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## Diabetes &amp; Metabolic Syndrome: Clinical Research &amp; Reviews

journal homepage: [www.elsevier.com/locate/dsx](http://www.elsevier.com/locate/dsx)

## Original Article

## A health needs assessment of adults with diabetic foot disease in the US



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## ARTICLE INFO

## Article history:

Received 21 April 2019

Accepted 12 May 2019

## Keywords:

Diabetic foot disease

American adults

Prevalence

Population at-risk priority needs

## ABSTRACT

**Introduction:** Diabetic foot disease has been considered as an important complication of diabetes mellitus. The main risk factor to cause diabetic foot disease is peripheral neuropathy. Diabetic foot disease usually started from diabetic foot ulceration, it would develop to diabetic foot infection and amputation even death when conducting the poor prognosis and management of diabetic foot ulceration. Despite this, incidence of diabetic foot disease is still increasing and is therefore potentially under-recognized, under-diagnosed and under-treated all over the world, especially in the US. The aim of this study is to clarify the needs of the adults at risk and health care providers in diagnosis and treatment of diabetic foot disease in the US.

**Methods:** Cochrane library, bibliographic databases, American Diabetes Association website and DFS questionnaire website have been used to search the relevant literature of diabetic foot disease among adults in the US. Additionally, conducting subgroup analysis to review the relevant literature.

**Results:** The findings of this health needs assessment described that diabetic foot disease in the adults is higher in men than women in the US. American Indian achieved the highest prevalence of diabetic foot disease, in comparison to other ethnic groups. Meanwhile, age has been defined as an important factor to influence the diabetic foot disease rate. Diagnosing properly is important, in accordance with understanding the etiopathogenesis of diabetic foot disease for health professionals. A comprehensive Foot Examination has been established and developed by the American Diabetes Association (ADA). It has been used widely with the characters of easy conducting and rapid performance. Moreover, treatment of DFUs with becaplermin gel obtained the lower cost and the larger clinical benefit when comparing the traditional wound care.

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## 1. Introduction

Diabetes Mellitus is a non-communicable disease, also known as a chronic disease which incidence and prevalence were growing around the world, especially in the US [1]. The clinical and economic burdens of diabetes mellitus are enormous and have been escalating at an alarming rate [1]. There were approximately 26 million American adults suffering from this disease [1]. Most of them have been experiencing Type 2 diabetes, about 1 million American adults were having Type 1 diabetes [1].

A significant economic cost has been resulted from the high prevalence of diabetes, particularly from the elderly patients [1]. Diabetes and prediabetes led to nearly \$218 billion in direct medical expenditures [1].

Individuals living with diabetes mellitus would have the higher probability to gain different forms of both short and long-term complications, even caused their premature death [2]. Risks of cardiovascular disease, end-stage renal disease, blindness and non-traumatic lower-limb amputations have been increased for American adults with diabetes [1]. Although medical advances significant decreasing the occurrence of complications and mortality, the trajectory of these decreases has been blunted by the overall increase in the number of patients afflicted with diabetes [2].

The Diabetic foot disease has been regarded as an important diabetes complication, which always initially silent due to attendant neuropathy and lower extremity problems in the US [3]. Thus, diabetic foot ulcers (DFUs) have been developed which achieved substantial risks of diabetic foot infections (DFIs) and lower limb amputations [3]. Approximately 25%–50% of patients with diabetic foot ulcers has been resulted in serious infections and lower extremity amputations as well as they were required hospitalization

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[3]. Additionally, the five-year death rate related to diabetic foot ulcers which required amputation ranged from 39% to 80%, significantly close to the most aggressive forms of cancer [3]. The development of diabetic foot ulcers and subsequent amputations had a close relationship with neuropathy, hypertriglyceridemia, smoking and peripheral artery disease or PAD [3]. Apart from this, the direct health expenditure associated with diabetic foot ulceration has been estimated to consist of 1/3 of all costs of diabetic treatments, with 2/3 of those costs induced in inpatient settings, especially for the working-aged adults who gained a two-fold higher probability to be admitted in emergency departments in the US [3].

A famous diabetes physician Elliott P. Joslin believed that diabetic foot ulceration developed because of an interaction between specific lower-limb pathologies and environmental hazards, instead it was not an inevitable consequence of experiencing diabetes [4]. Therefore, the aim of this study would be to determine the needs of both adults at-risk of diabetic foot disease, and the needs of health professionals faced with diagnosis, preventive approaches and treatment of diabetic foot conditions in the US.

