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Original article

Cost of diabetic foot in France, Spain, Italy, Germany and United Kingdom: A systematic review

Coût du pied diabétique en France, Espagne, Italie, Allemagne et Royaume-Uni : revue systématique

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Abstract

Aim. – Cost estimates for diabetic foot are available for developed countries based on cost data for different years. This study aimed to provide a comparison of the cost of diabetic foot in E5 (France, Spain, Italy, Germany, and the United Kingdom) and its characteristics across different conditions. *Methods.* – PubMed, Central and Embase databases were searched in February 2017 for English language publications. Bibliographies of relevant papers were also searched manually. Reviews and research papers from E5 regions reporting on cost of diabetic foot were included. Reported cost was converted to equivalent 2016 $ for comparison purposes. All the costs presented are mean cost per patient per year in 2016 $. *Results.* – Nine studies were included in the analysis. The total cost of amputation ranged from $ 15,046 in 2001 to $ 38,621 in 2005. The direct cost of amputation ranged from $ 13,842 in 2001 to $ 83,728 during 2005–2009. Indirect cost of amputation was more uniform, ranging from between $ 1,043 to $ 1,442. The direct cost of gangrene ranged from $ 3,352 in 2003 to $ 8,818 in Germany. Although, for the same year, 2003, the cost for Spain was almost double that for Germany. The total cost of an uninfected ulcer was $ 6,174 in 2002, but increased to $ 14,441 in 2005; for an infected ulcer the cost increased from $ 2,637 to $ 2,957. The different countries showed variations in the components used to calculate the cost of diabetic foot. *Conclusions.* – The E5 incurs a heavy cost from diabetic foot and its complications. There is an unmet need for the identification of cost-cutting strategies, as diabetic foot costs more than major cardiac diseases.

Keywords: Cost; Diabetic foot; Foot ulcer; Health economics; Gangrene: Amputation

Résumé

Objectif. – Les estimations de coûts pour le pied diabétique sont disponibles pour les pays développés en fonction des données sur les coûts pour différentes années. Cette étude visait à comparer le coût du pied diabétique dans E5 (France, Espagne, Italie, Allemagne et Royaume-Uni) et ses caractéristiques dans différentes conditions. *Méthodes.* – Les bases de données PubMed, Central et Embase ont étéconsultées en février 2017 à la recherche des publications en langue anglaise. Les bibliographies des documents pertinents ont également été effectuées manuellement. Les examens et les documents de recherche provenant des régions E5 rapportant le coût du pied diabétique ont été inclus. Le coût déclaré a été converti en équivalent 2016 $ pour obtenir une comparaison. Tous les coûts correspondent au coût moyen par patient et par année en 2016 $. *Résultats.* – Neuf études ont été incluses dans l'analyse. Le coût total de l'amputation variait de 15 046 $ en 2001 à 38 621 $ en 2005. Le coût direct de l'amputation

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variait de 13 842 $ en 2001 à 83 728 $ dans la période 200 à 2009. Le coût indirect de l'amputation était plus uniforme entre1043 $ et 1442 $. Le coût direct de la gangrène en Alleùmagne variait de 3352 $ en 2003 à 8818 $. A partir dl'année 2003, le coût pour l'Espagne était presque le double de celui de l'Allemagne. Le coût total d'un ulcère non infecté était de 6174 $ en 2002 et de 14 441 $ en 2005, et pour un ulcère infecté il variait de 2637 à 2957 $. Entre les différents pays il existait des variations dans la façon de c calculer le coût du pied diabétique.

Conclusions. – Le pied diabétique et ses complications entraînent un coût élevé pour le système de soin des pays E5. Il devient urgent d'identifier les stratégies de réduction des coûts, car le pied diabétiquea un cout plus élevés que les principales maladies cardiaques.

Mots clés : Coût ; Pied diabétique ; Ulcère du pied ; L'économie de la santé ; Gangrene ; Amputation

1. Introduction

A staggering 55 million (8.5%) European adults were affected with diabetes mellitus (DM) in 2010. The population of Europe is expected to grow from 891 million in 2010 to 897 million in 2030, and the number of diabetics is expected to reach 66.5 million [1]. Though there is a drastic regional difference in prevalence rates across Europe, up to 12% of Germans are affected by DM.

