

Prevalence and Correlates of Dyslipidemia among Adults in Saudi Arabia: Results from a National Survey

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ABSTRACT

Data were collected and analyzed from a cross-sectional study using the World Health Organization's STEPwise approach, to estimate the prevalence of various types of dyslipidemia and determine their associated factors among adults in Kingdom of Saudi Arabia. The study population included 4490 Saudi adults aged 15 years and older who were selected by a stratified, multistage, cluster random sampling technique. Lipid profile was determined by spectrophotometrically by biochemical methods, high total cholesterol (TC) was defined as TC of 5.2 mmol/L or more, hypertriglyceridemia as serum triglycerides level 1.7 mmol/L or more and low high-density lipoprotein cholesterol (HDL-C) as serum HDL-C 0.9 mmol/L or less, LDL-C 3.35 mmol/L or more and TC/HDL ratio 5 or more. Of the 4490 subjects (94.4% of total sample) included in the final analysis, 51% were females, 23% of study subjects were less than 25 years and 11% were 55 or more years of age. The overall prevalence of dyslipidemia ranged from about 20% to 40%. The highest prevalence was for triglycerides where about 44% of all subjects were affected. About a fifth of the subjects had high level of total cholesterol. Males had significantly higher prevalence of all types of dyslipidemia than female except LDL-C and TC. Higher dyslipidemia prevalence of total cholesterol and triglycerides were significantly found in older subjects, illiterates and housekeepers. Lower prevalence rates for HDL-C was significantly observed in retired and youngest subjects. There were significant regional variations and significantly higher prevalence of dyslipidemia among hypertensives, diabetics, obese/overweight, smokers and physically inactive subjects. There were no significant differences according to income or fruits and vegetable consumption. Logistic regression analysis revealed that obesity/overweight, gender, age, diabetes were the most important significant predictors of dyslipidemia. The findings of this study suggest that the prevalence of dyslipidemia is high in Saudi Arabia. Multisectorial intervention strategies are needed targeting the predictors and significant risk factors identified.

Keywords: Dyslipidemia; Prevalence; Risk Factors; Adults; Saudi Arabia

1. Introduction

Dyslipidemia is one of the most important risk factors for many chronic non-communicable diseases resulting in serious morbidity, and mortality, and medical costs worldwide [1-3]. This situation has become apparent in the Kingdom of Saudi Arabia (KSA), given the economic growth and associated sociodemographic, dietary, and lifestyle changes in recent decades coupled with a reduced burden of infectious diseases [4]. The prevalence of dyslipidemia varies according to the ethnic, socioeconomic, and cultural characteristics of distinct population groups.

Assessing the prevalence, risk factors, and predictors of this condition is of paramount importance for pre-

venting and controlling the disease and its sequelae. A few studies have recently addressed these issues in the KSA [5-8]. Due to the dramatic increases in the prevalences of both obesity and type 2 diabetes mellitus, which are linked to changes in lifestyle associated with modernization and socioeconomic development, adverse changes in the profile of blood lipids are not unexpected.

This study attempts to estimate the prevalence and patterns of serum lipid profiles and associated factors in Saudi adults.

2. Subjects and Methods

This is a cross-sectional community-based study covering the whole population of KSA in 2005. The World Health Organization's STEPwise approach to Surveillance (STEPS) of Non-Communicable Diseases (NCD)

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risk factors was the basis for conducting the survey and for collecting the data [9,10].

2.1. Study Population

All Saudi population from all the 20 health regions of the country aged 15 - 64 years was involved.

2.2. Sampling

A multistage stratified cluster random sampling technique was used to recruit the study subjects. Stratification was based on age (5 - 10 year age groups) and gender (Male/female 2 groups). All health regions of the country (20 regions) were covered. Based upon proposed methodology of the WHO STEPwise approach a sample size of 196 was calculated for each of these ten strata. A list of all Primary Health Care Centers (PHCCs) in each region was prepared and 10% of these PHCCs were randomly chosen, and allocated regional sample to them proportionate to the size of their catchment population in sampled PHCCs. To identify the households a map of the health center coverage area was used to choose the houses. Each house was assigned a number and a simple random draw was made.

