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# Dyslipidaemia prevalence and associated risk factors in the United Arab Emirates: a population-based study

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## ABSTRACT

**Objectives** To determine and describe the prevalence and pattern of dyslipidaemia and its associated risk factors among an adult Emirati population.

**Design** Population-based, cross-sectional study.

**Setting** Adults living in the Northern Emirates.

**Participants** 824 adult participants (51.8% men, 48.2% women, mean age 42.8±13.4 years old).

**Primary outcome measures** Fasting blood samples were collected, blood pressure and waist circumference were measured.

**Results** The overall dyslipidaemia prevalence was 72.5%, with 42.8% of the participants showing high total cholesterol (TC) level, 29% showing high triglyceride (TG) level, 42.5% showing low high-density lipoprotein cholesterol (HDL-C) level, 38.6% showing high low-density lipoprotein cholesterol (LDL-C) level and 72.3% showing high cholesterol ratio. The regression models showed that gender was a significant predictor of a high TG level, low LDL-C level and high cholesterol ratio. Middle-aged individuals (30–59 years old) had a significantly higher risk of having high TC, TG and LDL-C levels than young (<30 years old) and elderly (≥60 years old) individuals. Diabetes mellitus was a significant predictor of low TC, high TG and low HDL-C levels, while central obesity was a significant predictor of a high TG level, low HDL-C level and high cholesterol ratio. Smoking was a significant predictor of a high TG level only in men.

**Conclusions** The prevalence of dyslipidaemia was considerably high among the local adult Emiratis. The identified dyslipidaemia predictors were gender, age, smoking, central obesity and diabetes. Further studies are recommended to assess other important risk factors and aggressive preventive measures in the United Arab Emirates.

## Strengths and limitations of this study

- ► To the best of our knowledge, this is the first study to report the prevalence of the different types of dyslipidaemia based on fasting blood samples in the United Arab Emirates.
- ► This study is based on a large representative sample from a local Emirati population.
- ► Diabetes status was determined using haemoglobin A1c test.
- ► Due to the nature of a cross-sectional design, causality could not be established in this study.
- ► This study did not assess some important dyslipidaemia risk factors that have been identified in the literature, such as diet.

## INTRODUCTION

Dyslipidaemia is a well-documented potential risk factor for atherosclerotic cardiovascular disease (ACD), which includes ischaemic heart disease (IHD) and cerebrovascular diseases such as strokes.[1–3] The WHO revealed that 60% of IHD cases and 40% of stroke cases are caused by dyslipidaemia.[4] According to the WHO estimates, of the 56.9 million deaths worldwide in 2016, IHD and strokes were responsible for a combined 15.2 million (27%) of all causes of death.[4] Specifically, dyslipidaemia was responsible for an estimated 4.5% of the total global mortality and 2% of the total disability-adjusted life years worldwide.[5]

In the United Arab Emirates (UAE), IHD and strokes represent the first and the third cause of premature death, respectively, and they caused approximately 40% of all deaths in 2017.[6] The 2013 Global Burden of Disease Study reported that, in general, the rates of age-standardised deaths due to ACD have declined in developed countries in recent decades.[7] However, IHD is still the leading cause of premature adult mortality globally,[7] particularly in developing countries, such as the UAE, due to an increase in the associated risk factors and a lack of appropriate preventive interventions.[8]

Evidence has suggested that effective prevention and management of dyslipidaemia can significantly slow the development of atherosclerosis and the associated ACD. According to WHO, a 50% decrease in IHD risk was achieved over 5 years by a 10% reduction in serum cholesterol levels in

40-year-old men.[5] Moreover, a 50% reduction in deaths due to IHD in Finland was attributed to a reduction in the blood cholesterol levels of the population.[5]

Several population-based studies have identified various modifiable dyslipidaemia risk factors, and the causalities of some of these risk factors are now well established.[9 10] For example, smoking tobacco has been identified as a strong inflammatory mediator of the blood vessels and a key promoter in the atherosclerotic process.[10] The nicotine in tobacco weakens vascular activity and increases endothelial dysfunction, which are responsible for subendothelial oedema, leading to the accumulation of lipids in the blood vessels.[11]

The association between dyslipidaemia and obesity has been reported frequently in the literature; obesity causes abnormalities in an individual's lipid metabolism.[12] Increased visceral adipose tissue and increased subcutaneous waist adipose tissue are associated with higher triglyceride (TG) levels and lower high-density lipoprotein cholesterol (HDL-C) levels.[13 14] Moreover, the effect of physical inactivity on blood cholesterol levels is an independent risk factor for dyslipidaemia.[15] Lack of regular physical exercise induces undesirable changes in the plasma lipid levels by decreasing the extrahepatic lipoprotein lipase and hepatic lipase activity, which inhibits TG lipolysis and decreases the HDL-C level.[16] Furthermore, the roles of chronic diseases in dyslipidaemia, such as diabetes mellitus and hypertension, are well documented.[17 18]

At present, there is a limited body of literature describing the magnitude of the burden of dyslipidaemia and its associated risk factors that is unique and relevant to a local Emirati population. A better understanding of the epidemiology of dyslipidaemia will offer great opportunities to implement effective primary and secondary prevention strategies that can lead to a significant reduction in dyslipidaemia, and ultimately ACD and premature death, in the UAE.