It is estimated that 15% of diabetics develop at least one foot ulcer in their lifetime [2]. Diabetic foot exhibits rapid and complex progression, leading to neuropathy, infection, and gangrene, which may require lower extremity amputation. Foot ulcers are one of the most complicated conditions to manage in diabetics, as the ulcers attract infections which lead to further complications [3]. Eighty-five percent of amputations in diabetics are preceded by an ulcer [4]. While diabetes itself doubles the rate of mortality by all causes as compared to non-diabetics, foot ulceration imposes an even higher morbidity [4].

Developing countries spend almost 40% of their health expenditure on diabetics; in developed countries, it accounts for approximately 12–15% of health spend [5]. The economic burden of diabetic foot on the national exchequer can be understood by examining the 2010-2011 data for the United Kingdom [6]. Almost 0.6% of the NHS expenditure in England (£580 m) was spent on diabetic foot care; approximately half (£ 307 m) of this was spent on ulcer care at primary and community healthcare centres. Among diabetic hospital admissions in the UK, 8.8% were related to ulcer care or amputation. Further, diabetic foot was associated with a 2.5-fold increase in length of hospital stay. This cost the NHS £ 219 million for diabetic ulcer care, and £ 55 million for amputation. Direct cost estimates ranged from £ 3,456 for an ulcer to £ 9,477 for diabetic foot-associated amputation, per patient and per year.

A comparative examination of the cost of diabetic foot in five European Countries (E5) (France, Germany, Spain, Italy, and the UK) was planned to gain insight into variation in the economic burden of the condition across the major healthcare systems of Europe. Acker et al. conducted in 2014 a similar analysis iof data recorded up to 2005, and showed that diabetic foot is a major cost burden [7]. However, the costs were not converted to a fixed year value, which did not allow head-to-head comparison of the costs in different countries.

Therefore, the present systematic review was conducted to study the cost of diabetic foot in the E5 region by extrapolating the costs to an equivalent of the 2016 United States Dollar ($).

2. Methods

This systematic review was conducted and reported as per the PRISMA guidelines, in order to evaluate the cost of diabetic foot in the E5 region [8].

The study question was formed based on the stated aim of understanding and comparing the cost of diabetic foot in the E5 region. A two-step protocol was followed: step one was a literature search, including the identification of suitable studies, and data extraction; and the second step was a cost comparison, where expenditures stated in all the selected studies were converted to an equivalent of year 2016 USD.

2.1. Data sources and search terms

PubMed, Cochrane systematic reviews, and Embase databases were searched in February 2017 for all full-length papers reporting on the cost of diabetic foot in at least one of the E5 nations. Different combination of the following keywords were used for the search: "foot ulcer", "diabetic foot", and "economics". The search was limited to studies published after the year 2000. The bibliographies of relevant reviews and research papers were manually searched to further identify potentially relevant studies. Only English language papers were included. No limitations were applied regarding the study design (retrospective/prospective), or type of publication (research/review) if the requirements were met. Studies reporting on the cost of diabetic foot for adults in any setting were eligible.

Exclusion criteria – abstracts, conference proceedings, posters, case series/reports, editorials, and non-English language publications were not considered.

2.2. Study selection

Any duplicate articles were identified, and the duplicated record was removed. The titles and abstracts of the remaining articles were reviewed independently by two of the authors, who were responsible for determining whether the articles were eligible for inclusion. To address any inconsistencies, the authors compared listing before full texts were reviewed. When the final

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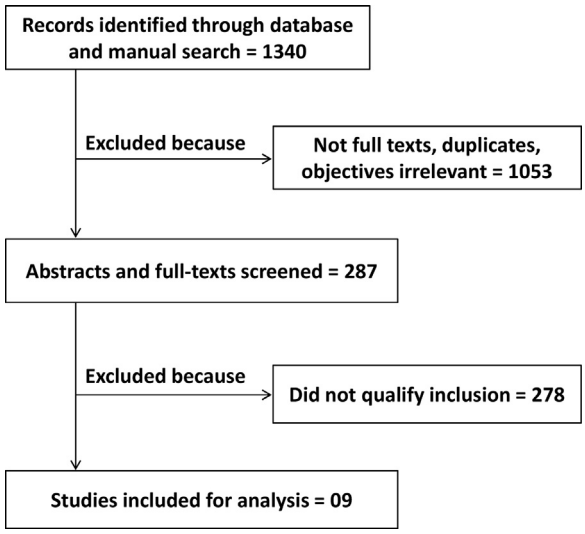

Fig. 1. PRISMA flow diagram of the study selection process.

list of articles was complete, a third investigator resolved any discrepancies.

