

REVIEW

Preventive foot care and reducing amputation: a step in the right direction for diabetes care



Zulfiqarali G Abbas*

Practice Points

- It is important to take off the shoes of diabetic patients.
- Regular inspection and examination of both feet are essential.
- High-risk diabetes patients should be identified.
- The diabetes patient should ensure that they have appropriate footwear and footwear should be recommended if necessary.
- Education regarding foot care should target all patients, relatives, friends and healthcare workers.
- Treatment of trivial injuries and nonulcerative pathologies should be taken seriously.
- For better outcomes in managing the diabetic foot, a multidisciplinary team approach is important.

SUMMARY Across the world, diabetic foot complications are increasing in prevalence and are associated with high morbidity and mortality. Approximately 40–60% of all lower extremity nontraumatic amputations in the world are carried out on patients with diabetes. Combined strategies of prevention, close monitoring of patients, multidisciplinary treatment of foot ulcers and education of the patients with diabetes, as well as healthcare providers, can lead to significant reductions in amputation rates by up to 85%. Education about foot care is the most important intervention for the prevention of amputation. It should be targeted at both patients with diabetes and healthcare workers. For improving the outcome of diabetic foot patients it is important to have a multidisciplinary approach in the management of diabetic foot ulcers, and empowering patients with diabetes to take better care of their feet is an important component of patient education. One of the programs mentioned in this article in detail as an illustrated example of education is the Step-by-Step Diabetic Foot Project, which was piloted and carried out in Tanzania and India. Importantly, the project was found to be associated with over a 50% reduction in amputation rates in Tanzania. Education is a powerful tool for both healthcare workers and patients in reducing amputation rates and can be achieved through a trained diabetes workforce working in an effective system of health. The Step-by-Step Diabetic Foot Project serves as a working model to reduce mortality and morbidity and improve patient outcomes by teaching health worker and patients about early detection and treatment of diabetic foot complications.

*Muhimbili University of Health & Allied Sciences, Dar es Salaam, Tanzania; and Abbas Medical Centre, PO Box 21361, Dar es Salaam, Tanzania; Tel.: +255 22 2183936; zabbas@cats-net.com

Epidemiology

Diabetes mellitus is a serious chronic condition with devastating implications for affected patients worldwide [1,2]. With little discrimination, it affects rich and poor, young and old, and industrialized areas or less economically developed areas in equal measure. In 2011, the prevalence was estimated at 366 million (i.e., >8.3% of the adult population worldwide) [1,2]. The number is expected to increase to 552 million by 2030 – a consequence of sedentary lifestyles, changes in dietary patterns and longer life expectancy [1,2]. In China, the Middle East and countries across the African continent, the number of people with diabetes has increased significantly and is expected to more than double during the coming decades. Similarly, the number of people diagnosed with diabetes is increasing in southeast Asia, South and Central America, western Pacific, North America, the Caribbean and Europe [1,2]. The majority of individuals (80%) with diabetes live in low- and middle-income countries. In 2011, it was estimated that there were 14.7 million individuals with diabetes in Africa and, should current trends continue, the overall prevalence is projected to increase by 90% by 2030 [1,2].

Not surprisingly, diabetes remains a leading cause of morbidity and mortality in both developed and less developed countries, and imposes a heavy burden on their health services [3–5]. Among all the various serious complications related to diabetes, complications of the foot are associated with the highest morbidity and mortality [3–10]. Across the world, data suggest that 40–60% of all lower limb nontraumatic amputations are related to diabetes [101]. Foot complications, especially those that are serious, such as the septic limb, can be critical and costly [3–10,101].

Therefore, the aim of this paper is to discuss how education may be the strongest preventative tool for foot ulcers to reduce the rate of amputation.

Education as a preventive tool to reduce amputation

In North America and western Europe, it has long been established that preventive foot care, a multidisciplinary approach for foot ulcers, close monitoring of patients, and education of people with diabetes and healthcare providers, can lead to significant reductions in amputation rates by up to 85% [11,101]. In particular, since the majority of diabetic foot ulcers in less developed

settings seem to have neuropathy as an underlying risk factor, such ulcers are largely preventable or potentially curable. There is also increasing evidence in the literature that management of diabetic foot problems carried out by multidisciplinary foot teams can reduce amputations among patients with diabetes [12–15].

