessary to study the recurrence rates of foot ulcers. The present recurrent rates, as presented by Boulton et al. [14], are less than 50% subsequent to 3 years. This recurrence rate is substantial for the determination of the economic impact posed by the foot ulcer [15]. The cost associated with the diabetic foot disease does not only comprise of the immediate cost but also cost in the form of home care and ulcers (subsequently). For understanding the total resource required, a broader view should

![Fig. 1.1 Pathways to diabetic foot ulceration](image)
be gathered comprising of the increasing quality of life and the ultimate outcome. This recurrence rate can be reduced through the instigation of the frequent screening as well as patient education which leads to a decrease in the expenditure and the screening healthcare costs. Figure 1.2 presents the overall procedure involved in the occurrence and reoccurrence of the diabetic foot ulcer. Majorly, the occurrence of the diabetic foot ulcer is based on the different factors that lead to the breakdown of the skin. The factors comprise of the sequelae related to sensory, autonomic, as well as motor neuropathies.

1.2.1 Diabetic Foot Ulcer (DFU) Burden in Asia

The data concerning the problems of diabetic foot ulcers in Asia are scarce. Such as the report of the International Working Group on the footcare clinics in China show that there are only five specialist foot care clinics in the region, where none offers podiatry services. The increase in the amputations remains a major and interesting area in the diabetic foot ulcer. Accordingly, another country such as India comprises of the more diabetic population as compared to other countries, where the
occurrence of amputations is quite frequent [14]. The most primary cause of foot ulceration is its late diagnosis and is generally associated with gross infection and neuropathy. Concerning a wide overview of the continent, diabetic foot problems are substantially scared. Other causes related to the increasing cost of diabetic patients is related to the barefoot gait, which is quite frequent, where the traditional healer or the elders in the village are contacted for help.

In contrast to the other Asian countries that have a link with the Europeans, a small degree of inclination is observed for education and training. For instance, the Netherland team comprising the podiatrist’s teams, surgeons, and diabetologists help deliver information as well as care concerning the diabetic foot ulcer patients in Jakarta. Another study in Canada, which used the diabetes population risk tool showed that diabetes development is at a higher risk in South Asia as compared to any other region. Another research further showed that the diabetic disease rate of prevalence for the South Asian patients is predicted to be four times high as compared to any other ethnic group [17]. Similarly, across the globe, the number of patients with diabetes is estimated to have escalated from 171 million in the year 2000 to 366 million until the year 2030 [18]. These figures are further expected to increase by 2030, which for India is expected to be 46 million, for Pakistan it is 14 million, whereas, for Bangladesh, it is 11.1 million [19].

1.2.2 Diabetic Foot Ulcer (DFU) Burden in European Continents

Despite the implementation of various international guidelines for the prevention of diabetic foot ulcers along with the establishment of the substantial multidisciplinary foot clinics, the disparity in clinical care is evident [4]. For instance, there are only a few countries in East Europe which have foot clinics or podiatry services. Also, in the UK, a community-based study showed that its patients that are at risk of ulceration are predicted to be further diagnosed as a result of a simple clinical test, which includes screening strategies implication for the developing countries. In the Soviet countries, difficulties related to the care are also present, although the multidisciplinary foot clinic is further becoming a common part of the large cities across different European countries. Boulton et al. [14] have reported that the provision of the best foot care is available at the Baltic state.

The provision of adequate care for the European countries is also integral given the increasing cases of diabetes with about 55 million people, where the risk of developing diabetic ulcers prevails in about eight million people. The burden of the diabetic ulcer on the European countries because of the unsuccessful DFU treatment which causes about 450,000 lower limb amputations that account for health authorities’ costs of about EUR 2–2.5 billion [20]. The diabetic foot ulcer management is substantially costly for the countries. For instance, Marion Kerr carried out a detailed investigation concerning the care cost associated with the foot complication in diabetic patients. The report findings stated that diabetic patients with low risk of ulcers require the regular change in the dressing as well as visits to the orthotics, podiatry, as well as the hospital in case the condition becomes worst. The
cost computed in England for managing such conditions is found to be £325 million. In case, the condition becomes worst, and patient’s hospitalization is required then the annual cost is about £213 million, where the cost of amputation is more, which ultimately leads to the total cost of management to vary across £639 to £662 million in England.