## 2. Methods

### 2.1. Search strategy

Literature associated specifically with diabetic foot disease among adults in the US and information regarding effective public health interventions have been searched from the following datasets.

1. Cochrane Library:
  - It is used for systematic reviews relating to diabetic foot disease in the US.
2. Bibliographic Databases- EMBASE and MEDLINE:
  - These two databases were used for RCTs, cohort studies, case-control studies and other journal articles relating to Diabetic foot conditions in the US.
  - In addition, some key words and MeSH terms used to search:
    - Prevalence and incidence of diabetic foot disease
    - Prevent\* or avoid\*or stop\* diabetic foot disease
    - Diagnosis and treatment? diabetic foot disease
    - Diabetic foot conditions and Adult? and the US.tw
3. The Diabetic Foot Ulcer Scale (DFS) Questionnaire Website:
  - The diabetic foot ulcer scale (DFS) questionnaire has been developed to evaluate how did the diagnosis and treatment of foot ulceration influence the quality of life for diabetes in clinical settings because of its good internal consistency [5]. The DFS would be suitable to use in clinical trials because the germane reliability and sensitivity to change in wound status during a specific period [5].
4. American Diabetes Association Website:
  - Searching information of diabetes and diabetic foot disease prevention and recommendations.
5. General Google searches

### 2.2. Exclusion criteria

The search excluded individuals less than 18 years old in the US. This ensured that the information extracted was informative of the wider elderly population.

### 2.3. Analysis

Conducting the subgroup analysis, in accordance with

demographic variables included age, gender and ethnicity group.

## 3. Results

### 3.1. Prevalence of diabetic foot disease in the US

Medicare FFS population referred to the people of beneficiaries who have been enrolled for at least a calendar year in Medicare Parts A and B FFS plans [6]. The prevalence of foot ulceration for diabetic patients was 19.2% in 2006, 18.9% in 2007 and 18.6% in 2008 in the US [6]. Additionally, the yearly prevalence of lower extremity amputation for diabetic adults was 6.5% in 2006, 6.1% in 2007 and 5.9% in 2008 in the US [6]. Disease trends varied by age, gender, ethnic group during this period in the US [6]. Highest prevalence rate of diabetic foot disease all over the world were seen in America (13%), while the worldwide prevalence rate of diabetic foot disease was 6.3% [7].

### 3.2. Demographics

People were over 95 years old who achieved the highest prevalence rate of diabetic foot ulceration (15%), while those in 65–74 age group obtained the lowest rate (6.1%) during these three years in the US [6]. For the lower extremity amputation rate, under 64 years diabetes gained a relative higher level than other age groups during the same period in the US [6]. (see [Graphs 1–6](#))

### 3.3. Diagnosis

It is important for both health professionals and patients to realize and understand of the etiopathogenesis of diabetic foot complications if they are prone to succeed in decreasing the incidence of lower-limb lesions and amputations [4]. Distal sensorimotor peripheral neuropathy has been regarded as a common situation among diabetes, particularly influencing up to 1/2 of elderly diabetic patients [4]. Patients would lose pain and temperature perception that protected them from tissue damage due to the fiber dysfunction [4]. Another main cause of foot lesions in diabetes is PAD because it may result in neuro-ischemic ulceration [4]. Age, sex, ethnicity and duration of diabetes would also impact on diabetic foot sufferings for American adults [4].

