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Prevalence of prediabetes and associated risk factors in the Eastern Mediterranean Region: a systematic review

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Abstract

Background Prediabetes increases the risk of diabetes mellitus and complications. The current study was planned to assess the prevalence and risk factors of prediabetes in Eastern Mediterranean Region countries.

Methods The PRISMA reporting guidelines were followed when reporting this study. Five electronic databases: PubMed, Embase, Scopus, CINAHL, and Web of Science, were searched to identify relevant studies. We included observational studies that used either the American Diabetes Association or World Health Organization prediabetes criteria as definitions for adult populations in any of the Eastern Mediterranean Region countries. We identified 13,851 references, of which 41 were included for data extraction. The Quality Assessment Tool for Cross-Sectional Studies and the Newcastle–Ottawa Scale for other studies were used to assess the quality of the included studies.

Results The overall prevalence of prediabetes ranged from 2.2% to 47.9%; Age, gender, obesity, and high blood pressure were the most reported risk factors in the EMR. Factors like low education, smoking, family history of diabetes, and physical inactivity were associated with prediabetes in some populations.

Conclusion The region was found to have a high prevalence of prediabetes, ranking it among regions with the most significant frequency. Modifiable factors such as obesity, hypertension, and inactivity, in addition to age and gender, are among the region's most frequently identified risk factors for prediabetes.

Keywords Eastern Mediterranean region, Prevalence, Prediabetes, Risk factors, Systematic review

Introduction

Prediabetes, defined as blood glucose levels above normal but below the threshold for diabetes, is associated with an increased risk of type 2 diabetes (T2DM) [1]. Moreover, it is an independent cardiovascular risk factor that elevates the likelihood of developing diabetes-related complications, including neuropathy, nephropathy, stroke, and all-cause mortality [2, 3].

Currently, there is no universally accepted definition of prediabetes [4]. According to the World Health Organization (WHO), prediabetes is diagnosed when blood glucose levels meet the criteria for both impaired fasting glucose (IFG), which is between 110 and 125 mg/dL, and impaired glucose tolerance (IGT), which is between 140 and 200 mg/dL [1]. The American

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Diabetes Association (ADA), on the other hand, defines IGT using the same range (140–200 mg/dL) but sets a lower threshold for IFG (100–125 mg/dL). Additionally, the ADA includes hemoglobin A1c (HbA1c) levels as a criterion, with an HbA1c range of 5.7% to 6.4% classified as prediabetes [5].

The increasing prevalence of prediabetes parallels the rise in its main risk factors, which are similar to those for T2DM: higher Body Mass Index (BMI), advanced age, gender, family history, lack of physical activity, and smoking [6].

The Eastern Mediterranean Region (EMR) comprises 22 countries with a combined population exceeding 700 million as of 2020, from Morocco in the west to Pakistan and Afghanistan in the east. These countries exhibit varying economic, environmental, political, and healthcare systems, with many facing challenges regarding access to primary healthcare and quality medical services [7]. Like other regions, the EMR faces a growing burden of non-communicable diseases. In 2012, the EMR's death rate from non-communicable diseases exceeded the global average and is expected to peak by 2030 [8]. Over the past 30 years, significant social and economic transformations have reshaped many countries within the region. While Gulf states have experienced rapid economic growth and urbanization, others have seen a slowdown due to political upheavals [9]. These changes have contributed significantly to the rise in prediabetes risk factors. Physical inactivity, overweight/obesity, unhealthy diets, tobacco use, hypertension, and diabetes are widespread across the EMR [10, 11], with some countries experiencing particularly alarming levels [12].

The primary goals of prediabetes management are to normalize glucose levels and to prevent or delay the onset of diabetes and its associated complications [13]. However, data on the prevalence and key risk factors of prediabetes in the region are limited. A 2018 systematic review and meta-analysis of studies from the EMR, which employed various diagnostic methods, reported a pooled prediabetes prevalence of 12.8% [14]. Since then, 14 additional studies have been published, including one reporting the highest recorded prevalence of prediabetes. However, this review did not examine prediabetes risk factors in detail. Therefore, this systematic review aims to describe the prevalence of prediabetes and its risk factors among the adult population in EMR countries. We believe that the findings will provide valuable insights for regional health policymakers and healthcare providers, helping them implement necessary measures to reduce and control prediabetes and prevent the progression to diabetes and its associated complications, as well as offering guidance for future research.

Materials and methods

This systematic review aimed to assess the prevalence of prediabetes and its associated risk factors in the EMR. The review protocol was registered with PROSPERO in October 2022 (registration number CRD42022364039). The study was conducted and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [15].

Data source and searches

The search protocol of this systematic review was executed in PubMed, Scopus, CINAHIL, the Web of Science, and Embase databases covering any period. The search strategy used variants and combinations of search terms related to (prevalence OR epidemiology OR Proportion OR Rate) AND (Prediabetes OR prediabetes Mellitus OR Prediabetic state OR Pre-diabetic State OR Pre-diabetic States OR Pre-Diabetes OR prediabetic OR dysglycemia OR pathoglycemia OR intermediate hyperglycaemia OR Borderline diabetes OR borderline glycaemic state OR glucose tolerance test OR glucose intolerance OR Insulin resistance OR glucose abnormalities OR Impaired glucose tolerance OR Impaired fasting glucose OR impaired fasting tolerance OR impaired glucose regulation OR hyperglycaemia OR Glycosylated haemoglobin OR "haemoglobin A1c") AND (United Arab Emirates OR Bahrain OR Oman OR Kuwait OR Qatar OR Saudi Arabia OR Yemen OR Jordan OR Palestine OR West Bank OR Gaza OR Lebanon OR Syria OR Syrian Arab republic OR Egypt OR Libya OR Tunisia OR Morocco OR Sudan OR Somalia OR Djibouti OR Afghanistan OR Iran OR Islamic republic of Iran OR Iraq OR Pakistan).