The aim of this study was to report the prevalence of dyslipidaemia based on fasting blood samples in a large representative sample of an adult population in the Northern Emirates. An additional aim was to describe the pattern and risk factors associated with dyslipidaemia among the study population.

## METHODS

The data accessed for this study came from the UAE National Diabetes and Lifestyle Study (UAEDIAB). The UAEDIAB is a cross-sectional survey designed to investigate the prevalence of diabetes and the associated risk factors among the adult UAE population. Anthropometric measurements and blood samples were also collected.

### Setting

For this study, data were collected from adult residents living in the Northern Emirates in UAE (Sharjah, Ajman, Ras al-Khaimah, Fujairah and Umm al-Quwain). In 2013, the UAE's population was estimated at just over nine million, of which 1.4 million were local Emiratis, with about a third of the total population living in the Northern Emirates.[19] The study data were collected from December 2012 through May 2013.

### Participants

UAE nationals 18 years of age and older were recruited via a household survey of non-institutionalised adults following a random selection of districts, and they were stratified by emirate using a cluster sampling method. Sample size in each emirate was proportional to the population size within each emirate. The household sample was drawn by the National Bureau of Statistics in Abu Dhabi based on the most recent census data, and was defined an Emirati household if the head of the family was an Emirati national. The methods are described in detail elsewhere.[20] The exclusion criteria were as follows: not fasting overnight, serious physical disabilities, learning disorders, severe communication barriers and pregnant women.

### Variables

The variables that were considered for the study included participants' demographic and lifestyle habits (eg, gender, date of birth, smoking and daily physical activity). Anthropometric measurements (weight, height and waist circumference) and systolic and diastolic blood pressures were also obtained. Additionally, fasting blood samples were assayed to determine the lipid profile, blood glucose level and haemoglobin A1c (HbA1c) level.

### Data sources/measurements

The blood samples were collected in the morning, after overnight fasting, in tubes containing sodium heparin as an anticoagulant. The samples were placed in a refrigerator or an insulated icebox to avoid temperature fluctuations. Before being transported to the reference laboratory (Rashid Centre for Diabetes and Research, Ajman, UAE) in an insulated icebox lined with dry ice pellets or sheets, all samples were centrifuged within 4 hours at 3000 revolutions per minute (rpm) for 15 min at 20°C to separate the plasma. The blood lipids and glucose levels were measured using the Dimension RxL Max Integrated Chemistry System (Siemens Healthineers, Malvern, Pennsylvania, USA) in the reference laboratory with a standard protocol.

The lipid profile included TG, low-density lipoprotein (LDL-C), total cholesterol (TC), cholesterol ratio (TC:HDL-C) and HDL-C values. LDL-C was measured using the direct method. Based on the blood cholesterol management guidelines of the American College of Cardiology/American Heart Association Task Force on Clinical Practice, dyslipidaemia was defined as follows[21 22]: a TG level of ≥1.7 mmol/L (≥150 mg/dL) indicated hypertriglyceridaemia, an LDL-C level of ≥3.4 mmol/L (≥130 mg/dL) indicated high LDL-C, an HDL-C level of <1 mmol/L (<40 mg/dL) indicated low HDL-C for men, an HDL-C level of <1.3 mmol/L (<50 mg/dL) indicated low HDL-C for women, a TC level of ≥5.2 mmol/L (≥200 mg/dL) indicated hypercholesterolaemia, and a high TC to HDL-C ratio was ≥3.4 (≥130).

Each participant's diabetes status was determined using an HbA1c test. The cut-off values for the test were defined according to the WHO criteria as follows: <6.5% was considered non-diabetic and ≥6.5% indicated diabetes.[23] Participants with self-reported diabetes in the medications section were also considered to have diabetes.

Hypertension was defined as self-reported high blood pressure in the medications section and/or a blood pressure of ≥140/90 mm Hg.[24]

A waist circumference of <102 cm for men and <88 cm for women was considered normal.[25]

The recommended physical activity levels for active adults, as defined by the WHO, are doing at least 150 min of moderate-intensity aerobic physical activity throughout the week, doing at least 75 min of vigorous-intensity aerobic physical activity throughout the week, or an equivalent combination of moderate-intensity and vigorous-intensity activity.[26]

### Bias

To standardise data collection procedure, all data collectors attended a comprehensive training workshop that included interview techniques, data collection tools, practical applications and field guidelines. Waist circumference as well as height, weight and blood pressure were measured three times and were recorded. Each physical measurement was completed by two data collectors. The average of all three measurements was considered the most accurate and was recorded. Blood pressure was measured at 10 min intervals.

