African Vision and Eye Health
ISSN: (Online) 2410-1516, (Print) 2413-3183

Keratoconus in Eastern Mediterranean Region: Prevalence and risk factors

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Dates:
Received: 06 Feb. 2025
Accepted: 22 May 2025
Published: 31 July 2025

How to cite this article:
Mohamed ZD. Keratoconus in Eastern Mediterranean Region: Prevalence and risk factors. Afr Vision Eye Health. 2025;84(1), a1044. https://doi.org/10.4102/aveh.v84i1.1044

Background: Keratoconus (KC) is common in areas with disease-related risk factors. It is characterised by progressive, non-inflammatory thinning of the cornea with unknown causes and is likely multifactorial.

Aim: To determine the prevalence and risk factors of KC in the Eastern Mediterranean Region (EMR).

Method: The study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (2020) guidelines using two sources: electronic databases and reference lists of selected articles. The electronic databases included Web of Science, PubMed, Scopus and Google Scholar. The search period spanned from January 2000 to January 2025. Data were extracted and analysed to determine KC prevalence and associated risk factors using a random-effects model.

Results: In this meta-analysis, 1801 articles were reclaimed, of which 20 were analysed. These 20 articles included 22 000 participants from eight countries in the EMR. The prevalence of KC in EMR was 3.96% (95% confidence interval: 3.75–4.16). The most common risk factors for KC in the region included positive family history in 11 studies, frequent eye rubbing in five studies and consanguinity.

Conclusion: The prevalence of KC in EMR was higher than the global estimate, highlighting significant regional variations between countries. Risk factors, including family history of KC, eye rubbing and consanguinity, were the most important risk factors for KC according to the available evidence.

Contribution: The findings indicate an increase in disease incidence rates and emphasise the necessity for implementing targeted interventions to mitigate the risks associated with the KC in the region.

Keywords: cornea; keratoconus; Eastern Mediterranean Region; prevalence; risk factors.

Introduction

Keratoconus (KC) is a degenerative disorder characterised by alterations in corneal morphology that result in impaired vision. This multifaceted condition is influenced by structural and non-inflammatory mechanisms.[1,2] The disease is influenced by environmental and genetic factors, usually in the second or third decade of life, which imposes heavy economic burdens on active groups in society in addition to social effects.[3] Although the exact origin of the condition remains unknown, the most probable explanation is that it develops in individuals with a genetic predisposition who experience recurrent physical trauma, commonly because of eye rubbing.[4] Keratoconus has potential links to several risk factors, including prolonged eye rubbing, allergic reactions, consanguineous and various systemic conditions such as Down syndrome, Leber congenital amaurosis and disorders affecting connective tissue.[5] The condition is believed to have a genetic component, with 6%–8% of cases reporting family history, and environmental influences contribute to the onset and progression of this ocular disease.[6,7] There were significant regional differences in the prevalence of KC.[8] However, the extent to which these differences are related to genetic, environmental and geographical factors remains unclear. However, the diverse diagnostic methods and age groups used in different studies likely contribute to this observed variability.[8]

The prevalence of KC varies between geographical locations, ranging from 1.38 individuals per 1000 globally[9] to 7.9% in Africa.[10] The Eastern Mediterranean Region (EMR) encompasses 22 countries and territories comprising Egypt, Sudan, United Arab Emirates, Bahrain, Iraq, Iran, Jordan, Saudi Arabia, Kuwait, Djibouti, Lebanon, Libya, Morocco, Oman, Pakistan, Palestine,

Qatar, Yemen, Somalia, Syria, Tunisia, and Afghanistan, with an estimated population of 597 million inhabitants.[11,12] Keratoconus occurrence rates show significant variation among these nations, ranging from 20.97% in Egypt[13] to a low of 0.98% in Iran.[14] Numerous investigations in this field have been constrained by factors such as limited sample sizes, specific study populations and inconsistent diagnostic criteria. In addition, there is a lack of comprehensive data on the prevalence and risk factors associated with KC in the EMR. Therefore, this systematic review and meta-analysis aimed to determine the prevalence and identify the risk factors associated with this condition within the population of the region. Such an understanding is vital for public health planning, improved clinical management and awareness campaigns.