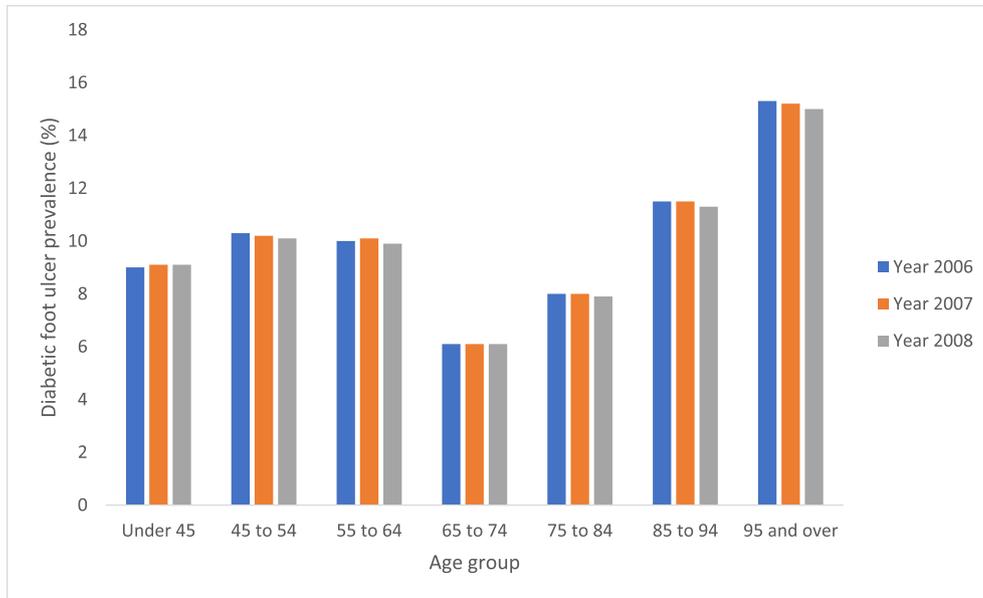
A widespread and comprehensive Foot Examination and Risk Assessment has been established and developed by the American Diabetes Association (ADA) which required minimal equipment as well as performed rapidly [4]. Furthermore, the dermatological examination included a visual inspection to observe any signs of peripheral neuropathy and sudomotor dysfunction has been proven as another important screening method for those with diabetic foot disease in the US [10].

### 3.4. Treatment

The Cochrane collaboration has published the systematic review of a few approaches to treat diabetic foot disease, including off-loading the diabetic foot wound, infection control, wound debridement, using becaplermin gel for wound care and revascularization procedures when indicated as well as other beneficial add-on therapies, such as hyperbaric oxygen therapy and negative-pressure wound therapy (NPWT) [4,11,15].

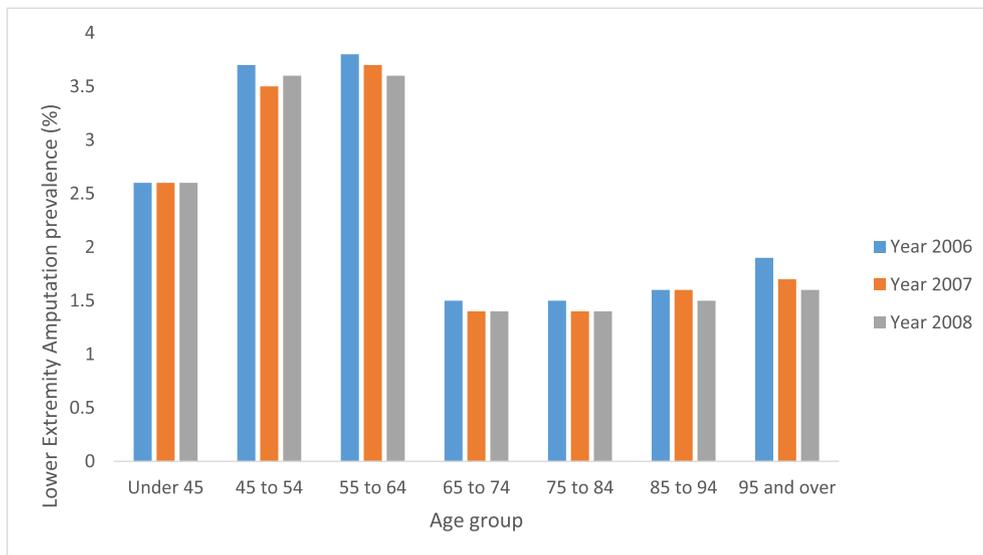
Off-loading is extremely essential to facilitate foot ulceration healing because it will be able to decrease pressure and shear forces at the site of ulceration so that it allows healing tissue to recover rapidly from continual damage [4].

A cost-effectiveness study indicated that treatment of DFUs with becaplermin gel led to better clinical outcomes and lower health



**Graph 1.** Yearly Prevalence for Diabetic Foot Ulcer in 2006–2008 in the US with respect to different age groups.

Note. Data for yearly prevalence of Diabetic Foot Ulcer/Lower Extremity Amputation in the US by D.J. Margolis, retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK63602/#dp1.r11> copyright 2011 by Agency for Healthcare Research and Quality (US).



**Graph 2.** Yearly Prevalence for Lower Extremity Amputation among diabetic population in 2006–2008 in the US with respect to different age groups

Men with diabetes were at higher risk whether to sustain foot ulceration or lower extremity amputation than women with diabetes between 2006 and 2008 in the US [6]. The reasons of this might relate to lower-limb pressure, less severe neuropathy and much more joint mobility for women [8].