Various studies have shown that simple education, care, motivation and action by patients with diabetes themselves are important in protecting the feet from complications [16–21]. The role of special diabetic foot clinics in reducing the incidence of foot problems has been shown by various clinical studies. It has been demonstrated in studies from western countries that education given to patients with diabetes results in an unequivocal reduction of foot ulcers and amputations [16–22]. Major amputations of the diabetic foot have reduced tremendously after the establishment of foot clinics in western countries [12–15]. The most important intervention for diabetic foot ulcers is preventive methods by educating individuals [16–21]. The inadequacy of primary preventive methods in low-income countries leads to increased numbers of amputation among diabetic patients [3–9]. The main challenge remains: what interventions are the most effective towards reducing the incidence of the diabetic foot ulcerations? Research in the prevention of diabetic foot disease is still sparse compared with the body of evidence for treatment. Current practices are mostly based on international consensus and traditional medicine rather than research- and evidence-based medicine. The most powerful preventive tool in less developed countries is education, and it should be a simple, repetitive and integral part of prevention programs [23–25].

In The Netherlands, through a nationwide study of all hospital admissions, a 40% reduction in the incidence of diabetes-related lower limb amputation has been documented [26].

In Italy, guidelines for the diabetic foot have been endorsed by all scientific societies. These guidelines proposed a network of diabetic foot screening at three different levels according to the severity of the lesions. People at low risk are those who have normal sensation and blood flow. People at high risk have abnormal sensation and people at very high risk have both peripheral neuropathy and peripheral arterial diseases. After implementation of guidelines and international consensus on the diabetic foot, a decrease in admission to hospitals and major amputations have been documented [27].

In Denmark, the rate of leg amputations in diabetes patients has decreased to an incidence of approximately 0.3%, which has remained stable over the last 10 years. This has been achieved by reimbursing most of the outgoing costs for special shoes, insoles and visits to the podiatrist [28]. Multidisciplinary settings with adequate treatment are now available for up to 75% of patients due to the increased number of diabetic foot clinics or wound healing centers over the years [28].

In conclusion, multidisciplinary care with specialist centers might be the best way to reduce amputations and costs caused by diabetic feet and it should be a main aim for all patients with diabetes.

In the USA, Howard studied interventions that involved the modification of risk factors that lead to an ulcer in patients with diabetes. Identified risk factors for amputation included the consequences or sequelae of peripheral neuropathy and peripheral arterial disease (e.g., callus formation, onychomycosis, structural foot deformities, circulatory disturbances, wounds and inappropriate footwear). It suggests that annual screening foot examinations should, at the very least, include evaluations for peripheral neuropathy, peripheral arterial disease and the aforementioned sequelae. High abnormal plantar pressure is a risk factor for ulceration that has been investigated by means of plantar pressure measurements and, therefore, identifying patients at high risk of ulceration and monitoring the after effect of pressure-reducing interventions is important [29].

Foot education programs for diabetic patients usually include basic elements such as daily feet inspection, avoidance of trauma (e.g., barefoot walking) and reporting any new symptoms to their healthcare worker. It is important to educate patients regarding foot care, but educating the healthcare provider is as important. Guidelines by the American Diabetes Association suggest that healthcare providers should at least be able to perform a basic screening examination of both feet that also includes examination of the neurological, vascular and musculoskeletal system of the patient [18]. Another recently investigated intervention for monitoring diabetic foot ulcers and detecting areas at risk in both feet for the development of diabetic foot ulcers is skin temperature monitoring [18].

Compared with the developed world, methods for foot examinations use are carried out by sophisticated machines, whereas in developing countries, an examination is carried out and is

kept very simple due to cost. Due to the unavailability of highly sophisticated technology in developing countries, simple methods for examination of feet are used; for example the simple turning fork for testing vibration sense instead of an expensive biothesiometer. For a long time, we have been using the handle of a turning fork to measure sensitivity to hot and cold, and it gives the same outcome.

Education, which is cost effective, should be targeted at both patients and healthcare workers. A comprehensive foot care program should include education, regular examination of both feet, identification of high-risk patients and educational programs for diabetes patients and their healthcare providers. Several educational programs aimed at preventing diabetic foot complications have been carried out and executed successfully in both developed and less economically developed countries [23–25]. One of these successful foot programs mentioned in this article and discussed in detail as an illustrated example of foot care education among healthcare workers and patients, is the Step-by-Step Diabetic Foot Project, which was piloted and carried out in Tanzania and India [23–25]. This program showed that infection, ulceration and limb amputation are potentially preventable through organized foot care programs and approaches that encompass comprehensive, preventive strategies, including patient and staff education, joint medical and surgical management of foot ulcers, appropriate use of microbiology resources, and regular follow-up. Importantly, the project was found to be associated with a more than 50% reduction in amputation rates [23–25].