Methods

Study design

This systematic review was reported in accordance with the guidelines outlined in the Preferred Reporting Items for Systematic Reviews (PRISMA, 2020).[15] Data were collected from the Web of Science, PubMed, Scopus and Google Scholar, focusing on relevant studies published between January 2000 and January 2025. The final analysis included all observational epidemiological studies examining the prevalence and risk factors of KC in EMR, provided that the necessary information was available within the article's main text, figures or tables. This systematic review utilised the Population, Concept, and Context (PCC) framework to define the study's scope: the population included individuals diagnosed with or suspected of having KC in the EMR; the concept focused on prevalence estimates and associated risk factors.

Search approach

A comprehensive search was conducted using the Web of Science, PubMed, Google Scholar and Scopus databases for regional countries. The search utilised a combination of essential terms, including KC AND prevalence OR rate OR frequency OR risk factors. All relevant text words and MeSH keywords were used during the search process. Furthermore, reference lists of relevant publications were examined to identify additional pertinent papers. Titles and abstracts were independently checked against the PCC eligibility requirements by two reviewers. For abstracts that satisfied inclusion requirements or in cases where there was uncertainty, full-text articles were obtained. Consensus was used to settle disputes.

Inclusion criteria

This comprehensive review and meta-Analysis examined studies available in English from online sources and peer-reviewed publications, investigating the occurrence and contributing factors of KC in the EMR. The included studies needed to involve a minimum of 100 participants from the region's population and employ population-based, cohort, cross-sectional or randomised controlled trial methodologies. Studies that were not conducted in this region were excluded. Furthermore, studies that omitted conference articles, editorial commentaries, meeting summaries and studies that lacked fundamental data collection were also excluded, as illustrated in Figure 1.

Data extraction

To ensure adherence to the inclusion criteria, two reviewers evaluated the search results independently. After removing duplicate entries, the titles and abstracts of the identified articles were examined by the author to determine their relevance, and following the implementation of the exclusion criteria, the remaining publications were thoroughly examined in their entirety. The data extracted by the author and evaluated by the reviewer included the lead author's name, publication year, study location, participants' average age and sex, research methodology, type of population studied and identified the prevalence risk factors. The quality of each study was independently evaluated using the checklist developed by Downs and Black.[16] The assessment involved rating each article based on 10 criteria, as outlined in Table 1.

Data analysis

MedCalc version 19.6.1 (MedCalc Software, Ostend, Belgium) was used for conducting the meta-analysis. Information was input individually from a predetermined format, encompassing the author's name, year of publication, study population, average age, research design, sample size, diagnostic criteria and prevalence and risk factors of KC. The Q statistic, distributed as χ^2 assuming homogeneous effect sizes, and the I^2 index (0% – 75%) were employed to assess heterogeneity among the selected studies. The examined data displayed the prevalence of KC with corresponding weights for each study. A random-effects model was used to estimate the overall pooled prevalence of KC along with associated 95% confidence intervals (CIs). Publication bias was evaluated using Egger's test and funnel plot. Publication

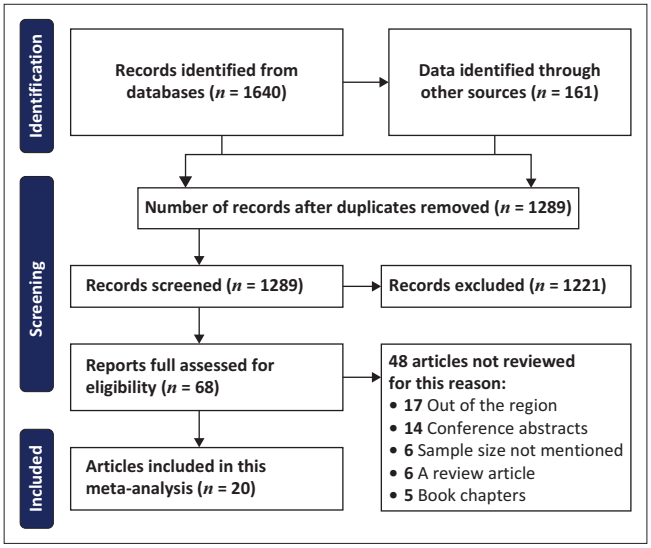


FIGURE 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 flow chart model for the systematic review of keratoconus prevalence in the Eastern Mediterranean Region.

bias occurs when the studies included in a meta-analysis do not represent all studies on a given topic, often because studies with statistically significant results are more likely to be published. For all analyses, a *P*-value below 0.05 was considered statistically significant.

Ethical considerations

Ethical waiver to conduct this study was obtained from the University of Buraimi College of Health Sciences.

