

# BMJ Open Prevalence of and risk factors for diabetes mellitus in the school-attending adolescent population of the United Arab Emirates: a large cross-sectional study

Caroline Barakat,<sup>1</sup> Susan Jamuria Yousufzai ,<sup>1</sup> Alison Booth,<sup>2</sup> Lenka Benova<sup>3</sup>

**To cite:** Barakat C, Yousufzai SJ, Booth A, *et al.* Prevalence of and risk factors for diabetes mellitus in the school-attending adolescent population of the United Arab Emirates: a large cross-sectional study. *BMJ Open* 2021;**11**:e046956. doi:10.1136/bmjopen-2020-046956

► Prepublication history for this paper is available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2020-046956>).

Received 13 November 2020  
Accepted 01 September 2021



© Author(s) (or their employer(s)) 2021. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

<sup>1</sup>Faculty of Health Science, Ontario Tech University, Oshawa, Ontario, Canada

<sup>2</sup>London School of Hygiene and Tropical Medicine Faculty of Epidemiology and Population Health, London, UK

<sup>3</sup>Department of Public Health, Institute of Tropical Medicine, Antwerpen, Belgium

## Correspondence to

Caroline Barakat;  
[caroline.barakat@ontariotechu.ca](mailto:caroline.barakat@ontariotechu.ca)

## ABSTRACT

**Objectives** The prevalence of diabetes has reportedly increased among adolescents in low-income and middle-income countries of the Middle East and may be linked to social, demographic and economic contextual factors. This study aimed: (1) to estimate the prevalence of self-reported diagnosis of diabetes in the adolescent population of the United Arab Emirates (UAE); (2) to assess differences in the prevalence based on gender and (3) to identify other characteristics of those with diabetes including parental marital status, smoking/illegal drug use, quality of life and nationality.

**Design** A secondary data analysis was performed on data from the National Study of Population Health in the UAE, conducted between 2007 and 2009.

**Setting** Large cross-sectional population-based survey study.

**Participants** Survey was administered to a stratified random sample of 151 public and private schools from the UAE, across 7 emirates. 6365 school-attending adolescents (12–22 years; mean=16 years) participated.

**Outcomes** Multivariable logistic regression analysis was used to examine the relationships between diabetes diagnosis and characteristics of participants after adjusting for confounding from other predictors.

**Results** The overall prevalence of self-reported diabetes was 0.9% (95% CI 0.7% to 1.2%) and was higher in males 1.5% (95% CI 1.0% to 2.1%) than females 0.5% (95% CI 0.3% to 0.8%), ( $p<0.001$ ). Children of parents who were not currently married had more than twice the odds of self-reporting diabetes ( $p=0.031$ ) compared with those with married parents. Adolescents who reported ever smoking/using illegal drugs had more than three times the odds of diabetes ( $p<0.001$ ).

**Conclusion** We found a positive association between certain characteristics of adolescents and their diabetes status, including male gender, parental marital status and smoking/illegal drug use. The high prevalence of smoking/illegal drug use among those reporting a diagnosis of diabetes suggests the need for behavioural and mental health interventions for adolescents with diabetes, as well as strong parental support and involvement.

## Strengths and limitations of this study

- This cross-sectional study allowed for data collection of a large population-based sample of adolescents who reside in the seven emirates of the United Arab Emirates (UAE).
- This study contributed to the limited data on the prevalence of diabetes diagnosis among adolescents from the UAE and highlighted potential predictors.
- The results of this study can be used to highlight vulnerable groups where interventions and increased screening may be beneficial.
- The temporality of the outcome vis-a-vis the exposures cannot be established, precluding any causal inference due to the cross-sectional design of this study.
- Measurement of diabetes in this study was self-reported and we did not assess other essential physiological predictors.

## INTRODUCTION

Diabetes mellitus, also referred to as ‘diabetes’, is a complex endocrine disorder and multifactorial disease, involving the interaction of genetic, behavioural and environmental risk factors.<sup>1</sup> It is considered one of four major chronic non-communicable diseases (NCDs), among cardiovascular diseases, cancers and chronic respiratory diseases.<sup>2</sup> Indeed, worldwide it is known as a public health concern due to an increase in associated risk factors, premature death and its substantial economic loss for individuals, families and health systems.<sup>2,3</sup> Young individuals in particular are becoming targets of intervention as they are impacted by both main forms of diabetes, specifically type 1 (T1D) and type 2 (T2D). T1D has been commonly witnessed as a prevalent endocrine metabolic disorder affecting children and adolescents across the globe,<sup>4</sup> especially in high-income and

upper-middle-income countries.<sup>5</sup> Recent worldwide estimations indicate that, at least 600 900 children under 15 are living with T1D, while the prevalence is almost double (1 110 100) among individuals under 20 years.<sup>5</sup> On the other hand, T2D accounts for 90% of global diabetes cases (463 million people).<sup>6</sup> Although it was once regarded as predominantly a disease affecting the middle-aged and older people, research shows a gradual decline in the age of onset of pre-diabetes and T2D diagnosis.<sup>3 5 7</sup> In fact, the global burden of diabetes is projected to increase to 578 million in the next decade,<sup>6</sup> which may be correlated to the problematic changes coinciding with practices during adolescence.<sup>5 6</sup> However, reliable data for current global T2D estimates among children and adolescents are sparse.<sup>8</sup>