Note. Data for yearly prevalence of Diabetic Foot Ulcer/Lower Extremity Amputation in the US by D.J. Margolis, retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK63602/#dp1.r11> copyright 2011 by Agency for Healthcare Research and Quality (US).

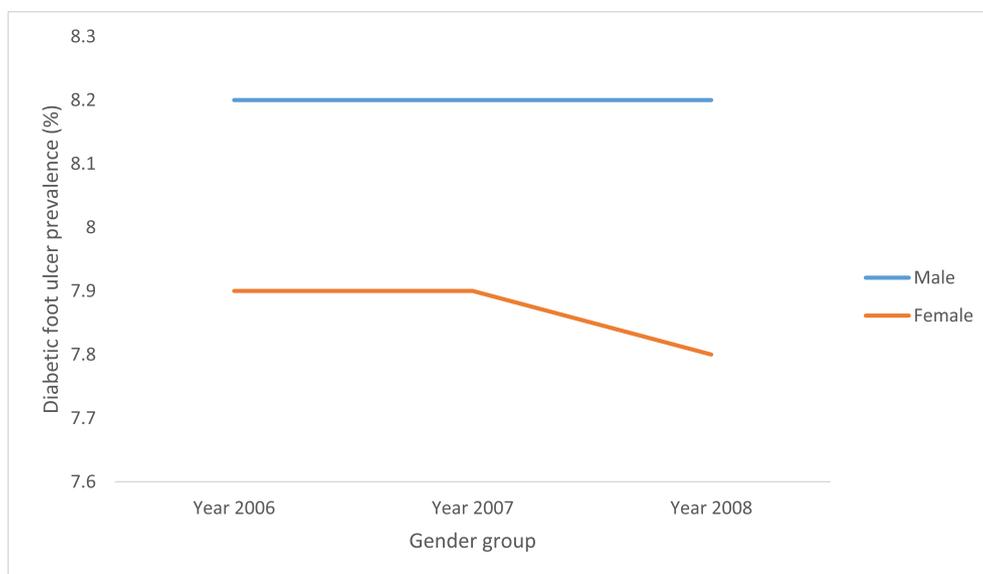
expenditure when comparing to the cost and benefit of the traditional wound care [15].

#### 4. Discussion

Diabetic foot disease was classified as the predominant reason of morbidity, disability, even mortality as well as economic burdens for diabetes [12]. The aim of a Cochrane review is to examine the effectiveness of an integrated combination of patient-level interventions, healthcare-professionals level interventions with respect to population at-risk [13].

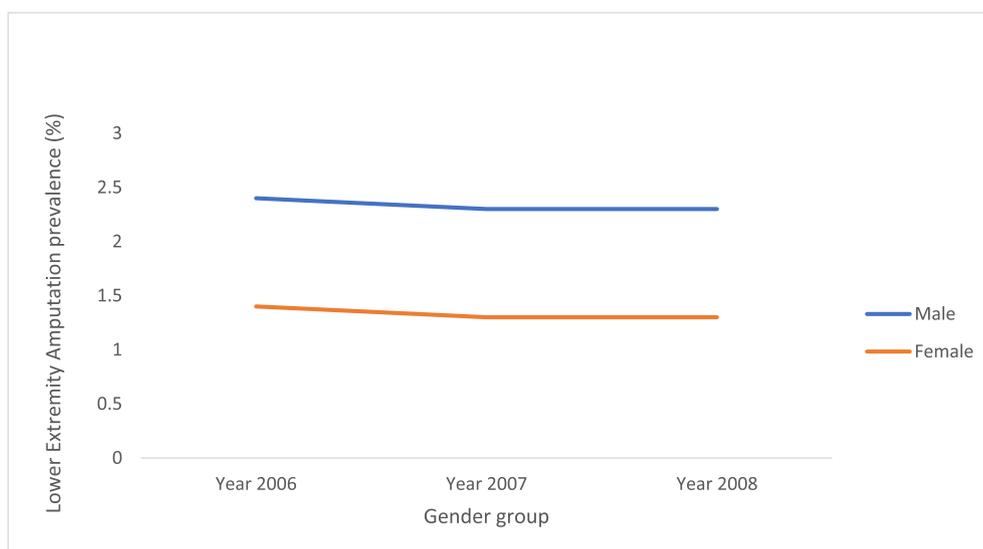
An integrated combination of patient-level interventions and healthcare-professional level interventions has been classified as the complex interventions [13].

