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Incidence and risk factors of type-2 diabetes mellitus in an overweight and obese population: a long-term study from a Gulf State

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3 **1 Incidence and risk factors of type-2 diabetes mellitus in an overweight and obese**
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5 **2 population: a long-term study from a Gulf State**
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3 **24 Abstract**
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5 **25 Objectives:** A high body mass index (BMI) is associated with a risk for type-2 diabetes mellitus
6 (DM). The United Arab Emirates (UAE) is experiencing a marked increase in obesity. Data on
7
8 **26** the incidence of type-2 DM in this high-risk adult UAE population is unavailable. This study
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10 **27** aimed to evaluate the incidence and risk of developing type-2 DM among individuals with
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12 **28** above-normal BMI in the UAE.
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17 **30 Design:** A retrospective cohort study.
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19 **31 Setting:** Outpatient clinics at a tertiary care centre in Al Ain, UAE.
20

21 **32 Participants:** 362 overweight or obese adult UAE nationals who visited outpatient clinics
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24 **33** between April 2008 and December 2008.
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26 **34 Primary outcome measure:** Patients with type-2 DM were identified based on diagnosis
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28 established by a physician or glycated hemoglobin (HbA1c) levels $\geq 6.5\%$ during the follow-up
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31 **36** period (until April 2018).
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33 **37 Results:** The overall incidence rate of type-2 DM during the median follow-up time of 8.7 years
34
35 **38** was 16.3 (95% CI: 12.1–21.4) cases per 1000 person-years. Incidence rates in males and females
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38 **39** were 17.7 (95% CI: 1.14–2.60) and 15.0 (95% CI: 0.99–2.35), respectively. Using multivariable
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40
40 **40** Cox proportional hazard analysis, older age and obesity in females and HbA1c levels in males
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42 **41** were determined to be independent risk factors for developing type-2 DM.
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44 **42 Conclusions:** The incidence rate of type-2 DM in overweight and obese UAE nationals is high.
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47 **43** In addition to screening, current strategies should strongly emphasize lifestyle modifications that
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49 **44** decrease HbA1c and BMI levels in this high-risk population.
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47 **Article Summary**

48 **Strengths and limitations of this study**

- 49 • A long-term (9-years) study that utilizes anthropometric and laboratory data to accurately
50 quantify previously unknown incidence rate of type-2 DM in a high-risk group in the United
51 Arab Emirates.
- 52 • In doing so, the results demonstrate different independent risk factors that influence the
53 development of type-2 DM in males and females suggesting unique focused gender based
54 strategies to be incorporated into the current preventative program.
- 55 • The study results provide a baseline to assess effectiveness of national diabetes preventative
56 programs in obese and overweight individuals while allowing epidemiologists to benchmark
57 the incidence rates globally.
- 58 • The usual limitations of a retrospective study apply here as well. A prospective study would
59 probably also allow capturing data on physical activity, and changes in weight, both of which
60 can influence development of type-2 DM.
- 61 • Another limitation of this study is missing baseline data on family history and history of
62 Gestational diabetes both of which are well-known risk factors for developing type 2-DM.
63 Their contribution if any to the development of new onset type-2 DM in our study population
64 is not accounted for.

66 **Keywords:** incidence; obesity; risk factors; type-2 diabetes mellitus; United Arab Emirates

70 INTRODUCTION

71 There has been a rapid increase in the prevalence of obesity and type-2 diabetes mellitus (DM)
72 globally. The United Arab Emirates (UAE) is one of the epicenters of this epidemic. Among
73 UAE nationals, the crude prevalence of obesity and type-2 DM is 37%[1] and 29%[2],
74 respectively and the number of people with type-2 DM in the country is estimated to reach over
75 2 million by 2040.[3]

76 Obesity, defined as a body mass index (BMI) ≥ 30 kg/m²[2,4], is a known risk factor for type-2
77 DM⁵ while lifestyle interventions such as weight loss in obese individuals with impaired glucose
78 tolerance have been shown to reduce the risk for type-2 DM.[6] There has been significant
79 attention and effort over the last decade in the UAE to curb the prevalence of overweight and
80 obesity, as well as to decrease the incidence of associated diseases.

81 The *Weqaya*, a population-wide CVD screening program, was initiated in 2008[7] to enable
82 individuals and healthcare providers to implement preventative measures. Epidemiological
83 studies on type-2 DM in the UAE have primarily focused on its prevalence in the general
84 population.[8] A decade after the implementation of the preventive program, data on the
85 incidence of type-2 DM among obese and overweight UAE nationals remain unknown.

86 In this retrospective longitudinal cohort study, we aimed to determine the incidence of DM
87 and elucidate the effect of BMI on type-2 DM risk in overweight and obese adult UAE nationals.

89 METHODS

90 Study setting

91 A retrospective electronic medical record review of adult patients who presented to outpatient
92 clinics at Tawam hospital in Al Ain, UAE between April 1st, and December 31st 2008 was

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3 93 performed. The tertiary care hospital is one of two governmental hospitals in the city and serves
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5 94 an estimated population of 650,000 patients, of which 30% are UAE nationals.[9] Tawam
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8 95 Hospital and the UAE University research and ethics board granted ethical approval for this
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10 96 study (CRD239/13). Informed consent was waived because patient records and information were
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12 97 anonymized and de-identified prior to analysis.
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16 17 99 **Subjects and procedures**

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19 100 The study population consisted of healthy overweight and obese UAE nationals, aged between
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21 101 18 and 75 years, who were seen at primary care and specialty outpatient clinics at Tawam
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23 102 hospital (obstetrics and gynecology, internal medicine, and surgery, as well as subspecialty
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25 103 clinics). The inclusion criteria were patients without type-2 DM, defined as having glycated
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27 104 hemoglobin (HbA1c) <6.5%; patients not taking anti-diabetic medications; and those with BMI
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29 105 ≥ 25 kg/m² at baseline. The exclusion criteria were patients with missing HbA1c data; those
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31 106 with a history of chronic medical conditions such as malignancy, human immunodeficiency virus
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33 107 infection, receiving steroids or immunosuppression medications, or stage 3–5 chronic kidney
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35 108 disease [estimated glomerular filtration rate (eGFR) of ≤ 59 mL/min/1.73 m²][10]. Those who
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37 109 had undergone weight reduction surgery defined as either restrictive or malabsorptive bariatric
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39 110 surgery or pharmacotherapy for weight loss were also excluded from the study. The final study
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41 111 group consisted of 362 subjects with a BMI of ≥ 25 kg/m² (Fig 1).
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49 113 **Definitions and measurements**

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51 114 Initial BMI was calculated from height and weight measured at baseline using the formula
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53 115 weight (kg) divided by height squared (m²). Overweight and obesity were defined according to
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3 116 the World Health Organization classification[4], with a BMI between 25 and 29.99 kg/m² and
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5 117 ≥ 30 kg/m², respectively. Hypertension (HTN) was defined as systolic blood pressure ≥ 140
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7 118 mmHg, diastolic blood pressure ≥ 90 mmHg, or the use of antihypertensive medications.[11]
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9 119 Dyslipidemia was defined as serum total cholesterol (TC) of ≥ 6.21 mmol/L or if the patient had a
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11 120 documented prescription of lipid-lowering medications.[12] Current or prior history of smoking
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13 121 tobacco was considered positive for smoking history. Patients were considered to have vascular
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15 122 disease if they had a documented history of either coronary heart disease, cerebrovascular
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17 123 disease, or peripheral vascular disease.
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25 125 **Outcomes**

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27 126 Our study endpoint was incident type-2 DM, defined as either HbA1c $\geq 6.5\%$ or a diagnosis of
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29 127 type-2 DM established by a physician occurring at any time during the follow-up period.[13] The
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31 128 occurrence of incident type-2 DM was based on a review of all of the electronic medical records
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33 129 until April 30, 2018. All laboratory assays at baseline and follow-up were conducted at the
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35 130 Medical Laboratory Department at Tawam Hospital. HbA1c levels were measured using an
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37 131 automated analyzer Integra 400 Plus (Roche Diagnostics, Mannheim, Germany).
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43 133 **Statistical analyses**

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45 134 Differences between sexes were determined using an independent-samples t-test or the Mann-
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47 135 Whitney U test for normal and non-normal data, respectively, with Fisher's exact test (two-tailed)
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49 136 being used for categorical variables. Person-years at risk for developing type-2 DM was
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51 137 calculated for each subject as the time from baseline visit to the diagnosis of type-2 DM or the
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53 138 most-recent outpatient visit, whichever occurred first. The incidence rate of type-2 DM with 95%
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3 139 confidence intervals (CI) was calculated per 1000 person-years by dividing the number of new
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5 140 cases of type-2 DM by the person-years at risk. Sex-specific incidence rates stratified by age and
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7 141 BMI categories were calculated. Kaplan-Meier time-to-event analysis was conducted with a log-
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9 142 rank test to compare age and BMI categories for incident type-2 DM.

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12 143 Univariable and multivariable Cox proportional hazards modeling (stratified by sex) were
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14 144 used to examine predictors of incident type-2 DM. The following predictor variables were
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16 145 examined by univariable Cox modeling: age (categorized as <44 years and \geq 44 years), sex
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18 146 (categorized as female/male), vascular disease (categorized as yes/no), HTN (categorized as
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20 147 yes/no), dyslipidemia (categorized as yes/no), smoking (categorized as yes/no), HbA1c
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22 148 (categorized as <5.7% and \geq 5.7%), and BMI (categorized as overweight and obese). All
23
24 149 covariables with $P < 0.1$ were included in the final multivariable modeling. Results were checked
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26 150 by a step-wise method based on likelihood ratios, with entry and removal probabilities set at 0.05
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28 151 and 0.10, respectively. The proportional hazards assumption was tested using a log-log plot and
29
30 152 were not significant. A P -value < 0.05 was considered statistically significant. SPSS version 25
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32 153 (IBM Corp., Armonk, NY) was used to analyze the data.
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40 155 **Patient and public involvement**

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42 156 There was no patient or public involvement in the design and conduct of the study.
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46 158 **RESULTS**

47 159 **Characteristics of study participants**

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49 160 The baseline patient characteristics, including demographic, clinical, and biochemical data of the
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51 161 362 subjects, are presented in Table 1. The ratio of males to females was almost 1:1. The mean
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162 age and BMI at baseline were 44.36 ± 14.45 years and 31.69 [interquartile range (IQR) 27.64,
 163 34.18 kg/m^2], respectively. When stratified by sex, females were older, had higher BMI and TC
 164 values, and had a higher prevalence of dyslipidemia, at baseline. Conversely, males had
 165 significantly higher baseline systolic and diastolic blood pressure values, as well as a higher
 166 prevalence of smoking history.