The retrieved studies were exported, and duplicate articles were removed. Two independent reviewers screened the titles and abstracts according to predefined inclusion and exclusion criteria. The studies included met the following criteria: (1) observational studies such as cross-sectional, cohort, and case–control designs; (2) studies utilizing ADA or WHO criteria for prediabetes based on HbA1c, fasting blood sugar, or impaired glucose tolerance (IGT) definitions; (3) studies focusing on adult populations (18 years and older); (4) research conducted in any of the 22 countries within the EMR; (5) studies published in English; (6) hospital-based, population-based, or clinic-based studies; and (7) any publication period. We excluded randomized controlled trials, systematic reviews, qualitative and modelling studies, case reports, case series, narrative reviews, conference abstracts lacking complete information, editorials, commentaries, letters to the editor, and author replies.

Data management

Throughout the study, we employed a systematic approach to manage the data, utilizing several tools to ensure accuracy and transparency. Initially, we imported the results from our database searches into EndNote X7.2.1, where duplicates were removed. The remaining records, including citations and full-text articles, were transferred to Covidence, where a secondary duplication check was performed.

Articles deemed irrelevant were excluded based on predefined inclusion and exclusion criteria, which two independent reviewers consistently applied. Any disagreements were resolved through discussion or, when necessary, by consulting a third reviewer. For articles excluded from the final analysis due to lack of access to the full text, all efforts to contact the authors, search alternative databases, and request interlibrary loans were carefully documented to obtain them.

Quality assessment

Two reviewers independently evaluated the methodological quality of each included study using the Quality Assessment Tool for Cross-Sectional Studies [16]. Any disagreements regarding the quality assessment were resolved through consultation with a third reviewer. The assessment tool evaluated factors such as the representativeness of the sample, sample size and selection technique, non-response bias, and the validity of the measurement instruments. The total score ranged from 0 to 9, with studies scoring 0–3 points classified as having a low risk of bias, 4–6 points as moderate risk, and 7–9 points as having a high risk of bias. The overall quality of the study was categorized as high, moderate, or low. The quality of the case–control studies was evaluated using the Newcastle–Ottawa Scale for quality assessment [17]. Seven of the 48 studies reviewed were excluded due to a high risk of bias, leaving 41 studies for data extraction (Table 1).

Data extraction

A data extraction form was developed to gather the necessary information for data synthesis. Before its implementation, pilot tests were conducted. Three different reviewers extracted the data twice, independently, with a fourth reviewer double-checking the data and resolving any disagreements. The following information was extracted: first author, year of publication, year of investigation, study design, country where the study was conducted, mean or median age of participants, total sample size, study population, percentage of female participants, and the prediabetes diagnostic criteria used the study (ADA, WHO, or both). Additionally, risk factors evaluated in each article were extracted, including marital status, education, employment, residency, physical activity, smoking, alcohol use, hypertension, BMI, waist circumference (WC), polycystic ovary syndrome (PCOS), parity, pregnancy loss, ethnicity, coffee consumption, consanguinity, hypertriglyceridemia, and family history. Any significant associations between these variables and prediabetes diagnosis were also recorded.

Data summary and reporting

The extracted data were analyzed to identify variations in how prevalence and incidence rates were reported and the types of studies conducted. Where feasible, efforts were made to minimize these variations. The results are presented in two separate tables: one for cross-sectional studies and the other for case–control and cohort studies. Descriptive statistics were used to summarize the data where applicable. Risk factors and their significance are outlined in a separate table.

Results

The PRISMA diagram showing the flow of articles' selection through the study is presented in Fig. 1. Our initial electronic search identified 13,851 potentially relevant articles. After removing duplicates (*n*= 2,126), we screened the titles and abstracts of 11,725 articles, excluding 11,581 as irrelevant. We then assessed the full texts of the remaining 144 potentially relevant studies against our inclusion and exclusion criteria. Following this detailed review, 96 additional articles were excluded for the following reasons: using prediabetes criteria other than ADA or WHO guidelines or employing different screening tools (*n*= 63), reporting irrelevant outcomes (*n*= 22), and studying different populations (*n*= 11). Ultimately, 48 studies were deemed eligible for quality assessment, with seven excluded due to a high risk of bias. As shown in Fig. 1 and Table 1, the remaining 41 studies were categorized as having either a low risk of bias (29 studies) or a moderate risk of bias (12 studies).

Characteristics of the moderate and high-quality reviews

Data on the prevalence of prediabetes in EMR countries, based on cross-sectional studies, and the characteristics and findings of other study designs, such as case–control and cohort studies, are summarized in Table 2. The 41 articles originate from eleven countries (Pakistan, Lebanon, Yemen, Kuwait, Oman, Saudi Arabia, Iran, United Arab Emirates, Syria, Qatar, and Jordan) (Fig. 2), with publication dates ranging from 2004 in Yemen to 2022 in Iran and Syria. Sample sizes in the articles varied from 186 to 163,770 participants. The review identified 28 cross-sectional studies, six cohort studies, and seven case–control studies (Table 2).

Table 1 Quality assessment of the included studies using the quality assessment tool for cross-sectional studies and Newcastle–Ottawa Scale