A special focus on identifying factors behind the aetiology of this epidemiological shift, particularly T2D, across adolescence is critical as it is a period of early habit formation and an opportunity to reduce the risk of diabetes expression from modifiable risk factors such as obesity and sedentary behaviour.<sup>9</sup> Current literature indicates that preventative measures for T1D remain unsuccessful and risk factors are unknown.<sup>3</sup> However, some research suggests an interplay of modifiable and nonmodifiable risk factors associated with T2D.<sup>1 3</sup> Aside from the highly inheritable disposition of the disease,<sup>1</sup> factors such as rapid economic developments aligned with changes in nutrition, exposure to environmental pollutants, low vitamin D levels, breastfeeding practices<sup>4</sup> and epigenetic changes associated with an adverse intra-uterine environment have been identified.<sup>9 10</sup> These risk factors have been attributed to the increase in prevalence of diabetes among children and adolescents living in Asia<sup>10</sup> and regions of the Middle East and North Africa (MENA).<sup>4</sup> Indeed, both forms of diabetes (T1D and T2D), including an increased risk for pre-diabetes, are being found among children and adolescents from the MENA region.<sup>4 11–14</sup> Currently, the MENA has the highest world-age standardised diabetes prevalence (12.2%).<sup>8</sup> Rapidly low-income and middle-income countries of the MENA contributing to this growing ‘epidemic’ includes the United Arab Emirates (UAE) in particular, which currently has a prevalence of 15.4% (for individuals 20–79 years old).<sup>8</sup> This prevalence may increase as result of a growing incidence of diabetes in children and adolescents living in the UAE.<sup>11–13</sup>

The UAE is composed of seven emirates situated in the Arabian Gulf peninsula consisting of, Abu Dhabi (AUH), Ajman, Dubai, Fujairah, Ras Al Khaimah, Sharjah and Umm Al Quwain. The federation has experienced tremendous economic growth over the last few decades,<sup>14</sup> which has attracted an influx of migrant workers, and influenced an increase in medical tourism, along with complications of a growing multiethnic and young population.<sup>15</sup> Expatriates make up approximately 88% of the total population (9.89 million) as of 2020, while children (0–14) and youth (15–24) account for 14.20% and 12.70% of the population, respectively.<sup>16</sup> In fact, the

UAE is composed of a large migrant population, many of whom come from countries with high prevalence of diabetes, particularly from South Asia.<sup>10 17</sup> Ethnicity has been recognised as a key determinant associated with diabetes diagnosis in relation to a positive family history.<sup>1</sup> This predisposition may be further augmented by the changing socioeconomic dynamic of the region, and subsequently lead to an increase in diabetes prevalence.<sup>17</sup>

While the economic diversification strategies employed in the UAE have enhanced the living conditions of its society, it may have concomitantly influenced behavioural health risks; especially among vulnerable populations.<sup>15 18 19</sup> Aligned with its rapid economic development and urbanisation in the 21st century, these social and environmental changes have influenced some of the key modifiable risk factors for diabetes among children and adolescents, such as physical inactivity, increased intake of refined carbohydrates and consequentially an increase in obesity.<sup>19–21</sup> The nutritional changes may be indicative of a ‘westernised’ transition in diet trends across the UAE, consisting of high-fat content, free sugars and sodium levels, from a previously more high-fibre content and low in fat, traditional diet.<sup>21</sup>

There is evidence to suggest that inhabitants of rapidly industrialising populations lack the metabolic capacity to deal with such changes within a short time.<sup>22 23</sup> Adolescents in particular are sensitive to metabolic changes during puberty<sup>12</sup> and heavily influenced by social and physical environmental changes.<sup>19</sup> These compounding factors may be associated with the high prevalence of pre-diabetes and T2D (5.4% and 0.87%, respectively) among overweight and obese Emirati school children and adolescents (11–17) in Sharjah.<sup>11</sup> Indeed, the burgeoning dynamic of viral nutritional practices in Arab countries are promoting the aetiological expression and incidence of diabetes among adolescents, as seen in Saudi Arabia.<sup>4 24</sup> These trends are dependent on improved measures and monitoring of risk factors among adolescents as predictions of early indication and prevention.<sup>14</sup>

While there are calls to increase screening, diagnosis and treatment of diabetes at younger ages, both in the UAE and globally,<sup>25</sup> the current lack of literature surrounding the epidemiology of diabetes in young populations poses a difficulty in making this a public health priority. Globally, and specifically in the UAE, the vast majority of research on diabetes prevalence, incidence, and risk factors refer to adults.<sup>8 26</sup> A recently published review of 24 epidemiological studies conducted in the UAE, reported only one recent study on adolescents.<sup>11 26</sup> Earlier findings on the emergence of T1D and early-onset T2D in the paediatric and adolescent population were reported in the UAE, over a decade ago,<sup>12</sup> and no studies to our knowledge have estimated the prevalence of diabetes in the Emirati and expatriate adolescent population across seven emirates of the UAE.

The impacts of this growing epidemic among the UAE adolescent population is of critical relevance for varying reasons. Early onset of T2D in adolescents can

substantially decrease life expectancy and can increase the risk of chronic complications during adulthood.<sup>1</sup> Moreover, managing diabetes in childhood and adolescence has been linked with poor self-esteem, negative impacts on mental health, and generally, a poor quality of life (QoL) for both adolescent patients and their caregivers.<sup>27–29</sup> Studies have found that adolescent diabetic patients are more likely to have psychological problems with significantly increased risk of depression, especially among females.<sup>27–30</sup> Evidence also suggests a correlation between experience of distress and trust put in parents by adolescents to handle their diabetes.<sup>30</sup> These challenges, in addition to the extensive psychological and emotional changes quite commonly experienced during adolescence, can increase the risk of negative health behaviours, such as substance abuse and poor diabetic control, commonly witnessed among adolescents.<sup>19</sup> However, there are a lack of studies placing emphasis on addressing the influence of sociocultural and behavioural factors on diabetes management and the impact they have on adolescents' QoL, especially in the UAE and MENA region.<sup>4</sup>