167

168 **Table 1. Baseline characteristics of the study participants.**

	Total (N=362) Mean \pm SD	Males (N=170) Mean \pm SD	Females (N=192) Mean \pm SD	p-value*
Females (%)	53.0	-	-	-
Age (years)	44.36 ± 14.45	40.2 ± 14.7	48.09 ± 13.2	<0.001
Anthropometric values				
BMI (kg/m^2)	31.69 (27.64, 34.18)	29.56 (27.33, 32.79)	31.22 (27.91, 35.77)	0.001
SBP (mmHg)	127.93 ± 17.34	129.92 ± 17.86	126.17 ± 16.72	0.040
DBP (mmHg)	76.94 ± 11.01	79.03 ± 11.34	75.09 ± 10.40	0.001
Laboratory values				
HbA1c (%)	5.62 ± 0.48	5.59 ± 0.50	5.64 ± 0.46	0.326
eGFR (mL/min/1.73 m^2)	105.87 ± 16.81 (N=359)†	104.16 ± 18.47 (N=167)†	107.35 ± 15.13	0.073
TC (mmol/L)	5.06 ± 0.88	4.89 ± 0.95	5.21 ± 0.99	0.002
History of n (%)				
HTN	181 (50.0)	91 (53.5)	90 (46.9)	0.247
Dyslipidemia	141 (39.0)	52 (30.6)	89 (46.4)	0.002
Vascular disease	18 (5.0)	10 (5.9)	8 (4.2)	0.478
Smoking	56 (15.5)	54 (31.8)	2 (1.0)	<0.001

169 *HTN* hypertension, *BMI* body mass index, *eGFR* estimated glomerular filtration rate, *SBP*
170 systolic blood pressure, *DBP* diastolic blood pressure, *SD* standard deviation, *HbA1c* glycated
171 hemoglobin, *TC* total cholesterol.

172 †The difference in N is due to missing data.

173 *Independent-samples t-test was used to calculate p values for continuous variables and Fisher's
174 exact test (two-tailed) for categorical variables.

176 **Incidence**

177 After a median follow-up time of 8.7 years (IQR, 8.2–9.0 years), 47 incident cases of type-2 DM
178 were identified. The overall incidence rate of type-2 DM was 16.3 (95% CI: 12.1–21.4) cases per
179 1000 person-years and the crude incidence of type-2 DM over the same period was 13.0% (95%
180 CI: 9.8–16.8%).

181 Sex-specific incidence rates, as stratified by BMI, were higher in obese females (21.1, 95%
182 CI: 13.3–32.0 cases per 1000 person-years), when compared to overweight females (5.1, 95%
183 CI: 1.3–14.0 cases per 1000 person-years) (P=0.013). Incidence rates for type-2 DM were higher
184 in older females (21.3, 95% CI: 13.5–31.9 cases per 1000 person-years), when compared to
185 younger females (3.7, 95% CI: 0.6–12.2 cases per 1000 person-years) (P=0.008), (Figs. 2 and 3,
186 respectively). However, these differences were not significant among males.

187 **Analyses of risk factors**

188 We used multivariable Cox regression analyses to examine the association of age, vascular
189 disease, dyslipidemia, smoking, HTN, BMI, and HbA1c levels with the risk of developing type-2
190 DM between males and females. When adjusted for all other variables, we found that in males,
191 an HbA1c level $\geq 5.7\%$ [hazard ratio (HR) = 3.02, 95% CI: 1.20–7.62] and for females age ≥ 44

192 years (HR = 4.84, 95% CI: 1.13–20.73) and obesity (HR = 3.42, 95% CI: 1.01–11.57) were
 193 significant risk factors for the development of type-2 DM (Table 2).

195 **Table 2. Predictors of incident type-2 diabetes mellitus in the study population.**

Predictor variables	Male (N=170)		Female (N=192)	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Age				
<44 years	Reference		Reference	
≥44 years	0.46 (0.17–1.13)	0.135	4.84 (1.13–20.73)	0.034
History of HTN				
No	Reference		Reference	
Yes	1.89 (0.74–4.81)	0.183	1.61 (0.67–3.88)	0.292
History of dyslipidemia				
No	Reference		Reference	
Yes	2.01 (0.80–5.04)	0.135	0.80 (0.34–1.90)	0.608
History of smoking				
No	Reference		Reference	
Yes	0.36 (0.12–1.04)	0.060	4.88 (0.44–54.08)	0.196
History of vascular disease				
No	Reference		Reference	
Yes	2.46 (0.65–9.27)	0.183	0.60 (0.06–5.50)	0.647
HbA1c				
<5.7%	Reference		Reference	
≥5.7%	3.02 (1.20–7.62)	0.019	2.30 (0.83–6.39)	0.109
BMI				
Overweight	Reference		Reference	
Obese	1.17 (0.51–2.68)	0.713	3.42 (1.01–11.57)	0.048

196 *HTN* hypertension, *BMI* body mass index, *HbA1c* glycated hemoglobin, *CI* confidence intervals,
 197 *HR* hazard ratio.

199 DISCUSSION

200 The results of this study showed that the incidence of type-2 DM among overweight and obese
 201 UAE nationals was 1.49% per year during the 9-year study period. The overall incidence rate

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3 202 was 16.3 per 1000 person-years. The independent risk factors for the development of type-2 DM
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5 203 were age (≥ 44 years) and obesity in females and HbA1c levels in males.
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8 204 **Incidence rates**

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10 205 The incidence rates of type-2 DM in the general population differ significantly worldwide. This
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12 206 is possibly due to variations in insulin sensitivity related to the interaction between genetic and
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14 207 environmental factors among different populations globally.[14] A study conducted over a 12-
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16 208 month period in Ajman, one of the emirates in the UAE, the incidence rate for type-2 DM in the
17
18 209 general Emirati population was 4.8 per 1000 person-years[8], while our study had an incidence
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20 210 rate 3 times higher. This is not unexpected as our study focused on overweight and obese
21
22 211 individuals and is comparable to other research in high-risk populations in the United States
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24 212 (15.2 per 1000 person-years)[15], while South-Asian countries e.g. India and Bangladesh
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26 213 reported incidence rates of 22.2 per 1000 person-years[16] and 16.4 per 1000 person-years
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28 214 respectively.[17]
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33 215 **Risk factors**

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35 216 This study revealed some interesting findings regarding the risk factors for developing type-2
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37 217 DM in this high-risk UAE population. Sex-specific incidence rates of type-2 DM showed a
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39 218 female preponderance, particularly among older females. These results were not unique and were
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41 219 also observed among the general population of the UAE.[8] The higher incidence of type-2 DM
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43 220 among older females may be attributable to the high prevalence of overweight and obesity[18],
44
45 221 sedentary lifestyle, nutritional habits[19], and early menopause witnessed in our population.[20]
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47 222 Local data shows that for every 1-year increase in age, the risk of obesity among females
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49 223 increases by 5%.[21]
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224 Individuals with high-normal HbA1c levels have a greater risk of developing type-2 DM.[22]
225 However, in our study, the independent predictive property of the HbA1c level was only
226 observed in males. An explanation for this finding could be the high prevalence of male smokers
227 seen, as smoking has been shown to increase HbA1c levels in people without diabetes.[23]
228 Obesity in females was also an independent risk predictor for type-2 DM. Studies have shown
229 that the risk of developing type-2 DM is significantly higher in individuals with BMI ≥ 30 kg/m²
230 when compared to those with normal BMI.[5] Interventions that promote weight loss and
231 decreased BMI, also reduce the risk of developing type-2 DM. An 8-week exercise intervention
232 program in a UAE student population demonstrated a significant reduction in BMI.[24] Other
233 controlled intervention studies in high-risk populations[6,25,26] also demonstrated a significant
234 decrease in the risk of type-2 DM as a result of BMI reduction.

235 **Clinical and public health implications**

236 Results from this study demonstrate that the incidence of type-2 DM in the high-risk UAE
237 population begins to increase by the fourth decade of life, and this trend significantly increases
238 with higher BMI values. Thus, targeting overweight or obesity, which are modifiable risk factors
239 for type-2 DM[27], is crucial in reducing this burden. A 2015 study of Emirati adolescents found
240 the prevalence of pre-diabetes and type-2 DM in overweight and obese children were 5.8% and
241 0.87%, respectively.[28] Although alarming, the results are unsurprising when we consider the
242 high prevalence of childhood obesity in the UAE. Furthermore, the rates of overweight and
243 obesity in young UAE adults was 36%[29], putting them at risk for developing type-2 DM.
244 Screening programs alone are inadequate and clinicians must strongly recommend lifestyle
245 modifications to reduce overweight and obesity.

246 **Strengths and limitations**

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3 247 The strengths of this study include the duration of follow-up for our representative sample of
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5 248 overweight and obese UAE nationals in the second-largest city in the Abu Dhabi Emirate of
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7 249 UAE. We utilized measured anthropometric and laboratory data in patient charts instead of self-
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9 250 reported information and diagnostic codes for the classification of risk factors and identification
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11 251 of incident cases. In addition, HbA1c levels or documented diagnosis by a physician were used
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13 252 to identify incident cases of type-2 DM instead of fasting plasma glucose, which has more
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15 253 variability.[30,31]
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19 254 This study has some limitations. These limitations include missing baseline data regarding
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21 255 family history of type-2 DM, history of gestational diabetes, physical activity, and abdominal
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23 256 obesity, all of which are well-researched risk factors for the development of DM. A prospective
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25 257 study will ensure more robust data, as well as changes in lifestyle variables such as exercise,
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27 258 weight loss or gain.
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32 33 260 **CONCLUSIONS**

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35 261 The overall incidence rate of type-2 DM in overweight and obese UAE nationals was 16.3 per
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37 262 1000 person-years. The HbA1c level in males and obesity in females, particularly in the older
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39 263 age group, were found to be independent risk factors for the development of type-2 DM. Thus,
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41 264 there should be a greater emphasis on reducing BMI through lifestyle modifications in these
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43 265 high-risk groups.
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47 266

48 49 267 **Acknowledgments**

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51 268 None
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2
3 269 **Author Contributions** D.R. conceived the study and its design, performed literature search and
4
5 270 drafted the initial manuscript. S.A.S. was involved in data management, statistical analysis,
6
7 271 interpretation of the data, and critical review of the manuscript. R.D.G. assisted in statistical
8
9 272 analysis, contributed to the discussion, reviewed and edited the manuscript. J.A.K. performed a
10
11 273 critical review of the manuscript was involved in data interpretation and also provided guidance
12
13 274 in research methodology. All authors read and approved the final manuscript.
14
15

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18
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20
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22
23 278 decision to publish, or preparation of the manuscript.
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25