Study ID	Year	Sample Representative of the national population	representation of the target population	Random sample	Minimal non-response bias	Direct data (participants)	Acceptable case definition	Study instrument reliability and validity	The same mode of data collection	Appropriate sample size	Summary on the overall risk of study bias
Aamir et al	2019	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Abdallah et al	2020	No	No	No	No	Yes	Yes	Yes	Yes	Yes	4–6 MR
Abshirini et al	2018	No	No	No	No	Yes	Yes	Yes	Yes	Yes	4–6 MR
Abshirini et al	2019	No	No	No	No	Yes	Yes	Yes	Yes	Yes	4–6 MR
Abtahi et al	2010	No	No	No	No	Yes	Yes	Yes	No	No	7–9 HR
Akhtar et al	2021	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	0–3 LR
Aldossari et al	2018	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	0–3 LR
Alfaqih et al	2018	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	4–6 MR
Al-Farsi et al	2010	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Al-Habori et al	2004	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	0–3 LR
Alkandari et al	2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Al-Shafaee et al	2011	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Al-Sharafi et al	2021	No	No	No	No	Yes	Yes	Yes	Yes	Yes	4–6 MR
Al-Sinani et al	2014	No	No	No	No	Yes	Yes	Yes	No	No	7–9 HR
Al-Zahrani et al	2019	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Amiri et al	2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Asadollahi et al	2015	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	0–3 LR
Auad et al	2022	No	No	No	No	Yes	Yes	Yes	Yes	Yes	4–6 MR
Bagheri et al	2016	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Bahijri et al	2020	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Basit et al	2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Bener et al	2009	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Dargham et al	2018	No	No	No	No	Yes	Yes	Yes	Yes	Yes	4–6 MR
Esteghamati et al	2014	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	0–3 LR
Gholizadeh et al	2018	No	No	No	No	Yes	No	No	Yes	No	7–9 HR
Hadaegh et al	2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	7–9 HR
Hallit et al	2020	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	4–6 MR
Hamoudi et al	2019	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Hariri et al	2021	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Hashemi et al	2022	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Johari et al	2022	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	0–3 LR
KazemiJaliseh et al	2017	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	7–9 HR

Table 1 (continued)

Study ID	Year	Sample Representative of the national population	representation of the target population	Random sample	Minimal non-response bias	Direct data (participants)	Acceptable case definition	Study instrument reliability and validity	The same mode of data collection	Appropriate sample size	Summary on the overall risk of study bias
Khalilzadeh et al	2015	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	4–6 MR
Khamseh et al	2021	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	0–3 LR
Malik et al	2005	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Meo et al	2020	No	No	No	No	Yes	Yes	Yes	Yes	Yes	4–6 MR
Meo	2021	No	No	No	No	Yes	Yes	No	Yes	Yes	7–9 HR
Meo	2021	No	No	No	No	Yes	Yes	Yes	Yes	No	4–6 MR
Mirmiran et al	2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	0–3 LR
Mirzaei et al	2020	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	7–9 HR
Mohammad et al	2021	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	0–3 LR
Najafipour et al	2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Rahmanian et al	2015	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	0–3 LR
Rahmati et al	2022	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	0–3 LR
Sadeghi et al	2015	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	0–3 LR
Vahid et al	2017	No	Yes	No	Yes	Yes	No	Yes	Yes	No	4–6 MR
Wahabi et al	2019	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR
Zahid et al	2008	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	0–3 LR

LR low risk, *MR* moderate risk, *HR* High risk

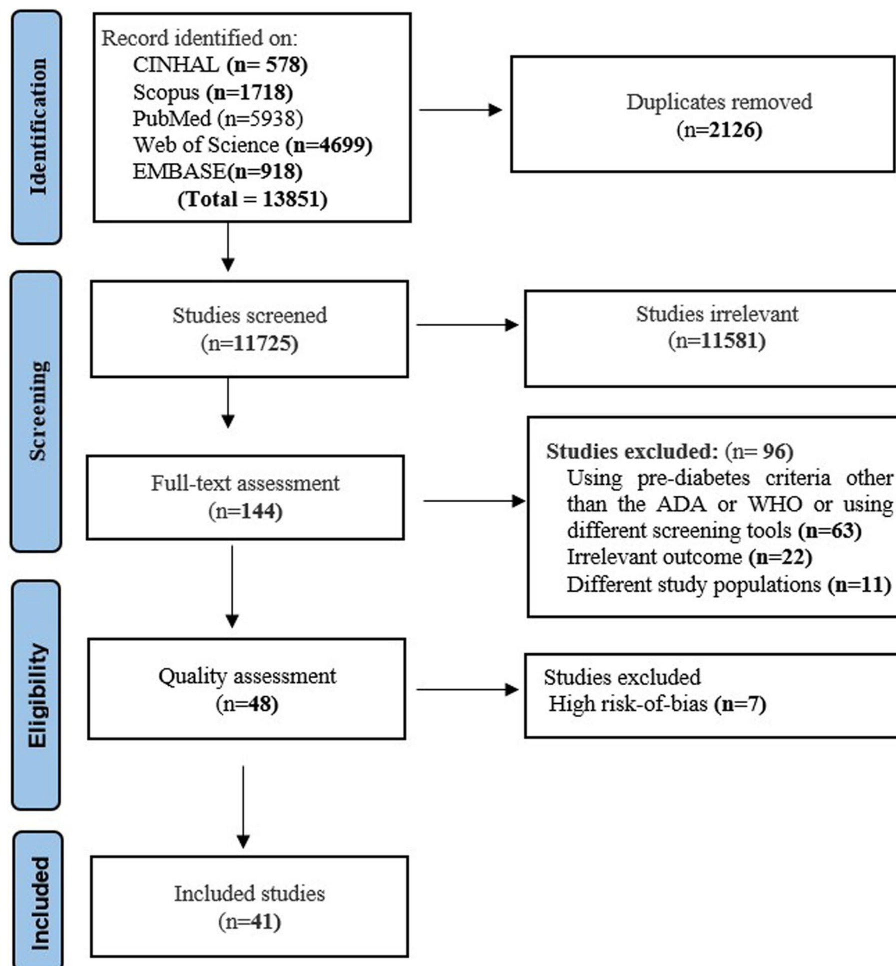

Fig. 1 Flowchart of search and screening results

In this systematic review, we observed significant variation in the prevalence of prediabetes across community-based studies. For instance, the highest prevalence was reported in Kuwait at 47.9%, while Yemen had the lowest at 2.2%. Additionally, the average age of the study populations varied widely, from a low of 32 years in Saudi Arabia to a high of 56.9 years in Iran. Among the 41 studies reviewed, 30 employed the ADA definition of prediabetes, 10 used the WHO definition, and three applied both definitions.