Review findings

This review encompassed 1801 articles, with 1640 articles from databases and 161 from additional sources. Following the elimination of duplicates, 1289 articles underwent title and abstract screening. Subsequently, 1221 articles were excluded based on predetermined criteria, leaving 68 articles for full-text review. The review aimed to include studies published since 2000; however, the final analysis incorporated 20 studies published between 2014 and January 2025 because of the unavailability of studies in the period preceding 2014, involving 35158 participants across eight EMR nations, to ascertain the overall prevalence of KC. The meta-analysis included studies from Saudi Arabia, Egypt, Iran, Iraq, Oman, Syria, Pakistan and Palestine, as detailed in Table 1.

The pooled prevalence of KC in EMR was 3.96% (95% CI: 3.75–4.16; $P < 0.001$). The estimated prevalence of 11 (55.0%) was notably higher than the pooled prevalence, whereas 45.0% ($n = 9$) showed a lower rate than the pooled expected prevalence. Among Egyptian ametropic patients, Mousa et al. observed the highest KC prevalence of 20.97% (95% CI: 16.07–26.57), 12 with a sample weight of 0.71%.[13] Conversely, Mohaghegh et al. reported the lowest prevalence in the Iranian population at 0.98% (95% CI: 0.64–1.45), 13 with a sample weight of 7.24%.[14] The studies included in this meta-analysis exhibited a highly significant level of heterogeneity between the population-based and cross-sectional studies ($P < 0.0001$), with an inconsistency of 98.73% (95% CI: 98.49–98.94), as listed in Table 2. Figure 2, depicting a forest plot, was used to illustrate the pooled and specific prevalence of KC.

To examine publication bias, Egger's test and funnel plot analysis were performed. The findings (intercept = 6.84, $P = 0.15$) indicate no substantial bias, as illustrated in Figure 3. Consequently, no significant evidence of publication bias was found regarding the prevalence of KC in EMR. Nevertheless, owing to the scarcity of available studies, it was not feasible to investigate the impact of publication bias on KC prevalence.

Most of the studies conducted in the region to assess the risk factors did not follow a unified method in presenting the results of the association between KC and the risk factors; this study will present them as outputs because of the difficulty in conducting the meta-analysis. A total of 13 studies that considered the risk factors for developing KC in the region, involving 7872 subjects in six EMR countries, were included in the risk factor review, as shown in Table 3, 11 of which reported that family history is the possibility of

TABLE 1: Characteristics of the included articles.

Study ID	Country	Sample size	KC positive cases	Age range (years)	Quality assessment score
Torres et al. 2018[17]	Saudi Arabia	522	29	6–21	9.5
Althomali et al. 2018[18]	Saudi Arabia	687	59	18–65	10.0
Khattak et al. 2024[19]	Saudi Arabia	110	3	13–23	8.5
Salman et al. 2022[20]	Syria	839	12	17–24	10.0
Al Saidi et al. 2024[21]	Oman	2750	96	19–34	10.0
Elbedewy et al. 2018[22]	Egypt	8124	91	NA	9.5
Mousa et al. 2025[13]	Egypt	248	52	NA	9.5
Elsuofy et al. 2022[23]	Egypt	1607	173	13–88	8.5
Sidky et al. 2020[24]	Egypt	547	26	6–18	9.5
Hamdy et al. 2024[25]	Egypt	1631	174	5–46	9.5
Abd-Elaziz et al. 2022[26]	Egypt	782	46	NA	9.5
Sayed and Hassan Ali 2017[27]	Egypt	2116	36	NA	9.5
Hashemi et al. 2018[28]	Iran	2667	107	NA	9.5
Hashemi et al. 2014[29]	Iran	1073	27	NA	9.5
Mohaghegh et al. 2023[14]	Iran	2546	25	25–62	10.0
Shehadeh et al. 2015[30]	Palestine	620	9	17–27	10.0
Hayawi and Khaudhair 2022[31]	Iraq	2000	98	14–39	9.5
Al-Amri 2018[32]	Saudi Arabia	2931	518	18–52	10.0
Hamed et al. 2019[33]	Egypt	2878	84	20–47	9.5
Alam and Mohammad 2022[34]	Pakistan	480	47	9–37	10.0
Total	-	**35 158**	**1712**	-	-

Note: Please see full reference list of this article, Mohamed ZD. Keratoconus in Eastern Mediterranean Region: Prevalence and risk factors. Afr Vision Eye Health. 2025;84(1): a1044. https://doi.org/10.4102/aveh.v84i1.1044, for more information.