26 279 **Competing interests**

27
28 280 The authors declare that they have no competing interests.
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31 281 **Patient Consent for publication**

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33 282 Not required
34

35 283 **Availability of data and materials**

36
37 284 The dataset used and analyzed during the current study is available from the corresponding
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39 285 author on reasonable request.
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44 287 **REFERENCES**

- 45
46 288 1. Malik M, Bakir A. Prevalence of overweight and obesity among children in the United
47
48 289 Arab Emirates. *Obes Rev Off J Int Assoc Study Obes*. 2007;8: 15–20. doi:10.1111/j.1467-
49
50 290 789X.2006.00290.x
51
52
53
54
55
56
57
58
59
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- 1
2
3 291 2. Saadi H, Carruthers SG, Nagelkerke N, Al-Maskari F, Afandi B, Reed R, et al. Prevalence
4
5 292 of diabetes mellitus and its complications in a population-based sample in Al Ain, United
6
7 293 Arab Emirates. *Diabetes Res Clin Pract.* 2007;78: 369–377.
8
9
10 294 doi:10.1016/j.diabres.2007.04.008
11
12
13 295 3. Center ICLD. UAE Diabetes Trends and Numbers [Internet]. [cited 30 Oct 2017].
14
15 296 Available: <http://www.icldc.ae/about-us/p/UAE-Diabetes-Trends-And-Numbers>
16
17
18
19 297 4. World Health Organization (WHO). BMI Classification [Internet]. 2006 [cited 18 Apr
20
21 298 2018]. Available: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html
22
23
24 299 5. de Mutsert R, Sun Q, Willett WC, Hu FB, van Dam RM. Overweight in early adulthood,
25
26 300 adult weight change, and risk of type-2 diabetes, cardiovascular diseases, and certain
27
28 301 cancers in men: a cohort study. *Am J Epidemiol.* 2014;179: 1353–1365.
29
30
31
32 302 6. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al.
33
34 303 Reduction in the incidence of type-2 diabetes with lifestyle intervention or metformin. *N*
35
36 304 *Engl J Med.* 2002;346: 393–403.
37
38
39
40 305 7. Hajat C, Harrison O, Al Siksek Z. Weqaya: a population-wide cardiovascular screening
41
42 306 program in Abu Dhabi, United Arab Emirates. *Am J Public Health.* 2012;102: 909–914.
43
44 307 doi:10.2105/AJPH.2011.300290
45
46
47
48 308 8. Sreedharan J, Muttappallymyalil J, Al Sharbatti S, Hassoun S, Safadi R, Abderahman I, et
49
50 309 al. Incidence of Type-2 Diabetes Mellitus among Emirati Residents in Ajman, United Arab
51
52 310 Emirates. *Korean J Fam Med.* 2015;36: 253–257. doi:10.4082/kjfm.2015.36.5.253
53
54
55
56
57
58
59
60

- 1
2
3 311 9. Statistics Center Abu Dhabi. Statistics Center. In: SCAD [Internet]. 2017 [cited 19 Apr
4
5 312 2018]. Available:
6
7
8 313 [https://www.scad.gov.abudhabi/Release%20Documents/Statistical%20Yearbook%20-](https://www.scad.gov.abudhabi/Release%20Documents/Statistical%20Yearbook%20-%20Population%20-%20EN.pdf)
9
10 314 [%20Population%20-%20EN.pdf](https://www.scad.gov.abudhabi/Release%20Documents/Statistical%20Yearbook%20-%20Population%20-%20EN.pdf)
11
12
13 315 10. Levin A, Stevens PE, Bilous RW, Coresh J, De Francisco AL, De Jong PE, et al. Kidney
14
15 316 Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2012 clinical
16
17 317 practice guideline for the evaluation and management of chronic kidney disease. *Kidney Int*
18
19 318 *Suppl.* 2013;3: 1–150.
20
21
22
23 319 11. National High Blood Pressure Education Program. The Seventh Report of the Joint
24
25 320 National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood
26
27 321 Pressure [Internet]. Bethesda (MD): National Heart, Lung, and Blood Institute (US); 2004.
28
29 322 Available: <http://www.ncbi.nlm.nih.gov/books/NBK9630/>
30
31
32
33 323 12. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults.
34
35 324 Executive Summary of The Third Report of The National Cholesterol Education Program
36
37 325 (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol
38
39 326 In Adults (Adult Treatment Panel III). *JAMA.* 2001;285: 2486–2497.
40
41
42
43 327 13. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes*
44
45 328 *Care.* 2010;33: S62.
46
47
48
49 329 14. Dagenais GR, Gerstein HC, Zhang X, McQueen M, Lear S, Lopez-Jaramillo P, et al.
50
51 330 Variations in Diabetes Prevalence in Low-, Middle-, and High-Income Countries: Results
52
53
54
55
56
57
58
59
60

- 1
2
3 331 From the Prospective Urban and Rural Epidemiological Study. *Diabetes Care*. 2016;39:
4
5 332 780–787. doi:10.2337/dc15-2338
6
7
8
9 333 15. Krishnan S, Rosenberg L, Djoussé L, Cupples LA, Palmer JR. Overall and central obesity
10
11 334 and risk of type-2 diabetes in U.S. black women. *Obes Silver Spring Md*. 2007;15: 1860–
12
13 335 1866. doi:10.1038/oby.2007.220
14
15
16
17 336 16. Anjana RM, Shanthi Rani CS, Deepa M, Pradeepa R, Sudha V, Divya Nair H, et al.
18
19 337 Incidence of Diabetes and Prediabetes and Predictors of Progression Among Asian Indians:
20
21 338 10-Year Follow-up of the Chennai Urban Rural Epidemiology Study (CURES). *Diabetes*
22
23 339 *Care*. 2015;38: 1441–1448. doi:10.2337/dc14-2814
24
25
26
27 340 17. Asghar S, Azad Khan AK, Ali SMK, Sayeed MA, Bhowmik B, Diep ML, et al. Incidence
28
29 341 of diabetes in Asian-Indian subjects: A five year follow-up study from Bangladesh. *Prim*
30
31 342 *Care Diabetes*. 2011;5: 117–124. doi:10.1016/j.pcd.2011.01.002
32
33
34
35 343 18. Sheikh-Ismail LI, Henry CJK, Lightowler HJ, Aldhaferi AS, Masuadi E, Al Hourani HM.
36
37 344 Prevalence of overweight and obesity among adult females in the United Arab Emirates. *Int*
38
39 345 *J Food Sci Nutr*. 2009;60: 26–33. doi:10.1080/09637480802331179
40
41
42
43 346 19. Trainer S. Negotiating weight and body image in the UAE: Strategies among young emirati
44
45 347 women. *Am J Hum Biol*. 2012;24: 314–324. doi:10.1002/ajhb.22251
46
47
48 348 20. Rizk DE, Bener A, Ezimokhai M, Hassan MY, Micallef R. The age and symptomatology of
49
50 349 natural menopause among United Arab Emirates women. *Maturitas*. 1998;29: 197–202.
51
52
53
54 350

- 1
2
3 351 21. Carter AO, Saadi HF, Reed RL, Dunn EV. Assessment of obesity, lifestyle, and
4
5 352 reproductive health needs of female citizens of Al Ain, United Arab Emirates. *J Health*
6
7 353 *Popul Nutr.* 2004; 75–83.
- 8
9
10
11 354 22. Bonora E, Kiechl S, Mayr A, Zoppini G, Targher G, Bonadonna RC, et al. High-normal
12
13 355 HbA1c is a strong predictor of type-2 diabetes in the general population. *Diabetes Care.*
14
15 356 2011;34: 1038–1040. doi:10.2337/dc10-1180
- 16
17
18
19 357 23. Clair C, Bitton A, Meigs JB, Rigotti NA. Relationships of Cotinine and Self-Reported
20
21 358 Cigarette Smoking With Hemoglobin A1c in the U.S.: Results from the National Health
22
23 359 and Nutrition Examination Survey, 1999-2008. *Diabetes Care.* 2011;34: 2250–2255.
24
25 360 doi:10.2337/dc11-0710
- 26
27
28
29 361 24. Dalibalta S, Mirshafiei F, Davison G. Exercise intervention on cardiovascular disease risk
30
31 362 factors in a university population in the United Arab Emirates. *Int J Adolesc Med Health.*
32
33 363 2017;0. doi:10.1515/ijamh-2016-0132
- 34
35
36
37 364 25. Lindström J, Eriksson JG, Valle TT, Aunola S, Cepaitis Z, Hakumäki M, et al. Prevention
38
39 365 of diabetes mellitus in subjects with impaired glucose tolerance in the Finnish Diabetes
40
41 366 Prevention Study: results from a randomized clinical trial. *J Am Soc Nephrol.* 2003;14:
42
43 367 S108–S113.
- 44
45
46
47 368 26. Penn L, White M, Lindström J, den Boer AT, Blaak E, Eriksson JG, et al. Importance of
48
49 369 weight loss maintenance and risk prediction in the prevention of type-2 diabetes: analysis of
50
51 370 European Diabetes Prevention Study RCT. *PLoS One.* 2013;8: e57143.
- 52
53
54
55
56
57
58
59
60

- 1
2
3 371 27. Souto SB, Souto EB, Braga DC, Medina JL. Prevention and current onset delay approaches
4
5 372 of type-2 diabetes mellitus (T2DM). *Eur J Clin Pharmacol*. 2011;67: 653–661.
6
7
8 373 doi:10.1007/s00228-011-1038-z
9
10
11 374 28. Al Amiri E, Abdullatif M, Abdulle A, Al Bitar N, Afandi EZ, Parish M, et al. The
12
13 375 prevalence, risk factors, and screening measure for prediabetes and diabetes among Emirati
14
15 376 overweight/obese children and adolescents. *BMC Public Health*. 2015;15.
16
17 377 doi:10.1186/s12889-015-2649-6
18
19
20
21 378 29. Al Junaibi A, Abdulle A, Sabri S, Hag-Ali M, Nagelkerke N. The prevalence and potential
22
23 379 determinants of obesity among school children and adolescents in Abu Dhabi, United Arab
24
25 380 Emirates. *Int J Obes*. 2013;37: 68–74. doi:10.1038/ijo.2012.131
26
27
28
29 381 30. Sacks DB. A1C versus glucose testing: a comparison. *Diabetes Care*. 2011;34: 518–523.
30
31
32 382 31. Selvin E, Crainiceanu CM, Brancati FL, Coresh J. Short-term variability in measures of
33
34 383 glycemia and implications for the classification of diabetes. *Arch Intern Med*. 2007;167:
35
36 384 1545–1551.
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40 385 **FIGURE LEGENDS**

