

Diabetic Foot Disease Research in Gulf Cooperation Council Countries

A bibliometric analysis

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أبحاث مرض القدم السكري في دول مجلس التعاون الخليجي تحليل بيبليوغرافي

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ABSTRACT: Objectives: Countries in the Gulf Cooperation Council (GCC) have some of the highest prevalence rates of diabetes mellitus (DM) in the world; however, DM-related research activity in this region is limited. This study aimed to examine trends in published diabetic foot disease (DFD) research undertaken in GCC countries. **Methods:** This bibliometric study was conducted in December 2016. Standardised criteria were used to search the MEDLINE® database (National Library of Medicine, Bethesda, Maryland, USA) for DFD-related publications authored by GCC researchers between January 1990 and December 2015. Various details such as the type of publication, journal impact factor and number of article citations were analysed. **Results:** A total of 96 research articles were identified. The number of publications per year significantly increased from nil prior to 1991 to 15 in 2015 ($P < 0.01$). Basic/clinical research articles accounted for 96.9% of publications, with three randomised controlled trials and no systematic reviews/meta-analyses. When adjusted for population size, Kuwait had the highest number of published papers per year, followed by Bahrain and Qatar. The number of authors per publication significantly increased during the study period ($P = 0.02$). However, 16 articles (16.7%) had no citations. The median journal impact factor was 0.15 ± 1.19 (range: 0–6.04). **Conclusion:** The number of publications authored by GCC researchers has risen in recent years. Increasing research funding and promoting collaboration between local and international researchers and institutes are recommended to bolster research regarding DFD prevention and management in GCC countries.

Keywords: Bibliometric Analysis; Diabetes Mellitus; Diabetic Foot; Research; Publications; Arab Countries; Gulf Cooperation Council.

المخلص: الهدف: يعتبر معدل انتشار مرض السكري في دول مجلس التعاون الخليجي عاليا مقارنة ببقية دول العالم. ومع ذلك، فإن الأنشطة البحثية المتعلقة بالسكري في هذه المنطقة محدودة. تهدف هذه الدراسة إلى تحليل الأبحاث المنشورة في مجال مرض مرض السكري في دول مجلس التعاون الخليجي. **الطريقة:** تم إجراء هذه الدراسة الببليوغرافية في ديسمبر 2016. باستخدام معايير بحثية موحدة تم البحث في قاعدة البيانات ميدلاين (المكتبة الوطنية للطب، بيتسدا، ماريلاند، الولايات المتحدة الأمريكية) لتحديد جميع المقالات المتعلقة بمرض القدم السكري التي نشرها باحثين من دول مجلس التعاون الخليجي بين يناير 1990 وديسمبر 2015. تم جمع وتحليل عدد من البيانات من ضمنها نوع المنشورة الطبية، عامل تأثير المجلة، ومعدل الاقتباس. **النتائج:** تم تحديد ما مجموعه 96 بحثا منشورا. تم ملاحظة ازدياد عدد المنشورات بشكل كبير من لا شيء في سنة 1991 إلى 15 في سنة 2015 ($P < 0.01$). شكلت البحوث المخبرية/السريرية 96.9% من إجمالي المنشورات فيما كان هناك ثلاثة تجارب عشوائية محكمة وعدم وجود أي مراجعات منهجية/تحليل تلوية. كانت الكويت أكثر الدول من حيث عدد المنشورات الطبية عند مقارنتها مع حجم السكان، تليها البحرين وقطر. لقد لوحظ ازدياد عدد المؤلفين لكل منشور مع الوقت خلال فترة الدراسة ($P = 0.02$). ومع ذلك، كان 16 (16.7%) بحثا منشورا بدون اقتباس. كان متوسط عامل تأثير المجلة 0.15 ± 1.19 (مجال: 0–6.04). **الخلاصة:** لقد زادت عدد المنشورات في دول مجلس التعاون الخليجي على مدى السنوات الماضية. دعم الأنشطة البحثية المتعلقة بعلاج والوقاية من مرض القدم السكري في دول مجلس التعاون الخليجي يتطلب زيادة تمويل البحوث الطبية وتشجيع التعاون بين الباحثين ومراكز البحوث داخليا وخارجيا.

الكلمات المفتاحية: تحليل بيبليوغرافي؛ السكري؛ القدم السكري؛ بحث؛ منشورات؛ الدول العربية؛ مجلس التعاون الخليجي.