Particularly concerning is the majority of studies reporting a higher diabetes prevalence among female adolescents compared with their counterparts.<sup>31–32</sup> Sex and gender differences are important in the epidemiology and health outcomes associated with NCDs such as diabetes.<sup>33</sup> Diabetes among females during adolescence can increase the risk of developing gestational diabetes, which is associated with complications during birth and foetal morbidity.<sup>9–34</sup> This can also raise the risk of childhood onset diabetes in offspring, generating an intergenerational cycle of ill health.<sup>34</sup> However, there is a lack of consistency and discrepancy on the association between sex and gender-related risk factors and adolescent diabetes, and this relationship is widely understudied among the UAE adolescent population.<sup>27–35</sup>

Accordingly, this study aimed to examine and characterise the diagnosis of diabetes among adolescents in the UAE. The primary objective of this study was to estimate the prevalence of self-reported diagnosed diabetes among the school-attending adolescent population. The secondary objectives were to assess differences in the prevalence of diabetes based on participants' demographic and socioeconomic profiles, using the presenting characteristics, including gender, parental marital status, smoking/illegal drug use, QoL and nationality (expatriate vs Emiratis) of adolescents with diabetes.

## MATERIALS AND METHODS

This study used data from the National Study of Population Health in the UAE, conducted between 2007 and 2009 by researchers at Zayed University, with the support of the UAE Ministry of Education (MOE). The aim of the study was to investigate the health status of the adolescent population in the UAE. This large-scale cross-sectional survey was administered to a stratified random

sample of 147 public and private schools from 9 regions of the UAE, located across all the seven emirates. Schools were selected randomly by lottery using a 2005–2006 list of schools from the UAE MOE. The educational zone of the school that the participant attended categorised the location of residence into one of nine geographical regions: city of AUH, western region of AUH, Al Ain AUH, Dubai, Sharjah, Ajman, Ras al-Khaimah, Fujairah and Umm al-Quwain. One class from each of grades 10, 11 and 12 was randomly selected from 52 public and 44 private schools that participated. All parents or guardians of the school-attending adolescent population were sent detailed letters of the study information, highlighting the aims and methodology of the research and requesting signed consent 2 days prior to the administration of the survey. In total 6365 adolescents who range in age between 12 and 22 years, were included in the study. The questionnaire consisted of two modules: the first module was assigned to be completed with parents/guardians and the second one was individually completed by students in the classroom. Data from the latter were used in this study. This module collected self-reported information on health behaviours, lifestyle, medical diagnoses, perception of QoL and basic demographic and socioeconomic data (see Barakat-Haddad<sup>15</sup> for more detailed information).

## Patient and public involvement

The development of the research question and outcomes were not informed by patient priorities, experiences and preferences. To maintain a uniform survey procedure across the emirates, several workshops were conducted to train social workers employed by the MOE on the administration of the survey, emphasising the importance of accurate and consistent reporting. Social workers were trained to administer the first component of the survey to participants from three classes from each selected school during a spare period in a classroom setting. The second component was sent home with the participants overnight to seek parental assistance with completion.

## Outcome

The outcome in this analysis was self-reported diagnosed diabetes. Participants were asked whether they were ever told by a doctor or health professional that they had a health condition. The diabetes status was determined as a binary variable obtained from responses in the questionnaire that indicated being diagnosed with diabetes. No distinction between T1d and T2D was made.

## Exposures

For the secondary aim of this study, we focused on investigating whether the prevalence of diabetes differed based on gender. In addition, we investigated three self-reported characteristics thought to be indicative of one's psychological well-being. They were parental marital status, perception of QoL and smoking/illegal drug use. Parental marital status, classified as married or

other (including separated, divorced and widowed), was examined due to evidence suggesting the importance of a stable and supportive environment on one's mental and physical health during childhood and adolescence.<sup>36 37</sup> In addition, an individual's perceived QoL could determine a need for support among those with diabetes. This variable was derived from a question in the survey which asked participants how they felt about life in general over the past 5 years. Responses were first recorded on a 7-point Likert scale and then recoded into a binary variable, below 5 (poor) and 5 or above (good). Smoking and/or use of illegal drugs are thought to be lifestyle indicators, potentially capturing negative coping mechanisms. Respondents were characterised as reporting ever smoked cigarettes, tobacco, shisha or midwakh, or if they used illegal drugs such as marijuana, hashish or cocaine. Other important characteristics were the adolescent's age in years and nationality (Emirati or expatriate).

### Analysis

Descriptive and multivariable analyses were conducted in Stata IC V.13. First, we estimated prevalence with 95% CIs accounting for sampling design by using the `svyset` function (weights, clusters=schools/classes and stratification by region). Crude ORs and corresponding p

values were then computed to estimate the effect of each characteristic on the outcome (self-reported diagnosed diabetes). Multivariable logistic regression analysis was then used to examine the relationship between key variables under study after adjusting for confounding from other predictors.