### Study size

Although the data used in this study came from the UAEDIAB, a power calculation was performed beforehand to determine whether there was a sufficient number of participants to estimate the prevalence of dyslipidaemia and its determinants with high precision. The sample size (n) needed was derived using the cross-sectional (prevalence) study formula[27]:

$$n = [Z^2 P (1-P)]/d^2$$

where Z is the statistical level of confidence, P is the estimated prevalence and d is the precision. The level of confidence was set at 95% (Z value=1.96), with a precision of 5%. We used 0.5 for the estimated prevalence because there were no credible data on the prevalence of dyslipidaemia in the UAE, which resulted in the highest sample size. Therefore, a total of 770 individuals were needed for this study.

### Quantitative variables

Continuous exposures or the main risk factor variables were transformed into categorical or grouped measures for analysis. Statuses of lipid profiles, diabetes, blood pressure, waist circumference and physical activity were categorised into two groups based on established guidelines[21–26] and analysed as binary variables. Age and income were categorised using equally spaced intervals, while arbitrary grouping order was used for educational level.

### Participant and public involvement

The participants were not involved in the development of the research questions, outcome measures or study design. In addition, the participants were not involved in the recruitment and performance of the study.

Beyond this publication, there is no plan for the dissemination of the results to the study participants.

### Statistical methods

To describe the demographic, lifestyle and clinical characteristics of the study population, we reported the frequencies with proportions and means with SDs for participants with an overall normal lipid profile and participants with an overall abnormal lipid profile. Bivariate analyses ($\chi^2$, t-test) were conducted to identify the factors associated with the different types of dyslipidaemia. As the prevalence of smoking among female participants was very low, the analysis of association between smoking and dyslipidaemia was limited only to male participants. Multiple binary logistic regression analyses for the significant predictors of the different types of dyslipidaemia were performed using stepwise forward modelling. The omnibus tests of model coefficients showed that the binary logistic regression models were statistically significant. Casewise plots were not produced because no outliers were found and no multicollinearity was detected (variance inflation factor of <3). Statistical significance was set at p≤0.05. The factors included in the regression model were age, educational level, physical activity level, smoking status, waist circumference and diabetes status.

Data analyses were performed using IBM SPSS Statistics for Windows V.25.0. The reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology statement for cross-sectional studies.

## RESULTS

There were 872 (88%) eligible subjects who participated in the study, of whom 824 (94%) had a complete lipid profile. Of the 824 study participants, 427 (51.8%) were men. The mean age of the entire population was 42.8 years old (SD ±13.4 years). Table 1 shows the characteristics of the study participants based on their overall lipid profile status (normal/abnormal). Bivariate analyses showed that gender, age, educational level, physical activity level, smoking status, waist circumference and diabetes status were significantly associated with dyslipidaemia (p≤0.05) (table 1).

The overall dyslipidaemia prevalence among the local adult population in the Northern Emirates was 72.5% (95% CI 69.3 to 75.4), with no significant difference between men (72.6%) and women (72.3%) (table 1).

Table 1 Participants' characteristics based on the overall lipid profile status (n (%) and mean (SD), N=824)

| Variable | Total | Normal lipid profile | Abnormal lipid profile | P value |
|---|---|---|---|---|
| Gender | | | | |
| Male | 427 (51.8) | 117 (27.4) | 310 (72.6) | 0.921 |
| Female | 397 (48.2) | 110 (27.7) | 287 (72.3) | |
| Age, years | | | | |
| Mean (SD) | 42.8 (13.4) | 39.7 (14.1) | 43.9 (12.9) | <0.0001 |
| Groups, years | | | | |
| 18–29 | 134 (16.3) | 57 (25.1) | 77 (12.9) | <0.0001 |
| 30–39 | 237 (28.8) | 71 (31.3) | 166 (27.8) | |
| 40–49 | 210 (25.5) | 44 (19.4) | 166 (27.8) | |
| 50–59 | 133 (16.1) | 20 (8.8) | 113 (18.9) | |
| 60–69 | 79 (9.6) | 27 (11.9) | 52 (8.7) | |
| ≥70 | 31 (3.8) | 8 (3.5) | 23 (3.9) | |
| Education (highest level) | | | | |
| Did not complete secondary school | 177 (21.5) | 36 (15.9) | 141 (23.6) | 0.011 |
| Completed secondary school | 298 (36.2) | 78 (34.4) | 220 (36.9) | |
| Tertiary education | 349 (42.2) | 113 (49.8) | 236 (39.5) | |
| Income, year (AED) | | | | |
| ≤35 999 | 184 (27.1) | 42 (22.7) | 142 (28.7) | 0.109 |
| 36 000–179 999 | 168 (24.7) | 42 (22.7) | 126 (25.5) | |
| ≥180 000 | 327 (48.2) | 101 (54.6) | 226 (45.7) | |
| Physical activity level | | | | |
| Inactive | 355 (70.6) | 90 (63.4) | 265 (73.4) | 0.026 |
| Active | 148 (29.4) | 52 (36.6) | 96 (26.6) | |
| Smoking status | | | | |
| No | 670 (85.9) | 197 (90.8) | 437 (84.0) | 0.015 |
| Yes | 110 (14.1) | 20 (9.2) | 90 (16.0) | |
| Waist circumference, cm | | | | |
| Mean (SD) | 96.7 (14.6) | 92.5 (15.9) | 98.3 (13.8) | <0.0001 |
| Groups, cm | | | | |
| <102 for men and <88 for women | 389 (48.2) | 137 (61.4) | 252 (43.2) | <0.0001 |
| ≥102 for men and ≥88 for women | 418 (51.8) | 86 (38.6) | 332 (56.8) | |
| Diabetes mellitus | | | | |
| No | 632 (76.7) | 185 (81.5) | 447 (74.9) | 0.045 |
| Yes | 192 (23.3) | 42 (18.5) | 150 (25.1) | |
| Hypertension status | | | | |
| No | 518 (69.1) | 145 (70.7) | 373 (68.4) | 0.545 |
| Yes | 232 (30.9) | 60 (29.3) | 172 (31.6) | |

