RESEARCH ARTICLE

Growth of Diabetes Research in United Arab Emirates: Current and Future Perspectives
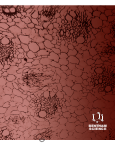
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Abstract: ***Background***: Diabetes mellitus (DM) is one of the most prevalent metabolic diseases in the UAE. During the last two decades, the United Arab Emirates (UAE) has experienced tremendous development in all fields including DM research. The present study sheds light on the growth in DM research in UAE and represents a guide for DM researchers to create more focused future directions in DM research.

Objectives: The main objective of the present study is to investigate and document the changes that occurred in DM research in the UAE over the last two decades.

Methods: Several research databases were reviewed and all the articles that involved any form of DM research within the UAE were selected. Inclusion criteria were: (i) Research studies related to DM and conducted by institutions based in UAE (ii) Research studies related to DM and conducted in the population of UAE and (iii) Research articles related to DM and the authors (principal investigators or co-investigators) are from UAE.

Results: Between the years of 1996 and 2000, there was an average of 6.4 articles about DM being published per year. This pattern changed dramatically between years 2011 to 2015 where an average of 22.8 articles were being published. In addition, a significant increase was noticed in the year 2015 with 42 articles published per year. It was also found that 46.8% articles involved clinical study, 12.1% were basic research, 17.5% cross-sectional studies, 8.91% reviews, 8.2% were cohort and all the other types of research represented about 5.58%.

Conclusion: Significant progress has been noticed in DM research in the UAE during the last two decades. Based on the findings of the present study, more focus should be given to the case reports and clinical trials.

1. INTRODUCTION

Recent reports published by the International Diabetes Federation (IDF) have shown that the number of patients with Diabetes Mellitus (DM) is estimated to be around 300 million by the year 2025 [1]. DM is characterized by high levels of blood glucose, termed as hyperglycemia, which results from defects in either insulin secretion, insulin action or combination of secretion of, and sensitivity to, insulin [2].

It is known to be a multifactorial disease that can be caused by several factors of genetic or environmental backgrounds [2]. It is well-documented that DM is a risk factor for several cardiovascular diseases including angina, myocardial infarction and stroke [3]. Other significant and long-term complications of DM include nephropathy, retinopathy and neuropathy. Therefore, it is important for patients with DM to make the necessary lifestyle modifications to maintain stable levels of blood glucose, blood pressure and lipid profile [4-8]. In addition, complications of DM significantly contribute to both morbidity and mortality among patients with DM and have raised an alarming situation that calls for immediate attention [9-11].

It has been found that population in the United Arab Emirates (UAE) are highly susceptible to DM and its complications. In 2013, the age-standardized comparative prevalence of DM in UAE was 18.98%, amongst the highest in the world whereas the global comparative prevalence was 8.3% [12]. IDF has revealed that, in 2017, 17.3% of the UAE

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population between the ages of 20 and 79 have, in particular, Type 2 DM (T2DM) [13]. According to the reports of World Health Organization (WHO) about the DM profile in the UAE, the number of deaths due to DM was found to be 130 for men and < 100 for women aged between 30-69 years in the year 2016 [14]. However, the prevalence of DM and its risk factors are noted to be higher in females (8.5%) than in males (7.8%) [14]. Reports from WHO also have demonstrated a drastic increase in the prevalence of DM population from 3, 50,000 in 2000 to an alarming number of 6, 84,000 by the year 2030 [15]. Currently over 1 million people are living with DM in the UAE, ranking the country as the 15th worldwide for age-adjusted comparative prevalence [13].

Thus, it is crucial to revisit the etiology, risk factors and epidemiology of DM in UAE on a regular basis [9]. The latter requires an establishment of policies and procedures to regulate and advance the DM research processes in UAE [9].