Various collaborative studies in the European countries such as one from Manchester, Athens, Antwerp, and Rome have shown no substantial difference for the patients at the hospitals and diabetic clinics concerning the determination of the foot lesion risk factors including neuropathy prevalence as well as of the peripheral vascular disease [15]. These findings highlight that foot prevention similar strategies should be instigated for the delivery of effective care across the European countries. Likewise, another research on the three districts of the UK supported that active foot ulcer is found among type 2 diabetic patients along with 5% of the population that have had an ulcer. Another research on the large community-based report endorsed that incidence rate concerning the foot ulcer is 2% on an annual basis, which is comparable to the primary care delivery of the foot ulcer in the Netherlands. A significant finding of the community study is that the simple tests help identify the ulceration risk, where the modified neuropathy disability score, i.e., a dichotomous variable composite score, is the best for prediction of the ulcer risk.

Concerning the ethnic minority in the region, the data is found to be interesting. For instance, the risks for the diabetic foot ulcer among the Asian and African Caribbean’s is much lower as compared to the other minorities [15]. The findings in France also report an increase for the diabetic foot ulcer, where the clinic in Paris reported the inpatient’s stays of the patients decline following the multidisciplinary foot care team establishment. The difference in the amputation rates is observed to vary across Europe, which generally shows a reduction in the success of the amputation rates. Despite the unchanged increase in Germany, the diabetic foot ulcer reports provide an optimistic result for the Netherlands as well as Italy. This amputation reduction might be associated with the International Consensus implementation consequences for the diabetic foot in Tuscany. The podiatry service increase might also be linked to the amputation reduction in the Netherlands.

### 1.3 Factors for Diabetic Foot Diseases in Asia and European Continents

#### 1.3.1 Poverty and Hygiene

Another factor that leads to the occurrence of diabetic foot ulcer is poverty. Most studies reported that the link of poverty with the unhygienic conditions lead to infectious sequelae. The other primary factors include the occurrence of diabetic foot ulcers which comprise walking barefoot or late diagnosis of the diabetic foot for initial clinical assessment. For the developing countries such as Asia, the difference in urban–rural life continues to prevail, where the Western lifestyle is being deployed along with the change in the behavior concerning the rural conditions.
Such as reflecting on the Asian countries, for instance, Sri Lanka, Nepal, India, Samoa, Thailand, the Solomon Islands, and more, where more than 50% of the national population in the rural areas has diabetes [21]. Accordingly, recent statistics, for instance, in India and China [22–24] the prevalence of diabetes is found to be greater for the rural area as compared to the urban area. Another research concerning the Hwang et al. [25] through its multiple surveys has shown that the diabetes prevalence was fivefold more from 1985 to 2010, among the developing countries’ rural population [26].

Barefoot walking is a common practice across different rural areas in Asia. Such as in the rural areas, the outhouses are located at a substantially considerable distance at the dwelling places, leading to foot injuries due to walking barefoot. Similarly, the lack of hygiene leads to other factors which cause diabetic foot ulcer. For instance, these individuals have a lack of awareness concerning the risk factor or the preventive measures which can be achieved through a better education level. Precisely, in the rural areas of the region, foot injuries often occur due to the house rate and other rodents [14]. For the peripheral neuropathy diabetic patients, these injuries are often not noticed until the patient starts observing symptoms [27]. These patients then present such injuries to the clinics for foot care with the injury or ulcer that has been progressed to fulminating foot sepsis.

Another care that must be taken care of includes occlusive footwear, which causes sweating and can lead to the occurrence of the fungal infection [28], especially for tropical countries. Dorresteijn et al. [29] writes that to prevent foot ulcer occurrence, the individuals must wear the prescribed footwear which does not usually wear at home, where these individuals are more active. Messenger et al. [30] report that the mortality ratio for the low-income countries is substantially high with increased hospitalization ratio. Therefore, in order to reduce the occurrence ratio, it is integral that caregivers must provide the patients with the information necessary for meeting the adequate level of hygiene along with the proper procedure for ensuring its adequate care. One primary thing that the diabetic patients need to ensure, in the words of Boulton et al. [14], is:

The two golden rules of prevention are regular foot inspection and not walking barefoot.