2.3. Data extraction

A standardised custom excel sheet was used to extract all the relevant and specific data from the included studies. These data were extracted independently by two investigators and compared to resolve discrepancies.

2.4. Cost of diabetic foot

The studies were distributed over a period of one and half decades, and costs were reported in terms of cost/patient/year in Euro and GBP. Hence, it was necessary to convert these costs into a uniform value, to make them comparable. Based on the available methods, it was possible to convert the costs into most recent USD values. The following steps were followed to obtain 2016 USD values for all the studies:

The multiplication factor for converting the cost to the corresponding year's USD value was generated using yearly average exchange rates for currencies as per the Canadian Forex website (https://www.goo.gl/2XnAe2).

The cost was then multiplied by the conversion factor to convert the values to USD.

Using the Inflation Calculator, this value was converted to the 2016 equivalent as per the US Annual Inflation database (https://www.goo.gl/P7S7Bi).

3. Results

The literature and manual search yielded 1,340 articles. Of these, 1,053 articles were excluded as they were duplicates, had irrelevant objectives, or were conference abstracts or posters. The remaining 287 articles were subjected to in depth screening by studying the abstracts, and full texts where necessary. This left 9 eligible articles for qualitative synthesis [9–16] (Fig. 1). The criteria for calculating the costs were explained in 6 studies (Table 1). These criteria were not uniform across the included studies.

Ray et al. reported on the cost of diabetic foot based on the national databases for 2003 recorded in Germany, France, Italy, and Spain [9]. Von Ferber et al. reported on the cost in Germany for 2001 based on the nationwide health insurance database [10]. Prompers et al. reported the 2005 costs for 10 European countries collected during the European Study Group on Diabetes and the Lower Extremity study (Eurodiale), which was conducted across 14 diabetic foot centres in 14 countries [11]. Happich et al. reported on the cost for Germany in a two-part study (for 2000 and prior to 2000) based on nationwide hospital data [15]. Hoffmann et al. also reported on the cost for Germany based on health insurance records, but for a more recent and longer duration of 2005–2009 [12]. Kerr et al. reported on the cost for the United Kingdom in 2010–2011, based on the NHS national database [13]. Girod et al. provided a breakdown of 1999 costs in a study of French patients with foot complications, using the Wagner classification [16]. Prompers et al. authored another report on the Eurodiale study, which provided a cost breakdown for foot complications in ten European countries [14].

3.1. Cost of amputation

Seven studies reported data on the cost of amputation in diabetic foot patients [9–13,15,17] (Table 2). The 2016 $ equivalent total costs of amputation were lowest before 2001 (15,046 $) [15], increased to 27,002 $ in 2002 [15], and further increased to 38,621 $ in 2005 [11]. The direct cost ranged from 2016 $ 13,842 before 2001 [15] to 2016 $ 83,728 2005–2009 for patients in Germany [15]. Interestingly, recent cost values for the United Kingdom in 2010–2011 [6] were much lower compared to the 2005–2009 costs for Germany. Indirect costs were reported by three papers and were quite similar at 2016 $ 1,043 [11], 1,074 [15], and 1,442 [15], though these data were from different years.

3.2. Cost of gangrene

Two studies reported on the direct cost of gangrene in diabetic foot patients (Table 3). Interestingly, the cost was highest in the earliest data from Germany (2001) at 2016 $ 8,818, and lowest for France in 2003, at 2016 $ 3,352. Though for the same year (2003), the cost for Spain was almost double that of Germany.

3.3. Cost of ulcers

Five studies reported on the cost of ulcers, with two studies also providing the cost of infected ulcers (Table 4). The total cost of an ulcer was 2016 $ 6,174 for German subjects in 2002 [15], and 2016 $ 14,441 across 10 European countries in 2005 [11]. The direct costs showed a drastic variation, with the lowest being 2016 $ 1,298 for Germany in 2003 [9], and increasing to 2016 $ 13,412 for 10 European countries in 2005 [11]. Costs in the United Kingdom for 2010–2011 were again much lower, at 2016 $ 6,087 [13], than stated in the Eurodiale report, and the 2001 cost for Germany [11]. The indirect costs were comparable, at

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Table 1
Components of cost of diabetic foot in included studies.