AED, United Arab Emirates dirham.

Table 2 shows the prevalence (crude and standardised) of the different types of dyslipidaemia according to their characteristics. Abnormal TC, TG, LDL-C and cholesterol ratio levels were more prevalent in men (46.1% (50.8), 36.3% (43.8), 43.3% (53.6) and 82.2% (52.7), respectively) than in women (39.3% (45.1), 21.2% (24.7), 33.5% (42.8) and 61.7% (27.7), respectively) (p≤0.05) (table 2). However, women had a higher prevalence of low HDL-C (47.4%, 60.2) than men (37.9%, 27.9) (p=0.006) (table 2). The prevalence of all types of dyslipidaemia was increased in the middle-aged groups (30–69 years) and decreased in individuals younger than 30 years

**Table 2** Prevalence of the different types of dyslipidaemia based on participants' characteristics (n (crude (%), standardised prevalence))

| Variable | High TC ≥5.2 mmol/L | High TG ≥1.7 mmol/L | Low HDL-C <1 mmol/L for men and <1.3 mmol/L for women | High LDL-C ≥3.4 mmol/L | High cholesterol ratio (TC:HDL-C) ≥3.4 mmol/L |
|---|---|---|---|---|---|
| Gender | | | | | |
| Female | 156 (39.3, 45.1) | 84 (21.2, 24.7) | 188 (47.4, 60.2) | 133 (33.5, 42.8) | 245 (61.7, 27.7) |
| Male | 197 (46.1, 50.8) | 155 (36.3, 43.8) | 162 (37.9, 27.9) | 185 (43.3, 53.6) | 351 (82.2, 52.7) |
| P value | **0.047** | **<0.0001** | **0.006** | **0.015** | **<0.0001** |
| Age (years) | | | | | |
| 18–29 | 31 (23.1, 30.6) | 18 (13.4, 17.2) | 48 (35.8, 49.3) | 29 (21.6, 31.3) | 83 (61.9, 30.6) |
| 30–39 | 114 (48.1, 53.6) | 64 (27, 34.2) | 88 (37.1, 45.6) | 107 (45.1, 54.9) | 174 (73.4, 53.6) |
| 40–49 | 102 (48.6, 54.3) | 69 (32.9, 38.6) | 98 (46.7, 43.3) | 90 (42.9, 55.2) | 164 (78.1, 54.3) |
| 50–59 | 71 (53.4, 54.9) | 50 (37.6, 43.6) | 68 (51.1, 36.8) | 61 (45.9, 55.2) | 102 (76.7, 54.9) |
| 60–69 | 28 (35.4, 41.8) | 28 (35.4, 39.2) | 35 (44.3, 35.4) | 26 (32.9, 39.2) | 54 (68.4, 41.8) |
| ≥70 | 10 (32.3, 25.8) | 7 (22.6, 35.5) | 13 (41.9, 51.6) | 5 (16.1, 29) | 19 (61.3, 25.8) |
| P value | **<0.0001** | **<0.0001** | 0.053 | **<0.0001** | **0.012** |
| Education (highest level) | | | | | |
| Primary | 73 (41.2, 45.8) | 65 (36.7, 39.5) | 97 (54.8, 36.7) | 54 (30.5, 41.1) | 122 (68.9, 42.4) |
| Secondary | 124 (41.6, 47) | 93 (31.2, 36.6) | 133 (44.6, 37.2) | 115 (38.6, 49.3) | 235 (78.9, 43.3) |