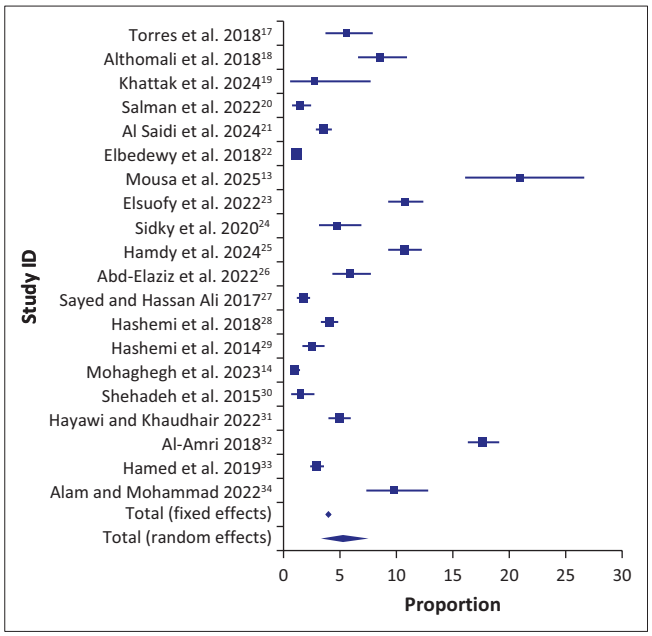
KC, keratoconus; NA, Not available.

TABLE 2: Prevalence of keratoconus in Eastern Mediterranean Region with confidence interval.

Study	Sample size	Proportion (%)	95% CI	Weight (%)
Torres et al. 2018[17]	522	5.56	3.75–7.88	1.49
Althomali et al. 2018[18]	687	8.59	6.6–10.94	1.96
Khattak et al. 2024[19]	110	2.73	0.57–7.76	0.32
Salman et al. 2022[20]	839	1.43	0.74–2.49	2.39
Al Saidi et al. 2024[21]	2750	3.49	2.84–4.25	7.82
Elbedewy et al. 2018[22]	8124	1.12	0.90–1.37	23.10
Mousa et al. 2025[13]	248	20.97	16.07–26.57	0.71
Elsuofy et al. 2022[23]	1607	10.77	9.29–12.38	4.57
Sidky et al. 2020[24]	547	4.75	3.13–6.89	1.56
Hamdy et al. 2024[25]	1631	10.67	9.21–12.27	4.64
Abd-Elaziz et al. 2022[26]	782	5.88	4.34–7.77	2.23
Sayed and Hassan Ali 2017[27]	2116	1.70	1.19–2.35	6.02
Hashemi et al. 2018[28]	2667	4.01	3.30–4.83	7.58
Hashemi et al. 2014[29]	1073	2.52	1.67–3.64	3.05
Mohaghegh et al. 2023[14]	2546	0.98	0.64–1.45	7.24
Shehadeh et al. 2015[30]	620	1.45	0.67–2.74	1.77
Hayawi and Khaudhair 2022[31]	2000	4.90	4.0–5.94	5.69
Al-Amri 2018[32]	2931	17.67	16.31–19.1	8.33
Hamed et al. 2019[33]	2878	2.92	2.34–3.6	8.18
Alam and Mohammad 2022[34]	480	9.79	7.28–12.81	1.37
Total	35 158	3.96	3.75–4.16	100.00
Heterogeneity between groups			$P < 0.0001$	
I^2 (inconsistency)	-	98.73	98.49–98.94	-

Note: Please see full reference list of this article, Mohamed ZD. Keratoconus in Eastern Mediterranean Region: Prevalence and risk factors. Afr Vision Eye Health. 2025;84(1): a1044. https://doi.org/10.4102/aveh.v84i1.1044, for more information.

CI, confidence interval.