Patient-level intervention concentrated on patients' self-care such as motivational controlling glycemic level and taking anti-diabetic medication regularly [13]. The interventions of healthcare workers' level aimed to improve the quality of assessment and referral as well as to introduce a multidisciplinary team approach [13]. Although the multidisciplinary team approach has been demonstrated to have serious limitations in the available evidence by Cochrane and non-Cochrane reviews, it still might be important



**Graph 3.** Yearly Prevalence for Diabetic Foot Ulcer in 2006–2008 in the US with respect to different gender groups.

Note. Data for yearly prevalence of Diabetic Foot Ulcer/Lower Extremity Amputation in the US by D.J. Margolis, retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK63602/#dp1.r11> copyright 2011 by Agency for Healthcare Research and Quality (US).



**Graph 4.** Yearly Prevalence for Lower Extremity Amputation among diabetic population in 2006–2008 in the US with respect to different gender groups

The highest prevalence rate of diabetic foot ulceration (9.7%) as well as lower-limb amputation (4%) have been found in American Indian group, in comparison to the American Asian group with the lowest rates, 4.3% and 0.7% respectively [6]. Multiple factors may result in the health disparities, including biological factors, socio-economic status and environmental contributors [9].

Note. Data for yearly prevalence of Diabetic Foot Ulcer/Lower Extremity Amputation in the US by D.J. Margolis, retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK63602/#dp1.r11> copyright 2011 by Agency for Healthcare Research and Quality (US).

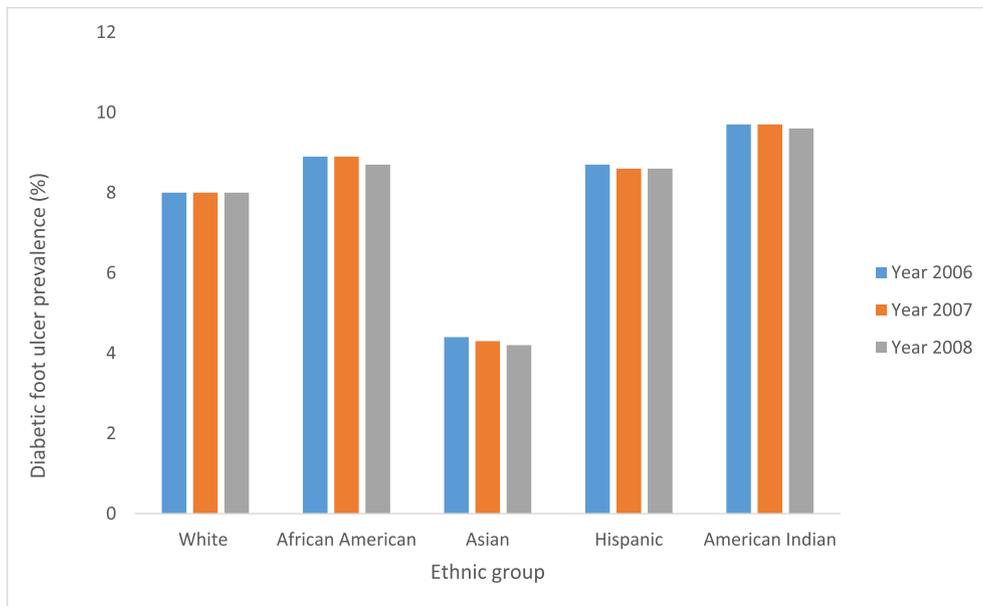
to use for preventing foot disease among diabetes.

Identifying risk would be considered as a priority for preventing the foot complications effectively among American diabetes [12]. The population at risk involved those adults with diabetes did not experience foot ulcer, but who had peripheral neuropathy, with or without the foot deformity presence, or a history of foot ulceration or amputation in the US [13]. Therefore, a variety of complex interventions specific to the individuals at risk should:

- Managing with well-fitted walking shoes would be suitable for patients with neuropathy [12]. Using footwear that cushions