| Tertiary | 156 (44.7, 50.1) | 81 (23.2, 30.4) | 120 (34.4, 52.1) | 149 (42.7, 48.4) | 239 (68.5, 37.5) |
| P value | 0.650 | **0.003** | **<0.0001** | **0.025** | **0.007** |
| Income, year (AED) | | | | | |
| ≤35 999 | 77 (41.8, 44.6) | 52 (28.3, 31) | 91 (49.5, 39.7) | 69 (37.5, 46.7) | 138 (75, 42.4) |
| 36 000–179 999 | 71 (42.3, 48.8) | 47 (28, 31.5) | 71 (42.3, 50) | 65 (38.7, 49.4) | 116 (69, 34.5) |
| ≥180 000 | 144 (44, 49.8) | 103 (31.5, 39.8) | 126 (38.5, 40.1) | 136 (41.6, 52.6) | 245 (74.9, 45.6) |
| P value | 0.869 | 0.629 | 0.056 | 0.628 | 0.323 |
| Physical activity | | | | | |
| Active | 56 (37.8, 43.9) | 38 (25.7, 31.1) | 55 (37.2, 42.6) | 53 (35.8, 44.6) | 108 (73, 37.8) |
| Inactive | 146 (41.1, 47.3) | 108 (30.4, 35.5) | 173 (48.7, 40.3) | 128 (36.1, 46.8) | 268 (75.5, 41.4) |
| P value | 0.493 | 0.285 | **0.018** | 0.958 | 0.553 |
| Smoking status | | | | | |
| No | 282 (42.1, 46.9) | 178 (26.6, 31.9) | 275 (41, 46.9) | 254 (37.9, 47.5) | 474 (70.7, 36.9) |
| Yes | 52 (47.3, 54.5) | 49 (44.5, 53.6) | 57 (51.8, 18.2) | 49 (44.5, 55.5) | 96 (87.3, 65.5) |
| P value | 0.309 | **<0.0001** | **0.034** | 0.186 | **<0.0001** |
| Waist circumference, cm | | | | | |
| <102 for men and <88 for women | 158 (40.6, 46.8) | 96 (24.7, 31.1) | 127 (32.6, 45.8) | 141 (36.2, 46) | 268 (68.9, 37.3) |
| ≥102 for men and ≥88 for women | 187 (44.7, 49.3) | 137 (32.8, 37.6) | 216 (51.7, 41.1) | 171 (40.9, 51) | 315 (75.4, 43.8) |
| P value | 0.237 | **0.011** | **<0.0001** | 0.174 | **0.040** |
| Diabetes mellitus | | | | | |
| No | 284 (44.9, 50.5) | 150 (23.7, 29.4) | 245 (38.8, 46.5) | 256 (40.5, 51.1) | 461 (72.9, 38.8) |
| Yes | 69 (35.9, 40.1) | 89 (46.4, 51.6) | 105 (54.7, 33.3) | 62 (32.3, 39.6) | 135 (70.3, 46.9) |
| P value | **0.027** | **<0.0001** | **<0.0001** | **0.041** | 0.476 |
| Hypertension status | | | | | |
| No | 222 (42.9, 48.8) | 129 (24.9, 30.7) | 207 (40, 46.7) | 206 (39.8, 50.4) | 371 (71.6, 39.6) |
| Yes | 94 (40.5, 44) | 87 (37.5, 42.7) | 113 (48.7, 38.4) | 79 (34.1, 42.2) | 168 (72.4, 39.2) |
| P value | 0.549 | **<0.0001** | **0.025** | 0.136 | 0.824 |

P values in bold are statistically significant.
AED, United Arab Emirates dirham; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol;TC, total cholesterol; TG, triglyceride.