### 1.3.2 Sociocultural Practices

Different sociocultural practices continue to affect the foot ulceration prevalence across different countries. For instance, the sociocultural practices, i.e., walking barefoot, religious practices, improper use of footwear, and inadequate knowledge concerning foot care can lead to an increase in the foot complications prevalence across Asia [31]. Other causes of the foot ulcer include stress, smell leading social isolation, as well as decreased mobility of the patients. Accordingly, the awareness concerning adequate foot care is also lacking among the Asian countries, with incomplete information of the foot care, including foot protection, and limited self-care practices. Various Asian studies have expressed that most of the patients do not
refer to healthcare due to fear and related healthcare factors. This includes the fear of contact with the healthcare nurses and professionals who are consulted for determining the glucose level in the blood, dressing of the wounds, and procedure for collecting the data. These fairs could be overcome through the provision of a better and organized diabetic clinic focused on providing adequate health education, availability of cheap drugs, as well as accessibility and opening hours [32].

Other sociocultural factors that serve as a risk include beliefs which the people hold, generally in the developing countries, toward illness and health. These beliefs are generally related to individual as well as nature-related factors infused together with the social factors, and few cases related to the supernatural factors. Whereas, in the European countries, the healthcare sectors were referred to when required. This indicates the stark difference among the population of the two regions [33, 34]. Studies suggest that the focus of the non-westerners is mainly on the social and supernatural spheres, where the first contact point includes family, friends, relatives, and traditional healers. Whereas, in comparison to the western countries, particularly Europeans, the focus is on the individual characteristics as well as nature, following the consultation with the profession [33, 34].

1.3.3 Ignorance

Lack of awareness of the diabetic foot ulcer refers to another factor for its occurrence. Particularly in the developing countries of Asia, various diabetic foot burden is observed, where the prevalence of other socioeconomic factors leads to its hindrance. This also includes the lack of integration of their foot care into their lives. Such as the finding of the earlier study showed that diabetic patients who do not practice foot care are at a 2.52% increased risk of developing foot ulcers as compared to those who do. Similar findings are observed across different countries in Asia, including Kenya, Ethiopia, Arbaminch, India, Mekele, and more [35, 36]. The self-care practice can also lead to a reduction in diabetic foot ulcer development because of the benefits it provides. This includes washing of the feet on the regular basis, following by the drying of feet appropriately, status evaluation of the foot on a regular basis, adequate circulation as well as proper management of the abnormality at an earlier age that can occur on the foot. Thereby, for the prevention of the diabetic patient foot ulcer, preventive measures, and proper care of the feet should be maintained.

1.3.4 Environment and Other Related Factors

There are various environments as well as other related risk factors that can lead to the development of foot ulcers among diabetic patients. Different factors are found to be associated with the increase in the ulceration risk, which are generally linked to the economic development in the region, along with urbanization [37]. Different
dietary patterns, individuals’ sedentary behavior, as genetic background, epigenetic susceptibility, as well as obesity, are found to increase the prospects of foot complications among the diabetic patients. Concerning the history of the Asians and the studies conducted on them, it is found that the majority had undergone some sort of nutritional transition, increase in the refined carbohydrates consumption, animal fats, meats, as well as low intake of the dietary fibers as well as vegetables [38]. Similar practices are observed in terms of intake of the sugar-sweetened beverages in China as well as European countries, as provided by the recent statistics and behavior [39]. Various risk factors concerning the diet can be significantly related to Asians. For instance, the diet of the South Asians, substantially depends on the increased carbohydrate consumptions, along with saturated fats and Trans fats [40], which is substantially conducive to the development of the foot complications. For instance, early studies in China have shown that the people who consume the extensive amount of white rice have increased level of glycemic load, linked with the diabetes risks [40, 41]. The similar findings are noted for the diabetic care of the patients who consume white rice in India [41]. Despite rice being recognized as the staple food item for centuries, however, the shift is observed to occur among the traditional rice types (such as polished rice), which increase the glycemic excursion as compared to the offering of a traditional rice type. Conclusively, it is found that increased glycemic excursion exists for Asians as compared to other population groups.