Amputation rates of lower limbs in patients with diabetes can be reduced by 50% if the following recommendations are implemented: inspection of the feet and footwear regularly; patients with high-risk feet should be given preventive footwear; management of diabetic foot ulcers by implementation of a multidisciplinary approach; high-risk feet (peripheral neuropathy and peripheral arterial disease) have to be diagnosed early; and patients with a high-risk foot, foot ulcer or past history of amputation must be followed-up.

Education targeted to risk stratification in reducing amputation

To design interventions for the prevention of diabetic foot ulceration and ascertain patients' risks of developing foot ulcers, various epidemiologic studies have evaluated cohorts of patients with

diabetes to identify and characterize risk factors associated with foot ulceration and lower limb amputation. Educational programs may appear ineffective when applied in a standardized way to large, unselected populations. However, as yet, there is no hard scientific evidence that ‘general education’ of diabetes actually reduces the incidence of foot ulceration and lower limb amputation in less developed countries. By contrast, there is a growing body of evidence that structured, continuous education for individuals identified to be at risk of foot ulcerations reduces the incidence of foot ulcerations and lower limb amputation. Thus, it is more beneficial to patients when education is delivered according to the individual’s risk classification for ulceration and needs. Generalized foot care education to all individuals with diabetes has questionable value: a person at a relatively low risk may receive education that is irrelevant while a person at high risk may receive education not intensive enough for preventing the condition. Identification of risk factors for foot ulceration is challenging and requires the conduct of epidemiologic studies that include all putative risk factors, including behavior patterns associated with the pathogenesis of foot ulcers.

Different people with diabetes require different levels of foot education. This is because there is a wide range of levels of foot risk (Table 1). This needs to be taken into consideration when providing foot education programs. We know that living with diabetes is not easy; people with diabetes must assimilate a great deal of information and complete a series of daily tasks in order to effectively self-manage their condition. Lifestyle and behavioral changes regarding the feet, therefore, should be required only from people who are at high risk (i.e., people with decreased sensation and/or blood flow in lower limbs).

No country has the resources to provide comprehensive foot care to all people with diabetes. Therefore, a system has been developed for

stratifying services based on levels of risk. This system is used widely around the world. We should stratify people with diabetes according to their level of risk – from low risk to very high risk. The people at low risk are those who have normal sensation in both feet and normal blood flow. These people need simple advice. They do not need to change their lifestyle but it should be emphasized that they need an annual assessment of both feet. People at high risk have decreased sensation, and have had an ulcer at some point or have peripheral arterial disease. These people need intensive, time-consuming education that involves practical demonstrations. People who are at high risk require significant behavioral changes (Table 1). People with normal sensation can be followed-up and examined annually and there is no need for intensive education. Patients with a loss of sensation, but good blood supply and no deformity in either foot can be examined every 6 months and need intensive education to promote practical self-care skills and routine care. Those with diminished sensation, decreased blood flow and foot deformity should be examined at follow-up every 3 months and they need intensive practical education that emphasizes behavior and lifestyle modification.

Many healthcare providers have experienced the traditional medical model of learning, and we think it is important to teach people about neuropathy and arterial disease; in fact, they should focus on teaching people how to avoid situations that cause ulcers. They should not walk barefoot and should wash and examine their feet daily. Research findings from around the world demonstrate that ill-fitting shoes are the most common cause of ulceration – the cause of approximately 60% of new ulcers.

Individuals with diabetes should receive an education that corresponds to their individual level of risk [17,22,101]. Risk stratification and screening of patients with diabetes should be

Table 1. Diabetic foot risk categorization system for patients with diabetes.

Category	Risk profile	Follow-up frequency	Targeted education
0	Sensation intact	Once a year	No lifestyle changes, basic care
1	Diminished sensation, blood supply intact, no foot deformity	Every 6 months	Intensive education to promote practical self-care skills, routine care
2	Diminished sensation, blood supply compromised, foot deformity	Every 3 months	Intensive practical education that emphasizes strategies to modify behavior and lifestyle
3	Previous ulceration or amputation	Every 1–3 months	Intensive practical education that emphasizes strategies to modify behavior and lifestyle

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carried out before a person with diabetes receives education on foot care. Those with active foot problems, such as ulceration, ideally should be managed by a multidisciplinary team.