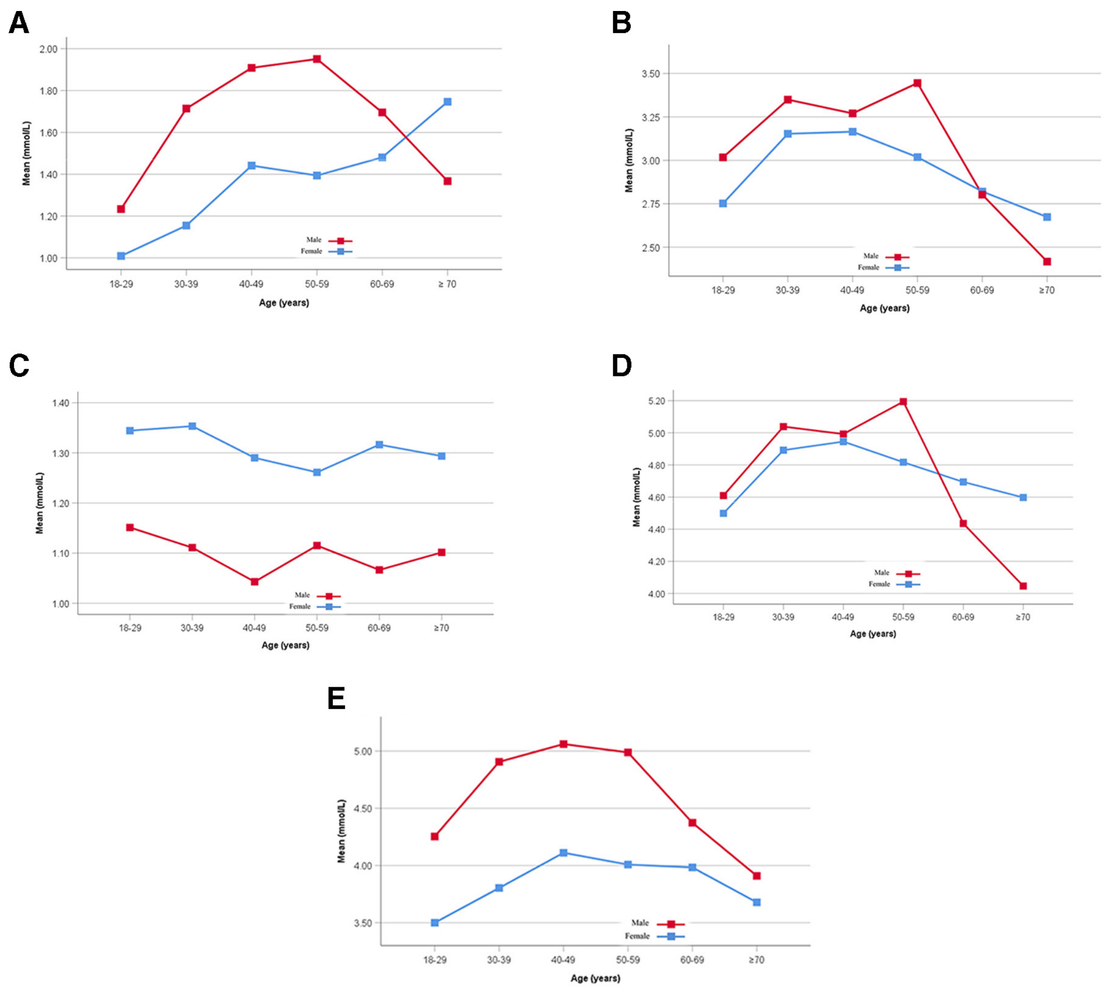


**Figure 1** Gender and age-specific mean values of lipid profiles among Northern Emirati local population: (A) triglyceride, (B) low-density lipoprotein, (C) high-density lipoprotein, (D) total cholesterol and (E) cholesterol ratio.

old and older than 70 years old, except for low HDL-C. Educational level was also significantly associated with the prevalence of dyslipidaemia. Those individuals with a primary education showed higher prevalence of high TG and low HDL-C levels than individuals with a tertiary education. Income was not significantly associated with any type of dyslipidaemia. Prevalence of smoking among female participants was 2.2% (8 of 364) and for male participants was 24.5% (102 of 416) ($p<0.0001$). Smoking was associated with increased prevalence of high TG and low HDL-C levels and a high cholesterol ratio in men, while physical activity was only associated with an increased prevalence of low HDL-C. The prevalence of high TG and low HDL-C levels was significantly increased with the presence of diabetes mellitus, while the prevalence of high TC and high LDL-C levels was significantly decreased with the presence of diabetes mellitus. Central obesity was associated with increased prevalence of high TG and low HDL-C levels and a high cholesterol ratio, while hypertension was only associated with increased prevalence of high TG and low HDL-C levels.

Figure 1A–E shows the gender-specific and age-specific estimations of the lipid profile means. Overall, men had higher mean TG values than women, which decreased sharply after 50 years of age but increased after the same age in women (figure 1A). Similarly, men had higher mean values than women for LDL-C, TC and cholesterol ratio levels, which decreased with age in both groups (figure 1B,D,E). Moreover, there were fluctuations in mean HDL-C values with age; all men in all age groups had levels above the recommended value (>1 mmol/L), while women between 40 and 55 years old were below the desirable value (>1.3 mmol/L) (figure 1C). Both men and women exhibited higher cholesterol ratios (TC to HDL-C cholesterol) than the recommended value (<3.37) in all age groups (figure 1E).

Logistic regression analyses were conducted for the significant predictors (table 3). All of the significant variables are shown in table 2, and they were included in the regression models. Gender was a significant predictor of high TG and low LDL-C levels and a high cholesterol ratio. Middle-aged individuals (30–59 years old) had a significantly higher risk of having high TC, TG and LDL-C levels than young (<30 years old) and elderly (≥60 years old) individuals. Diabetes mellitus was a significant predictor of low TC, high TG and low HDL-C levels, while central obesity was a significant predictor of high TG and low HDL-C levels and a high cholesterol ratio. Smoking