Another factor identified includes physical inactivity. In many populations, the risk factor in T2DM is physical inactivity [42]. Specifically, in the occupational setting, the decline has been observed in physical activity because of increasing urbanization [43], along with the sedentary behavior, which has also risen. To prevent diabetes in large communal areas such as Asia and the Pacific, this research highlights the significance of encouraging physical activities and minimizes sedentary behavior. In this study, the researchers examined the multiethnic cohorts and observe the relationship between diabetes and adiposity, researchers comparing with Europids, Asian develop diabetes with lower BMI [22, 44]. In the Asian population, this is assumed to visceral adiposity [45]. As a result, lower BMI cutoffs in Asians are being used to describe obesity [46]. Central obesity is defined by the circumference of the lower waist [46, 47]. According to the two observational studies, there is an association between diabetes with increasing adiposity. This condition does not differ between Asian populations and Europid [48]. Thus, there is a traditional difference in the relationship between adiposity-diabetes is probably characterized as a chance for diabetes at each and every level of BMI (waist circumference) or diabetes with a lower level of BMI.

It is seen that diabetes risk in all ages of Asian populations is quite high. Studies highlighted other factors related to age or obesity that raised the awareness regarding diabetes in Asian Population. Many novel putative risk factors have appeared recently as a significant environmental determinant and behavioral for T2DM. Environmental risk due to toxic waste, other chemical, and sleep disturbance are also included. Many developing countries are suffering from pollution
issues, during adult life it has the potential to contribute to the diabetes epidemic or sometimes in utero exposure.

According to the observations made by Hales and Barker [49] on the association between the metabolic disturbance and risk of diabetes in adult age with the lower birth weight. The essential role of utero environments in physiology and customized developmental trajectory and this is highly appreciated, thereby modifying the obesity’s risk, other chronic diseases, and T2DM in adult age [26]. Likewise, a hypothetical study designed for adulthood utero nutritional deprivation may predispose a person to T2DM [26]. During early life, in some parts of China, it exposed to some serious famine, therefore it becomes the cause to increase the risk of diabetes in adults as compared to those who do not face the extreme nutritional deprivation in utero development.

During midlife, the risk of diabetes is higher among the generations unprotected by utero low nutrition and who are later exposed to the richest diet [50]. The phenomena concerning the condition of undernutrition at the early life followed by environmental exposure to a “metabolically challenging” along with a diet that is highly energizing may lead to the high occurrence of diabetic patients [26]. The emergency rate in Cambodia about T2DM is at the same rate as those developed countries [17]. In 1975, Cambodia faced a severe shortage of food because of the upheaval condition of socioeconomic and politics. Nauruans were exposed to famine conditions during World War II on another Pacific Island and on Nauru such as Truk, where they were relocated. After three-decade, the rate of diabetes prevalence was high in Nauru in the entire world [51]. Due to war and famine, these are unexpected health issues, which were later pursued by overnutrition. Moreover, Yajnik study [52] suggested that India is experiencing the burden of diabetes due to the early developed health issues and epigenetic. In addition, according to the epidemiological studies, there is a link between the offspring risks and utero undernutrition, among the Pima Indians specifically. Exposed to maternal obesity and diabetes there is a high risk of T2DM and obesity in offspring [26, 53]. Comparing with USA and Europe, Asia is also having a high risk of prevalence of GDM and young-onset diabetes [54]. In future generations, there is an increase in the risk of diabetes; therefore, Asia may operate the intergenerational cycle [26].

1.4 Evaluation of Diabetic Foot Infections (DFI)

The understanding of DFI is significant due to its reporting of 1–5% of the foot ulcer among diabetic patients. Countries across the world dedicate a substantial amount of time as well as resources to reduce its occurrence [8]. This requires the patients to be reviewed on a routine basis along with the community podiatry foot protection to provide primary care and nursing. The evaluation of this care is substantially critical as it helps in prevention against the diabetic foot ulcer patient’s emergency admission to the hospital, prevention against avoidable amputations, and care delivery.
1.4.1 Evaluation: Physical Examination