Loss of protective sensation, care of the foot including nail and skin care, checking of the foot on a daily basis and selection of footwear are very important for the patients with high-risk feet.

Importantly, patients' understanding of these issues and their ability to conduct proper self-evaluations and care should be assessed regularly. Patients with difficulties, physical or cognitive, that impair their ability to assess their own condition in order to take the necessary steps towards seeking or initiating the appropriate care, will need special attention and assistance from their care providers (**Box 1**) [17,22,101].

These practical approaches to stratify high-risk patients with diabetes can be applied in both developing and developed countries. This method can be practiced by professionals dealing with this problem all over the world. The differences between developing and developed countries is that in developing countries care is taken using a very simple, low-cost and unsophisticated techniques, and the diabetic foot is saved from amputation. On the other hand, in developed countries highly sophisticated techniques with high costs are applied and, in the end, the outcome will be the same, reducing amputation rates. Education is a powerful tool and can be used by everyone around the world. It all depends on what and how it is used and applied to reduce rates of amputations (**Table 1**).

The Scottish Foot Action Group Education Leaflet 2008 is a good example of the development and implementation of a risk education program that has addressed these concerns [22]. It is hoped that introduction of this model will enable a better understanding of the risks by patients and appropriate use of management plans for patients and care providers, respectively [17,22,101]. For healthcare systems with limited resources, the utility and benefits of group-based diabetes self-management education is obvious and should be considered.

Group-based diabetes self-management education programs have been found to improve the treatment outcome, reduce costs and encourage lifestyle modification. Group programs are usually designed according to personal requirement and at the same time take advantage other patients who are already experienced in group programs [22]. Large studies carried out in the UK

and USA have shown that most of the patients who have been diagnosed with peripheral neuropathy have no knowledge of their condition, which results in a lack of proper self-care of the foot [19–21]. It is important that healthcare providers understand and empathize with the patient's common sense. Findings suggests that healthcare providers will need to pick up those patients with misconceptions and will need to correct them by providing clear practical self-care education [19–21].

Who to target for preventing foot ulcers & reducing amputation

All healthcare providers for individuals with diabetes should be able to conduct simple screening of the neurological, vascular, dermatological and musculoskeletal systems to identify those at high risk. In addition, educational programs should also be the responsibility of care givers and should be structured to ensure that the person with diabetes receives consistent information.

The Step-by-Step Diabetic Foot Project in Tanzania targeted district and regional centers in the country with limited resources, but were already running diabetes clinics. Healthcare workers at these centres were not well trained in foot management [23–25]. In addition to this, the problem was a lack of diabetic foot management, as well as a podiatrist or trained person in this field in the country. This was common in many other less developed countries as there are no proper established training programs for training healthcare providers on how to identify high-risk feet and manage diabetic foot ulcers effectively. There were no specialized centers in the country to take care of people suffering with diabetic foot ulcers. No trained healthcare workers or professionals were able to handle cases of diabetic foot disease. For all these reasons, the Step-by-Step Diabetic Foot Project was initiated, an educational program targeting healthcare providers in several districts and regions across the country. We carried out the study to determine the outcome of the Step-by-Step Diabetic Foot Project [23–25].

The Step-by-Step Diabetic Foot Project is a training program that focuses on: creating more awareness of diabetic foot problems; providing sustainable training of healthcare professionals in diabetic foot management; facilitating the transfer of information and expertise among health professionals and export ideas to other developing countries; reducing the risk of lower

Box 1. Key message: preventing diabetic foot amputation.

- Stratify people according to level of risk, as not everybody with diabetes carries the same risk of ulceration/amputation in both feet
- High-risk patients are those patients who already have peripheral neuropathy, peripheral arterial diseases and previous history of ulceration or amputation
- Those at high risk need intensive education that involves practical demonstrations
- Patients at high risk require significant behavioral changes
- People need to learn to identify any problems that occur early
- Footwear is the most common cause of ulceration
- Problems should be identified early and treated promptly
- Health professionals need to be specially trained in caring for people with diabetic foot disease

limb complications in people with diabetes; and empowering people with diabetes to care for their feet better, detect problems earlier and seek timely help when problems arise [23–25]. The potential benefits of the Step-by-Step Diabetic Foot Program, particularly for less developed countries, is to manage the diabetic foot with limited human and financial resources more effectively [23–25].