ADVANCES IN KNOWLEDGE

- This study presents a systematic bibliometric analysis of diabetic foot disease (DFD) research originating from the Gulf Cooperation Council (GCC) region.
- Although the number of DFD-related publications showed a slow but significant increase between 1990 and 2015, GCC countries still lag behind other countries in this field, despite having some of the highest diabetes mellitus (DM) prevalence rates worldwide.

APPLICATION TO PATIENT CARE

- The findings of this study are intended to highlight and promote research related to the epidemiology, management and prevention of DFD in GCC countries. Such research efforts would help to inform patient care, policy planning and DM management in this region.

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DIABETES MELLITUS (DM) IS A PUBLIC HEALTH challenge in the Arabian Gulf region.¹ With an estimated population of 53 million, the Gulf Cooperation Council (GCC) consists of the member states of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE), all of which share similar demographic characteristics, socioeconomic profiles and healthcare systems.² Over the past five decades, these countries have undergone rapid economic growth and urbanisation, facilitating lifestyle changes which have contributed to a marked rise in the prevalence of obesity and nutrition-related noncommunicable diseases, such as type 2 DM.³ Overall, GCC countries have some of the highest global age-adjusted DM prevalence rates among adults, ranging from 14.8% in Oman to 20% in Kuwait, Qatar and Saudi Arabia.¹ Moreover, the healthcare systems of GCC countries are inadequately resourced and structured to tackle the growing DM burden, resulting in suboptimal care.^{4,5}

Poorly-controlled DM increases the risk of complications such as diabetic foot disease (DFD), a group of heterogeneous conditions which cause deformity, ulceration and infection due to peripheral neuropathy and vascular disease in the lower limbs.⁶ Worldwide, DFD is associated with significant morbidity and mortality, in addition to being a major financial burden to both individuals and healthcare systems.^{7,8} The lifetime risk of an individual with DM developing a foot ulcer is approximately 25%.⁸ Foot ulceration increases the risk of lower limb amputation, one of the most debilitating complications of DM. More than 50% of non-traumatic lower limb amputations are attributable to DFD.⁸

Population-based studies conducted in high-income countries have shown the prevalence of active diabetic foot ulcers to be 1–5%, which is much lower than rates reported in certain middle- and low-income countries (>11%).^{7,8} Marked differences have also been observed in GCC countries, with the prevalence of diabetic foot ulcers ranging from 0.2% in the UAE to 5.9% in Bahrain.⁹ While DM-related lower limb amputations are reportedly uncommon (1.1%) among patients attending primary care centres in Saudi Arabia, 47.3% of all lower limb amputations in Oman are performed on DM patients.^{10,11}

Current understanding of DFD has become possible as a result of decades of international research and collaboration.⁷ Nevertheless, locally driven DM-related research, particularly regarding DFD, appears to be limited in the GCC region, despite the high DM prevalence rates.^{5,11,12} Publication in peer-reviewed journals is generally regarded as one of the key indicators of research productivity.^{13,14} In a recent bibliometric analysis, Alzahrani *et al.* examined the research contributions of 22 Arab countries to the DFD literature and found that only 11.6% of 906 DM publications were related to DFD, although the

highest number of publications originated from GCC countries.¹⁵ However, this study had methodological limitations. Only articles published between January 1996 and April 2012 were examined; in addition, non-original research studies were included.¹⁵ Moreover, publication-related characteristics (e.g. the quality of the publications and extent of local and international collaboration) were not evaluated.

The aim of the current study was to provide an updated analysis of DFD-related publications emanating from GCC countries and to examine trends in publication quality and quantity. Specifically, the study aimed to determine the total number and type of GCC-produced DFD-related publications, country-specific contributions, the degree of local and international research collaboration and the impact of the published research.

Methods

This study was conducted in December 2016 and involved a bibliometric analysis of DFD-related publications authored or co-authored by researchers from the GCC region. A comprehensive literature search for relevant publications was conducted using the MEDLINE® database (National Library of Medicine, Bethesda, Maryland, USA), the largest and most widely used biomedical indexing database in the world.¹⁶ Two search strategies were employed—the first using Medical Subject Headings (MeSH) classifications and the second based on free-text searching—to ensure maximal retrieval of relevant articles. In both strategies, the following search terms were used in combination with the Boolean operator “or”: “diabetes”, “diabetes complications”, “diabetic foot”, “diabetic foot disease”, “diabetic foot ulcer”, “peripheral arterial disease”, “peripheral neuropathy”, “diabetic foot ulceration” and “amputation”. The Boolean operator “and” was then used to link these terms to the ethnogeographical terms “Gulf Cooperation Council”, “GCC”, “Arabian Gulf”, “Arab”, “Arabs”, “Bahrain”, “Kuwait”, “Oman”, “Qatar”, “Saudi Arabia” and “United Arab Emirates”. The reference lists of identified articles, as well as any Scopus® citations (Elsevier, Amsterdam, the Netherlands), were also scanned to find additional publications.