**Table 3** Binary logistic analyses for the predictors of the different types of dyslipidaemia (OR (95% CI))

| Variable | High TC ≥5.2 mmol/L | High TG ≥1.7 mmol/L | Low HDL-C <1 mmol/L for men and <1.3 mmol/L for women | High LDL-C ≥3.4 mmol/L | High cholesterol ratio (TC:HDL) ≥3.4 mmol/L |
|---|---|---|---|---|---|
| Gender | | | | | |
| Female | 1 | 1 | 1 | 1 | 1 |
| Male | 1.33 (1.00 to 1.76) | 2.23 (1.49 to 3.34) | 0.74 (0.48 to 1.16) | 1.50 (1.11 to 2.02) | 2.91 (1.99 to 4.27) |
| P value | 0.054 | **<0.0001** | 0.189 | **0.008** | **<0.0001** |
| Age (years) | | | | | |
| 18–29 | 1 | 1 | | 1 | 1 |
| 30–39 | 3.07 (1.91 to 4.95) | 2.53 (1.31 to 4.87) | – | 2.88 (1.76 to 4.70) | 1.49 (0.90 to 2.47) |
| P value | **<0.0001** | **0.006** | | **<0.0001** | 0.122 |
| 40–49 | 3.30 (2.03 to 5.38) | 3.21 (1.67 to 6.17) | – | 2.88 (1.74 to 4.74) | 2.16 (1.27 to 3.69) |
| P value | **<0.0001** | **<0.0001** | | **<0.0001** | **0.005** |
| 50–59 | 4.24 (2.47 to 7.28) | 2.40 (1.15 to 5.01) | – | 3.64 (2.07 to 6.43) | 1.36 (0.73 to 2.54) |
| P value | **<0.0001** | **0.019** | | **<0.0001** | 0.330 |
| 60–69 | 2.20 (1.16 to 4.17) | 1.55 (0.64 to 3.78) | – | 2.56 (1.25 to 5.26) | 1.04 (0.84 to 2.26) |
| P value | **0.016** | 0.332 | | **0.011** | 0.926 |
| ≥70 | 1.18 (0.45 to 3.10) | 1.20 (0.39 to 3.74) | – | 1.03 (0.33 to 3.19) | 0.69 (0.26 to 1.85) |
| P value | 0.731 | 0.748 | | 0.958 | 0.464 |
| Education (highest level) | | | | | |
| Primary | – | 1 | 1 | 1 | 1 |
| Secondary | – | 0.85 (0.49 to 1.48) | 1.00 (0.58 to 1.73) | 1.29 (0.80 to 2.08) | 1.40 (0.78 to 2.49) |
| P value | | 0.586 | 0.993 | 0.304 | 0.261 |
| Tertiary | – | 0.56 (0.31 to 1.01) | 0.70 (0.39 to 1.24) | 1.50 (0.92 to 2.44) | 0.93 (0.51 to 1.68) |
| P value | – | 0.052 | 0.216 | 0.105 | 0.806 |
| Physical activity level | | | | | |
| Active | – | – | 1 | – | – |
| Inactive | – | – | 1.19 (0.76 to 1.85) | – | – |
| P value | | | 0.452 | | |
| Smoking status | | | | | |
| No | – | 1 | 1 | – | 1 |
| Yes | – | 1.75 (1.07 to 2.86) | 1.60 (0.90 to 1.83) | – | 1.85 (0.97 to 3.53) |
| P value | | 0.026 | 0.110 | | 0.061 |
| Waist circumference, cm | | | | | |
| <102 for men and <88 for women | – | 1 | 1 | – | 1 |
| ≥102 for men and ≥88 for women | – | 1.67 (1.14 to 2.44) | 1.91 (1.27 to 2.88) | – | 1.96 (1.34 to 2.87) |
| P value | | **0.009** | **0.002** | | **<0.0001** |
| Diabetes mellitus | | | | | |
| No | 1 | 1 | 1 | 1 | – |
| Yes | 0.65 (0.45 to 0.94) | 2.29 (1.50 to 3.50) | 1.70 (1.04 to 2.76) | 0.72 (0.49 to 1.06) | – |
| P value | **0.022** | **<0.0001** | **0.033** | 0.093 | |
| Hypertension status | | | | | |
| No | – | 1 | 1 | – | – |
| Yes | – | 1.25 (0.82 to 1.92) | 0.98 (0.62 to 1.55) | – | – |
| P value | | 0.302 | 0.931 | | |

P values in bold are statistically significant.
HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; TG, triglyceride.

was only a significant predictor of a high TG level in men, while hypertension and physical activity level were not significant predictors of any type of dyslipidaemia.

## DISCUSSION

To the best of our knowledge, this is the first study to report the prevalence of dyslipidaemia based on fasting blood samples from a large representative sample of local Emirati population in the Northern Emirates of the UAE.

Of the participants in this study, 42.8% had hypercholesterolaemia, 29% had hypertriglyceridaemia, 38.6% had high LDL-C level, 42.6% had low HDL-C level and 72.3% had high TC to HDL-C ratio. The mean cholesterol levels and the prevalence of dyslipidaemia in men were significantly higher than those in women, with the exception of HDL-C level. Approximately three-fourths (72.5%) of the subjects had abnormalities in at least one of the lipid profiles, with no significant difference between men (72.6%) and women (72.3%). These numbers nearly double the global prevalence of dyslipidaemia, which the WHO estimated as 39% (37% for men and 40% for women) in 2008.[5] Similarly, a systematic review conducted from 1990 to 2014 reported that the overall hypercholesterolaemia prevalence in the Gulf Cooperation Council (GCC) countries ranged from 17% to 54.9% in men and from 9% to 53.2% in women.[28] Moreover, using our data, the prevalence was higher than the rate previously reported for the UAE (36%) and other GCC countries, such as Bahrain (45%), Kuwait (37%), Oman (35%), Qatar (29%) and Yemen (12%).[29] These large variations between our study and the other studies may have been due to differences in research methods and population types. Our study was restricted to a local Emirati population, and we believe that they were at a higher risk for dyslipidaemia due to dramatic lifestyle changes over the last few decades. Furthermore, the local Emiratis in this study account for only 12% of the total UAE population, with expatriates making up the remaining 88%.[30] Therefore, the local Emiratis may have been less represented in previous studies, and the findings among them might not have been well highlighted.