Most of the studies included in this review were community-based. Three of them were conducted in Saudi Arabia: one reported a prevalence of 18.8% among women, another reported 27.9% among men, and the third reported 15.1% among workers in the cement industry. Additionally, a study of university staff in Lebanon found a prevalence of 18.8%, while a study in Qatar reported a prevalence of 10.6% among women with PCOS.

Prediabetes risk factors

Table 3 illustrates that the studies reviewed on prediabetes prevalence did not evaluate a consistent set of risk factors. Each study examined a distinct combination of factors. While many studies concentrated on common risk factors such as sex, age, BMI, WC, blood pressure, and smoking—factors frequently linked with prediabetes—others focused on more specific factors including dietary habits, genetic predisposition, multiparity, and medical conditions like PCOS.

Sex

Twenty-four studies investigated the relationship between sex and the prevalence of prediabetes. Ten of these studies identified a statistically significant association, with most concluding that being male is a risk factor for prediabetes. However, two studies reported a higher prevalence among females. Five studies did not address

Table 2 Characteristics of the studies included in the review and their finding related to prediabetes ($n = 41$)

Author	Publication year	Type of the study	Study country	Diagnostic criteria	Study period	Population	Sex -Female (%)	Age—mean (years)	Sample size	Prevalence/ Incidence of PD (%)	CI	Quality assessment
Aamir et al. [18]	2019	Cross-sectional	Pakistan	WHO	April -Nov 2017	CB	46.5	45.2	18,856	10.9	10.5–11.4	LR
Abdallah et al. [19]	2020	Cross-sectional	Lebanon	ADA	Jan 2018—May 2019	University staff	55.2	48.4	397	22.9	18.9–27.4	MR
Abshirini et al. [20]	2019	Case–control	Iran	WHO	May-Oct 2014	Prediabetes and Control	66.0	47.7	297	NA	NA	MR
Abshirini et al. [21]	2018	Case–control	Iran	WHO	May-Oct 2014	Prediabetes and Control	50.0	47.7	300	NA	NA	MR
Akhtar et al. [22]	2021	Cross-sectional	Pakistan	WHO	Jan- March 2018	CB	58.0	NR	1447	21.4	19.3–23.6	LR
Aldossari et al. [23]	2018	Cross-sectional	Saudi Arabia	ADA	Jan—June 2016	CB males	0.0%	31.4	381	27.6	23.1–32.3	LR
Alfaqih et al. [24]	2018	Case–control	Jordan	WHO	April 2017 Feb2018	Clinic patients Case: Pre-DM Control: free	50.7	50.8	260	NA	NA	MR
Al-Farsi et al. [25]	2010	Cohort	Oman	ADA	2004-NR	Multipara women	100	NR	532	30 per1000 person-years	2.80–4.91	LR
Al-Habori et al. [26]	2004	Cross-sectional	Yemen	WHO\ADA	NR	CB	NR	50.5	498	2.2	1.1–3.9	MR
Alkandari et al. [27]	2018	Cross-sectional	Kuwait	WHO\ADA	March-Sep 2014	CB	62.7	36.4	2561	19.4	17.9–21.0	LR
Al-Shafaee et al. [28]	2011	Cross-sectional	Oman	ADA	NR	CB	62.7	NR	1313	35.0	32.4–37.6	LR
Al-Sharafi et al. [29]	2021	Cross-sectional	Yemen	ADA	May 2019-July 2021	CB	68.0	39.5	612	34.0	30.2–37.9	MR
Al-Zahrani et al. [30]	2019	Cross-sectional	Saudi Arabia	ADA	NR	CB Female	100.0	23.4	638	18.8	15.8–21.9	LR
Amiri et al. [31]	2017	Cross-sectional	Iran	ADA	2008 – 2010	CB	55.4	40.5	5568	23.6	22.5- 24.8	LR
Asadollahi et al. [32]	2015	Cross-sectional	Iran	WHO\ADA	2011–2012	CB	72.0	45.5	2158	7.8	7.2–8.3	LR
Auad et al. [33]	2022	Cross-sectional	Syria	ADA	Mar 2021 Oct 2021	CB	89.4	46.0	406	22.4	18.5 – 26.8	MR
Bagheri et al. [34]	2016	Case–control	Iran	ADA	May-Oct 2014	Prediabetes and Control	66.0	47.6	300	NA	NA	MR
Bahijri et al. [35]	2020	Cross-sectional	Saudi Arabia	WHO	July 2016-Feb 2017	CB	43.6	32	1403	18.4	15.6 – 19.6	LR
Basit, et al. [36]	2018	Cross-sectional	Pakistan	WHO	Feb 2016-Aug 2017	CB	56.1	43.8	10 800	14.4	13.7–15.1	LR

Table 2 (continued)