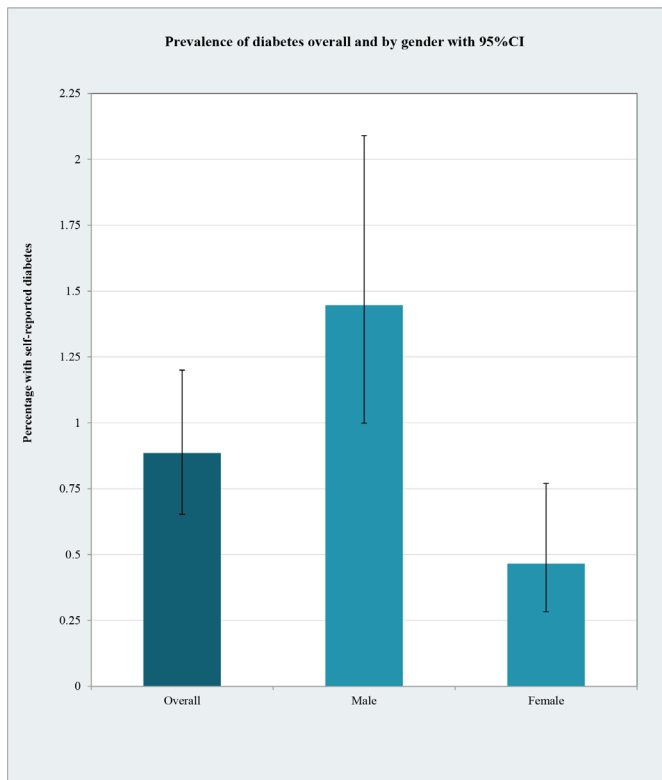
## RESULTS

### Descriptive results

This analysis is based on responses from a national representative sample of 6365 adolescents who resided in the UAE. A slightly higher proportion of the sample were females (54.3%). Age of the sample varied from 12 to 22 years. Over half were aged 15–17 years and the mean age was 16 years. [Table 1](#) shows the characteristics of the sample in relation to predictors of interest overall and by diabetes status. Background characteristics showed that the vast majority of the sample reported having married parents (85.5%). Overall, 78.2% reported having a good QoL in the preceding 5 years. Less than a fifth of adolescents reported smoking and/or the use of illegal drugs (16.4%). The overall prevalence of self-reported diabetes was 0.9% (95% CI 0.7% to 1.2%) ([figure 1](#)). Stratified by

**Table 1** Distribution and sociodemographic profile of the sample based on characteristics of adolescent participants that reside in the United Arab Emirates and self-reported diagnosis of diabetes (n=6365)

	n	Overall	Self-reported diagnosed diabetes		
			Yes	No	Missing
		6365	55	6159	151
<b>Exposures</b>					
Gender	Male (%)	43.9	70.9	43.1	63.6
	Female	54.3	29.1	55.5	17.9
	Missing	1.8	0.0	1.4	18.5
Age (years)	Mean	16.2	16.4	16.2	16.5
	Median	16.0	16.5	16.0	16.5
	IQR	15–17	15–17	15–17	16–17
	Range	12–22	14–19	12–22	14–21
	Missing (%)	4.5	12.7	4.1	15.2
Nationality	Emirati (%)	48.2	54.6	48.6	30.5
	Expatriate	49.6	43.6	49.6	51.0
	Missing	2.2	1.8	1.8	18.5
Current parental marital status	Married (%)	85.5	70.9	86.0	72.2
	Other	11.5	27.3	11.4	9.3
	Missing	3.0	1.8	2.6	18.5
Quality of life	Good (%)	78.2	65.5	78.9	53.6
	Poor	19.9	32.7	19.8	19.9
	Missing	1.9	1.82	1.3	26.5
Smoking/illegal drug use	No (%)	80.4	52.7	81.2	60.3
	Yes	16.4	41.8	15.9	27.8
	Missing	3.2	5.5	2.9	11.9



**Figure 1** Per cent proportion of overall sample and each gender reporting a diabetes diagnosis.

gender, this prevalence was significantly ( $p < 0.001$ ) higher in males than females, 1.5% (95% CI 1.0% to 2.1%) and 0.5% (95% CI 0.3% to 0.8%), respectively. Among those

with diagnosed diabetes, 12.7% were missing information on age.

### Crude and multivariable analysis

Table 2 shows the results of both crude and multivariable analysis examining the association between exposures and outcomes before and after adjusting for other factors. At a crude level all variables in table 2 were associated with diabetes status other than age group and nationality. After adjusting for all other variables in the model, gender, parental marital status, smoking/illegal drug use, still showed strong evidence of being associated with diabetes. In adjusted analysis, females had 67% lower odds of diabetes compared with males, an association that remained highly significant ( $p = 0.007$ ). Neither age nor nationality appeared to be significant predictors of diabetes in the multivariable model. Children of parents who were not currently married had more than twice the odds of self-reporting diabetes ( $p = 0.031$ ) compared with those with married parents. Of the adolescents who reported a diabetes diagnosis, 41.8% reported smoking/illegal drug use, and had more than three times the odds of diabetes ( $p < 0.001$ ).

### DISCUSSION

The burden of diabetes is growing in the UAE, including among the adolescent population, thus having a consequential impact on healthcare and complications for future generations.<sup>13</sup> Adolescence is a period that involves extensive physical, psychological and emotional

**Table 2** Associations between characteristics of school-attending adolescent population and self-reporting a diabetes diagnosis

Characteristics		n	Univariable			Multivariable*		
			OR	95% CI	P value	OR	95% CI	P value
n=5729								
Gender	Male	2695	(ref)	–	–	(ref)	–	–
	Female	3434	0.32	0.17 to 0.60	<0.001	0.43	0.23 to 0.79	0.010
Parental marital status	Married	5294	(ref)	–	–	(ref)	–	–
	Other	717	2.90	1.59 to 5.28	<0.001	2.19	1.08 to 4.43	0.031
Smoking/illegal drug use	No	5025	(ref)	–	–	(ref)	–	–
	Yes	1005	4.04	2.32 to 7.01	<0.001	3.06	1.84 to 5.08	<0.001
Quality of Life	Good	4893	(ref)	–	–	(ref)	–	–
	Poor	1238	1.99	1.09 to 3.64	0.026	1.77	0.90 to 3.49	0.095
Age group (years)	≤15	1985	(ref)	–	–	(ref)	–	–
	16	1742	0.81	0.32 to 2.01	0.650	0.82	0.33 to 2.05	0.668
	≥17	2226	1.53	0.75 to 3.15	0.240	1.07	0.51 to 2.25	0.848
	Missing	254	2.67	1.34 to 11.20	0.013	3.15	0.99 to 10.03	0.052
Nationality	Emirati	3023	(ref)	–	–	(ref)	–	–
	Expatriate	3079	0.78	0.45 to 1.36	0.382	0.72	0.37 to 1.39	0.320

n may vary due to missing data.