2.3. Data Collection

Data were collected using the WHO STEPwise approach [9,10] which includes a questionnaire, physical measurements plus biochemical measurements covering hypertension and other chronic diseases and risk factors in addition to physical activity pattern, intensity and duration. The questionnaire was translated into Arabic by a team of physicians and was back translated to ensure the accuracy of translation. Arabic instrument was pre-tested and corrected before using on 51 eligible respondents for wording and understanding of the questions, and necessary adjustments were made in the instrument in light of the pre-test.

2.4. Data Collectors

Data was collected by 54 males and 54 female collectors who worked in teams. Each field team was made up of four persons: a male data collector, a female data collector, a driver and a female assistant. Data collection teams were supervised by a hierarchy of local supervisor, regional coordinators and national coordinator.

2.5. Training of Data Collectors

All individuals involved in data collection attended a comprehensive training workshop that included interview techniques, data collection tools, practical applications and field guidelines.

2.6. Analytical Techniques

5 ml of blood was collected in the morning after the participants had abstained from eating overnight. Sodium heparin was used as an anticoagulant, and the samples were centrifuged at 3000X rpm for 15 min at 20°C to separate plasma. Aliquots were prepared for storage (-20°C or -80°C) until further analysis. Total cholesterol (TC), triglycerides, and glucose were measured with commercially available enzymatic colorimetric kits from QCA (Amposta, Spain). Seriscann Normal (ref 994148) (QCA, Amposta, Spain) was used for quality control measures. Plasma high-density lipoprotein cholesterol (HDL-C) levels were analyzed by enzymatic method after precipitating plasma reagents with phosphotungstic acid and magnesium and LDL-cholesterol (LDL-C) was calculated according to the Friedewald's formula. This equation calculates the concentration of LDL-C based upon the presence of total cholesterol, HDL and triglyceride levels: $LDL = \text{total cholesterol} - HDL - (\text{triglycerides}/5)$ [11]. Although this equation is fairly accurate, there are certain factors that could cause your LDL cholesterol levels to be incorrect by using this calculation. These would include triglyceride levels over 400 mg/dL and consuming a meal before having your cholesterol levels. The cut off levels were used according to the suggestions of the National Cholesterol Education Program-Adult Treatment Panel III [12].

2.7. Data Management

Questionnaires collected from the field were reviewed by team leaders assigned to each team before submitting them to the headquarters for data entry. Double entry of the questionnaires was performed using EPI-INFO 2000 software and EpiData software developed by the Menzes centre for validation. After data entry, data cleaning was conducted. New variables were defined by adopting the standard Steps variables (STEPS Data Management Manual, Draft version v1.5, October 2003).

2.8. Statistical Analysis

Descriptive statistics, t-test or Mann Whitney test and ANOVA or Kruskal Wallis tests were used as appropriate after checking for normality. Multiple logistic regressions for significant predictors were performed. Dyslipidemia was the dependent variable and all significant variables in bivariate analysis were the independent variables. Level of significance was set to be <0.05 throughout the study. The data were processed using SPSS version 17. Total frequency in some columns may vary due to missing data from certain variables.

2.9. Ethical Clearance and Confidentiality

The protocol and the instrument of the surveillance were

approved by the Ministry of Health, Center of Bio-medical Ethics and the concerned authorities in KSA. Informed consent of all subjects was obtained. Confidentiality of data was assured and that data will be used only for the stated purpose of the survey.

3. Results

Of the 4490 subjects (94.4% of the total sample) included in the final analysis, 51% were females, 23% were aged less than 25 years, and 11% were aged 55 years and older. **Table 1** shows the mean concentrations of the lipid profile according to gender. Triglycerides and the ratio of total cholesterol (TC)/high-density lipoprotein (HDL-C) were significantly higher in males, while HDL-C and TC were significantly higher in females. No significant differences in low-density lipoprotein Cholesterol (LDL-C) concentration according to gender $P = 0.341$.