Author	Publication year	Type of the study	Study country	Diagnostic criteria	Study period	Population	Sex -Female (%)	Age—mean (years)	Sample size	Prevalence/ Incidence of PD (%)	CI	Quality assessment
Bener et al. [37]	2009	Cross-sectional	Qatar	ADA	Jan 2007- July 2008	CB	48.9	NR	1117	13.8	11.0 – 15.1	LR
Dargham et al. [38]	2018	Cross-sectional	Qatar	ADA	2017	PCOS women	100.0	30.7	676	10.6	7.6—11.9	MR
Esteghamati et al. [39]	2014	Cross-sectional	Iran	ADA	May—June 2011	CB	NR	NR	54,199	14.6	12.4–16.8	LR
Hallit et al. [40]	2020	Cross-sectional	Lebanon	ADA	May-Sep 2017	CB	55.4	NR	495	4.8	3.0–6.7	MR
Hamoudi et al. [41]	2019	Cross-sectional	United Arab Emirates	WHO	2012	National Emirati—Arab	NR	NR	797	11.4	9.3–13.8	LR
Hariri et al. [42]	2021	Cross-sectional	Iran	ADA	Oct 2016—Nov 2018	CB	54.5	41.6	30,498	30.8	30.2–31.3	LR
Hashemi et al. [43]	2022	Cross-sectional	Iran	ADA	May 2016 Aug 2018	CB	58.8	47.7	7629	25.7	24.7 – 26.7	LR
Johari et al. [44]	2022	Cross-sectional	Iran	ADA	2015–2016	CB	55.8	52.35	10,474	15.7	15.5–15.9	LR
Kazemi Jaliseh et al. [45]	2017	Case–control	Iran	ADA	NR	reproductive-aged women CASE: PCOS	100	27.7	1702	NA	NA	LR
Khalilzadeh et al. [46]	2015	Cross-sectional	Iran	ADA	July 2013- NR	CB	62.0	56.9	403	34.7	30.1–39.6	MR
Khamseh et al. [47]	2021	Cohort	Iran	ADA	2014–2020	Population-based	NR	NR	163,770	25.4	18.6–32.1	LR
Malik et al. [48]	2005	Cross-sectional	United Arab Emirates	WHO	Jan 1999 – Jan 2000	CB	57	40.9	5758	6.5	5.8–7.1	LR
Meo et al. [49]	2020	Cross-sectional	Saudi Arabia	ADA	Oct 2016—June 2017	Cement Industry Workers	0	37.3	186	15.1	10.2 – 21.0	M risk
Meo et al. [50]	2021	Case–control	Saudi Arabia	ADA	Oct 2019 Feb 2020	Cases: cricket players	0	33.5	500	NA	NA	MR
Mirmiran et al. [51]	2018	Prospective cohort	Iran	ADA	2006–2014	Coffee drinkers and normal people	55.0	NR	1878	5.3% per year	NR	LR
Mohammad et al. [52]	2021	Cross-sectional	Kuwait	ADA	Nov 2012—Oct 2017	CB	50.1	43.0	1238	47.9	58.8 – 64.3	LR
Najafipour et al. [53]	2015	Cohort	Iran	ADA	2010–2011	Population-Based	54.9	45.4 (SD 16.4 >W	5900	18.7	NR	LR

Table 2 (continued)

Author	Publication year	Type of the study	Study country	Diagnostic criteria	Study period	Population	Sex -Female (%)	Age—mean (years)	Sample size	Prevalence/ Incidence of PD (%)	CI	Quality assessment
Rahmanian et al. [54]	2015	Cross-sectional	Iran	ADA	NR	CB	54.3	NR	788	17.8	15.2- 20.6	LR
Sadeghi et al. [55]	2015	Cohort	Iran	ADA	2001–2008	CB	52.6	50.1	2980	32.3 per1000 person-year	29.7–35.1	LR
Vahid et al. [56]	2017	Case–control	Iran	ADA	NR	CB Case: pre-DM	58	48.0	414	NA	NA	MR
Wahabi et al. [57]	2019	Cohort	Saudi Arabia	ADA	NR	CB women only	100	32.6	407	35%	30.7–38.8	LR
Zahid et al. [58]	2008	Cross-sectional	Pakistan	WHO	March -July 2006	CB	64.7	44.2	2011	5.4	4.4–6.4	LR

LR low risk, *MR* moderate risk, *CB* community-based, *PCOS* Polycystic ovary syndrome, *NR* not reported, *NA* not available

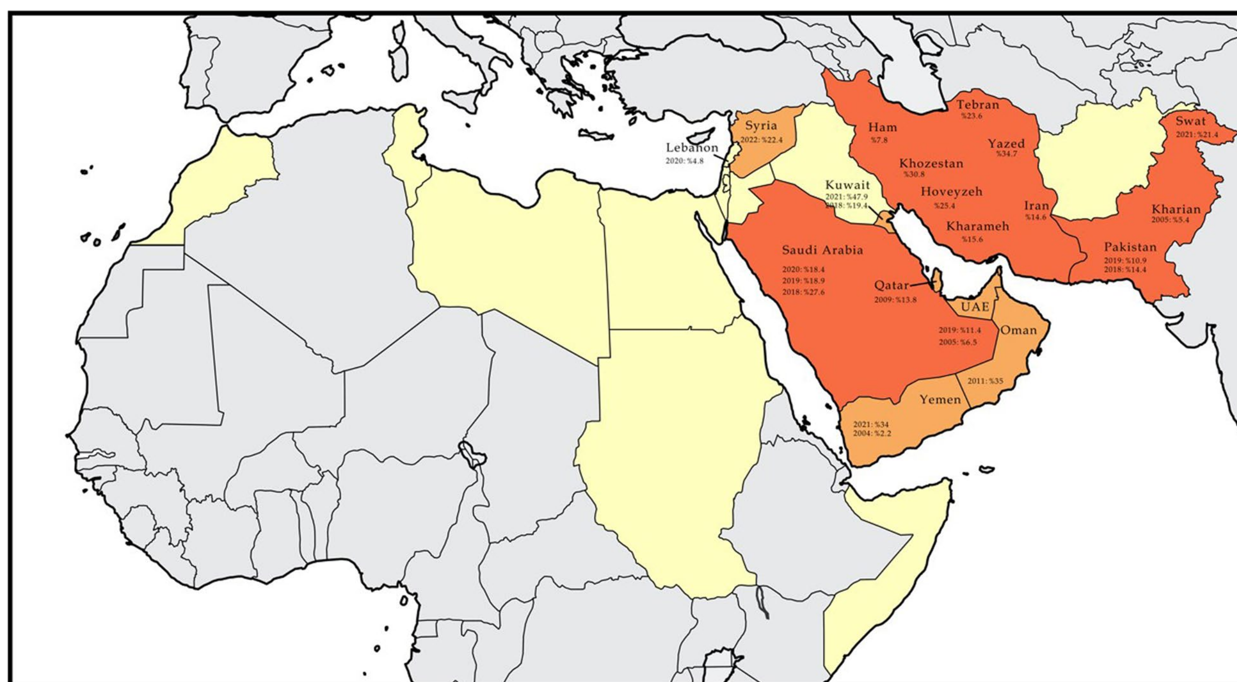

Fig. 2 Eastern Mediterranean countries with studies on the prevalence of prediabetes

this association, as their samples were exclusively male or female.