The DFI management incepts by examining the medical history of the patients along with their physical examination using laboratory as well as imaging findings. The diabetic patients with foot infection might not integrate the general symptoms and signs of the infection (such as vomiting, nausea, malaise, fever, and anorexia) due to the modifications in the leukocytic immune response [8]. The earliest sign concerning the patient with diabetic foot ulcers is unexplainable hyperglycemia. The physical examination of the patients, either in Asia or Europe, may present the “diabetic flu” symptoms including the anorexia, vomiting, fevers, chills, and nausea, which should prompt close inspection for the ulcer foot or infectious signs. This examination should be closely linked to the ulcer size, its depth, odor, drainage, or the margins. The suspiciousness concerning the osteomyelitis should occur based on a close examination of the erythrocyte sedimentation rate of below 70 mm/h, ulcer >2 cm², positive probe for testing the bone, and the abnormal radiographic findings including the cortical disruption. The presence of osteomyelitis and its high sensitivity and specificity are based on the bone test probe [8]. The accurate osteomyelitis diagnosis is based on the positive predictive values which range from 53% to 89% along with a positive probe to bone test. Substantially, the probe to bone inability is linked with a negative predictive value of about 98%. The elevation of the extremity should occur for determination of the extremity as to whether the Charcot sets as a base for the erythema stems or the infection. Among the patient’s supine for about 5–10 min, the low extremity should be elevated, while simultaneously observing the erythema resolution, which provides the noninfectious injury. The infection can be clinically diagnosed due to the purulent drainage, or at least the presence of two inflammation signs (i.e., warmth, swelling, erythema, induration, pain, or tenderness).

1.4.2 Evaluation: Laboratory Testing

The evaluation of the patients through laboratory testing is integral to present the infection severity in the quantifiable form, following a response to the treatment. The laboratory finding is required to include the information concerning the patients’ blood count, metabolic panel, C-reactive protein, as well as erythrocyte sedimentation rate. Also, the patient’s nutritional status should also be assessed by collecting prealbumin and albumin. The level of the glucose should also be assessed, as the glycemic control loss occurs at the initial stage of the infection. Also, the imaging modalities are used for the characterization of the bony involvement and the degree of soft tissues affected [8]. For the initial workup of the foot infection in diabetic patients, the plain radiographs are also useful. The radiographic abnormalities should be paid special attention, which includes soft tissue gas, radiopaque foreign bodies, cortical erosion, and periosteal reactions. Also, for assessing the progressive signs, the repetition of the plain radiographs can be held. However, these
radiographs are not very sensitive and should be combined with the different modalities for better characterization of the suspected infection [8]. The osteomyelitis evaluation through magnetic resonance imaging (MRI) is found to present good specificity as well as sensitivity. Similarly, in the absence of the MRI, nuclear medicine scans can be used.

1.4.3 Evaluation: Microbiology

Following infection identification, antibiotic therapy requires culture. For this, deep tissue cultures should be attained. It is because these will present more reliable detection of the causative organism as compared to the superficial swabs. The use of these tissues is more reliable for deriving the causative organism in comparison to the superficial swabs. Despite bone cultures being ideal, these assessments of deep soft tissue culture might be beneficial in the detection of the osteomyelitis offending organism [8]. Following its proper evaluation, the IDSA system can be used for the classification of the infection which assists in the selection of the best treatment for improving communication among providers.

1.5 Strategy for Prevention of Diabetic Foot Management

Preventive strategies concerning the management of the diabetic foot are integral. This requires healthcare financers and decision-makers to optimize the resource allocation in an effective way of delivering adequate care quality. This involves funding as well as investing in different programs that help prevent diabetes as well as prevent foot complications among the diabetic patients. The diabetic patient’s organization, as well as other advocating the diabetic care change, need to provide arguments that help devise decision for adequate care of the patients reducing the diabetic foot ulcer occurrence. These strategies should be centered on improving the patient’s awareness level, where the diabetic ulceration prevention is prioritized, which serves as a substantial healthcare agenda. The preventive strategies also require the partnership of the different industry players, which is not only linked to their valuable contribution for improvement toward their therapeutic care but also facilitates education, research, as well as diabetes awareness programs. From an epidemic perspective, there exists a need for professionals to find a new way of organizing the delivery of the care program and for managing the extensive workload. These preventive strategies require effective working such as shared responsibility, better work management, and improved team work.

1.5.1 Education

For preventing the occurrence of diabetic foot problems, the primary prevention strategy is education. Although this might be particularly targeted for the providers