Subsequently, the titles and abstracts of identified publications were reviewed. For an article to be included in the study, the research had to have been conducted in one or more of the GCC countries and the author(s) based in the GCC region (i.e. affiliated with a GCC medical or research centre). Furthermore, only English-language articles related to DFD and its components (e.g. DM-related peripheral neuropathy, peripheral vascular disease, infections, deformity, ulceration and/or amputation) published between January 1990

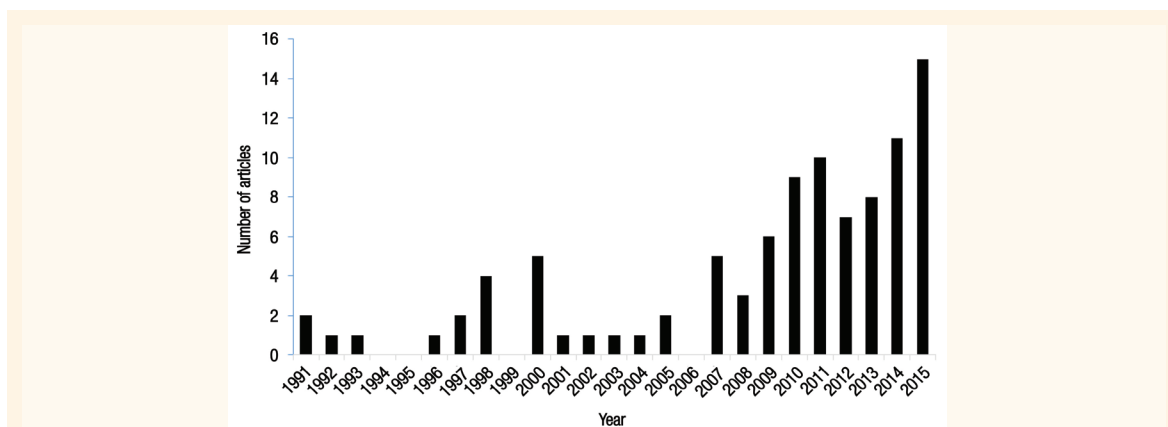


Figure 1: Chart showing the number of diabetic foot disease-related publications per year originating from Gulf Cooperation Council countries between 1990–2015 (N = 96). There was a significant increase in publications per year during the study period ($P < 0.01$).

and December 2015 were included in the study. Non-original research publications, including reviews, case reports, commentaries, letters and editorials, were excluded from the study. Thereafter, the remaining publications were classified into three general categories—basic/clinical research papers, systematic reviews/meta-analyses and randomised controlled trials (RCTs)—based on their level of evidence as defined by the Oxford Centre for Evidence-based Medicine.¹⁷

For each included publication, various author- and article-related data were extracted, including the number of authors, their institutional affiliations, the year and type of publication and the name of the publishing journal at the time of publication. In addition, the degree of local (defined as the presence of authors affiliated with two or more GCC countries) and international (defined as the presence of one or more author(s) affiliated with a non-GCC country) collaboration was determined. As a measure of research quality, the impact factor of the publishing journal was obtained using the Journal Citation Reports tool (Clarivate Analytics, Philadelphia, Pennsylvania, USA).¹⁸ The number of citations per article was determined using the Scopus[®] database (Elsevier). The number of DFD-related articles from each GCC country per year was normalised according to the population size of the respective country for an estimation of the number of publications per million population (PPMP) per year.^{19,20}

Collected data were entered into a pre-designed Excel spreadsheet, Version 2016 (Microsoft Corp., Redmond, Washington, USA). Descriptive statistics were used to analyse the data. Comparisons were conducted using an independent samples Student's t-test. The Cox-Stuart test was performed to identify significant trends over the investigated publication period. Statistical significance was based on a type I error rate of $< 5\%$ ($P < 0.05$). All analyses were performed using R Statist-

ical Software (R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 105 publications from the GCC region were initially identified, of which six (5.7%) were excluded due to unrelated content (non-DFD-related research) and three (2.9%) due to article type (two letters and one case series). Of the remaining 96 articles, the vast majority (96.9%) focused on basic/clinical research. Only three (3.1%) RCTs were published, examining the effect of different treatments for chronic diabetic foot ulcers, peripheral neuropathy and wet gangrene prevention. These were published between 2013–2015 and had small sample sizes (23–112 patients). No systematic reviews/meta-analyses were identified. Collaborative research was reported in 19 publications (19.8%), with one instance (5.3%) of local collaboration between Kuwait and the UAE, 16 cases (84.2%) of international collaboration and two (10.5%) involving both local and international collaboration. There were three (3.1%) international multicentre studies. None of the collaborative studies were RCTs.