Age

The relationship between age and prediabetes was explored in 28 studies, with 25 of them finding a statistically significant association. There was variability in the age group with the highest prevalence, but most studies reported a notable increase in risk among young adults (aged 50 years or younger) across various countries.

Hypertension

Eighteen studies explored the relationship between hypertension and prediabetes. Fourteen of these studies identified hypertension as a significant risk factor for prediabetes, with two specifically highlighting high diastolic pressure as the key risk factor. Conversely, four studies found no significant association between hypertension and prediabetes.

Obesity and physical activity

The link between obesity and prediabetes was assessed using BMI and WC. Twenty-six studies investigated the relationship between BMI and prediabetes, with 22 finding a statistically significant association. Notably, one study indicated that BMI is a significant risk factor specifically among females. Additionally, 18 studies evaluated the connection between WC and prediabetes, with 14 reporting statistically significant findings. Moreover, six studies identified low physical activity as a significant risk factor for prediabetes. In one case–control study, prediabetes prevalence was notably lower among cricket players.

Smoking

Thirteen studies investigated the relationship between smoking and prediabetes, yielding mixed results. Five studies identified a significant relationship between smoking and prediabetes, while three studies found a higher prevalence of prediabetes among non-smokers. Two studies determined smoking to be a significant risk factor, with one specifically noting it as a risk factor among women. Conversely, eight studies found no significant association between smoking and prediabetes.

Residency, marital status, and family history

Seven studies examined the effect of residency on the risk of prediabetes. Four studies indicated that living in an urban area increases the risk of prediabetes, while three studies suggested that living in a rural area is associated with higher risk. Additionally, one study reported that rural residency poses a significant risk for men aged 40–49, whereas urban residency is a risk factor for women aged 30–39. Regarding marital status, seven studies found that being married is associated with a higher likelihood of prediabetes, and another seven

Table 3 Summary statistics for the prevalence of PD by risk factors for each study

Author, year	Statistical model	Study design	Sex	Age	HTN	BMI (kg/m2)	WC	Smoking	Physical activity	Family history	Education	Other associated factors
Hashemi et al. 2022 [43]	Multivariate	Cross sectional	Sig F > M	Sig Older age	Sig	Sig	Sig	Sig Among F	Sig	NR	NR	Married female Arab ethnicity Hypertriglyceri-demia
Johari et al., 2022 [44]	Univariate	Cross sectional	Sig M > F	Sig for (60–70) age group	Sig	NR	Sig	Sig N/S	NR	Sig	Sig	Living in rural Single individuals Unemployed Hypertriglyceri-demia Hypercholester-olemia Very high socio-economic
Auad et al., 2022 [33]	Multivariate	Cross sectional	NS	Sig with advanced age	NS	Sig	Sig Among F	NS	NR	Sig	NR	Married Hypercholester-olemia
Najafipour et al., 2015 [53]	Multivariate	Cohort	NR	NR	NR	NR	NR	NR	NR	NR	NR	
Meo et al.,2021 [50]	Multivariate	Case control	NR	NR	NR	NR	NR	NR	Sig	NR	NR	
Hariri et al., 2021 [42]	Multivariate	Cross sectional	Sig M > F	Sig 50–65 age group 35–49.9 age group	Sig	Sig Among obese	Sig	Sig N/S	NR	NR	Sig	Arab ethnicity Urban
Mohammad et al., 2021 [52]	Multivariate	Cross sectional	Sig M > F	Sig For (> 55) age group	NR	Sig Among obese	NR	NR	NR	NR	NR	
Akhtar et al., 2021 [22]	Multivariate	Cross sectional	NS	Sig Men (< 60 years)	Sig	NS	NR	NS	NR	Sig	NR	Living in urban areas
Khamseh et al., 2021 [47]	Multivariate	Cohort	Sig M > F	Sig	NR	Sig	Sig	Sig N/S	Sig	NR	Sig	Single individuals
Al-Sharafi et al., 2021 [29]	Multivariate	Cross sectional	NS	Sig 30–39 Age group	NS	Sig for OO	NS	NS	NR	Sig for sibling DM	NR	Khat chewing
Abdallah et al., 2020 [19]	Univariate	Cross sectional	Sig M > F	NR	NR	NR	NR	NR	NR	NR	NR	
Bahijri et al., 2020 [35]	Multivariate	Cross sectional	NR	NR	NR	NR	NR	NR	Sig	NR	NR	
Hallit et al.,2020 [40]	Multivariate	Cross sectional	NS	Sig	Sig	Sig	NR	NS	Sig	Sig	Sig	Alcoholic
Meo et al., 2020 [49]	Multivariate	Cross sectional	NR	Sig	NR	NS	NR	NR	NR	NR	NR	Cement industry workers

Table 3 (continued)