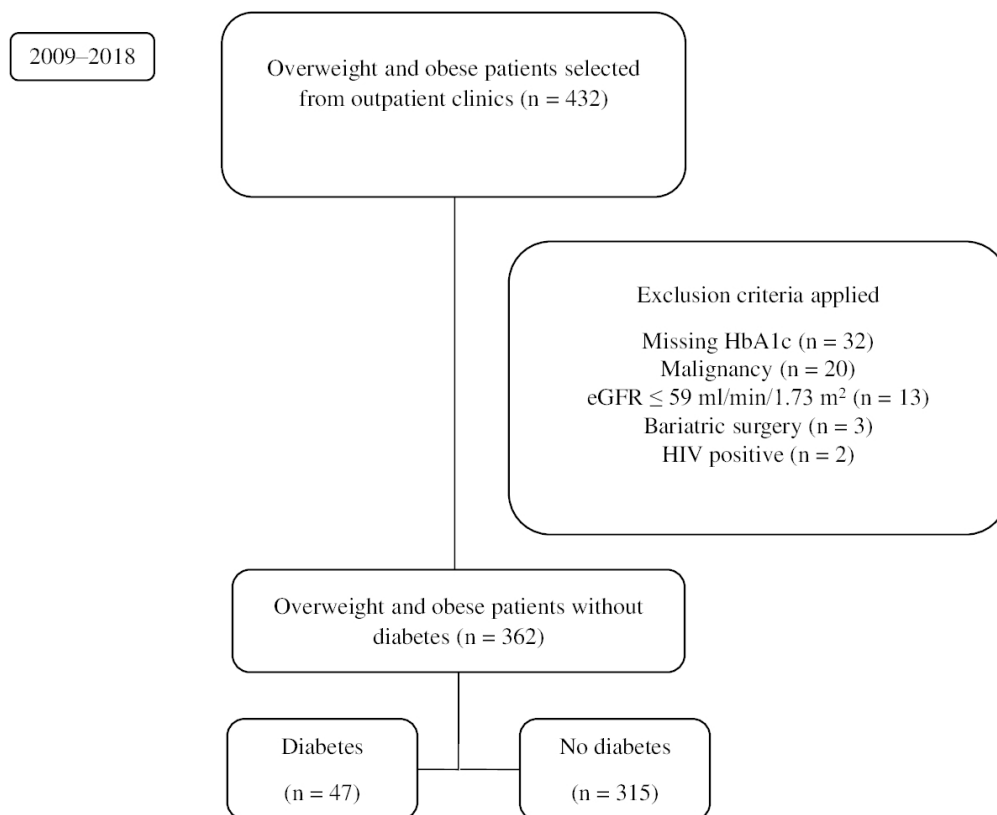
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42 386 **Fig 1. Flow chart for the inclusion and exclusion of patients.** *HbA1c* glycated hemoglobin,
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44 387 *eGFR* estimated glomerular filtration rate, *HIV* human immunodeficiency virus.
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47 388 **Fig 2. The sex-specific incidence rate of type-2 diabetes mellitus (cases/1000 person-years)**
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49 389 **stratified by BMI categories.** *BMI* body mass index.
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52 390 **Fig 3. The sex-specific incidence rate of type-2 diabetes mellitus (cases/1000 person-years)**
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54 391 **stratified by age.**
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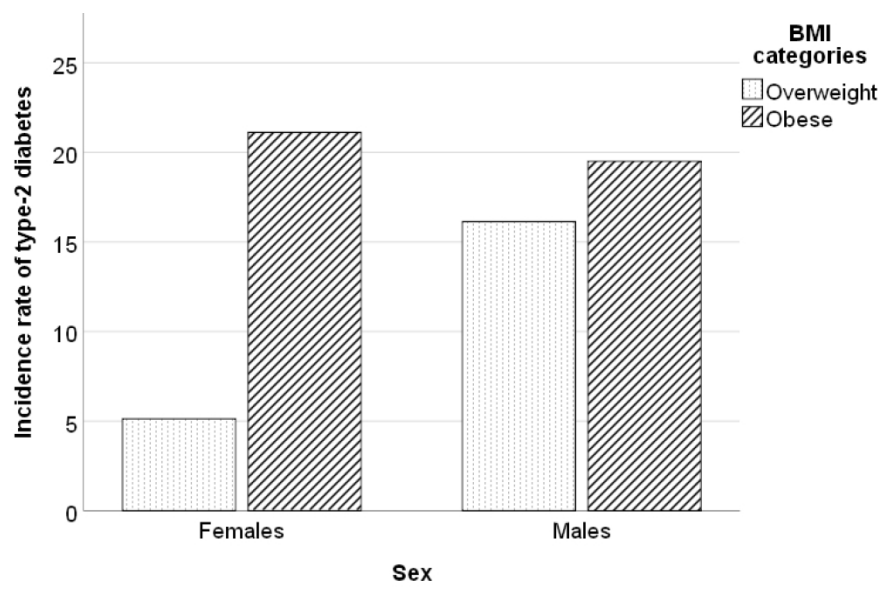
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33 Flow chart for the inclusion and exclusion of patients.
34 HbA1c glycated hemoglobin, eGFR estimated glomerular filtration rate, HIV human immunodeficiency virus.

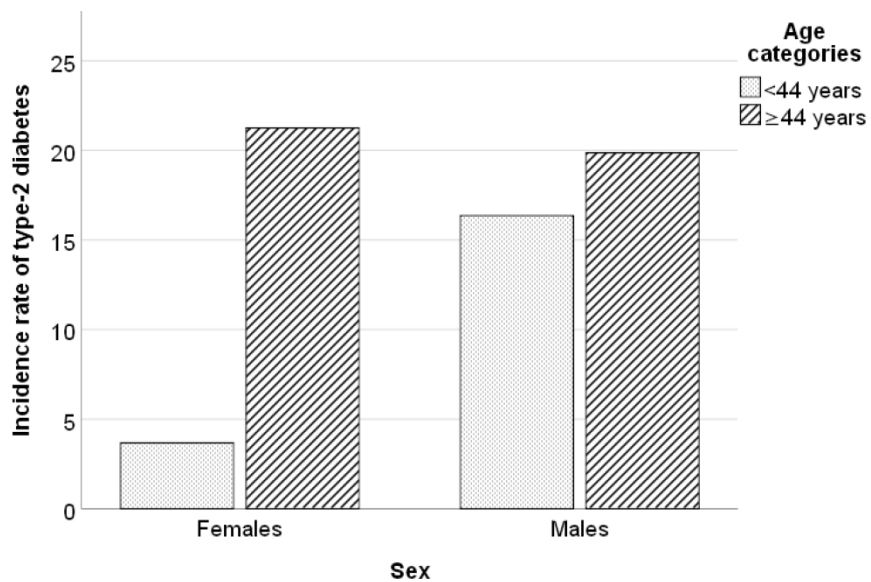
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The sex-specific incidence rate of type-2 diabetes mellitus (cases/1000 person-years) stratified by BMI categories. BMI body mass index.

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The sex-specific incidence rate of type-2 diabetes mellitus (cases/1000 person-years) stratified by age.

144x84mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4, 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(b) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5,6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6,7
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6,7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	NA
		(d) If applicable, explain how loss to follow-up was addressed	NA
		(e) Describe any sensitivity analyses	NA
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7,8
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) Summarise follow-up time (eg, average and total amount)	9
Outcome data	15*	Report numbers of outcome events or summary measures over time	9
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9,10
		(b) Report category boundaries when continuous variables were categorized	9,10
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9,10
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11,12
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13,14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Incidence and risk factors of type 2 diabetes mellitus in an overweight and obese population: a long-term retrospective study from a Gulf State

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3 **1 Incidence and risk factors of type 2 diabetes mellitus in an overweight and obese**
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5 **2 population: a long-term retrospective study from a Gulf State**
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10 4 Dybesh Regmi¹, Saif Al-Shamsi^{2*}, Romona D. Govender³, Juma Al Kaabi²
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51 22 **Word count (excluding title page, abstract, references, figures and tables): 2604**
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3 **24 Abstract**
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5 **25 Objectives:** A high body mass index (BMI) is associated with a risk of type 2 diabetes mellitus
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7 (DM). The United Arab Emirates (UAE) is experiencing a marked increase in obesity.
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10 **27** Nonetheless, no data is available regarding the incidence of type 2 DM in the high-risk adult
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12 **28** UAE population. Therefore, this study aimed to evaluate the incidence rate and risk of
13
14 **29** developing type 2 DM among individuals with above-normal BMI in the UAE.
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17 **30 Design:** A retrospective cohort study.
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19 **31 Setting:** Outpatient clinics at a tertiary care center in Al Ain, UAE.
20

21 **32 Participants:** Three hundred sixty-two overweight or obese adult UAE nationals who visited
22
23 outpatient clinics between April 2008 and December 2008.
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26 **34 Primary outcome measure:** Patients with type 2 DM were identified based on diagnosis
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28 established by a physician or through glycated hemoglobin (HbA1c) levels $\geq 6.5\%$ during the
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30 follow-up period (until April 2018).
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33 **37 Results:** The overall incidence rate of type 2 DM during the median follow-up time of 8.7 years
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35 was 16.3 [95% confidence interval (CI): 12.1–21.4] cases per 1000 person-years. Incidence rates
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37 in men and women were 17.7 (95% CI: 11.6–25.9) and 15.0 (95% CI: 9.8–22.2) cases per 1000
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39 person-years, respectively. Multivariable Cox proportional hazard analysis determined older age
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41 and obesity in women, and prediabetes in men to be the independent risk factors for developing
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43 type 2 DM.
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45 **43 Conclusions:** The incidence rate of type 2 DM in overweight and obese UAE nationals is high.
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47 In addition to screening, current strategies should strongly emphasize lifestyle modifications to
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49 decrease HbA1c and BMI levels in this high-risk population.
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47 Article Summary

48 Strengths and limitations of this study

- 49 • This long-term longitudinal cohort study determines the incidence rate and risk factors of
50 type 2 diabetes mellitus in overweight and obese United Arab Emirates nationals.
- 51 • Anthropometric and laboratory data were obtained instead of self-reported information for
52 the classification of risk factors and identification of incident cases.
- 53 • The study's subjects were recruited from a single large public hospital's ambulatory clinics;
54 therefore, our findings may not apply to the general UAE population.
- 55 • No data were available for review regarding additional confounders, such as family history
56 and changes in weight and physical activity.