The overall prevalence of the different types of dyslipidemia was according to sociodemographic characteristics appear in **Table 2**. The overall prevalence of all types of dyslipidemia was ranged from about 20% to 44%. The highest prevalence was for triglycerides, where about 44% of all subjects were affected. More than 25% of the subjects exhibited low levels of HDL-C, and approximately one-fifth of the subjects had high levels of TC. Males had significantly higher prevalences of all types of dyslipidemia except cholesterol associated with LDL-C and TC. Prevalence of dyslipidemia increases with advancing age. These differences were significant for all types of dyslipidemia except cholesterol associated with HDL-C. Education level was also significantly

associated with dyslipidemia prevalence. Illiterates showed the highest prevalence for TC, triglycerides, and LDL-C. Significant regional variations emerged from the data; the North region was associated with the highest prevalence of triglycerides, while the Eastern region reported the highest low levels of HDL-C. Housekeepers were associated with a significantly higher prevalence of dyslipidemia, while students had the lowest prevalence rates. Income was not significantly associated with any type of dyslipidemia.

Calculations of the prevalence of dyslipidemia according to co morbidity, with odds ratios and 95% confidence intervals reported in **Table 3**. All types of dyslipidemia except low HDL-C were significantly associated with the presence of hypertension, diabetes mellitus, and obesity/overweight.

Dyslipidemia was affected by lifestyle (**Table 4**); smoking and lower physical activity were significantly associated with some types of dyslipidemia. There were no significant differences associated with the consumption of fruits and vegetable.

A logistic regression analysis was performed for significant predictors (**Table 5**). All significant variables in **Tables 2** and **3** were included in the regression model. Obesity/overweight was a significant predictor for all types of dyslipidemia. Gender was a significant predictor for all dyslipidemia types except LDL-C, while age was significant for all types except HDL-C. Diabetes mellitus was a significant predictor for all dyslipidemia types except HDL-C and LDL-C. Occupation and hypertension co morbidity were not significant predictors for any of the types of dyslipidemia.

Table 1. Mean concentration of lipid profile according to gender.

Sex		TGs (mmol/L)	TC (mmol/L)	HDL-C (mmol/L)	LDL-C	TC/HDL ratio
	Mean	1.77	4.42	1.28	2.80	4.39
Male	N	2178	2198	2198	2176	2196
	SD	1.07	1.14	0.81	1.21	2.35
	Mean	1.50	4.51	1.45	2.76	3.77
Female	N	2267	2291	2291	2265	2290
	SD	0.83	1.20	0.79	1.19	2.14
	Mean	1.63	4.47	1.37	2.78	4.08
Total	N	4445	4489	4489	4441	4486
	SD	0.96	1.17	0.81	1.19	2.26
P-value		<0.001	0.014	<0.001	0.341	<0.001

4. Discussion

As demonstrated in the current study, the prevalence of dyslipidemia among adults in the KSA ranges from 20% to 44%, which is comparable to the prevalences reported in previous studies [5-8]. Reported rates of dyslipidemia ranged from 2.7% to 51.9% in several studies worldwide [13-24]. This relatively large range in recent years may be due to socioeconomic status, genetic races or to differences in definitions, methodologies, and study populations. The TC/HDL-C and LDL-C/HDL-C ratios are good predictors of a positive response to lipid-lowering intervention [23]. This study showed that more than 30% of males have a mean TC/HDL-C of 4.39 ± 2.35 , with the highest levels occurring between ages 45 - 54 years, indicating that this group is at higher risk of developing coronary disease. There was no significant statistical difference in the prevalence of high LDL-C levels between men and women, which is consistent with other studies [24,25].

Interestingly, this study revealed higher TC and HDL

Table 2. Prevalence of dyslipidemia according to subject's demographics % (n).