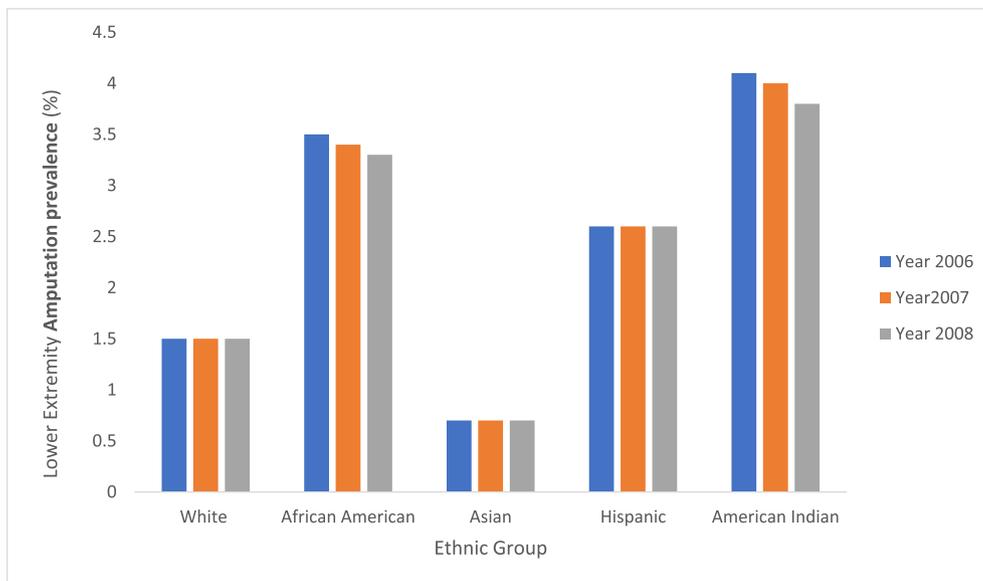
and redistributes the pressure would be supposed for patients with evidence of increased plantar pressure [12].

- Diabetic patients with high risk of foot disease suffering should be educated in terms of their risk factors and proper control [12]. They would be supposed to realize the risk of loss protective sensation and understand how to take care their feet properly [12]. Meanwhile, if patients with vulnerable characteristics such as cognitive problems that impaired their ability to institute germane response, they would need to their relatives or other friends to assist in their care [12].
- The foot examination needs to be done every year in order to identify high-risk foot situations for all patients with diabetes



**Graph 5.** Yearly Prevalence for Diabetic Foot Ulcer in 2006–2008 in the US with respect to different ethnic groups.

Note. Data for yearly prevalence of Diabetic Foot Ulcer/Lower Extremity Amputation in the US by D.J. Margolis, retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK63602/#dp1.r11> copyright 2011 by Agency for Healthcare Research and Quality (US).



**Graph 6.** Yearly Prevalence for Lower Extremity Amputation among diabetic population in 2006–2008 in the US with respect to different ethnic groups.

Note. Data for yearly prevalence of Diabetic Foot Ulcer/Lower Extremity Amputation in the US by D.J. Margolis, retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK63602/#dp1.r11> copyright 2011 by Agency for Healthcare Research and Quality (US).

[12]. Assessments of protective sensation, foot structure, vascular status and skin integrity would be involved in this examination [12].

Using antimicrobial dressing has been regarded as an important method to improve wound healing and avoid secondary infection as much as possible [13].

The limitations of this study included some information or data is collected a few years ago, but it is released recently, which is not up-to-date. Meanwhile, it is difficult to assess the accuracy of the data of diabetic foot disease because it relies on the physicians' diagnosis and self-report. Moreover, foot ulceration and lower-limb

amputation could be resulted from other disease, which may not be diabetic foot disease specific.

The profile of diabetic foot disease would be supposed to raise awareness nationally and internationally through inclusion in wider projects. Although several systematic reviews of the evidence and effectiveness of interventions to support the healing of diabetic foot disease have been conducted, the large randomized controlled trials would still be essential so that the cost-effectiveness of the new treatment could be established [11]. Furthermore, improve the evidence based for clinical practice from several aspects, including describing the target population in sufficient detail, using RCTs, conducting systematic reviews and meta-

analysis [14]. Apart from this, increase emphasis placed on diabetic foot disease for physicians and nurses with basic training and continuing education in order to reduce the variation in clinical outcome and decrease the inequality of management among patients with diabetic foot disease [14]. Increase the integration of primary, secondary and tertiary health care services, meanwhile ensure all health care professionals advocating health equality at all levels.

### Funding

The study was not supported by any organization.

### Competing interests

The authors declare no conflict of interest regarding publication of this article.

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