58 **Keywords:** incidence; obesity; risk factors; type 2 diabetes mellitus; United Arab Emirates

60 INTRODUCTION

61 A rapid worldwide increase has been observed regarding the prevalence of type 2 diabetes
62 mellitus (DM) and obesity. The United Arab Emirates (UAE) is one of the epicenters of this
63 epidemic. In a 2007 study, the age-standardized rates for prediabetes and type 2 DM among
64 UAE nationals were 24.2% and 29%, respectively.[1] However, in a 2019 study of young
65 Emirati men, the age-adjusted prevalence of prediabetes was much higher at 41.3%.[2] By
66 contrast, the prevalence of type 2 DM in North America and Western European countries are
67 well below 12%.[3-6] Notably, the number of people with type 2 DM in the UAE is estimated to
68 reach over two million by 2040.[7]

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3 69 Overweight, defined as body mass index (BMI) between 25 and 29.99 kg/m² and obesity,
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5 70 defined as BMI \geq 30 kg/m²,^[8] are known risk factors of type 2 DM.^[9] More recently, the age-
6
7 71 adjusted prevalence of overweight and obesity among Emirati men between the ages of 18 and
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9 72 30 years was noted to be 27% and 30%, respectively.^[2] In contrast, the corresponding
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11 73 prevalence in another study was 23% and 10% among young Emirati women.^[10] Both these
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13 74 studies determined increased BMI to be strongly associated with diabetes.
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17 75 Both obesity and type 2 DM are well known cardiometabolic risk factors for vascular
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19 76 complications, such as coronary heart disease and peripheral vascular disease. The prevalence of
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21 77 these vascular diseases in the UAE is 10.5% and 11.1%, respectively.^[1] These and other
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23 78 vascular-related complications have resulted in the UAE having one of the highest reported
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25 79 global death rates for cardiovascular disease—204 per 100,000 for women and 309 per 100,000
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27 80 for men.^[11]
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31 81 The rise in the incidence of diabetes and its complications among the UAE population has
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33 82 been in parallel to the economic surge, resulting in growing urbanization and changing lifestyle
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35 83 habits in the country. Nevertheless, over the last decade, UAE has diverted its attention and
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37 84 endeavored to curb the burden of overweight and obesity, as well as to decrease the incidence of
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39 85 associated conditions like diabetes. The *Weqaya* program, a population-wide CVD screening
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41 86 program, was initiated in 2008^[12] to enable individuals and healthcare providers to implement
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43 87 CVD preventative measures. For continued assessment of the effectiveness of these local
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45 88 interventions, ad hoc analysis of population data at pre-defined intervals over a long period is
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47 89 required. However, epidemiological studies on type 2 DM in the UAE have primarily focused on
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49 90 its prevalence in the general population.^[1, 2, 13] Despite having information from the *Weqaya*
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51 91 program, data regarding the incidence of type 2 DM among obese and overweight UAE nationals
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3 92 remains poorly researched. This lapse is primarily because of the significant resource investment
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5 93 required to conduct observational cohort studies with prolonged follow-up.
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8 94 Therefore, in this long-term, longitudinal retrospective study, we aimed to calculate the
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10 95 incidence rate of type 2 DM and elucidate the effects of BMI on DM risk in adult UAE nationals
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12 96 who are overweight and obese.
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15 97

17 98 **METHODS**

19 99 **Study setting**

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22 100 A retrospective electronic medical record review was performed of adult patients who presented
23
24 101 to outpatient clinics at Tawam Hospital in Al Ain, UAE, between April 1, 2008, and December
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26 102 31, 2008. Tawam Hospital is one of the two large government hospitals in the city of Al Ain and
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28 103 serves an estimated 60,000 adult UAE nationals in the city who are overweight and obese.[14,
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30 104 15] The Research and Ethics Board of Tawam Hospital and the UAE University granted ethical
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32 105 approval for this study (CRD239/13). Informed consent was waived because patient records and
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34 106 information were anonymized and de-identified before analysis.
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40 108 **Subjects and procedures**

42 109 The study population consisted of UAE nationals who were overweight and obese, aged between
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44 110 18 and 75 years, who were seen at the outpatient departments at Tawam Hospital. The inclusion
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46 111 criteria were patients without type 2 DM, defined as having glycated hemoglobin (HbA1c)
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48 112 <6.5%; patients not taking antidiabetic medications; and those with BMI \geq 25 kg/m² at baseline.
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50 113 The exclusion criteria were patients with missing HbA1c data; those with a history of chronic
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52 114 medical conditions, such as malignancy, human immunodeficiency virus infection, receiving
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3 115 steroids or immunosuppression medications, or stage 3–5 chronic kidney disease [estimated
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5 116 glomerular filtration rate (eGFR) of ≤ 59 mL/min/1.73 m²].[16] Moreover, patients who had
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7 117 undergone weight reduction surgery, defined either as restrictive or malabsorptive bariatric
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9 118 surgery or pharmacotherapy for weight loss were excluded from the study. The final study group
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12 119 consisted of 362 subjects with a BMI of ≥ 25 kg/m² (Fig. 1).
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17 121 **Definitions and measurements**

19 122 Initial BMI was calculated from baseline height and weight measurements using the formula
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21 123 weight (kg) divided by height squared (m²). Overweight and obesity were defined according to
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23 124 the World Health Organization classification,[8] based on a BMI between 25 and 29.99 kg/m²
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25 125 and ≥ 30 kg/m², respectively. Hypertension (HTN) was defined as systolic blood pressure ≥ 140
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27 126 mmHg, diastolic blood pressure ≥ 90 mmHg, or the use of blood pressure medications.[17] The
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29 127 definition of dyslipidemia was a serum total cholesterol (TC) of ≥ 6.21 mmol/L or if the patient
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31 128 had a documented prescription of lipid-lowering medications.[18] Prediabetes was defined as
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33 129 having an HbA1c level between 5.7% and 6.4%.[19] Current or prior history of smoking tobacco
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35 130 was considered a positive smoking history. Patients with a documented history of coronary heart
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37 131 disease, cerebrovascular disease, or peripheral vascular disease were identified to have a vascular
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39 132 disease.
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47 134 **Outcomes**

50 135 Our study endpoint was incident type 2 DM, defined as either HbA1c $\geq 6.5\%$ (based on the
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52 136 definition of DM by the American Diabetes Association) or a diagnosis of type 2 DM established
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54 137 by a physician at any time during the follow-up period.[19] The occurrence of incident type 2
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3 138 DM was based on a review of all the electronic medical records until April 30, 2018. All
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5 139 laboratory analyses were performed at the Medical Laboratory Department of Tawam Hospital.
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7 140 An automated analyzer, Integra 400 Plus (Roche Diagnostics, Mannheim, Germany) was used to
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9 141 measure HbA1c levels. The HbA1c results were reported as a percentage using the International
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11 142 Federation of Clinical Chemistry-National Glycohemoglobin Standardization Program master
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13 143 equation.[20]
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19 145 **Statistical analyses**

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21 146 Using a formula by Rosner (2015),[21] a sample size of 353 was calculated. This was based on
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23 147 the anticipated incidence of diabetes of 17.3% [22] and using 80% power at a two-sided
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25 148 significance level of 0.05. The sample size was further increased by 20% to account for patients
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27 149 lost to follow-up and those with missing data.
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31 150 Inter-sex differences were determined using the Mann-Whitney U test or the independent-
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33 151 samples *t*-test for non-normal and normal data, respectively. For categorical variables, Fisher's
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35 152 exact test (two-tailed) was used. Person-years at risk for incident type 2 DM was calculated for
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37 153 each patient as the time from the baseline visit to the diagnosis of type 2 DM or the most recent
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39 154 outpatient visit, whichever occurred first. The incidence rate of type 2 DM with a 95%
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41 155 confidence interval (CI) was calculated per 1000 person-years by dividing the number of new
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43 156 cases of type 2 DM by the person-years at risk. Sex-specific incidence rates were calculated
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45 157 stratified by age and BMI categories. Kaplan-Meier time-to-event analysis was conducted with a
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47 158 log-rank test to compare age and BMI categories for incident type 2 DM.
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51 159 Univariable and multivariable Cox proportional hazard models were evaluated to examine
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53 160 predictors of incident type 2 DM in the entire cohort and stratified by sex. The following
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3 161 predictor variables were examined using univariable Cox modeling: age (categorized as <44
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5 162 years and ≥ 44 years), sex, vascular disease, HTN, dyslipidemia, smoking, HbA1c (categorized as
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7 163 <5.7% and $\geq 5.7\%$), and BMI (categorized as overweight and obese). All covariables with $P < 0.1$
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9
10 164 were included in the final multivariable model. A stepwise method based on likelihood ratios,
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12 165 with entry and removal probabilities set at 0.05 and 0.10, respectively, was used to check the
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14 166 results. The log-log plot was used to evaluate the proportional hazards assumption and was not
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16 167 significant. A P value < 0.05 was considered statistically significant. SPSS version 25 (IBM
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18 168 Corp., Armonk, NY) was used to analyze the data.
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23 170 **Patient and public involvement**

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26 171 There was no patient or public involvement in the design and conduct of the study.
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30 173 **RESULTS**

31 174 **Characteristics of study participants**

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33 175 The baseline patient characteristics of the 362 subjects, are presented in Table 1. The ratio of
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35 176 men to women was almost 1:1. At baseline, the mean age was 44.4 ± 14.5 years and the BMI
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37 177 was 31.7 kg/m^2 [interquartile range (IQR) 27.6, 34.2 kg/m^2]. When stratified by sex, women
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39 178 were older, had higher BMI and TC values, and had a higher prevalence of dyslipidemia at
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41 179 baseline. Conversely, men had significantly higher baseline systolic and diastolic blood pressure
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43 180 values, as well as a higher prevalence of smoking history.
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51 182 **Table 1.** Baseline characteristics of the study participants
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	Total (N = 362) Mean ± SD	Men (N = 170) Mean ± SD	Women (N = 192) Mean ± SD	P value*
Women (%)	53.0	-	-	-
Age (years)	44.4 ± 14.5	40.2 ± 14.7	48.1 ± 13.2	<0.001
Anthropometric values				
BMI (kg/m ²)	31.7 (27.6, 34.2)	29.6 (27.3, 32.8)	31.2 (27.9, 35.8)	0.001
SBP (mmHg)	127.9 ± 17.3	129.9 ± 17.9	126.2 ± 16.7	0.040
DBP (mmHg)	76.9 ± 11.0	79.0 ± 11.3	75.1 ± 10.4	0.001
Laboratory values				
HbA1c (%)	5.6 ± 0.5	5.6 ± 0.5	5.6 ± 0.5	0.326
eGFR (mL/min/1.73 m ²)	105.9 ± 16.8 (N = 359)†	104.2 ± 18.5 (N = 167)†	107.4 ± 15.1	0.073
TC (mmol/L)	5.1 ± 0.9	4.9 ± 1.0	5.2 ± 1.0	0.002
History of n (%)				
HTN	181 (50.0)	91 (53.5)	90 (46.9)	0.247
Dyslipidemia	141 (39.0)	52 (30.6)	89 (46.4)	0.002
Vascular disease	18 (5.0)	10 (5.9)	8 (4.2)	0.478
Smoking	56 (15.5)	54 (31.8)	2 (1.0)	<0.001

183 *HTN* hypertension, *BMI* body mass index, *eGFR* estimated glomerular filtration rate, *SBP*

184 systolic blood pressure, *DBP* diastolic blood pressure, *SD* standard deviation, *HbA1c* glycated

185 hemoglobin, *TC* total cholesterol.