Another alarming finding identified in this study was the fact that the participants, no matter what their age group, had high mean cholesterol ratios that were greater than the desired value (<3.37), which increases the risk of developing ACD.

The results of this study demonstrated that gender, age, smoking, central obesity and diabetes were significant predictors of the different types of dyslipidaemia in the local Emiratis. These findings are aligned with the biological understanding of the atherosclerosis process, which elevates cholesterol levels.

This study revealed that men and middle-aged participants (30–60 years old) were significantly more affected by dyslipidaemia than women and older (over 60 years old) and younger (younger than 30 years old) participants. In the UAE, the overall smoking prevalence is 24.3% in men and 0.8% in women, which is consistent with our study, with the highest prevalence in those individuals between 20 and 49 years old.[31] This is consistent with our identified risk factors and groups. Hence, the association between smoking and dyslipidaemia was determined among male participants only given the very low prevalence of smoking among Emirati women. Consequently, the primary and secondary preventive measures against dyslipidaemia in our study population should target middle-aged smoking men more specifically. In addition, based on the evidence from several clinical trials, starting statin therapy for primary prevention in middle-aged adults can significantly reduce future clinical events.[32]

The results of the current study also identified central obesity and diabetes mellitus as strong predictors of the different types of dyslipidaemia. Obesity is an epidemic in the UAE, and it has become a major public health concern.[33] An elevated waist circumference has clinical significance in predicting risks beyond body mass index,[34] which is why it was included in our regression models. Based on the UAEDIAB data, the prevalence of central obesity among the local population was 65.8% for women and 38.9% for men, with an overall prevalence of 51.8%.[35] Obesity is largely preventable through the implementation of continuous evidence-based and population-based measures that promote awareness about a healthy diet and the need for regular physical activity.[36] Evidence has shown that there is an interaction between glucose and lipid metabolism, which results in a condition called 'diabetic dyslipidaemia'.[37] Diabetic dyslipidaemia is characterised by low HDL-C and high TG levels, which is consistent with our study findings. Furthermore, our study showed an interesting association between diabetes and a low TC level, which may be worthy of further investigation. Diabetic dyslipidaemia increases the risk of heart disease and stroke,[37] which are the leading causes of premature death among our study population.[6] Recent studies, including the UAEDIAB, have found alarmingly high rates of diabetes among the local UAE population.[35 38 39] Applying effective prevention strategies in the UAE, as identified in the literature, such as lifestyle changes, social support and ensuring medication adherence, can reduce the incidence of diabetic dyslipidaemia and its complications.[40]

This current study did not identify associations between dyslipidaemia and physical inactivity and hypertension. Several studies have shown that a lack of exercise and high blood pressure can change the lipid metabolism and put patients at a high risk for developing dyslipidaemia.[16 18] These discrepancies between the prior studies and ours could have been due to the differences in the study designs, ethnicities, genetics and environmental factors.

From a public health point of view, our study findings suggest that dyslipidaemia may represent a major health concern in the UAE. Therefore, a comprehensive prevention plan should be implemented targeting the identified predictors and other significant risk factors from the literature. Increasing public awareness, lifestyle modifications, introducing health policies that emphasise regular screening and aggressive pharmacological treatments are highly recommended.

This study did have some limitations. First, it was conducted among local Emiratis in the Northern Emirates, which might have limited the generalisability of the findings to the whole UAE population. Second, the causality could not be established in this study due to the nature of the cross-sectional design. Moreover, our study relied on self-reporting for physical activity level, which may have introduced bias. Third, our sample size was relatively small for a cross-sectional study; therefore, there were variations between crude and standardised prevalence values. Fourth, advanced lipid testing, such as the lipoprotein(a) and apolipoprotein B levels and the LDL-particle number, was not performed. Finally, this study did not assess some important predictors of dyslipidaemia that were identified in the literature, such as alcohol consumption, poor diet and certain medications.

## CONCLUSION

This study provided reliable and current epidemiological data about the magnitude of the burden of dyslipidaemia and its pattern among the local adult population in the Northern Emirates. This study also identified some modifiable risk factors associated with dyslipidaemia in the study population. High rates of dyslipidaemia were reported; therefore, aggressive preventive measures for modifiable risk factors targeting the whole population as well as individuals at a higher risk are highly recommended.

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