\*Multivariable model adjusted for all variables listed.



changes,<sup>15</sup> which can influence gender differences in health behaviours, and health outcomes associated with risk of diabetes.<sup>27</sup> In addition, a disease that involves multiple lifestyle and psychosocial changes in behaviour may further compound an already dynamic period.<sup>19</sup>

This is the first study to investigate differences between diabetes prevalence and between the genders among a large population of school-attending adolescents in varying regions of the UAE. Multiple characteristics were positively associated with reporting a diagnosis of diabetes among the adolescent study population, including, parental marital status, ever having smoked or used illegal drugs and male gender. Our finding that males were significantly more likely to self-report diabetes than females conflicts with evidence on gender-specific diabetes prevalence rates in the MENA region, with most research showing that the prevalence of T2D<sup>38–40</sup> and the incidence rates of T1D are higher among female children and adolescents.<sup>41 42</sup> However, our findings are consistent with a study in Kuwait conducted by Moussa *et al*<sup>35</sup> among a random sample of school children and adolescents.<sup>35</sup> The estimated prevalence of diabetes in our study sample was 1.5% (95% CI 1.0% to 2.1%) for males and 0.5% (95% CI 0.3% to 0.8%) for females. Our prevalence estimates were comparatively higher than data for T2D found in the Kuwait study, yet were in line with findings showing a higher prevalence rate of diagnosis in males than females (aged 6–18 years) of 47.3/100 000 (95% CI 28.7 to 65.8) and 26.3/100 000 (95% CI 14.8 to 37.8), respectively. When considering age, Moussa *et al*<sup>35</sup> found that the highest prevalence was reported for the age group 14–18 (46.8 cases per 100 000 population) in male and females combined. This indicates that the adolescent population may be at heightened risk, aligned with the findings in this study. The higher incidence rate of diabetes diagnosis during these ages may also be due to biological risk factors associated with the temporary evolution of insulin resistance during pubertal maturation, indicating a clear need for diabetes surveillance among this population.<sup>35</sup>

It is important to note that we were not able to define the type of diabetes the adolescent population self-reported in this study. However, it is likely that the self-reported cases of diabetes in this study consist of adolescents with T1D and those with T2D; with T1D constituting the majority of such cases. In addition, since a diagnosis of T1D in adolescents is more likely, and the overall prevalence of self-reported diabetes diagnosis is low in this study, we may speculate that the majority of diabetes cases could be type 1 patients. Comparatively, the prevalence of diabetes in our study sample is higher than results from a retrospective study analysing data between 1991 and 1998 in the UAE by Punnose *et al*,<sup>12</sup> which found 40 new patients of Arab ethnic origin aged 0–18 years to be diagnosed; with most patients (n=35) satisfying the diagnostic criteria for T1D.<sup>12</sup> Moreover, T1D is one of the most common NCDs diagnosed during the stages of childhood and adolescence (<19 years of age), with a peak incidence around puberty.<sup>13</sup> As the mean age of our study sample

was 16 years, it is possible that since they fall under the age group below 19 years old, a T1D diagnosis is more likely among this population. Although we did not find an association between age groups and a diabetes diagnosis in our study, it is important that future research focus on the age of onset and the type of diabetes to help delineate differences in clinical diagnosis. This is particularly important, as the increasing incidence of T2D in children and adolescents, is making it challenging to estimate the distinction and presentation of T1D from T2D.<sup>13 43</sup> In addition, people of Arab descent are considered a high-risk population of developing T2D.<sup>43 44</sup> Thus, future research should focus on identifying the presence of specific clinical risk factors, (eg, history of T2D in a first-degree or second-degree relative or obesity), mode of presentation and early course of the disease in children, which may help differentiate a diagnosis of T1D from T2D.<sup>43</sup>

Genetic susceptibility also increases the risk of disease development during adolescence, which is often augmented by exposure to adverse environmental factors.<sup>35</sup> Literature shows that ethnicity and genetic susceptibility are positively associated with diabetes prevalence, especially T2D in adolescents.<sup>24</sup> In the UAE, studies have found a high prevalence of diabetes among adult expatriates,<sup>17 44</sup> which may increase the risk of genetic susceptibility in future offspring. Interestingly, the present study did not find nationality as a significant predictor of diabetes in adolescents. However, given the high prevalence and increased risk of diabetes among the large migrant population in the UAE,<sup>17</sup> in addition to adverse sedentary lifestyle conditions with poor nutritional practices,<sup>35</sup> early screening and preventative measures for T2D should be emphasised among vulnerable populations.

In relation to social risk factors, one explanation for the differences found in our study regarding a higher prevalence of diabetes in males, is that diabetes in females may be underdiagnosed, especially among adolescents in the UAE. A study by Barakat-Haddad and Siddiqua<sup>45</sup> using the same study population like this research, found that females living in the UAE were less likely to seek health-care than males for many reasons; one main reason was due to being afraid of doctors. Such findings could be explained by gender inequality and son preference tendency of local populations in this region, which are influenced by the culturally conservative affiliations and familial patriarchy ensued throughout the UAE.<sup>46</sup> For example, studies report males receiving more attention and superior medical care than females in MENA societies.<sup>46 47</sup> In fact, a large number of expatriates living in the UAE are from MENA regions (eg, Egypt, Iran, Iraq, Lebanon). Although 43.6% of the sample from the present study were expatriates, 31% were from countries within the MENA region, including Gulf Cooperation Council (GCC) states, as well as Lebanon, Syria, Jordan, Palestine, Iraq, Iran, Egypt, Tunisia, Morocco, Algeria, Libya and Sudan. Therefore, it is possible that the higher

prevalence of diabetes is a consequence of males' more frequent medical care seeking behaviour than females', resulting in more visits to medical professionals and subsequently more diagnoses of diabetes being made. In this case, the prevalence of clinical diabetes may be the same if not greater in females. Alternatively, this could be an accurate finding and may indicate that a strong relationship indeed exists between gender and the development of diabetes in this population. This may be because young males have been particularly affected by societal change and exhibit a preference for the western diet such as convenience foods.<sup>48</sup> As a result, a gender difference in the prevalence of diagnosed diabetes in this population could be a product of higher rates of adopting an unhealthy lifestyle by adolescent males compared with females.