Author, year	Statistical model	Study design	Sex	Age	HTN	BMI (kg/m2)	WC	Smoking	Physical activity	Family history	Education	Other associated factors
Wahabi et al., 2019 [57]	Multivariate	Cohort	NR[a]	NS	Sig DBP	Sig	Sig	NR	NR	NR	NR	History of gestational diabetes
Al-Zahrani et al.,2019 [30]	Multivariate	Cross sectional	NR[a]	Sig	NR	Sig	Sig	NS	NR	NR	NR	Married
Abshirini et al., 2019 [20]	Univariate	Case–control	NR	NR	Sig	Sig	Sig	NR	Sig	NR	Sig	Low fiber intake High dietary acid load
Abshirini et al., 2018 [21]	Univariate	Case–control	NS	NS	NR	Sig	Sig	NR	Sig	NR	Sig	Low dietary phytochemical index
Aldossari et al., 2018 [23]	Multivariate	cross-sectional	NR[a]	Sig	NR	Sig	Sig	NS	NR	NR	Sig	Married Unemployed
Mirmiran et al., 2018 [51]	Multivariate	Cohort	NR	NR	NR	NR	NR	NR	NR	NR	NR	Non-coffee drinker
Alkandari et al., 2018 [27]	Multivariate	cross-sectional	NS	Sig	NS	Sig	NS	NR	NR	NR	NR	
Basit, et al., 2018 [36]	Multivariate	cross-sectional	NR	NR	NR	NR	NR	NR	NR	NR	NR	Rural men among the age group of 40–49 Urban females among the age group 30–39
Alfaqih et al., 2018 [24]	Multivariate	Case–control	NR	Sig	NR	Sig	Sig	NR	NR	NR	NR	Low serum adiponectin
Amiri et al., 2017 [31]	Univariate	cross-sectional	Sig M > F	Sig	Sig	Sig	NR	NR	Sig	Sig for Female	Sig High Edu increase	Married Hypertriglyceridemia Unemployed
Kazemi Jaliseh et al., 2017 [45]	Multivariate	Case–control	NR[a]	Sig For (< 40) Age group	NS	NR	NS	NR	NR	NR	NR	PCOS patients aged < 40
Vahid et al., 2016 [56]	Multivariate	Case–control	MD	MD	NR	Sig	NA	NA	NR	NR	NR	High pro-inflammatory diet
Bagheri et al. [34], 2016	Multivariate	Case–control	NS	NS	Sig	Sig	Sig	NR	Sig	NR	Sig with high education	Low VFL dietary pattern
Khalilzadeh et al.,2015 [46]	Univariate	cross-sectional	NS	NR	Sig DBP	NS	NR	NR	NR	NR	Sig	
Sadeghi et al., 2015 [55]	Multivariate	Cohort	NS	Sig	Sig	Sig	Sig	NA	NR	NR	Sig	Living in a rural, unhealthy diet, hypertriglyceridemia

Table 3 (continued)

Author, year	Statistical model	Study design	Sex	Age	HTN	BMI (kg/m2)	WC	Smoking	Physical activity	Family history	Education	Other associated factors
Rahmanian et al., 2015 [54]	Multivariate	cross-sectional	NS	Sig	NR	Sign in female	NR	NR	NR	NR	Sig	
Asadollahi et al., 2015 [32]	Multivariate	cross-sectional	NS	Sig	Sig	NS	Sig	Sig	NS	Sig	NR	Married Living in urban
Esteghamati et al., 2014 [39]	Multivariate	cross-sectional	NS	Sig 56–70	NR	NR	NR	NR	NR	NR	Sig	
Al-Shafaee et al.,2011 [28]	Univariate	cross-sectional	Sig M > F	Sig for > 45	NR	Sig for OO	NR	NR	NR	NR	NR	Married Hypertriglyceri-demia
Al-Farsi et al., 2010 [25]	Multivariate	Cohort	NR[a]	NR	NR	NR	NR	NR	NR	NR	NR	High parity
Bener et al.,, 2009 [37]	Multivariate	cross-sectional	NS	Sig	NR	NR	NR	NR	NR	NR	NR	
Zahid et al., 2008 [58]	Multivariate	cross-sectional	NS	Sig	NR	NR	NR	NR	NR	NR	NR	Hypertriglyceri-demia Low HDL
Malik et al., 2005 [48]	Multivariate	cross-sectional	Sig F > M	Sig	Sig	Sig	Sig	NR	NR	NR	NR	
Al-Habori et al.,2004 [26]	Multivariate	cross-sectional	Sig M > F	Sig	Sig	Sig	NR	NR	NR	NR	NR	Hyperlipidaemia

PD prediabetes, *NS* not significant, *NR* not reported, *F* Female, *M* Male, *OO* overweight and obese, *N/S* Non-smoker

[a] The study population was either male or female

studies reported that having a family history of prediabetes increases the risk.

Others

Thirteen studies identified low educational level as a significant risk factor for prediabetes, and eight studies found an association with hypertriglyceridemia. Additionally, high parity, unhealthy or pro-inflammatory diets, PCOS, not drinking coffee, a history of gestational diabetes, and working in cement manufacturing were also associated with an increased risk of prediabetes.

Discussion

The 41 studies reviewed revealed a wide range of prediabetes prevalence, ranging from 2.2% to 47.9%, depending on the population, period, and sample size. This contrasts with the reported prevalence of 15.4% in North America and the Caribbean, and 3% in South-East Asia in 2017 [6]. The highest prevalence was observed in Kuwait in 2021, at 47.9% [52], with the studied population having an average age of 43 years. Obesity and being over the age of 55 were identified as significant risk factors for prediabetes in this population. The lowest prevalence was recorded in Yemen in 2004 [26], where males, obesity, hypertension, and dyslipidemia were identified as risk factors for prediabetes. These findings suggest an increasing trend in prediabetes prevalence over time, in line with the International Diabetes Federation's projection that the number of people with impaired glucose tolerance (IGT) will reach 80.5 million by 2045 [59]. This trend is also consistent with a previous systematic review in EMR, which highlighted variation in prediabetes prevalence across countries and over time [14]. These results underscore the importance of early detection and intervention, as elevated glucose levels can go undetected for years. Addressing the economic, environmental, and political challenges in the region, along with improving healthcare services—especially primary healthcare—could help mitigate this issue and its associated risk factors.

Prediabetes prevalence also varied within different regions of the same country. For instance, in Iran, prevalence ranged from 7.8% in Ilam Province to 34.7% among Zoroastrians in Yazd Province. Such disparities may be attributed to variations in risk factors across geographical areas, social behaviors, nutritional conditions, or differences in study methodologies. Similarly, significant differences in results were observed in the Gulf region, known for its rapid economic growth due to oil reserves, urbanization, and improved living conditions [60]. Factors such as the presence of international fast-food chains, easy access to cars, increased consumption of processed foods, and a more sedentary lifestyle all contribute to prediabetes risk [61]. In our review, the highest prevalence rates were recorded in Kuwait (47.9%), Oman (35%), and Saudi Arabia (27.6%, 18.4%, and 15.1%), while the lowest rates were found in the United Arab Emirates (11.4% and 6.5%) and Qatar (13.8%).