According to a report published by the UAE University Center for Public Policy and Leadership in collaboration with the United Nations Development Programme, about 11 % of total global health care expenditure is spent on DM care [16, 17]. In comparison, the average spent on DM patients in the US is about $8,468 and $4,267 in the UK but in the UAE, expenditure on DM care is just $1,775 per patient [17]. Research studies on health care cost of DM have shown that over a 10-years period after implementation of some interventions for diabetes in the UAE, estimated gross savings ranged from 573 million AED to 4.5 AED billion [16, 17]. Medical costs attributable to DM and pre-diabetes in the UAE are forecast to increase to about 3.82 billion AED by 2020, representing 58% increase from an estimated AED 2.41 billion in 2010 [16, 17]. More research studies have to be conducted to highlight the economic burden of DM and the outcomes of these studies will contribute considerably to the care and management plans for DM in UAE.

Screening tests, lifestyle changes, and management plans can help to prevent and treat DM, it also reduces the risk of developing several complications, such as heart and kidney disease, nerve damage, blindness and limb amputation [18]. Education and awareness about early detection will have a positive impact on preventing DM, in particular, in children and young adults who represent a significant resource in the future of UAE [19-21].

Another important aspect to control the invasion of DM is the collaboration between the government authorities, public health agencies, nonprofit organizations and the private sector in UAE. This will help in designing and implementing culturally-appropriate, community-based initiatives for DM prevention and control in the UAE [18]. Collaboration between the health authorities and governments is also an essential process for advancement of DM research in UAE. High-quality research can only emerge through collaboration with various healthcare and educational partners, both locally and internationally, to achieve common goals.

DM has become a hot topic among researchers within the UAE and there is a dramatic increase in the published articles during recent years. Although these previous reports on DM research in UAE have covered various topics including

childhood and adolescent DM [20-22], managing DM during Ramadan [23, 24], caste-specific, region-specific and familial studies [25], there has been no further analysis and review of this type of research within the UAE.

The present study represents a significant step to investigate the DM research in UAE and this will help in highlighting the strengths and weaknesses in this field and in identifying the gaps in the DM research in UAE. In addition, it is important that researchers can keep track of the various studies that have been conducted and remain updated on the current stream of new data pouring in from different parts of UAE. This will further facilitate an easier access to such data and prevent the chances of studies being replicated and also it will encourage new and innovative ideas.

Therefore, the objectives of this study are (i) to investigate the growth in DM research in the UAE during the last two decades and (ii) to identify the different types of research studies that have been conducted using the literature of published articles as the main source of data collection.

2. METHODS

The present cross-sectional study has been designed to investigate the growth in the DM research based on the published studies. The analysis was made using three main internet databases including PubMed, Google Scholar and Science Direct. These databases were chosen due to their ease of access, free availability of full texts and extensive coverage of medical, biomedical and life sciences.

Online search was carried out for published articles that met the following criteria: (i) research related to DM and conducted by an institution based in UAE (ii) research related to DM conducted on population of UAE and (iii) articles related to DM and the authors (principal investigators or co-investigators) are from UAE. The keywords used to carry out these searches were: "UAE Diabetes", "Diabetes and Emirates", "Diabetes in UAE" and "Diabetes Research in UAE". All the abstracts that contained these key words were selected and the full text articles were reviewed to identify the nature and the types of DM research studies that have been conducted. Exclusion criteria were (i) studies that had been conducted outside UAE, and (ii) studies that were conducted by authors from outside UAE. In addition, articles which mentioned UAE only in text but had no research done in the country or had no UAE specific results were also excluded.

Upon completion of the broad search, a total of 314 articles were shortlisted which were exported to a database with all their information including, but not limited to, the authors, the journals, the titles, the institutions, the Emirates and the years of publication. Out of these, 221 articles were obtained from PubMed, 41 articles were found on Google Scholar including the Wiley Online Library, while 1 article was obtained from Science Direct and the remaining 51 articles were obtained from other sources. The snowball approach was applied by searching references of published articles however it was not useful as the search was limited to the UAE region.

Furthermore, the selected articles were classified based on the following criteria: (i) prevalence of DM and/or any of

its major complications in the UAE and (ii) prognosis of DM in patients residing in the UAE including development of complications, quality of life and morbidity or mortality and (iii) management of DM and the guidelines related to DM that are used in the UAE. Moreover, classification of different types of DM (Type I, Type II and Gestational DM) was considered as an important aspect and included in the analysis. All the articles that did not specify the type of DM or included more than one type were listed under the unclassified category.