Study	Data year, currency	Country	Setting	Cost	
				Direct	Indirect
Girod, 2003				1. Medical consultations 2. Outpatient care 3. Para-clinical exams 4. Surgery 5. Local treatment 6. Physical reeducation 7. Prescription 8. Medication 9. Orthopedic equipment 10. Hospitalization	1. Sick leave
von Ferber, 2007	2001, Euro	Germany	Health insurance database	Based on health insurance covered services: 1. Inpatient care 2. Medications 3. Physicians' outpatient services 4. Medical devices (e.g. glasses, wheelchairs, etc.) 5. Home care 6. Transportation (necessary for rendering services) 7. Other remedies (e.g. physiotherapy)	NR
Prompers, 2008a and 2008b	2005, Euro	Europe (Ten Countries)	14 Diabetic Foot Centers	1. Diagnostic procedures 2. Off-loading 3. Interventional procedures 4. Antibiotic therapy 5. Hospitalization 6. Management by clinical specialists 7. Topical treatment 8. Transportation	1. Loss of production
Happich, 2008[a]	2002, Euro Prior to 2002, Euro	Germany	Nationwide hospitals	1. Medical devices 2. Hospitalization 3. Nursing 4. Medication 5. Further non-drug therapy 6. Other services 7. Visits to investigators 8. Transport 9. Home help 10. Rehabilitation 11. Other physician visits	1. Temporary working disability 2. Early retirement
Hoffmann, 2013	2005–2009, Euro	Germany	Health insurance database	1. Hospitalization 2. Rehabilitation 3. Outpatient care and drug prescriptions 4. Non-physician services (including physical therapy, occupational therapy, speech therapy and podiatry) 5. Durable medical equipment (e.g. wheelchairs, joint prostheses, shoes, wound dressings) 6. Long-term care under hospital	NR
Kerr, 2014	2010–2011, British Pound	United Kingdom	National database	1. Dressing management 2. Medications 3. Off-loading 4. High-risk podiatry services 5. Multidisciplinary team consultations 6. Imaging 7. Plaster services 8. NHS Transport 9. Inpatient cares (Ulcer/amputation specific inpatient care and excess bed days in other admissions) 10. Post-amputation care (physiotherapy, prosthetic provision and care, wheelchair, transport)	NR

[a] Cost of complications per diabetic patient and year.

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Table 2
Cost of amputation in patients with diabetic foot.

Study	Data year, currency	Country	Setting	Cost of amputation					
				Total cost		Direct cost		Indirect cost	
				No. of subjects	2016 $	No. of subjects	2016 $	No. of subjects	2016 $
Ray, 2005	2003, Euro	Germany	National database	NR	NC	NR	32,688	NR	NC
		France	National database	NR	NC	NR	47,336	NR	NC
		Italy	National database	NR	NC	NR	15,055	NR	NC
		Spain	National database	NR	NC	NR	21,875	NR	NC
von Ferber, 2007	2001, Euro	Germany	Health insurance database	NR	NC	432	20,060	NR	NC
Prompers, 2008b	2005, Euro	Europe (Ten Countries)	14 Diabetic Foot Centers	36	38,621	36	37,577	36	1043
Happich, 2008[a]	2002, Euro	Germany	Nationwide hospitals	24	27,002	24	25,930	24	1074
	Prior to 2002, Euro	Germany	Nationwide hospitals	47	15,046	47	13,842	47	1442
Hoffmann, 2013	2005–2009, Euro	Germany	Health insurance database	NR	NC	259	83,728	NR	NC
Kerr, 2014	2010–2011, British Pound	United Kingdom	National database	NR	NC	2608	16,689	NR	NC
Alva, 2014	1997–2007, British Pound	United Kingdom	Patient records and questionnaire	NR	NC	6380	18,767	NR	NC

NR: not reported; NC: cannot be calculated.
[a] Cost of complications per diabetic patient and year.

Table 3
Direct cost of gangrene in diabetic foot. Indirect cost and total cost were not reported by any study.

Study	Data year, currency	Country	Setting	Gangrene	
				No. of subjects	2016 $
Ray, 2005	2003, Euro	Germany	National database	NR	4713
Ray, 2005	2003, Euro	France	National database	NR	3352
Ray, 2005	2003, Euro	Spain	National database	NR	8301
von Ferber, 2007	2001, Euro	Germany	Health insurance database	863	8818

NR: not reported; NC: cannot be calculated.