Demographics	Hypercholesterolemia >5.2 mmol/l	Hypertriglyceridemia >1.27 mmol/l	Low HDL-C <-0.90 mmol/l	LDL-C 3.35 mmol/l	TC/HDL Ratio >-5
Gender					
Male	18.7 (411)	40.2 (876)	33.7 (741)	30.7 (659)	30.6 (672)
Female	19.9 (455)	28.8 (652)	17.7 (405)	29.8 (662)	17.5 (400)
P-value	0.170	<0.001	0.001	0.272	<0.001
Age (Years)					
15 - 24	7.0 (69)	19.9 (190)	25.6 (251)	13.6 (127)	15.4 (150)
25 - 34	16.0 (168)	29.8 (311)	26.7 (280)	26.6 (272)	21.8 (229)
35 - 44	22.3 (248)	38.2 (422)	24.3 (271)	35.0 (37.8)	25.1 (239)
45 - 54	27.9 (228)	44.0 (359)	25.3 (207)	41.5 (334)	31.2 (25.5)
55+	28.9 (153)	40.7 (246)	25.9 (137)	40.3 (210)	30.1 (159)
P-value	<0.001	<0.001	0.804	<0.001	<0.001
Geographical region					
East	19.7 (132)	28.6 (181)	30.1 (202)	32.9 (203)	27.0 (181)
North	24.2 (96)	54.2 (215)	24.2 (96)	27.4 (101)	26.6 (105)
South	20.0 (191)	33.9 (324)	25.4 (243)	31.8 (303)	23.3 (225)
West	18.2 (261)	33.2 (477)	26.0 (373)	33.9 (483)	25.5 (366)
P-value	0.068	<0.001	0.013	<0.001	0.001
Education					
Illiterate	23.6 (288)	39.1 (47.5)	19.6 (239)	35.7 (42.8)	22.4 (273)
Primary	21.7 (250)	36.2 (412)	25.7 (296)	33.9 (380)	25.4 (292)
Intermediate	14.3 (101)	28.0 (19.3)	27.8 (196)	21.5 (145)	21.7 (153)
Secondary	15.1 (109)	31.1 (22.1)	28.9 (20.8)	260 (180)	24.4 (175)
University +	16.8 (96)	33.0 (189)	29.1 (167)	27.9 (150)	24.8 (142)
Vocational	18.8 (21)	32.1 (36)	32.7 (37)	28.4 (31)	32.1 (36)
P-value	<0.001	<0.001	<0.001	<0.001	0.096
Occupation					
Government employee	20.4 (267)	39.4 (516)	31.5 (413)	33.4 (428)	31.4 (411)
Non-government employee	21.0 (88)	36.1 (149)	29.1 (122)	30.6 (125)	25.3 (106)
Self employed	5.7 (34)	19.9 (115)	27.7 (164)	12.6 (71)	16.2 (96)
Student	22.2 (370)	32.5 (508)	17.5 (291)	32.9 (535)	18.7 (311)
Housekeeping	28.0 (84)	50.3 (151)	30.0 (90)	39.7 (11.7)	33.1 (99)
Retired	11.8 (23)	31.2 (59)	33.2 (65)	24.3 (45)	25.1 (49)
P-value	<0.001	<0.001	<0.001	<0.001	<0.001
Monthly income					
<3000 Saudi Riyals	19.8 (282)	33.2 (467)	23.6 (337)	31.2 (433)	23.5 (334)
<7000	19.8 (190)	34.6 (330)	25.8 (24.8)	29.9 (279)	23.1 (222)
<10000	17.6 (219)	35.8 (438)	26.7 (331)	29.1 (349)	23.9 (296)
<15000	20.5 (87)	37.0 (157)	28.7 (122)	31.5 (131)	29.6 (117)
15000+	20.1 (43)	30.2 (64)	29.9 (64)	33.8 (71)	29.0 (62)
P-value	0.556	0.301	0.103	0.594	0.169

Table 3. Dyslipidemia according to comorbidity with hypertension, diabetes, overweight/obesity.

Comorbidity	Elevated total cholesterol N (%)	High triglycerides N (%)	Low HDL-C N (%)	LDL-C N (%)	TC/HDL ratio N (%)
Hypertension					
Yes	147 (28.2)	226 (43.6)	139 (26.7)	194 (38.3)	158 (30.4)
No	715 (18.1)	1299 (33.2)	1001 (25.3)	1121 (29.2)	910 (23.1)
OR (95% C.I.) [*]	1.78 (1.45 - 2.19)	1.55 (1.29 - 1.87)	1.07 (0.87 - 1.32)	1.50 (1.24 - 1.82)	1.46 (1.19 - 1.78)
P-value	<0.001	<0.001	0.264	<0.001	<0.001
Diabetes mellitus					
Yes	219 (31.7)	342 (49.5)	179 (25.9)	268 (39.6)	212 (30.8)
No	638 (17.1)	1147 (30.8)	958 (25.7)	1038 (28.7)	850 (22.8)
OR (95% C.I.) [*]	2.25 (1.87 - 2.69)	2.51 (2.07 - 3.03)	1.01 (0.84 - 1.22)	1.63 (1.38 - 1.93)	1.50 (1.26 - 1.80)
P-value	<0.001	<0.001	0.476	0.001	<0.001
Obesity					
Overweight					
Yes	700 (22.9)	1213 (40.0)	822 (26.9)	1053 (35.5)	834 (27.4)
No	164 (11.6)	311 (22.4)	316 (22.4)	262 (19.1)	232 (16.5)
OR (95% C.I.) [*]	2.26 (1.89 - 2.72)	2.32 (2.00 - 2.68)	1.28 (1.10 - 1.48)	2.34 (2.01 - 2.73)	1.91 (1.63 - 2.25)
P-value	<0.001	<0.001	0.001	<0.001	0.001

OR (95% C.I.)^{*} = Odds Ratio (95% Confidence Interval).