Overall, the number of publications per year showed a gradual yet significant upward trend, increasing from zero publications prior to 1991 to 15 in 2015 ($P < 0.01$) [Figure 1]. The number of authors per publication also significantly increased during the study period ($P = 0.02$), with a median of three authors per publication. The country with the highest absolute number of publications was Saudi Arabia (62.5%), followed by Kuwait (19.8%) and the UAE (7.3%). However, after adjusting for population, Kuwait had the highest PPMP per year (7.66), followed by Bahrain (4.55) and Qatar (3.85). There were no publications identified from Oman [Table 1].

Table 1: Country-specific rate of diabetic foot disease-related publications originating from Gulf Cooperation Council countries between 1990–2015 (N = 96)

Country	n (%)	Population per year in millions*	Estimated PPMP per year
Bahrain	4 (4.2)	0.88	4.55
Kuwait	19 (19.8)	2.48	7.66
Oman	0 (0)	2.65	0.00
Qatar	4 (4.2)	1.04	3.85
Saudi Arabia	60 (62.5)	23.70	2.53
UAE	7 (7.3)	4.89	1.43
Total	94 (97.9)[†]	35.64	2.64

PPMP = publications per million population; UAE = United Arab Emirates.

*Population data sourced from the World Bank.²⁰ †Two publications were not included as they involved both local and international collaboration.

The articles were published in 65 different journals, of which the *Saudi Medical Journal* (9.4%) and *Diabetes Research and Clinical Practice* (4.2%) were most common. The majority of journals (72.3%) had only one published article. In total, 20 articles (20.8%) were published in GCC-based journals, including the *Saudi Medical Journal*, *Bahrain Medical Bulletin*, *Journal of King Abdulaziz University - Medical Sciences*, *Annals of Saudi Medicine*, *Saudi Journal of Kidney Diseases & Transplantation* and the *Journal of Family & Community Medicine*. Data regarding the impact factor of the publishing journal was only available for 52 articles (54.2%). The median impact factor was 0.15 ± 1.19 (range: 0–6.04).

As of December 2015, the articles had a total of 1,097 citations, with an average of 11.43 citations per

article (range: 0–98 citations). In total, 80 papers (83.3%) were cited at least once; however, 16 articles (16.7%) were uncited. Moreover, the five most cited articles represented 32.8% of all citations. The most frequently cited paper was a cross-sectional population-based study examining the prevalence of DM and its complications in the UAE. The other four most cited articles were laboratory-based studies from Kuwait and Saudi Arabia related to the pathogenesis of diabetic wound healing and the bacteriology of diabetic foot infections [Table 2].^{21–25}

Discussion

Bibliometric analyses can help to identify trends in the quantity (i.e. publication output, areas of research focus and trends over time) and quality (i.e. the level of evidence, degree of collaboration, impact factor and citation rates) of published research.^{14,16} Such analyses are crucial when identifying gaps in knowledge and directing research efforts to answer pertinent unaddressed issues, whether on an international or local scale. In the present study, Kuwait was the most productive GCC country after adjusting for population size, while Oman had no publications during the study period. These findings are consistent with those of two other recent bibliometric analyses of biomedical and DFD-related publications from GCC countries.^{15,26}

In the GCC region, DFD-related research has become a growing topic of interest among researchers. The current study observed a gradual but significant increase in the annual number of DFD-related publications originating from GCC countries between 1990–2015, most noticeably from 2007 onwards. A

Table 2: Most cited diabetic foot disease-related publications originating from Gulf Cooperation Council countries between 1990–2015 (N = 96)^{21–25}