3. RESULTS

Based on the inclusion criteria mentioned in the methods section, a total of 487 articles were found. However, 64.47% (*n* = 314) of these articles were selected to be included in the present study. These articles were reviewed and analyzed extensively and classified into different subtypes to provide detailed and systemic information about DM research in UAE.

DM research within the UAE has been going for over 20 years and has shown a tremendous rise over the last 10 years. As shown in Fig. (**1**), during the period of 1991-1995, the

total number of articles published was as low as 7 articles. Gradually, the number of publications increased per five years and has shown a drastic rise to 114 articles for the period of 2011-2015 (Fig. **1**). Interestingly, in the year 2015 alone, 42 articles were published (Fig. **1**).

Among different research institutions across the seven Emirates constituting the UAE, the UAE University (UAEU) located in the city of Al Ain which is located in the Emirate of Abu Dhabi had the highest number of publications and contributed as much as 80.89% (254 out of 314) of the total research conducted (Figs. **2** and **3**).

UAEU seems to be the first institute to investigate and publish research in DM. The first article was published in 1985, titled "Early morphological remodelling of neuromuscular junction in a murine model of diabetes" [26]. Interestingly, all the research done between the time periods of 1991- 2000 was solely conducted at the UAEU.

Notably, there were 23 articles (accounting to 7.32%) published from the capital Emirate of Abu Dhabi (Figs. **2** and **3**). In the latter, the articles were published from different institutions including a range of universities, hospitals, laboratories and ministry health centres. On the other hand,
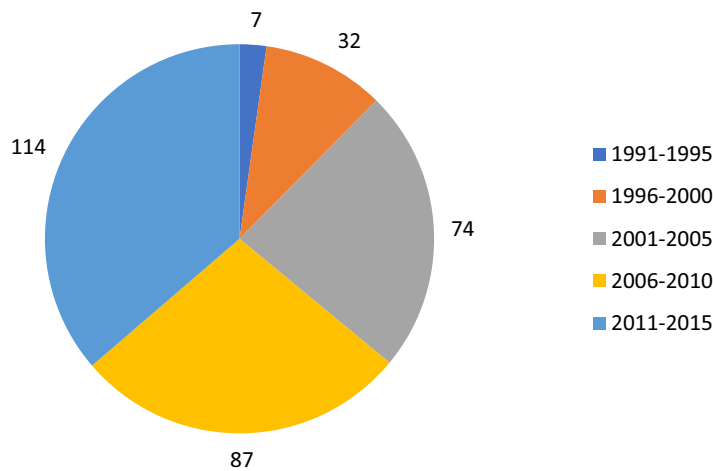