Table 4. Prevalence of dyslipidemia according to some life style practices.

Life style habit (N)	High total cholesterol N (%)	High triglycerides N (%)	Low HDL-C [*] N (%)	LDL-C N (%)	TC/HDL Ratio N (%)
Physical activity					
High (733)	125 (17.1)	223 (30.4)	184 (25.1)	221 (30.2)	180 (24.6)
Low (3625)	720 (19.9)	1272 (35.1)	941 (26.0)	1077 (29.7)	878 (24.2)
P-value	0.043	0.012	0.333	0.443	0.449
Daily smoker					
Yes (549)	115 (20.9)	212 (38.6)	175 (31.9)	187 (34.1)	171 (31.31)
No (3809)	730 (19.2)	1247 (32.7)	918 (24.1)	1099 (28.9)	853 (22.4)
P-value	0.166	0.004	<0.001	0.005	<0.001
Daily fruits/vegetables consumption					
Below 5 servings (4081)	791 (19.4)	1437 (35.2)	1049 (25.7)	1219 (29.9)	988 (24.2)
5 + servings (270)	61 (22.6)	96 (35.6)	80 (29.6)	89 (33.0)	76 (28.1)
P-value	0.114	0.486	0.089	0.077	0.086

*HDL-C = High Density Lipoprotein cholesterol; LDL-C = Low Density Lipoprotein cholesterol; TC = Total Cholesterol.

cholesterol levels in females versus males, reflecting socioeconomic and cultural status in these communities. There were significant regional variations in lipid profile in this study, which may be related to the level of urbanization and genetic variation. Migration to urban centers and adoption of a sedentary lifestyle is likely re-

lated to rising lipid levels and prevalence of dyslipidemia [16]. Regional variations in the prevalence of dyslipidemia were previously reported in national and international studies [5-8,26,27] and may be due to other variables in addition to geographical location.

The associations between dyslipidemia and male

Table 5. Logistic regression analysis for predictors of dyslipidemia prevalence.

Lipid/predictors	Sex	Age	Edu.*	Occ.*	Region	Smoking	PA*	HBP*	DM*	BMI*
TC										
Odds ratio	0.78	0.96	1.01	1.03	1.01	1.25	0.81	1.08	1.52	0.56
95% C.I.										
Lower	0.63	0.95	0.98	0.99	0.791	0.96	0.79	0.84	1.22	0.46
Upper	0.96	0.97	1.02	1.07	1.28	1.63	1.27	1.38	1.98	0.69
P-value	0.01	0.01	0.92	0.20	0.97	0.09	0.96	0.56	0.01	0.01
HDL										
Odds ratio	2.09	1.00	0.98	0.98	1.27	1.66	0.97	1.12	1.01	0.84
95% C.I.										
Lower	1.75	0.99	0.96	0.94	1.02	1.34	0.89	.87	0.88	0.78
Upper	2.50	1.01	0.99	1.01	1.58	2.04	1.08	1.43	1.37	0.91
P-value	0.01	0.29	0.01	0.19	0.027	0.010	0.78	0.375	0.39	0.01
TG										
Odds ratio	1.74	0.979	1.008	0.98	0.89	1.26	0.96	0.99	1.64	0.71
95% C.I.										
Lower	1.47	0.973	0.993	0.95	0.87	1.02	0.87	0.79	1.34	0.66
Upper	2.07	0.986	1.024	1.01	1.08	1.56	1.05	1.25	2.01	0.77
P-value	0.01	0.001	0.291	0.347	0.257	0.029	0.432	0.96	0.01	0.01
LDL										
Odds Ratio	0.93	0.96	0.99	1.03	1.70	1.27	0.99	0.99	1.16	0.77
95% C.I.										
Lower	0.78	0.96	0.98	0.993	1.38	1.02	0.90	0.79	0.94	0.71
Upper	1.11	0.97	1.02	1.07	2.11	1.59	1.09	1.26	1.43	0.83
P-value	0.42	0.01	0.871	0.122	0.001	0.037	0.819	0.89	0.15	0.01
TC/HDL										
Odds ratio	1.85	0.98	0.97	1.01	1.492	1.54	0.99	1.12	1.26	0.77
95% C.I.										
Lower	1.54	0.98	0.97	0.98	1.193	1.24	0.89	0.88	1.02	0.71
Upper	2.22	0.99	1.03	1.05	1.866	1.915	1.09	1.42	1.57	0.84
P-value	0.01	0.01	0.09	0.57	0.001	0.01	0.08	0.36	0.03	0.01