Author and year of publication	Publication title	Country	Journal	Number of citations*
Saadi <i>et al.</i> ²¹ (2007)	Prevalence of diabetes mellitus and its complications in a population-based sample in Al Ain, United Arab Emirates	UAE	<i>Diabetes Research and Clinical Practice</i>	98
Bitar <i>et al.</i> ²² (1996)	Transforming growth factor-beta and insulin-like growth factor-I in relation to diabetes-induced impairment of wound healing	Kuwait	<i>Journal of Surgical Research</i>	86
Abdulrazak <i>et al.</i> ²³ (2005)	Bacteriological study of diabetic foot infections	Kuwait	<i>Journal of Diabetes and its Complications</i>	74
El-Tahawy ²⁴ (2000)	Bacteriology of diabetic foot	Saudi Arabia	<i>Saudi Medical Journal</i>	56
Bitar ²⁵ (1997)	Insulin-like growth factor-1 reverses diabetes-induced wound healing impairment in rats	Kuwait	<i>Hormone & Metabolic Research</i>	46

UAE = United Arab Emirates.

*Citation data sourced from the Scopus® database (Elsevier, Amsterdam, the Netherlands).

number of factors could explain this observation. Before the 1990s, healthcare systems in the region were underdeveloped, with limited opportunities for medical education and minimal institutional support and investment in biomedical research.²⁷ In addition, the health burden in GCC countries prior to 1990 was still dominated by infectious diseases.^{27,28} More recently, the burden of noncommunicable diseases has increased substantially in this region, thus prioritising DM research.^{9–12} Furthermore, politically-stable GCC countries have recently increased spending on research and development, along with the establishment of independent organisations to fund biomedical research.²⁶

In the current study, there was evidence of a growing body of basic/clinical research articles, including three RCTs published between 2013–2015. In addition, a considerable proportion of the published articles represented local or international collaboration and the number of authors per publication significantly increased over the study period. Both of these factors are indicators of the exchange of knowledge and research skills among researchers, reflecting a trend towards increasingly collaborative research. However, according to the Oxford Centre for Evidence-based Medicine, the three RCTs were classified as level 2 evidence, which is insufficient to change clinical practice.¹⁷

The findings of the present study indicated that the majority of the DFD-related publications originating from the GCC region were of poor quality, particularly in light of the low citation rate. The five most cited articles represented a relatively large proportion of all citations and were classified as level 3 or 4 evidence.¹⁷ Moreover, 20.8% of the articles were published in GCC-based journals, the majority of which are not MEDLINE®-indexed.²⁹ Improving the quality of DFD-related research will require the provision of further training opportunities so that researchers in the GCC region can conduct impactful high-quality research.⁵ To this end, the allocation of additional funding to support strategic research projects examining noncommunicable diseases in general, and DM specifically, is crucial.

In the current study, the median journal impact factor of the publications was fairly low. However, the validity and utility of the impact factor as a measure of research quality has been vigorously debated.^{18,30,31} The value of published research to a specific population or in a certain context is not necessarily reflected by its publication in high-impact factor journals.³² It is possible that the authors may have deemed publication in a local journal more appropriate than in a higher-ranked international journal in light of the intended audience. Therefore, while the impact factor remains the most common

and, arguably, the best existing metric for evaluating the bibliometric impact of published research to date, caution must be exercised when using it as the sole indicator of research quality and impact, especially for research originating from low-income countries and those with emerging economies.³³

The current study was subject to several limitations. First, the methods used in the analysis may have underestimated the publication rate of DFD-related research originating from GCC countries. As the search strategy was restricted to the MEDLINE® database (National Library of Medicine), articles published in journals not included in this database would have been omitted. Additionally, while publication in peer-reviewed journals is usually the preferred vehicle for the dissemination of medical research, it is possible that certain DFD-related studies, such as those conducted by governmental entities, may have been disseminated by other means (i.e. internal reports).¹³ Second, some article types not included in the analysis, such as reviews and case reports, may nevertheless represent valuable contributions to the literature. However, it is widely acknowledged that original research articles are an accurate reflection of research activity in a particular field and represent higher-quality evidence when compared to other types of publications.¹⁷ Finally, it was outside the scope of this study to estimate the contribution of GCC-researchers to international literature. Despite these limitations, the findings from this study are a reliable representation of GCC-based DFD-related research activity and may help to inform future efforts in this region.

Conclusion

The current study found that the number of DFD-related publications authored by GCC researchers increased significantly during the study period. Nevertheless, GCC countries lag behind other countries in terms of output and quality of DFD-related research, despite having some of the highest DM prevalence rates worldwide. This undoubtedly leaves gaps in knowledge related to the burden and management of DFD. Improving research funding and infrastructure and promoting local and international collaboration is crucial to enhancing DFD-related research in this region.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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