Another important contribution of this study relates to findings suggesting diabetes is associated with psychological health. The literature reporting an association between diabetes and poor psychological health is vast.<sup>29 30 49</sup> Consistent with literature findings, those who reported poor QoL had double the odds of having diabetes in this study. Mental and physical health are intrinsically linked, and factors including parental marital status and QoL may operate as proximate determinants of diabetes through which other factors operate. The fact that our study found an association between parental marital status and increased odds of self-reporting diabetes, indicates that adolescents with not currently married parents may be at increased risk of psychological distress and are need of extra support. Reduced parental involvement is suggested to predict poorer self-care and management of diabetes among adolescents.<sup>27</sup> In addition, studies have shown that, obesity is more prevalent among children with divorced parents, which can increase the risk for developing T2D.<sup>37</sup>

Additional risk behaviours identified in this study, including smoking and/or the use of illegal drugs can be viewed as a psychosocial factor as well as a lifestyle. It can be hypothesised that smoking and/or the use of illegal drugs is higher in those with diabetes as this behaviour is used as a coping mechanism by those living with the disease. Although the overall prevalence of smoking and/or the use of illegal drugs in our sample was only 16.4%, it was substantially higher among those who reported a diabetes diagnosis (41.8%). Smoking has also been significantly associated with higher distress scores among adolescents for both genders with diabetes.<sup>30</sup> This is particularly important given that smoking is fairly prevalent in the UAE, and this behaviour may be easily adopted by youth living with diabetes.<sup>15 45</sup> In addition, our findings are consistent with literature that documents an association between illicit drug use and diabetes among adolescents.<sup>50</sup>

Finally, adolescents in GCC countries, such as the UAE may be at greater risk for diabetes compared with other ethnic groups, due to a lack of paediatric services compared with western countries and other areas in the

world.<sup>19 45</sup> Healthcare practices in the UAE have a curative rather than preventative focus, hampering its ability to deal with this evolving diabetes 'epidemic'.<sup>51</sup> The lack of reported incidence of diabetes among the juvenile cohort has also posed challenges in screening, diagnosis and treatment of diabetes in adolescents due to non-specific clinical symptoms and low awareness of the disease.<sup>8 24 32</sup>

In fact, a study of young adults in the UAE found that they had a severe lack in understanding of the disease and its severity despite the fact that a large proportion were at risk for diabetes as a result of lifestyle and family history.<sup>52</sup> Therefore, more research is needed to better understand those with diabetes in order to identify and screen at-risk groups; it is also important to inform vulnerable populations how to manage diabetes in order to reduce the risk of its complications.

Examining such characteristics will aid the identification of at-risk groups who may benefit from targeted interventions to prevent or delay the onset of diabetes, in addition to aiding in the identification of those who may have the condition but are currently undiagnosed. Furthermore, highlighting characteristics of those with diabetes may provide direction into developing health management skills, as well as increasing the need for mental and social support during the most productive years of life for adolescents. A critical step towards reducing the prevalence of diabetes among the adolescent population is recognising gender differences in health disparities, modifiable risk factors and implementing health promotion programmes that encourage physical activity, improve dietary behaviours and knowledge on managing diabetes in rapidly low-income and middle-income countries. If policies aiming to tackle the increasing prevalence of diabetes are to succeed, we must understand not only the biological mechanisms of diabetes, but also the underlying social and cultural factors which work to influence ones' risk of developing diabetes.

### Limitations

As with any cross-sectional study, a major limitation of the current analysis is the fact that the temporality of the outcome vis-a-vis the exposures cannot be established. Self-completed questionnaires are also subject to poor response to questions, particularly those of a sensitive nature, and can lead to high proportion of missing data. In addition, administration of the survey to this adolescent population in a classroom setting may have had an impact on participants' responses due to the presence of their peers and school social workers when the survey was self-administered. This also means results are limited to the school-attending population of adolescents and may have missed groups such of those with disabilities. Measurement of diabetes in this study was self-reporting of a diagnosis. As a result, the study only captured those who knew they had the condition and were willing to report about it. In addition,

we did not distinguish the type of diabetes with which the school-attending adolescent population had been diagnosed. Future studies would benefit from screening children and adolescents for clinical risk factors and obtaining objective data to test for diabetes.

## CONCLUSIONS

This study indicates a need for further investigation into diabetes prevalence in relation to sex-specific and gender-specific differences, specifically among the adolescent population in the UAE. These results provide an evidence base for further exploration and determination of the predictors for diabetes across adolescence. In addition, the high prevalence of smoking and the use of illegal substances among those reporting a diagnosis of diabetes suggests that there is a need for behavioural and mental health interventions for adolescents with diabetes, as well as strong parental support and involvement. The literature regarding psychological health and diabetes is ever increasing, highlighting an unmet need for support among those with the disease which should be addressed. Finally, the results of this study can be used to highlight vulnerable groups where targeted interventions and increased screening may be beneficial.

**Acknowledgements** We acknowledge Dr. Rania Dghaim for her contribution in the design and data collection phase of 'The National Study of Population Health in the United Arab Emirates' research programme. We acknowledge Zayed University and the UAE Ministry of Education for their contribution in the initial phase of this research.

**Contributors** CB was involved in the acquisition of data. LB, AB, SJY and CB performed analysis and interpretation of data. All authors drafted the manuscript. CB, LB, SJY and AB gave critical revision feedback and suggestions to ensure accuracy of data and representation of literature for the manuscript. CB, LB, AB and SJY had full access to all data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors approved the final version of this manuscript.