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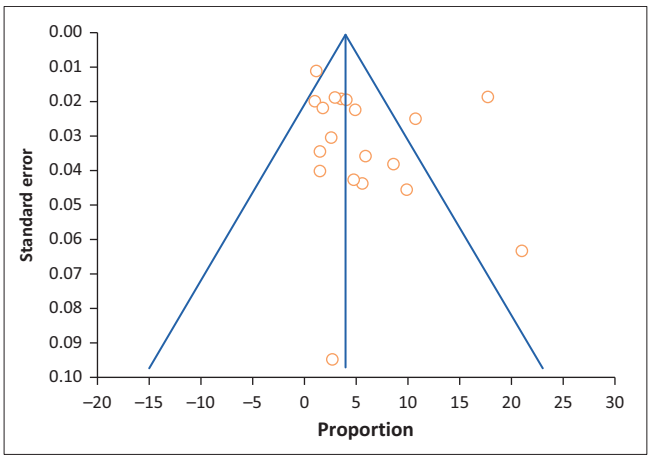
ID, Identity.

FIGURE 2: Forest plots of the pooled proportions of keratoconus in Eastern Mediterranean Region.



Note: Risk factors of KC in the EMR.

KC, keratoconus; EMR, Eastern Mediterranean Region.

FIGURE 3: Funnel plot showing publication bias related to the proportion of keratoconus in the Eastern Mediterranean Region.

the occurrence of KC.[13,14,19,25,28,29,35,36,37,38,39] Five studies investigated the association between the occurrence of KC and eye rubbing,[19,20,29,36,37] while two studies have shown that parental consanguinity can be a risk factor.[36,38] In addition, other factors discussed included allergy, family history of atopic dermatitis, vernal keratoconjunctivitis, socioeconomic status and low levels of education.

Discussion

Determining the pooled prevalence of KC in EMR is essential to enhance ocular health outcomes, develop effective public health initiatives, direct medical investigations and ensure fair allocation of healthcare resources throughout the nation. This comprehensive review synthesised data from 20 studies

TABLE 3: Risk factors of keratoconus in the Eastern Mediterranean Region.

Study ID	Country	Sample size	Risk factors	Statistical significance
Khattak et al. 2024[19]	Saudi Arabia	110	Eye rubbing and family history	$P < 0.001$
Salman et al. 2022[20]	Syria	839	Eye rubbing	$P < 0.001$
Mousa et al. 2025[13]	Egypt	248	Family history	$P = 0.001$
Hamdy et al. 2024[25]	Egypt	1631	Family history and allergy	Not mentioned
Hashemi et al. 2018[28]	Iran	2667	more in males, family history	less than 1.0. Odds ratio
Hashemi et al. 2014[29]	Iran	1073	Eye rubbing and family history	OR = 11.4, 95% CI: 2.5–51.3 and OR = 6.3, 95% CI: 1.6–24.3
Mohaghegh et al. 2023[14]	Iran	2546	Family history	$P < 0.001$
Hayawi and Khaudhair 2022[31]	Iraq	2000	Females	$P = 0.009$
Assiri 2005[35]	Saudi Arabia	125	Positive family history of atopic dermatitis	Not mentioned
Mohammad-Rabei et al. 2023[36]	Iran	100	Eye rubbing, vernal keratoconjunctivitis, positive familial history of KC, socioeconomic status, parental consanguinity and low levels of education	OR = 10.625, $P < 0.001$; OR = 7.510, $P = 0.003$; OR = 1.758, $P = 0.029$ and OR = 12.533, $P < 0.001$
Naderan et al. 2015[37]	Iran	922	Eye rubbing and positive family history	< 0.001
Almusawi and Hamied 2021[38]	Iraq	166	Family history of keratoconus, eye rubbing and parental consanguinity	OR 25.52; $P < 0.01$, OR 4.93; $P < 0.01$ and 2.89; $P = 0.02$
Alqudah et al. 2021[39]	Jordan	234	Female	$P < 0.001$
Total	-	**7872**	-	-

Note: Please see full reference list of this article, Mohamed ZD. Keratoconus in Eastern Mediterranean Region: Prevalence and risk factors. Afr Vision Eye Health. 2025;84(1): a1044. https://doi.org/10.4102/aveh.v84i1.1044, for more information.