186 †The difference in N is because of the missing data.

187 *Independent-samples t-test was used to calculate *P* values for continuous variables and Fisher's

188 exact test (two-tailed) for categorical variables.

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190 Incidence

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3 191 After a median follow-up time of 8.7 years (IQR, 8.2–9.0 years), 47 incident cases of type 2 DM
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5 192 were identified. The overall incidence rate of type 2 DM was 16.3 (95% CI: 12.1–21.4) cases per
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7 193 1000 person-years, and the crude incidence over the same period was 13.0% (95% CI:
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9 194 9.8–16.8%). The incidence rate of type 2 DM increased with patient age (Fig. 2). When stratified
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11 195 by sex, the incidence rates, were 17.7 (95% CI: 11.6–25.9) and 15.0 (95% CI: 9.8–22.2) cases
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13 196 per 1000 person-years in men and women, respectively.
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17 197 Sex-specific incidence rates, as stratified by BMI, were higher in obese women (21.1, 95%
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19 198 CI: 13.3–32.0 cases per 1000 person-years) compared with overweight women (5.1, 95% CI:
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21 199 1.3–14.0 cases per 1000 person-years) ($P = 0.013$). Incidence rates for type 2 DM were higher in
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23 200 older women (21.3, 95% CI: 13.5–31.9 cases per 1000 person-years) compared with younger
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25 201 women (3.7, 95% CI: 0.6–12.2 cases per 1000 person-years) ($P = 0.008$), (Fig. 3). However,
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27 202 these differences were not significant among men.
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30 203 **Analyses of risk factors**

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33 204 We used multivariable Cox regression analyses to examine the association of age, sex, vascular
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35 205 disease, dyslipidemia, smoking, HTN, BMI, and HbA1c levels with the risk of developing type 2
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37 206 DM in the entire study cohort, as well as between men and women. When adjusted for all other
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39 207 variables, we observed that in men an HbA1c level $\geq 5.7\%$ [hazard ratio (HR) = 3.02, 95% CI:
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41 208 1.20–7.62] and in women age ≥ 44 years (HR = 4.84, 95% CI: 1.13–20.73) and obesity (HR =
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43 209 3.42, 95% CI: 1.01–11.57) were significant risk factors for the development of type 2 DM (Table
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52 212 **Table 2.** Predictors of incident type 2 diabetes mellitus in the study population

Predictor	Total (N = 362)	Men (N = 170)	Women (N = 192)
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variables	HR (95% CI)	<i>P</i> value	HR (95% CI)	<i>P</i> value	HR (95% CI)	<i>P</i> value
Age						
<44 years	Reference		Reference		Reference	
≥44 years	1.20 (0.59–2.44)	0.619	0.46 (0.17–1.13)	0.135	4.84 (1.13–20.73)	0.034
Sex						
Women	Reference					
Men	1.60 (0.83–3.05)	0.160				
History of HTN						
No	Reference		Reference		Reference	
Yes	1.78 (0.94–3.37)	0.075	1.89 (0.74–4.81)	0.183	1.61 (0.67–3.88)	0.292
History of dyslipidemia						
No	Reference		Reference		Reference	
Yes	1.32 (0.70–2.51)	0.393	2.01 (0.80–5.04)	0.135	0.80 (0.34–1.90)	0.608
History of smoking						
No	Reference		Reference		Reference	
Yes	0.58 (0.23–1.49)	0.259	0.36 (0.12–1.04)	0.060	4.88 (0.44–54.08)	0.196
History of vascular disease						
No	Reference		Reference		Reference	
Yes	1.57 (0.54–4.54)	0.408	2.46 (0.65–9.27)	0.183	0.60 (0.06–5.50)	0.647
HbA1c						
<5.7%	Reference		Reference		Reference	
≥5.7%	2.29 (1.16–4.52)	0.016	3.02 (1.20–7.62)	0.019	2.30 (0.83–6.39)	0.109
BMI						
Overweight	Reference		Reference		Reference	
Obese	1.86 (0.99–3.50)	0.053	1.17 (0.51–2.68)	0.713	3.42 (1.01–11.57)	0.048

213 *HTN* hypertension, *BMI* body mass index, *HbA1c* glycated hemoglobin, *CI* confidence intervals,

214 *HR* hazard ratio.

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216 DISCUSSION

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3 217 The results of this study revealed that the crude incidence of type 2 DM among the UAE
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5 218 nationals who are overweight and obese was 1.49% per year during the 9-year study period. The
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7 219 overall incidence rate was 16.3 per 1000 person-years. The independent predictors for the
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9 220 development of type 2 DM were age (≥ 44 years) and obesity in women and prediabetes in men.
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12 221 **Incidence rates**

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14 222 The incidence rates of type 2 DM in high-risk populations differ worldwide. This difference is
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16 223 probably because of variations in insulin sensitivity related to the interaction between genetic
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18 224 and environmental factors among different ethnic and population groups globally.[23] In a
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20 225 United States study of predominantly overweight and obese African-American women, reported
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22 226 the incidence rate of type 2 DM was 15.2 per 1000 person-years[24] and is comparable to our
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24 227 study. There has been only one other study that has assessed the incidence rate of type 2 DM in
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26 228 the UAE.[13] The study was conducted over 12 months in Ajman, one of the emirates in the
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28 229 UAE and revealed that the incidence rate for type 2 DM was 4.8 per 1000 person-years.
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32 230 However, this study cannot be directly compared with our study because it was conducted on the
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34 231 general population, and our study cohort comprised only overweight and obese UAE nationals.
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37 232 **Risk factors**

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39 233 This study revealed some interesting findings regarding the risk factors for developing type 2
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41 234 DM in the high-risk UAE population. Sex-specific incidence rates of type 2 DM exhibited a
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43 235 female preponderance, particularly older women. Nevertheless, these results were not unique and
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45 236 were also observed among the general population of the UAE.[13] The higher incidence of type
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47 237 2 DM among older women may be attributable to the high prevalence of overweight and obesity,
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49 238 sedentary lifestyle, nutritional habits, and early menopause witnessed in our population.[25-28]
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3 239 Furthermore, individuals with high-normal HbA1c levels have a greater risk of developing
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5 240 type 2 DM.[29] However, when we stratified our cohort by sex, the independent predictive
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7 241 property of the HbA1c level was only observed in men. An explanation for this finding could be
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9 242 the high prevalence of smoking history in men, as smoking has been shown to increase HbA1c
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11 243 levels in individuals without diabetes.[30] Moreover, obesity in women was noted to be an
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13 244 independent risk predictor for type 2 DM. Studies have demonstrated that the risk of developing
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15 245 type 2 DM is significantly higher in individuals with BMI ≥ 30 kg/m² compared with those with
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17 246 normal BMI.[9] Therefore, interventions that promote weight loss and reduce BMI can reduce
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19 247 the risk of developing type 2 DM. Notably, an eight-week exercise intervention program in a
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21 248 UAE student population demonstrated a significant reduction in BMI.[31] In addition, other
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23 249 controlled intervention studies in high-risk populations[32,33] demonstrated a significant
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25 250 decrease in the risk of type 2 DM consequent to BMI reduction.

251 **Clinical and public health implications**

252 In the UAE, much of the increase in type 2 DM has occurred because of social and economic
253 changes—from traditional, semi-nomadic lifestyle to sedentary, urban, and high-income
254 lifestyle. Consequently, the progression toward type 2 DM and cardiovascular disease starts early
255 in the UAE because of the high prevalence of childhood obesity.[1, 34] A 2015 study of Emirati
256 children and adolescents with a BMI ≥ 25 kg/m² determined the prevalence of prediabetes and
257 type 2 DM to be 5.4% and 0.87%, respectively.[35] Therefore, reducing the burden of type 2
258 DM in the UAE will require intensive population-wide interventions to promote regular physical
259 activity and a healthy diet,[33, 36] particularly among the Emirati youth.

260 Furthermore, the results of this study highlight the need to focus on Emirati women as a
261 specific target group for obesity prevention programs. These programs should begin in childhood

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3 262 because 21% are obese by the time they are 30 years of age.[26] In addition, it is imperative to
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5 263 have a multidisciplinary approach to address the high incidence of type 2 DM, wherein
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7 264 pediatricians, primary care providers, dieticians, and specialists work collaboratively toward
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9 265 promoting weight reduction and maintaining a healthy BMI in our population.
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12 266 **Strengths and limitations**

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14 267 The strengths of this study include the long duration of follow-up for our representative sample
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16 268 of overweight and obese individuals in the second-largest city in the Abu Dhabi Emirate of UAE.
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18 269 We used the anthropometric and laboratory data documented in patient charts instead of self-
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20 270 reported information and diagnostic codes for the classification of risk factors and identification
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22 271 of incident cases. In addition, HbA1c levels or physician diagnosis formed the basis to identify
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24 272 incident cases of type 2 DM instead of fasting plasma glucose that has more variability.[37,38]
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28 273 Nonetheless, this study had some limitations. Baseline data regarding family history of type 2
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30 274 DM, history of gestational diabetes, physical activity, and abdominal obesity were unavailable—
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32 275 all of which are well-researched risk factors for the development of DM. Nevertheless, a
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34 276 prospective study can provide more robust results. Furthermore, data on additional confounders,
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36 277 such as family history, changes in weight and physical activity, were unavailable for review.
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38 278 Finally, subjects for this study were recruited from a single largest tertiary care hospital's
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40 279 ambulatory clinics; thus, our findings may not apply to the general UAE population.
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46 281 **CONCLUSIONS**

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48 282 The overall incidence rate of type 2 DM in UAE nationals who are overweight and obese was
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50 283 16.3 per 1000 person-years. Notably, prediabetes in men and obesity in women, particularly
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52 284 older women, were determined to be independent predictors for the development of incident type
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3 285 2 DM. Hence, it is imperative to emphasize BMI reduction through lifestyle modifications in
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5 286 these high-risk groups.
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10 288 **ACKNOWLEDGMENTS**

11
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14
15 290 **AUTHOR CONTRIBUTIONS**