Fig. (1). Number of DM articles published in UAE per 5 years.
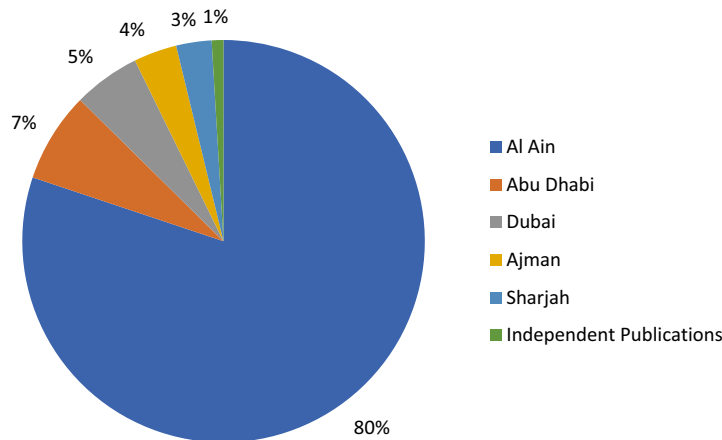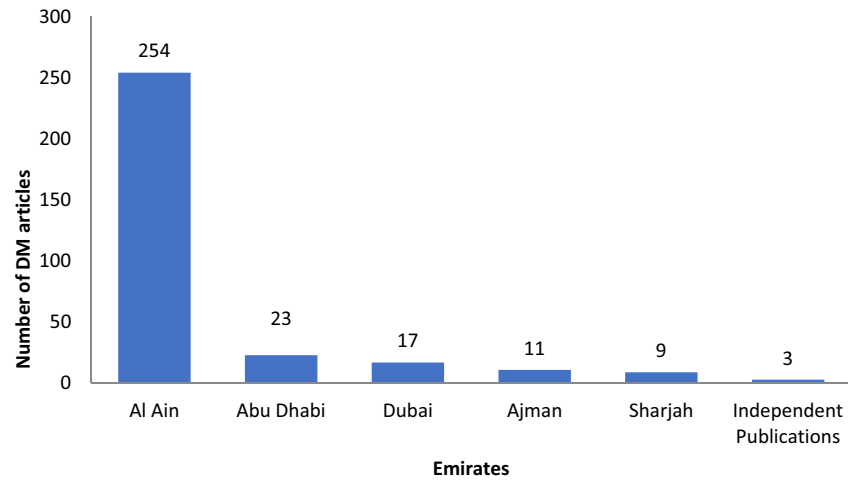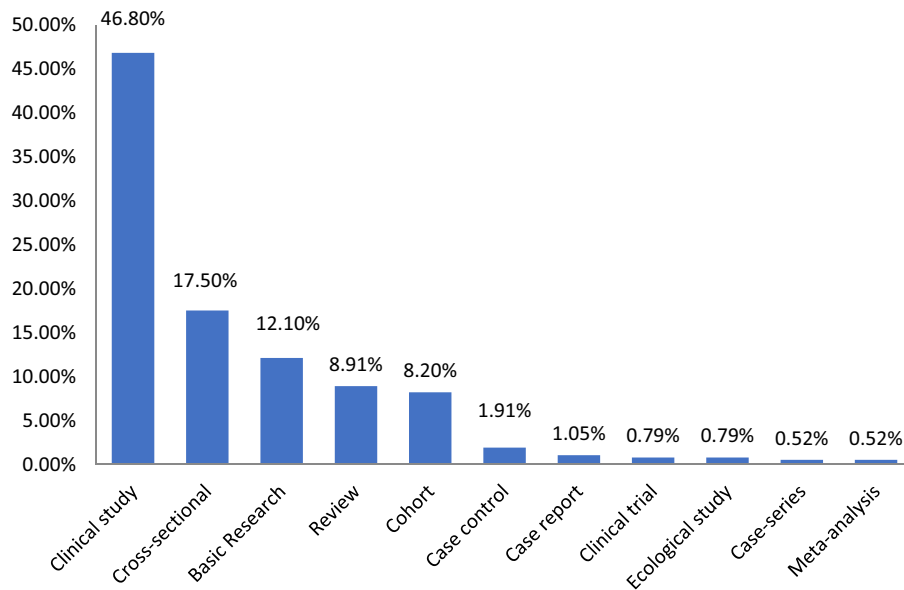

Fig. (2). Percentage of DM articles published per Emirate/City.

Fig. (3). Number of DM articles published per Emirate/City..

Fig. (4). Percentage of DM articles based on the types of the studies.

5.41% (*n* = 17) of the articles were published in the Emirate of Dubai and they were mostly clinical studies (Figs. **2** and **3**).

The Emirates of Sharjah and Ajman published a total of 20 articles over the years 2006-2015. The percentage of articles published from Sharjah alone was 2.86% (*n* = 9) and almost all the articles were published from the University of Sharjah, except for one article that was published from the Al Qassimi Hospital (Figs. **2** and **3**). However, Ajman showed a pattern which had more than one participating institution in the publications and contributed to 3.5% (*n* = 11) of the articles, with the highest number of publications coming from the Rashid Centre for Diabetes Research (Figs. **2** and **3**). Three articles were published in collaboration with institutions based in Dubai, Sharjah and Ajman. On the other hand, three articles were independent publications without mentioning a specific location in the UAE and accounting to about 0.95% of the total articles published (Figs. **2** and **3**).

Out of all the 314 articles reviewed, 89 of them were available for open access with full text, whereas the remaining 225 articles either required a subscription or online payment for access.

Upon conducting further analysis to identify the type of DM research that was conducted, the results have shown that 42 out of the 314 published articles focused on T2DM, whereas 14 of them investigated Type 1 DM (T1DM). A total number of 41 articles represented research conducted on gestational DM and 217 of the remaining articles either discussed both T1DM and T2DM or had a general finding, without specifying the exact type of DM.