**Funding** The National Study of Population Health in the United Arab Emirates was supported by a grant from 'Zayed University Research Incentive Fund'.

**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

**Patient consent for publication** Not required.

**Ethics approval** The study was given approval by the ethics boards within the UAE ministry of education and the UAE ministry of health prior to administration of the questionnaire. The secondary data analysis for this study was approved by the Research Ethics Committee of the London School of Hygiene and Tropical Medicine, UK under a Master of Science (MSc) student thesis (approval number: 7789).

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** No data are available.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

## ORCID ID

Susan Jamuria Yousufzai <http://orcid.org/0000-0002-5418-8200>

## REFERENCES

- 1 D'Adamo E, Caprio S. Type 2 diabetes in youth: epidemiology and pathophysiology. *Diabetes Care* 2011;34 Suppl 2:S161–5.
- 2 World Health Organization. *Global report on diabetes. Report No.: 9789241565257*. WHO, 2016.
- 3 Sirdah MM, Reading NS. Genetic predisposition in type 2 diabetes: a promising approach toward a personalized management of diabetes. *Clin Genet* 2020;98:525–47.
- 4 Robert AA, Al-Dawish A, Mujammami M, et al. Type 1 diabetes mellitus in Saudi Arabia: a soaring epidemic. *Int J Pediatr* 2018;2018:9408370.
- 5 Patterson CC, Karuranga S, Salpea P, et al. Worldwide estimates of incidence, prevalence and mortality of type 1 diabetes in children and adolescents: results from the International diabetes Federation diabetes atlas, 9th edition. *Diabetes Res Clin Pract* 2019;157:107842.
- 6 Saeedi P, Petersohn I, Salpea P, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Res Clin Pract* 2019;157:107843.
- 7 Osman HAM, Elsadek N, Abdullah MA. Type 2 diabetes in Sudanese children and adolescents. *Sudan J Paediatr* 2013;13:17.
- 8 International Diabetes Federation. *IDF diabetes atlas*. 9th edn. Brussels, Belgium, 2019. <https://www.diabetesatlas.org>
- 9 Al-Rifai RH, Majeed M, Qambar MA, et al. Type 2 diabetes and pre-diabetes mellitus: a systematic review and meta-analysis of prevalence studies in women of childbearing age in the middle East and North Africa, 2000–2018. *Syst Rev* 2019;8:268.
- 10 Nanditha A, Ma RCW, Ramachandran A, et al. Diabetes in Asia and the Pacific: implications for the global epidemic. *Diabetes Care* 2016;39:472–85.
- 11 Al Amiri E, Abdullatif M, Abdulle A, et al. The prevalence, risk factors, and screening measure for prediabetes and diabetes among Emirati overweight/obese children and adolescents. *BMC Public Health* 2015;15:1–9.
- 12 Punnose J, Agarwal MM, El Khadir A, et al. Childhood and adolescent diabetes mellitus in Arabs residing in the United Arab Emirates. *Diabetes Res Clin Pract* 2002;55:29–33.
- 13 Saraswathi S, Al-Khawaga S, Elkum N, et al. A systematic review of childhood diabetes research in the middle East region. *Front Endocrinol* 2019;10:805.
- 14 Majeed A, El-Sayed AA, Khoja T, et al. Diabetes in the Middle-East and North Africa: an update. *Diabetes Res Clin Pract* 2014;103:218–22.
- 15 Barakat-Haddad C. Prevalence of high blood pressure, heart disease, thalassemia, sickle-cell anemia, and iron-deficiency anemia among the UAE adolescent population. *J Environ Public Health* 2013;2013:680631.
- 16 United Arab Emirates Population. United Arab Emirates Population 2020 (Live) [Internet] (Demographics, Maps, Graphs), 2020. Available: <https://worldpopulationreview.com/countries/united-arab-emirates-population> [Accessed 07 Oct 2020].
- 17 Sulaiman N, Albadawi S, Abusnana S, et al. High prevalence of diabetes among migrants in the United Arab Emirates using a cross-sectional survey. *Sci Rep* 2018;8:6862.
- 18 Haroun D, Mechli R, Sahuri R, et al. Metabolic syndrome among adolescents in Dubai, United Arab Emirates, is attributable to the high prevalence of low HDL levels: a cross-sectional study. *BMC Public Health* 2018;18:1284.
- 19 Al Makadma AS. Adolescent health and health care in the Arab Gulf countries: today's needs and tomorrow's challenges. *Int J Pediatr Adolesc Med* 2017;4:1–8.
- 20 Farrag NS, Cheskin LJ, Farag MK. A systematic review of childhood obesity in the middle East and North Africa (Mena) region: prevalence and risk factors meta-analysis. *Adv Pediatr Res* 2017;4:8.
- 21 bin Zaal AA, Musaiger AO, D'Souza R. Dietary habits associated with obesity among adolescents in Dubai, United Arab Emirates. *Nutr Hosp* 2009;24:437–44.
- 22 Baschetti R. Diabetes epidemic in newly westernized populations: is it due to thrifty genes or to genetically unknown foods? *J R Soc Med* 1998;91:622–5.
- 23 Eapen V, Mabrouk A, Yousef S. Metabolic syndrome among the young obese in the United Arab Emirates. *J Trop Pediatr* 2010;56:325–8.
- 24 Al-Rubeaan K. National surveillance for type 1, type 2 diabetes and prediabetes among children and adolescents: a population-based study (SAUDI-DM). *J Epidemiol Community Health* 2015;69:1045–51.