16
17 291 D.R. conceived the study and its design, performed literature search and drafted the initial
18
19 292 manuscript. S.A.S. was involved in data management, statistical analysis, interpretation of the
20
21 293 data, and critical review of the manuscript. R.D.G. assisted in statistical analysis, contributed to
22
23 294 the discussion, reviewed and edited the manuscript. J.A.K. performed a critical review of the
24
25 295 manuscript was involved in data interpretation and also guided the research methodology. All
26
27 296 authors read and approved the final manuscript.
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30
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32
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34
35 299 University (No. 31M325). The funders had no role in study design, data collection, and analysis,
36
37 300 decision to publish, or preparation of the manuscript.
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40 301 **COMPETING INTERESTS**

41
42 302 The authors declare that they have no competing interests.
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45 303 **PATIENT CONSENT FOR PUBLICATION**

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47 304 Not required
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49 305 **AVAILABILITY OF DATA AND MATERIALS**

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51 306 The dataset used and analyzed during the current study is available from the corresponding
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53 307 author on reasonable request.
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309 **REFERENCES**

- 310 1. Saadi H, Carruthers SG, Nagelkerke N, et al. Prevalence of diabetes mellitus and its
311 complications in a population-based sample in Al Ain, United Arab Emirates. *Diabetes Res*
312 *Clin Pract* 2007;78:369–77. doi:10.1016/j.diabres.2007.04.008
- 313 2. Alzaabi, A, Al-Kaabi, J, Al-Maskari, F, Farhood, AF, Ahmed, LA. Prevalence of diabetes
314 and cardio-metabolic risk factors in young men in the United Arab Emirates: A
315 cross-sectional national survey. *Endocrinol Diab Metab* 2019;2:e00081.
- 316 3. Eschwege E, Basdevant A, Crine A, et al. Type 2 diabetes mellitus in France in 2012: Results
317 from the ObEpi survey. *Diabetes Metab* 2015;41(1):55–61.
318 doi:10.1016/j.diabet.2014.11.007.
- 319 4. Caspard H, Jabbour S, Hammar N, et al. Recent trends in the prevalence of type 2 diabetes
320 and the association with abdominal obesity lead to growing health disparities in the USA: an
321 analysis of the NHANES surveys from 1999 to 2014. *Diabetes Obes Metab* 2018;20(3):667–
322 71.
- 323 5. Tamayo T, Brinks R, Hoyer A, et al. The prevalence and incidence of diabetes in Germany.
324 *Dtsch Arztebl Int* 2016;113(11):177–82.
- 325 6. Greiver M, Williamson T, Barber D, et al. Prevalence and epidemiology of diabetes in
326 Canadian primary care practices: a report from the Canadian primary care sentinel
327 surveillance network. *Can J Diabetes*. 2014;38(3):179–85. doi:10.1016/j.jcjd.2014.02.030

- 1
2
3 328 7. Center ICLD. UAE Diabetes Trends and Numbers [Internet]. [cited 19 Apr 2018]. Available:
4
5 329 <http://www.icldc.ae/about-us/p/UAE-Diabetes-Trends>
6
7
8
9 330 8. World Health Organization (WHO). BMI Classification [Internet]. 2006 [cited 18 Apr 2018].
10
11 331 Available: <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
12
13
14 332 9. Ganz ML, Wintfeld N, Li Q, et al. The association of body mass index with the risk of type 2
15
16 333 diabetes: a case-control study nested in an electronic health records system in the United
17
18 334 States. *Diabetol Metab Syndr* 2014;6:50. doi:10.1186/1758-5996-6-50
19
20
21
22 335 10. Al Dhaheri AS, Mohamad MN, Jarrar AH, et al. A cross-sectional study of the prevalence of
23
24 336 metabolic syndrome among young female emirati adults. *PLoS ONE* 2016;11(7):e0159378.
25
26
27
28 337 11. Loney T, Aw TC, Handysides DG, et al. An analysis of the health status of the United Arab
29
30 338 Emirates: the 'Big 4' public health issues. *Glob Health Action* 2013;6:20100.
31
32
33
34 339 12. Hajat C, Harrison O, Al Siksek Z. Weqaya: a population-wide cardiovascular screening
35
36 340 program in Abu Dhabi, United Arab Emirates. *Am J Public Health* 2012;102:909-14.
37
38 341 doi:10.2105/AJPH.2011.300290
39
40
41
42 342 13. Sreedharan J, Muttappallymyalil J, Al Sharbatti S, et al. Incidence of type-2 diabetes mellitus
43
44 343 among Emirati residents in Ajman, United Arab Emirates. *Korean J Fam Med* 2015;36:253-
45
46 344 7. doi:10.4082/kjfm.2015.36.5.253
47
48
49 345 14. Statistics Center Abu Dhabi. Statistics Center. In: SCAD [Internet]. 2017 [cited 19 Apr
50
51 346 2018]. Available:
52
53
54
55
56
57
58
59
60

- 1
2
3 347 [https://www.scad.gov.abudhabi/Release%20Documents/Statistical%20Yearbook%20-](https://www.scad.gov.abudhabi/Release%20Documents/Statistical%20Yearbook%20-%20Population%20-%20EN.pdf)
4
5 348 [%20Population%20-%20EN.pdf](https://www.scad.gov.abudhabi/Release%20Documents/Statistical%20Yearbook%20-%20Population%20-%20EN.pdf)
6
7
8
9 349 15. Razzak H, Qawas A, El-Metwally A, et al. The prevalence and risk factors of obesity in the
10
11 350 United Arab Emirates. *Saudi Journal of Obesity* 2017;5(2):57. doi:10.4103/sjo.sjo_9_17
12
13
14 351 16. Levin A, Stevens PE, Bilous RW, et al. Kidney Disease: Improving Global Outcomes
15
16 352 (KDIGO) CKD Work Group. KDIGO 2012 clinical practice guideline for the evaluation and
17
18 353 management of chronic kidney disease. *Kidney Int Suppl* 2013;3:1–150.
19
20
21
22 354 17. National High Blood Pressure Education Program. The Seventh Report of the Joint National
23
24 355 Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure
25
26 356 [Internet]. Bethesda (MD): National Heart, Lung, and Blood Institute (US); 2004. Available:
27
28 357 <http://www.ncbi.nlm.nih.gov/books/NBK9630/>
29
30
31
32 358 18. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults.
33
34 359 Executive Summary of The Third Report of The National Cholesterol Education Program
35
36 360 (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In
37
38 361 Adults (Adult Treatment Panel III). *JAMA* 2001;285:2486–97.
39
40
41
42 362 19. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes*
43
44 363 *Care* 2010;33:S62.
45
46
47
48 364 20. Consensus Statement on the Worldwide Standardization of the Hemoglobin A1C
49
50 365 Measurement: The American Diabetes Association, European Association for the Study of
51
52 366 Diabetes, International Federation of Clinical Chemistry and Laboratory Medicine, and the
53
54 367 International Diabetes Federation. *Diabetes Care* 2007;30:2399–400. doi:10.2337/dc07-9925
55
56
57
58
59
60

- 1
2
3 368 21. Rosner B. Fundamentals of biostatistics. 7th ed. Boston: Cengage Learning, Inc 2010.
4
5
6 369 22. International Diabetes Federation. IDF diabetes atlas. 8th ed. Brussels, Belgium:
7
8 International Diabetes Federation 2017.
9 370
10
11
12 371 23. Dagenais GR, Gerstein HC, Zhang X, et al. Variations in diabetes prevalence in low-,
13
14 372 middle-, and high-income countries: results from the prospective urban and rural
15
16 373 epidemiological study. *Diabetes Care* 2016;39:780–7. doi:10.2337/dc15-2338
17
18
19
20 374 24. Krishnan S, Rosenberg L, Djoussé L, et al. Overall and central obesity and risk of type-2
21
22 375 diabetes in U.S. black women. *Obes Silver Spring Md* 2007;15:1860–6.
23
24 376 doi:10.1038/oby.2007.220
25
26
27
28 377 25. Sheikh-Ismail LI, Henry CJK, Lightowler HJ, et al. Prevalence of overweight and obesity
29
30 378 among adult females in the United Arab Emirates. *Int J Food Sci Nutr* 2009;60:26–33.
31
32 379 doi:10.1080/09637480802331179
33
34
35
36 380 26. Carter AO, Saadi HF, Reed RL, Dunn EV. Assessment of obesity, lifestyle, and reproductive
37
38 381 health needs of female citizens of Al Ain, United Arab Emirates. *J Health Popul Nutr*
39
40 382 2004;75–83.
41
42
43
44 383 27. Trainer S. Negotiating weight and body image in the UAE: Strategies among young emirati
45
46 384 women. *Am J Hum Biol* 2012;24:314–24. doi:10.1002/ajhb.22251
47
48
49 385 28. Rizk DE, Bener A, Ezimokhai M, et al. The age and symptomatology of natural menopause
50
51 386 among United Arab Emirates women. *Maturitas* 1998;29:197–202.
52
53
54
55
56
57
58
59
60

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2
3 387 29. Bonora E, Kiechl S, Mayr A, et al. High-normal HbA1c is a strong predictor of type-2
4
5 388 diabetes in the general population. *Diabetes Care* 2011;34:1038–40. doi:10.2337/dc10-1180
6
7
8
9 389 30. Clair C, Bitton A, Meigs JB, et al. Relationships of cotinine and self-reported cigarette
10
11 390 smoking with hemoglobin A1c in the U.S.: Results from the National Health and Nutrition
12
13 391 Examination Survey, 1999-2008. *Diabetes Care* 2011;34:2250–5. doi:10.2337/dc11-0710
14
15
16
17 392 31. Dalibalta S, Mirshafiei F, Davison G. Exercise intervention on cardiovascular disease risk
18
19 393 factors in a university population in the United Arab Emirates. *Int J Adolesc Med Health*
20
21 394 2017;0. doi:10.1515/ijamh-2016-0132
22
23
24 395 32. Lindström J, Eriksson JG, Valle TT, et al. Prevention of diabetes mellitus in subjects with
25
26 396 impaired glucose tolerance in the Finnish Diabetes Prevention Study: results from a
27
28 397 randomized clinical trial. *J Am Soc Nephrol* 2003;14:S108–13.
29
30
31
32 398 33. Penn L, White M, Lindström J, et al. Importance of weight loss maintenance and risk
33
34 399 prediction in the prevention of type-2 diabetes: analysis of European Diabetes Prevention
35
36 400 Study RCT. *PLoS One* 2013;8:e57143.
37
38
39
40 401 34. Al Junaibi A, Abdulle A, Sabri S, et al. The prevalence and potential determinants of obesity
41
42 402 among school children and adolescents in Abu Dhabi, United Arab Emirates. *Int J Obes*
43
44 403 2013;37:68–74. doi:10.1038/ijo.2012.131
45
46
47
48 404 35. Al Amiri E, Abdullatif M, Abdulle A, et al. The prevalence, risk factors, and screening
49
50 405 measure for prediabetes and diabetes among Emirati overweight/obese children and
51
52 406 adolescents. *BMC Public Health* 2015;15. doi:10.1186/s12889-015-2649-6
53
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3 407 36. Souto SB, Souto EB, Braga DC, et al. Prevention and current onset delay approaches of type-
4
5 408 2 diabetes mellitus (T2DM). *Eur J Clin Pharmacol* 2011;67:653–61. doi:10.1007/s00228-
6
7 409 011-1038-z
8
9