Over half of the research on prediabetes in the region comes from Iran, Pakistan, and Saudi Arabia. A study on the geographic distribution of biomedical and health research in the EMR found that five countries—Iran, Egypt, Pakistan, Tunisia, and Saudi Arabia—accounted for 80% of all published research in the region [62]. Notably, no publications were included from Afghanistan, Djibouti, Sudan, Somalia, Tunisia, Morocco, Mauritania, Egypt, Iraq, Libya, or Palestine. Some of these studies were excluded based on exclusion criteria, while others may not have been published due to regional instability, lack of freedom, limited funding, brain drain, or the challenges of publishing locally relevant research [63].

Age is a key factor in prediabetes prevalence, with the risk increasing significantly in younger adults (aged 45 or younger) across most countries, and peaking in the 50–60 age group. For example, in Iran, prediabetes prevalence was highest among individuals aged 60–70, while in Kuwait, it decreased significantly among this age group. The aging process affects energy homeostasis, carbohydrate metabolism, insulin release, and insulin resistance [61]. However, individual differences in genetics, lifestyle, and overall health mean that aging affects populations differently [61], which may explain the lack of significant correlations in some studies.

The EMR has some of the highest obesity rates in the world, a trend that has coincided with decreasing physical activity and increasing body weight due to modernization and technological advancements [64]. Unsurprisingly, prediabetes prevalence correlates with high rates of obesity, hypertriglyceridemia, and sedentary lifestyles. These risk factors for diabetes are well-documented in the literature. Consequently, prediabetes should not be viewed in isolation; rather, its risk factors, which significantly influence its onset and prognosis, should be monitored. High blood pressure, prediabetes, and their coexistence are major risk factors for cardiovascular disease (CVD). Globally, 1 in 10 people have both prehypertension and prediabetes. In our review, more than half of the studies identified hypertension as a risk factor for prediabetes [65–67]. This aligns with the well-established hypothesis that hyperinsulinemia and insulin resistance contribute significantly to hypertension in individuals with obesity and metabolic syndrome [68, 69]. These findings could help healthcare workers (HCWs) identify individuals at high risk of developing both high blood pressure and prediabetes, thus reducing their risk of type 2 diabetes and CVD.

Our data also suggest that a family history of diabetes, particularly in first-degree relatives, is strongly associated with prediabetes development, likely due to genetic factors and shared lifestyle habits. Furthermore, educational attainment can influence health behaviors, with lower levels of education often associated with poorer health outcomes. Many studies indicated that individuals with lower education levels were less likely to adopt healthy lifestyles, possibly due to poor compliance with appropriate diets and exercise routines [70]. Finally, while smoking is a well-known risk factor for chronic noncommunicable diseases, its relationship with prediabetes remains debated. Some researchers found smoking to be a risk factor for prediabetes, while others reported a negative association [71], consistent with our findings.

Generally, urban populations exhibit more risk factors for prediabetes than rural populations, likely due to differences in lifestyle and nutritional habits. Prediabetes prevalence is often higher in urban areas. Regarding the relationship between marital status and prediabetes, most studies in our review found a significant association, indicating that being married increases the likelihood of developing prediabetes.

Our review of prediabetes in the EMR highlighted the most commonly reported risk factors, many of which are modifiable and could be prevented or delayed. This offers an opportunity to target public health interventions toward these factors and provides a guide for future research. Additionally, there is an urgent need to promote healthy diets and physical activity in the region. However, this study has several limitations. First, the review may be subject to language publication bias, as it was limited to English-language publications. Second, we only included studies that used the WHO and ADA criteria for venous blood glucose, excluding those that may have used capillary blood. Finally, the findings are based on research from only half of the region's countries, with most data coming from Iran, Saudi Arabia, and Pakistan. No data were available from Bahrain, Palestine, Egypt, Libya, Tunisia, Morocco, Sudan, Somalia, Djibouti, Afghanistan, or Iraq, so caution is necessary when generalizing the findings to the entire region.

Conclusions

The prevalence of prediabetes varies across countries in the EMR region, reaching over 40% in some nations, making it one of the regions with the highest rates of prediabetes. Commonly reported risk factors for prediabetes in the EMR include age, gender, BMI, WC, and high blood pressure, with studies often identifying males and individuals aged 30 to 50 as being at higher risk. Additional factors associated with prediabetes include physical inactivity, low educational attainment, dyslipidemia, and family history.

To reduce the prevalence of prediabetes, we recommend raising awareness about the condition, its complications, and its risk factors among HCWs in the region. This will help ensure that screening and appropriate management of at-risk individuals are taken seriously. The risk factors identified in this study are similar to those for diabetes, suggesting that addressing these factors would benefit both conditions. Prevention and control efforts should prioritize the most common risk factors, such as high blood pressure and obesity, in the region.

Many countries in the EMR lack adequate data and research on the burden of prediabetes. Therefore, we encourage these nations to study the issue and its risk factors as a critical first step in planning for prediabetes prevention and control.

Abbreviations

ADA American Diabetes Association
BMI Body Mass Index
EMR Eastern Mediterranean Region
HbA1c Haemoglobin A1c
HCWs Healthcare workers
IGT Impaired glucose tolerance
T2DM Type 2 diabetes
WC Waist Circumference
WHO World Health Organization

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Authors' contributions
ZN led the review, and LS and BeM assisted with its design and coordination. ZN and BeM peer-reviewed the search strategies for the review. MZ conducted the literature searches, imported records, and removed duplicates. MZ, LS, BaM, BeM, and ZN screened the records, extracted the data, and appraised the quality of the evidence. MZ led the collection of full-text articles. BeM and ZN led the analysis and interpretation of data. MZ and ZN led the writing of the paper. All authors were responsible for critically revising the manuscript for important intellectual content. The final manuscript was read and approved by all authors.

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Data availability
The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

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