As shown in Fig. (**4**), research was conducted to identify and categorize the articles based on the type of study. Clinical studies accounted for the highest percentage (46.8%), whereas studies related to meta-analysis and case-series focusing on DM gave the lowest percentage (0.52% each). The

exact number of articles in each category based on the study type is presented in Table **1**.

Table 1. **Number of DM articles published for each type of study.**

Type of Study	Number of Articles
Clinical study	147
Cross-sectional	55
Basic Research	38
Review	28
Cohort	26
Case control	6
Case report	4
Clinical trial	3
Ecological study	3
Case-series	2
Meta-analysis	2

Furthermore, articles were subcategorized based on the body systems and the main subject of the research as shown in Table **2** and Fig. (**5**), respectively. 55 articles out of the total number of 314 were dedicated to research within the cardiovascular system whereas the field of neurosciences was represented by 17 articles. The field of hematological sciences and the renal system was covered by 11 and 13 articles, respectively. Finally, 48 articles discussed investigations on the gastrointestinal system. The number of articles that focused on the following subjects were comparable as shown in Fig. (**5**): basic research, prevalence, prognosis, management, guidelines and unclassified.

## 4. DISCUSSION

The outcomes of the present study have shown that UAEU in Al-Ain had the most significant contribution to the number of articles that had been published in the field of DM research. It is noteworthy that the reason for this is the strong emphasis of the university on research work and the multiple sources of research funding. In addition, the availability of animal facilities in this university has supported the process of conducting various research studies.

Investigations of the nature of the studies that were conducted across different areas in the UAE, have shown that

Table 2. **Number of DM articles sub-categorized based on the investigated body system,**

System	Basic Research	Guidelines	Prevalence	Management	Prognosis	Unclassified
Cardiovascular	37	1	4	5	6	2
Renal	11	-	1	-	-	1
Hematological	7	-	-	2	-	2
Neurosciences	12	-	-	1	2	2
Gastrointestinal	44	-	-	2	-	2
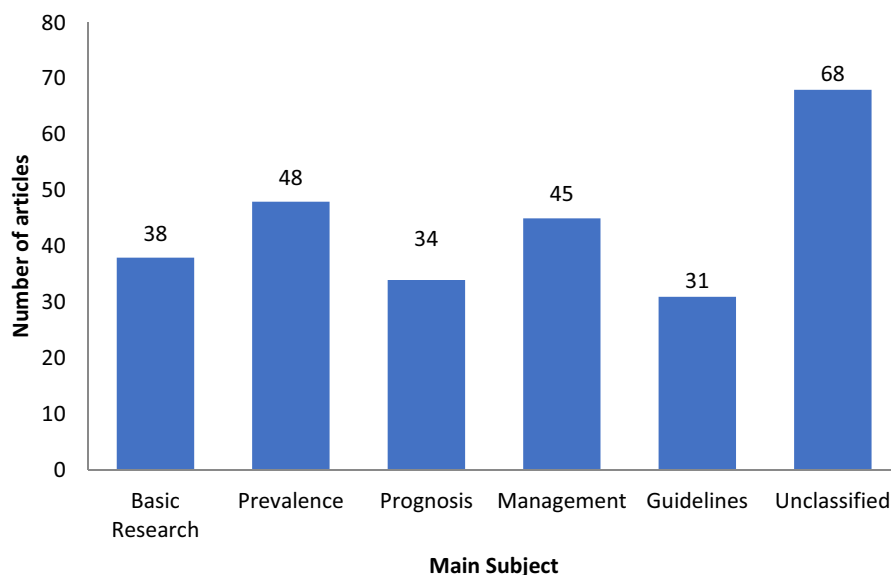
Fig. (5). Number of DM articles based on the main subject of investigation.

the focus of the researchers and their participating institutions was mainly on clinical research, accounting to 46.8% of the total number of research studies. The plausible reason for this finding is that, during the last two decades, the clinical settings in UAE were developing more faster compared to the basic medical research [27, 28].