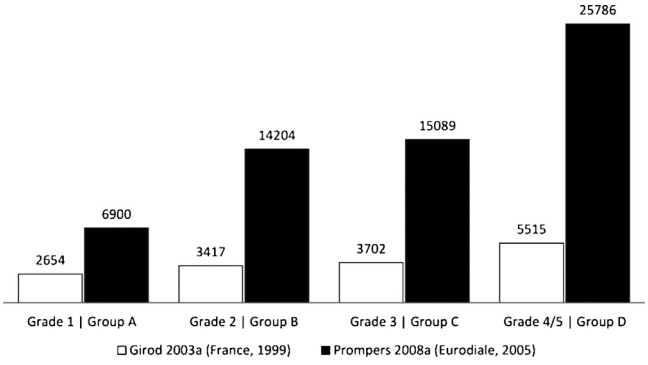

Fig. 2. A comparison of cost of complications in diabetic foot.

2016 $ 1,027 for Eurodiale [11], and 1,476 for Germany [15]. Data regarding the direct cost of an infected ulcer was available for Germany and France for 2003, and the costs were quite similar at 2016 $ 2,637 and 2,957 [9].

Two studies provided a breakdown of the costs of diabetic foot complications (Fig. 2). Girod et al. reported monthly cost data for 1999 based on the Wagner classification severity grades for French patients. The cost was 2016 $ 2,654 for grade 1 (patients with superficial lesions), 3,417 for grade 2 (patients with deep extensions), 3,702 for grade 3 (patients with tendonitis), and 5,515 for grade 4/5 (patients with gangrene). Prompers et al., as part of the Eurodiale study, reported on severity-based annual cost by classifying wounds into four groups. The cost was 2016 $ 6,900 for group A (patients with no infection or peripheral artery disease), 14,204 for group B (patients with infection with no peripheral artery disease), 15,089 for group C (patients with no infection with peripheral artery disease), and 25,786 for group D (patients with infection and peripheral artery disease).

4. Discussion

This study aimed to evaluate the cost of diabetic foot across five European countries by converting the historical cost of diabetic foot to a common year value, which allowed a rational comparison of the economic burden of diabetic foot in these E5 nations to be conducted. The eligible studies had reported on the costs of amputation due to complications, gangrene, and ulcer management in diabetic foot patients.

The costs were highest for amputation, followed by lower costs for gangrene, infected ulcers, and non-infected ulcers, respectively. However, all costs were considerable and showed a drastic variation across E5 due to differences in provision and coverage of health services. For example, the 2016$ cost of amputation in Germany for 2005–2009 [12] was more than three times the cost observed in 2002 [15]. This increase is most likely due to the rising costs of treatment, coupled with the inclusion of additional provisions like equipment and non-physician services (like speech, physical and occupational therapies) for 2005–2009 compared to earlier periods [9,10,15].

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Table 4
Cost of ulcer in diabetic foot. Indirect and total cost were not available for ulcer with infection.

Study	Data year, currency	Country	Setting	Ulcer						Ulcer with infection	
				Total		Direct		Indirect		Direct	
				No. of subjects	2016 $	No. of subjects	2016 $	No. of subjects	2016 $	No. of subjects	2016 $
von Ferber, 2007	2001, Euro	Germany	Health insurance database	NR	NC	863	8818	NR	NC	NR	NC
Happich, 2008[a]	2002, Euro	Germany	Nationwide hospitals	32	6174	32	4699	32	1476	NR	NC
Ray, 2005	2003, Euro	Germany	National database	NR	NC	NR	1298	NR	NC	NR	2637
		France	National database	NR	NC	NR	1689	NR	NC	NR	2957
Prompers, 2008b	2005, Euro	Europe (Ten Countries)	14 Diabetic Foot Centers	751	14441	751	13,412	751	1027	NR	NC
Kerr, 2014	2010–2011, GBP	United Kingdom	National database	NR	NC	32,644	6087	NR	NC	NR	NC

NR: not reported; NC: cannot be calculated.
[a] Cost of complications per diabetic patient and year.

The included studies did, however, differ in terms of the included population, care setting, data collection method utilised, resources used, price per item, and reimbursement. Therefore, the results of this analysis should be interpreted with caution.