- 25 Al Busaidi N, Shanmugam P, Manoharan D. Diabetes in the middle East: government health care policies and strategies that address the growing diabetes prevalence in the middle East. *Curr Diab Rep* 2019;19:8.
- 26 Razzak HA, Harbi A, Shelpai W, et al. Epidemiology of diabetes mellitus in the United Arab Emirates. *Curr Diabetes Rev* 2018;14:542–9.
- 27 AlBuhairan F, Nasim M, Al Otaibi A, et al. Health related quality of life and family impact of type 1 diabetes among adolescents in Saudi Arabia. *Diabetes Res Clin Pract* 2016;114:173–9.
- 28 Buckloh LM, Lochrie AS, Antal H, et al. Diabetes complications in youth: qualitative analysis of parents' perspectives of family learning and knowledge. *Diabetes Care* 2008;31:1516–20.
- 29 Eapen V, Mabrouk AA, Sabri S, et al. A controlled study of psychosocial factors in young people with diabetes in the United Arab emirates. *Ann N Y Acad Sci* 2006;1084:325–8.
- 30 Forsander G, Bøgelund M, Haas J, et al. Adolescent life with diabetes-Gender matters for level of distress. experiences from the National TodS study. *Pediatr Diabetes* 2017;18:651–9.
- 31 Huebschmann AG, Huxley RR, Kohrt WM, et al. Sex differences in the burden of type 2 diabetes and cardiovascular risk across the life course. *Diabetologia* 2019;62:1–2.
- 32 Fagot-Campagna A. Emergence of type 2 diabetes mellitus in children: epidemiological evidence: division of diabetes translation, National center for chronic disease prevention and health promotion, centers for disease control and prevention, Atlanta, Georgia, USA. *Journal of Pediatric Endocrinology and Metabolism* 2000;13:1395–402.
- 33 Kautzky-Willer A, Harreiter J, Pacini G. Sex and gender differences in risk, pathophysiology and complications of type 2 diabetes mellitus. *Endocr Rev* 2016;37:278–316.
- 34 Xiong X, Saunders LD, Wang FL, et al. Gestational diabetes mellitus: prevalence, risk factors, maternal and infant outcomes. *Int J Gynaecol Obstet* 2001;75:221–8.
- 35 Moussa MAA, Alsaeid M, Abdella N, et al. Prevalence of type 2 diabetes mellitus among Kuwaiti children and adolescents. *Med Princ Pract* 2008;17:270–5.
- 36 Saucier JF, Ambert AM. Parental marital status and adolescents' optimism about their future. *J Youth Adolesc* 1982;11:345–54.
- 37 Biehl A, Hovengen R, Grøholt E-K, et al. Parental marital status and childhood overweight and obesity in Norway: a nationally representative cross-sectional study. *BMJ Open* 2014;4:e004502.
- 38 Ali BA, Abdallah ST, Abdallah AM, et al. The frequency of type 2 diabetes mellitus among diabetic children in El Minia Governorate, Egypt. *Sultan Qaboos Univ Med J* 2013;13:399.
- 39 Al-Ghamdi AH, Fureeh AA. Prevalence and clinical presentation at the onset of type 1 diabetes mellitus among children and adolescents in AL-Baha region, Saudi Arabia. *J Pediatr Endocrinol Metab* 2018;31:269–73.
- 40 Punnose J, Agarwal MM, Bin-Uthman S. Type 2 diabetes mellitus among children and adolescents in Al-Ain: a case series. *East Mediterr Health J* 2005;11:788–97.
- 41 Habeb AM, Al-Magamsi MS, Halabi S, et al. High incidence of childhood type 1 diabetes in Al-Madinah, North West Saudi Arabia (2004–2009). *Pediatr Diabetes* 2011;12:676–81.
- 42 Shaltout AA, Wake D, Thanaraj TA, et al. Incidence of type 1 diabetes has doubled in Kuwaiti children 0–14 years over the last 20 years. *Pediatr Diabetes* 2017;18:761–6.
- 43 Diabetes Canada Clinical Practice Guidelines Expert Committee, Panagiotopoulos C, Hadjiyannakis S, et al. Type 2 diabetes in children and adolescents. *Can J Diabetes* 2018;42 Suppl 1:S247–54.
- 44 Hamoudi R, Saheb Sharif-Askari N, Saheb Sharif-Askari F, et al. Prediabetes and diabetes prevalence and risk factors comparison between ethnic groups in the United Arab Emirates. *Sci Rep* 2019;9:1–7.
- 45 Barakat-Haddad C, Siddiqua A. Primary health care use and health care accessibility among adolescents in the United Arab Emirates. *East Mediterr Health J* 2015;21:171–84.
- 46 Obermeyer CM, Cárdenas R. Son preference and differential treatment in Morocco and Tunisia. *Stud Fam Plann* 1997;28:235–44.
- 47 Yount KM. Provider bias in the treatment of diarrhea among boys and girls attending public facilities in Minia, Egypt. *Soc Sci Med* 2003;56:753–68.
- 48 Baglar R, God “Oh. “Oh God, save us from sugar”: an ethnographic exploration of diabetes mellitus in the United Arab Emirates. *Med Anthropol* 2013;32:109–25.
- 49 Hislop AL, Fegan PG, Schlaeppi MJ, et al. Prevalence and associations of psychological distress in young adults with type 1 diabetes. *Diabet Med* 2008;25:91–6.
- 50 Martínez-Aguayo A, Araneda JC, Fernandez D, et al. Tobacco, alcohol, and illicit drug use in adolescents with diabetes mellitus. *Pediatr Diabetes* 2007;8:265–71.
- 51 Koornneef E, Robben P, Blair I. Progress and outcomes of health systems reform in the United Arab Emirates: a systematic review. *BMC Health Serv Res* 2017;17:1–3.
- 52 Saadi H, Carruthers SG, Nagelkerke N, et al. Prevalence of diabetes mellitus and its complications in a population-based sample in al Ain, United Arab Emirates. *Diabetes Res Clin Pract* 2007;78:369–77.