Cross-sectional studies have been ranked as the second category with 17.5% articles focusing on DM research in UAE. These studies covered many areas of DM research including knowledge and awareness of the UAE citizens about various aspects of DM. In addition, several articles discussed DM prevalence and risk factors. However, it was interesting to note that other types of community-based research were not given as much attention. For instance, only 8.2% of the studies that were conducted were cohort and it is important to increase this type of studies to provide more detailed information and identify key variables in the long-term compared to cross-sectional studies.

Based on the findings of the present study, most research done in UAE was not specific to a certain type of DM but rather shared features of different types of DM and thus we urge researchers to do more focused studies on either type of DM to understand the characteristics of each type, in particular, T1DM which was discussed only in 14 published articles.

Furthermore, we found that case reports were very few ($n = 4$) and thus we propose that it is crucial for the hospitals to encourage their medical staff to document important cases that are reported during their line of work to advance the field of DM research in the future.

As shown in the results section, the topics and subjects of DM research in UAE were well-distributed among the major categories and this gives an indication that researchers are generally well-oriented towards important aspects of DM research.

It was also noted that four body systems (Cardiovascular, Gastrointestinal, Neurosciences and Renal) were considered as the main areas of DM research whereas very few to none articles were published to discuss the involvement of other body systems. This was supported by the finding that diabetic retinopathy, which despite being very common [10, 11], affecting one third of the diabetic patients and possibly leading to blindness [10], is highly understudied with only four articles published. In addition, other systems including reproductive and endocrine systems demand more attention and new studies should be conducted to provide a more comprehensive understanding of DM as a multifactorial disease.

Out of the four major systems, the cardiovascular system was the most studied system. Despite most articles were about basic research being done on rats, these articles were found to be well distributed and covered the most important and relevant topics about the cardiovascular system. Interestingly, regarding the gastrointestinal system, 44 of the 48 articles published were on basic research, and only four articles covered all other topics and types of research studies.

Given the findings of the present studies, it is crucial to highlight the areas of DM research that were never covered before by any published articles in UAE. We emphasize that the following areas demand more attention and would bring about a drastic change in DM research in the UAE. These include the prognosis/progression of diabetic retinopathy, its management and reviewing the guidelines currently followed in the UAE or worldwide. In addition, the prevalence of diabetic neuropathy related gastrointestinal complications in the UAE, their progression, and reviewing the guidelines also need to be investigated intensely. Furthermore, more research should be conducted to investigate acute complications associated with DM including diabetic coma, erectile dysfunction, respiratory infections and periodontal diseases [7, 22].

It is evident that the number of DM research articles being published per year is increasing in a significant fashion in the UAE. The main reason for this is the new research facilities that have been established and activated during the last ten years, including the Sharjah Institute for Medical Research (University of Sharjah) and Rashid Center for Diabetes and Research (Sheikh Khalifa Medical City). Another important aspect is that more funding was allocated for research from various organizations including the Sheikh Hamadan Award founded in 1999 and Al Jalila foundation founded in 2013. In addition, most of the universities including the University of Sharjah have increased the funding of the research projects, significantly [17, 18]. This will shape the future of DM research in UAE and enhance the growth of DM research in the region.

It is noteworthy that the concept of investigating and documenting DM research to reduce the burden of DM and to better the management and care plans have been used in other regions around the world. The European Diabetes Research has launched the DIAMAP Project which provides an outlook on the current DM research and funding landscape in Europe [29]. It also discusses strategies for DM research for the next 10 years and recommends to create a European platform for clinical research in DM (EPCRD) taking into account main issues such as ethics, governance and training [29]. There is no comprehensive data available about the growth of research on DM in other regions such as US and UK. Hence we emphasize the need for such an approach, proposing UAE to start the trend and lead the way to create a platform focused DM research.

CONCLUSION

UAE has experienced a pronounced growth in different fields during the last two decades and this includes DM research. The outcomes of this study speculate that DM research in UAE is evolving to tackle major challenges that are associated with DM and more research funding bodies, facilities and institutes have been established to execute these plans. This study has documented and provided evidence that the futuristic DM research in UAE will help in reducing the DM burden in UAE and the Gulf region.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No Animals/Humans were used for studies that are the basis of this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The data sets used and/or analysed during this study are available from the corresponding author on request.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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