The cost burden of diabetic foot is expected to increase further, as 10% of the world population will be diabetic by 2030 [1]. This means that healthcare providers will experience a higher burden of managing diabetic foot patients, whereas the cost of care will also increase significantly for the government. The healthcare providers and government must therefore find ways to reduce the steep rise in diabetes cases, as well as foot complications, to be able to curtail these alarming costs.

Diabetic foot care costs countries more than major diseases like cancer, lung disease and depression [18]. A 2014 comparison of the direct costs of various conditions in diabetics showed that from 1997–2007, annual average amputation costs (£ 12,245) were much higher than the cost of non-fatal ischemic heart disease (£ 10,631), non-fatal stroke (£ 7,824), non-fatal myocardial infarction (£ 8,342), and heart failure (£ 4,170) [17]. These patterns were also reported by other studies from Germany [10].

The significantly higher costs of diabetic foot and associated complications, even when compared to other major diseases, indicates a deficiency of cost-preventive strategies for treating these patients. Diabetic foot complications are more likely to incur higher costs owing to their lack of response to treatment. In addition, there is a general lack of awareness amongst diabetics about foot complications, which further increases the chances of these complications arising [19]. However, proper care and rigorous implementation of preventive strategies to reduce the initiation of diabetic foot is the best possible means of avoiding the complications and associated costs. This has been shown to be an effective strategy; patients who have been enrolled for regular counselling with specialist clinicians at a diabetic foot care clinic tend to have much better prognosis [20,21].

There is a wide gap in the recommendations put forth in the guidelines for diabetic foot management and the actual practices followed by healthcare providers. Further, patient behaviour is also a major factor contributing to the higher cost of managing diabetic foot. Multidisciplinary approaches have been proven to reduce the limb salvage rates in diabetics, as reported for Belgium, France, Germany, Netherlands, and the UK [7]. A reduction of 25% and 9% in limb salvage rates between 1998–2002 and 2004–2008 respectively was recorded in the UK [22,23]. After the implementation of a local multidisciplinary management team, the rate of major amputations was reduced to 2.5% in a cohort of 118 high-risk foot ulcer patients in France [24]. Germany and the Netherlands also recorded a reduction of 49% (1990 to 2004) and 35% (1991 to 2000) in amputation rates following the implementation of multidisciplinary preventive strategies [25,26]. Furthermore, in France, multidisciplinary approaches also improved primary and secondary prevention of complications. In the Tuscany region of Italy, implementation of international guidelines improved peripheral revascularisation, which led to a reduction in major amputations during 1999 [27].

The implementation of multidisciplinary approaches also provides cost benefits. For instance, in France, after such an implementation, the cost of microbial diagnostics and antimicrobial therapy reduced from 75,731 Euros in 2003 down to 17,859 Euros in 2007 [28]. Hence, implementation of uniform guidelines across countries can achieve improvements in outcomes as well as reduce the cost of diabetic foot care.

4.1. Limitations and future directions

Our initial approach was to conduct a quantitative synthesis of the cost of diabetic foot in E5 countries. However, most of the identified studies had not reported the standard deviations and sample size for the cost data, which led us to instead carry out a systematic review. Although the data was drawn from a common geographical region, costs were drastically different, owing to differences in methods of cost calculations by each country. However, when a single country is considered, such as Germany, for which many studies were available, a pattern of increase in cost can be identified.

The budget for the treatment and care of diabetic foot is set by the government of the nation, and there is likely a difference in the cost calculation method across the different countries. There is thus an urgent need to implement a guideline with uniform components of direct cost, indirect cost and total cost, which will help in assessing the economics of diabetic foot across different countries. Further, this will also help in identifying higher value resources, the consumption of which could be minimised through cost-cutting strategies.

Author contributions

Huidi Tchero designed the study, conducted the literature search and study selection, performed the data extraction and wrote the report. Pauline Kangambega, Lucien Lin, Martin Mukisi-Mukaza, Solenne Brunet-Houdard, Christine Briatte, and Gerald-Reparate Retali assisted with the data extraction and systematic review of the data. Emmanuel RUSCH designed the study, guided HT and provided laboratory facilities for conducting the work. All the authors have seen and agreed to the final version of the paper.

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Disclosure of interest

The authors declare that they have no competing interest.

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