The Step-by-Step Diabetic Foot Project for reducing amputation rates

The Step-by-Step Diabetic Foot Project in Tanzania led to better management of patients with foot ulceration, resulting in an improved outcome among people with diabetic foot ulcers at local levels and fewer referrals to the secondary and tertiary referral care center for amputation. In Tanzania, the Step-by-Step Diabetic Foot Project has enabled a functioning foot clinics alone or in combination with diabetes clinics across the country. The program has also created awareness of diabetic foot complications among patients, relatives of patients, and nursing and medical personnel involved in diabetic foot care. It has also highlighted the importance of the development and training of staff, and employing additional and more skilled personnel [23–25].

To determine whether the Step-by-Step Diabetic Foot Project was effective in diabetic foot ulcer patients' outcomes, we monitored temporal trends in rates of major amputation among people with foot ulcers in one of the centers that already had an established surveillance system for diabetic foot ulcers. For this, we chose the diabetes clinic at Muhimbili National Hospital (MNH) in Dar es Salaam, Tanzania, where the principal investigator had been conducting active surveillance of upper and lower limb complications among diabetes patients since 1997. All the patients referred to MNH for further

management during 2000–2008 resulted in major amputations as a result of diabetic foot ulcers [23–25].

There were 4324 patients with diabetes admitted at MNH during the study period. There were 736 (17%) patients with active foot ulcers referred and admitted at MNH (Figure 1). Ulcer occurrence in these patients peaked in 2005 and then declined over the subsequent years [23–25].

During the study period from 2000 to 2008, the mean annual amputation rate was 17.6% for all the diabetic foot ulcer patients referred to MNH. Before introduction of the Step-by-Step Diabetic Foot Project, amputation rates for MNH referrals were >1 standard deviation above the mean annual rate (Figure 2). After 2005, the amputation rates in the patients referred to MNH decreased significantly and, by the year 2008, fell to almost 2 standard deviations below the mean (Figures 1 & 2) [23–25].

A significant reduction in the number of amputations was noted at MNH after implementation of the Step-by-Step Diabetic Foot Project, and this may be due early observation and management of foot complications in trained centers in rural areas, compared with before training had been introduced and amputation rates were higher. For patients who are referred for foot care at MNH, the improved management at the primary care level is translated into better opportunities to save limbs in the tertiary care setting, leading to better outcomes [23–25].

Multidisciplinary team approach

In 1994, a comparative study of diabetes patients attending teaching hospital outpatient clinics in various European countries found no major differences in the risk factors for foot ulceration. On the basis of these findings, the researchers concluded that similar strategies for the prevention of foot problems should, theoretically,

be equally successful in 26 different European countries. In fact, the multidisciplinary foot care model is indeed considered the most effective approach for the management of the ulcerated diabetic foot in Europe, and healthcare systems across the continent have tried to implement such multifactorial approaches to diabetic foot care with varying success and some failures. In truth, because there are remarkable differences among the various healthcare systems, there is no common program for diabetic foot care across Europe.

The principles of structured diabetic foot management include, not only management of infection, aggressive angioplasty or distal revascularization, application of off-loading principles, surgical debridement and stage-adapted local wound care, but also optimization of metabolic and glycemic control, and treatment of relevant comorbidities. If diabetic foot lesions are managed with a model based on this systematic approach, the incidence of amputation could potentially be significantly reduced, or amputations, when unavoidable, could be carried out in a manner that carries a lower morbidity risk to patients – the ultimate desired outcome in treating diabetic foot problems. Clear evidence of the success of a multidisciplinary approach should lead to wider adoption than is currently the case. Ideally, multidisciplinary foot clinics should involve the following clinical professions: podiatrist; diabetes nurse; diabetologist; angiologist/interventional radiologist; vascular surgeon; infectious diseases consultant; microbiologist; orthopedic surgeon; orthotist; and shoemaker. Individuals (e.g., physiotherapists, psychologists and rehabilitation physicians) who do not work regularly within the foot clinic often have an input into the management process when appropriate.

In the developing world, diabetic foot clinics are running, but with limited human resources. Most of the work involving clinical professionals is carried out by consultant physicians and most of the interventions are carried out by nurses who are trained to perform the job of the podiatrist, orthotist and other professions. Minor surgeries are conducted by nurses who are trained to do it owing to a lack of human resources. Cobblers are trained to produce off-loading devices and shoes for the patients whose feet are at high risk and patients with ulcers.