CI, confidence interval; ID, Identity; OR, odds ratio.

across eight countries in the EMR published over the past decade, offering updated estimates of KC prevalence and associated risk factors. The analysis revealed a KC prevalence of 3.96% (95% CI: 3.75–4.16; $P < 0.001$) in EMR, with notable variations observed both within and between countries, including discrepancies among studies conducted in the same nation. The study also highlighted substantial heterogeneity among the examined studies. The reported figure exceeds the worldwide average of 1.38 per 1000,[9] and some countries in the Mediterranean region such as Italy.[40] However, the KC prevalence in EMR was found to be lower than the 7.9% observed in a meta-analysis in Africa.[10] The EMR exhibits a higher KC prevalence compared to global estimates, likely because of a mix of genetic, environmental, cultural and healthcare factors. Specific regional characteristics, including ultraviolet radiation exposure, eye-rubbing cultural practices and genetic susceptibility, may account for this disparity.[36,38] Furthermore, enhanced screening and diagnostic methods in certain EMR countries could explain the observed elevated prevalence compared to other global regions.[9]

The highest prevalence of KC appeared in ametropic-based community,[13] and the lowest was population based.[14]

This difference is likely to be an overestimation because of the higher likelihood of KC being detected among individuals with refractive errors and the use of more advanced diagnostic tools. In contrast, the prevalence in the population-based sample[20,21] was more reflective of the general population, where KC is diagnosed less frequently, especially in its early stages or in individuals with mild forms of the condition. One important factor that can be attributed to the differences in KC prevalence is the methods of measurement.[41] Most of the prevalence studies were from Saudi Arabia and Egypt, the highest estimation in Saudi Arabia was 17.67%[32] and lowest was 2.73%,[19] while in Egypt it ranged between 20.97%[13] and 1.12%.[22] These results reinforce the concept of heterogeneity even within a single country

Family history was among the risk factors evaluated in this study and was considered the strongest risk factor in the 11 studies conducted in the region,[13,14,19,25,28,29,35,36,37,38,39] which is consistent with studies conducted in different regions around the world.[41,42,43] Eye rubbing is one of the most important risk factors for KC.[43] The results of this review showed that the probability of developing KC was higher in five studies conducted in the EMR.[19,20,29,36,37] Some studies have indicated that consanguinity is a major risk factor for KC as it increases family history.[44] The results of our study confirmed the impact of this factor through its inclusion in two recent studies conducted in this region.[35,37] Consanguinity is widespread in the region as a cultural aspect site.[45] Other risk factors studied included allergy, family history of atopic dermatitis, vernal keratoconjunctivitis, socioeconomic status and a low educational level.

The main limitations of KC prevalence research include most prevalence studies from Saudi Arabia and Egypt and risk factors studies from Iran, selection bias, varying diagnostic approaches, underreporting and cultural influences, especially when comparing ametropic and general populations. These factors may lead to underestimation in population-based studies using basic screening methods, overestimation in research focusing on ametropic individuals or employing advanced diagnostic techniques. Comparing prevalence rates is further complicated by differences in healthcare systems, socioeconomic conditions and geographical locations among the studied populations in countries such as Egypt and Iran. To address these limitations and generate more accurate KC prevalence, a standardised diagnostic protocol is necessary.

Conclusion

The pooled prevalence of KC in EMR was high. An analysis of population and ametropic patient studies revealed KC prevalence rates ranging from 0.98% to 4.01% in the general population, with a notably higher rate of 20.97% among ametropic individuals. These statistics emphasise the necessity of addressing KC as a crucial public health issue in the area. The prevalence of the disease exhibits substantial variability across the region's countries and even within individual nations, which is attributed to disparities in geographical features and climatic conditions. Risk factors for KC include positive family history, frequent eye rubbing and consanguineous union. Specific studies have also identified additional contributing factors, such as allergies, familial history of atopic dermatitis, vernal keratoconjunctivitis, socioeconomic circumstances and lower educational levels.

Acknowledgements

Z.D.M. expresses gratitude to the Ministry of Higher Education, Research and Innovation (MoHERI) of the Sultanate of Oman for their financial support. In addition, appreciation is extended to the administration team of the University of Buraimi for their logistical assistance. Z.D.M. also acknowledges the contributions of Dr Saif Alrasheed, Dr Gopi Vankudre and Mr Babu Naushad.

Competing interest

The author reported that he received funding from the Ministry of Higher Education, Research and Innovation (MoHERI) of the Sultanate of Oman under the Block Funding Program which may be affected by the research reported in the enclosed publication. The author has disclosed those interests fully and has implemented an approved plan for managing any potential conflicts arising from their involvement. The terms of these funding arrangements have been reviewed and approved by the affiliated university in accordance with its policy on objectivity in research.

Author's contribution

Z.D.M. is the sole author of this review article.

Funding information

The author reported that they received funding from the Ministry of Higher Education, Research and Innovation (MoHERI) of the Sultanate of Oman under the Block Funding Program.

Data availability

The data that support the findings of this study are available on reasonable request from the corresponding author, Z.D.M.

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