10
11 410 37. Sacks DB. A1C versus glucose testing: a comparison. *Diabetes Care* 2011;34:518–23.
12
13

14 411 38. Selvin E, Crainiceanu CM, Brancati FL, et al. Short-term variability in measures of glycemia
15
16 412 and implications for the classification of diabetes. *Arch Intern Med* 2007;167:1545–51.
17
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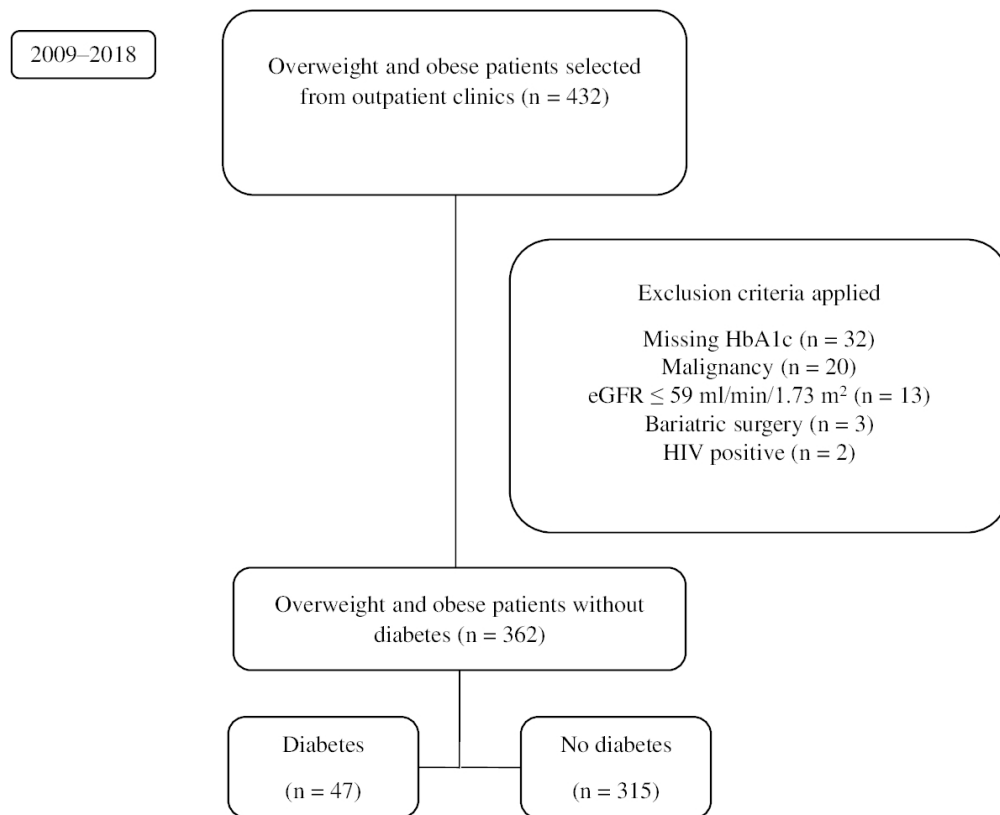
23 414 **FIGURE LEGENDS**

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25 415 **Figure 1.** Flow chart for the inclusion and exclusion of patients
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28 416 *HbA1c* glycated hemoglobin, *eGFR* estimated glomerular filtration rate, *HIV* human
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30 417 immunodeficiency virus.
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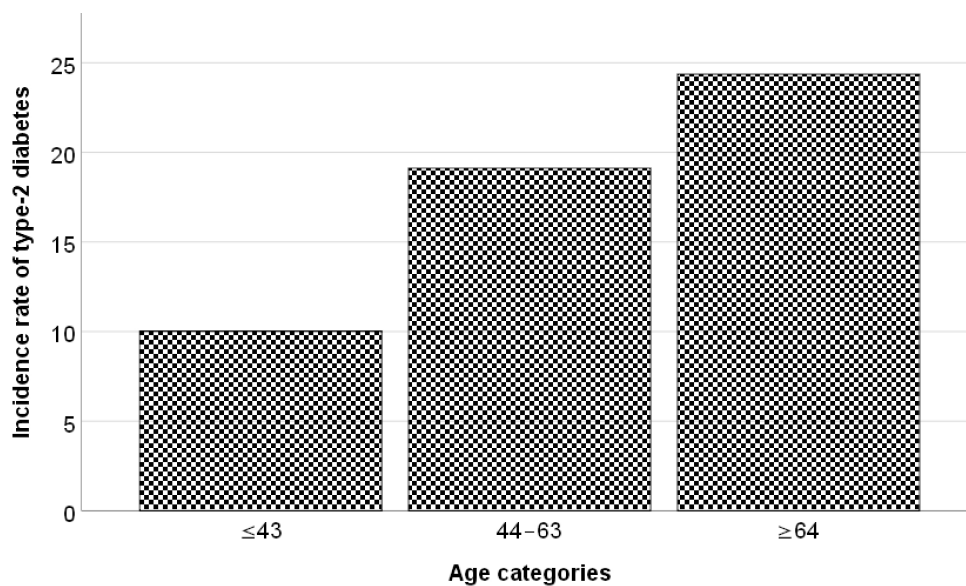
32 418 **Figure 2.** Overall incidence rate of type 2 diabetes mellitus (cases/1000 person-years) by
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34 419 increasing age
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37 420 **Figure 3.** Sex-specific incidence rate of type 2 diabetes mellitus (cases/1000 person-years)
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39 421 stratified by BMI categories (A) and by age (B)
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41 422 *BMI* body mass index.
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33 Flow chart for the inclusion and exclusion of patients.
34 HbA1c glycated hemoglobin, eGFR estimated glomerular filtration rate, HIV human immunodeficiency virus.

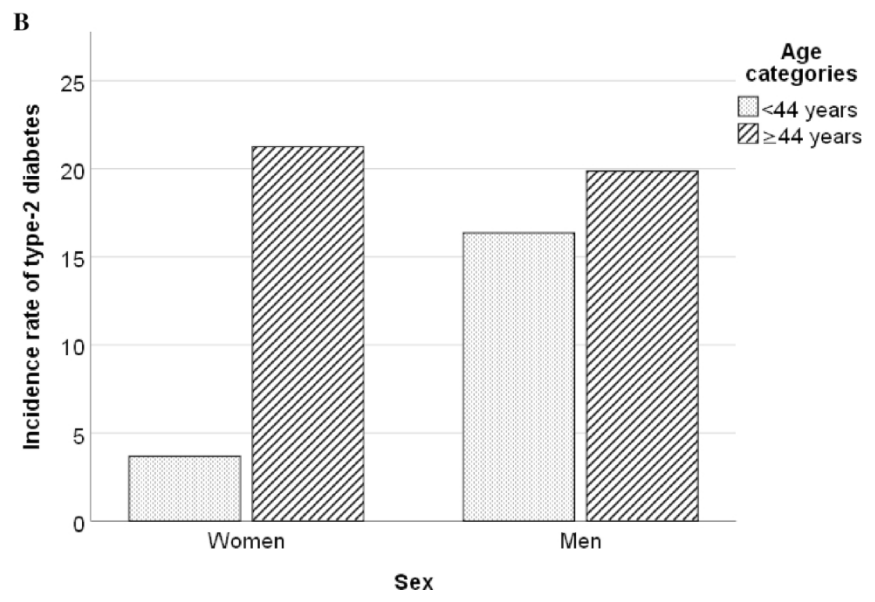
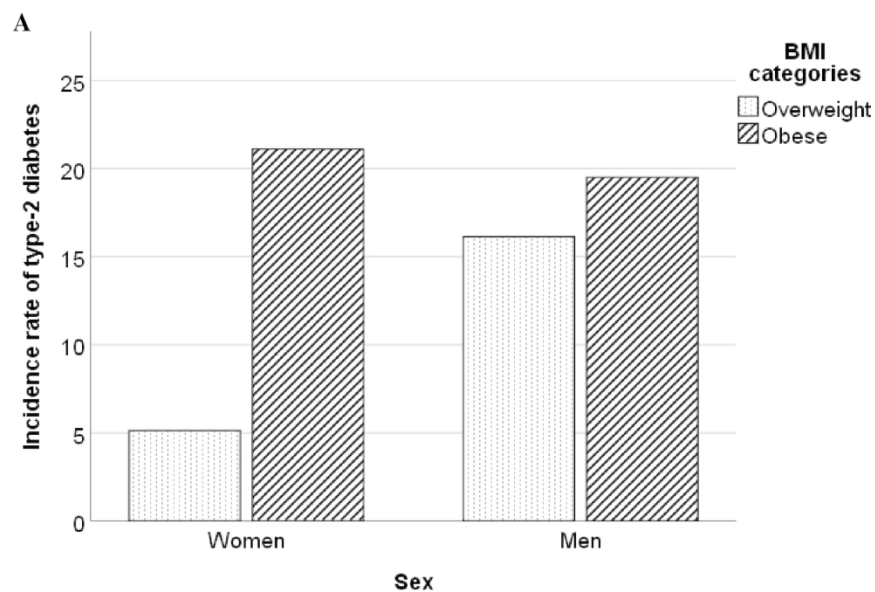
35 100x81mm (300 x 300 DPI)



Overall incidence rate of type 2 diabetes mellitus (cases/1000 person-years) by increasing age

144x84mm (300 x 300 DPI)

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Sex-specific incidence rate of type 2 diabetes mellitus (cases/1000 person-years) stratified by BMI categories (A) and by age (B)

158x222mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3, 4
Objectives	3	State specific objectives, including any prespecified hypotheses	4, 5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5, 6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6, 7
		(b) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6, 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6,7
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	5
		(d) If applicable, explain how loss to follow-up was addressed	5
		(e) Describe any sensitivity analyses	NA
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5, 6
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Table 1
		(c) Summarise follow-up time (eg, average and total amount)	10
Outcome data	15*	Report numbers of outcome events or summary measures over time	10
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 2
		(b) Report category boundaries when continuous variables were categorized	Table 2
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12–14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.