While development of diabetic foot structures in the industrialized world gradually seems to

be moving in the right direction, the need for knowledgeable specialists appears to be even greater in less economically developed countries, where the scarcity of resources (human and financial) aggravates an already difficult situation. At the same time, cultural, religious, behavioral and climatic factors all play a role in the pathogenesis, course and management of diabetes and its complications in these countries, creating particular conditions that influence outcomes [3–10].

As described above, the implementation of programs to educate doctors and nurses in less developed countries, using structured programs in diabetic foot care, has resulted in the training of numerous doctors with their paramedics in India and Tanzania [23–25].

Conclusion & future perspective

A targeted foot care education program can allow a diabetes care system with limited resources to be more efficient and effective. In low income settings, resources that are already limited should not be wasted on inappropriate education and treatment programs, especially for patients deemed to be at low risk for foot disease. All providers of foot care should participate in ongoing professional education development programs to obtain skills aimed at assisting people to adopt a more positive attitude and pragmatism towards their condition, and the importance of self-care behavior modification. A reduction in the amputation rate is feasible and can be achieved through a trained



Figure 1. Incidence of foot ulcers among all patients referred and admitted to Muhimbili National Hospital with a foot complication, Dar es Salaam, Tanzania, 2000–2008.

SD: Standard deviation.

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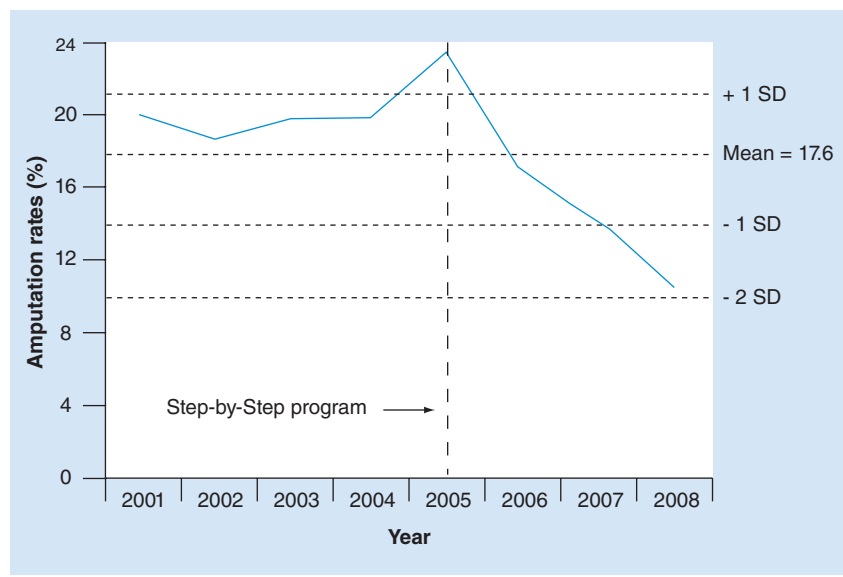


Figure 2. Temporal trends in amputation rates among diabetic foot ulcer referrals to Muhimbili National Hospital, Dar es Salaam, Tanzania, 2000–2008. SD: Standard deviation. Reproduced with permission from [23].

workers in their centers who were involved in patient care empowerment of those with diabetes to take care of their feet, detect problems earlier and seek help when problems arise. Sustained education and targeted screening programs, such as the Step-by-Step Diabetic Foot Project, is one of the unique models to reduce morbidity and mortality through early detection and treatment of diabetic foot complications, leading to improved patient outcomes in developed and developing countries.

In my opinion, improvements in the field of preventive foot care and reducing amputation will only be achieved by focusing on education. Education is the only powerful tool that can work all over the world. The education of healthcare workers who would, in turn, educate other colleagues in the centers and surrounding areas of the health center has a cascading effect. These healthcare workers in the periphery of each country would, in turn, educate patients, families of the patients, relatives and friends.

diabetes workforce working in an effective system of care that focuses on education of both the healthcare provider and patient. For example, introduction of the Step-by-Step Diabetic Foot Project in Tanzania has definitely improved foot ulcer management for individuals with diabetes, enhanced the sharing of knowledge and skills among doctors and nurses, and resulted in new foot clinics across the country. The Step-by-Step Diabetic Foot Project showed better management of high-risk feet at the district and regional levels through this program of education, which was aimed at medical healthcare workers, nurses and patients. Healthcare professionals trained through the Step-by-Step Diabetic Foot Project disseminated information to other healthcare

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