*Edu = Education; *Occ = Occupation; *PA = Physical activity; HBP = Hypertension; DM = Diabetes mellitus.

gender and advancing age detected in this study are in agreement with previous studies in the KSA [5-8] and other population-based and hospital-based studies [19, 21-23]. While the exact mechanisms of the impact of age on lipid levels are unknown, they may be related to hereditary characteristics and degenerative processes. Males were significantly more affected by dyslipidemia

than females in the present investigation. Previously, females were reported to be more affected than males in some studies [22,28], while other studies did not uncover a significant statistical difference in the prevalence of high TC and high LDL-C between men and women [16,17,26]. These variations and apparent inconsistencies may be explained by the differential gender distribution

of other risk factors among different communities.

The data from the current study are in agreement with previous studies in the KSA that showed that dyslipidemia was associated with education and occupation [5-8]. A higher education level was strongly associated with hypercholesterolemia and high LDL-C levels, even after adjusting for age and body mass index [23,27]. In contrast, the level of education was not associated with dyslipidemia [28], but exhibited a strong inverse association in other studies [28-30] in agreement with this study. One study hypothesized that the high prevalence of dyslipidemia in subjects with a low education level may result from risk factors such as stress, poor working conditions, poor nutritional habits, or greater difficulties in securing access to health care services [21].

The prevalence of dyslipidemia was significantly higher among housekeepers in this study, possibly due to constant exposure to food and lack of physical activity [21]. Previous studies reported that dyslipidemia rates were higher in men and women who described their occupation as administrative/management compared with those performing physical/labor positions [23]. Other studies, however, reported that, there was no significant association between occupational status and dyslipidemia [30]. These apparent inconsistencies may be due to the confounding effects of other risk factors. Smoking was significantly associated with dyslipidemia in this study, in agreement with other studies [23-25]. The risk of low HDL-C and TC/HDL-C was significantly higher in smokers in a logistic regression analysis [21]. There was no significant association between income and dyslipidemia in this study, consistent with a previous study [25]; other studies reported that household income was inversely related to the prevalence of dyslipidemia [21]. The accuracy of information on income levels may be questionable in many communities, making comparison difficult.

Intensive physical activity was associated with favorable lipid profiles in this study. Intervention studies have demonstrated improvements in lipid profile with increases in exercise [19-21], as physical activity mainly results in a reduction in triglyceride levels and an increase in HDL-C [25]. Dyslipidemia was significantly associated with co-morbidity from obesity, diabetes, and hypertension in this study. The term "secondary dyslipidemia" was used if the dyslipidemia followed a primary cause. It is difficult to assess cause and effect in cross-sectional studies such as this one; obesity was significantly associated with dyslipidemia in previous national, regional, and international studies [5-8,16-28]. Hypertension was previously associated with HDL-C, TC/HDL-C, and triglycerides even after the exclusion of obesity, diabetes, and smoking [31,32]. In diabetic individuals, significantly more dyslipidemia was observed [21,33].

This study did not detect significant associations that depended on dietary habits such as fruit/vegetable consumption. However, several other lifestyle factors have been shown to be related to lipid levels in adults, including dietary habits and the intake of certain foods. [26-29,34].

5. Conclusion

Hyperlipidemia is increasing at fast pace and reaching higher prevalence rates in KSA. This finding suggests that metabolic syndrome may represent a major health problem. There is an urgent need for a multisectorial intervention plan targeting identified predictors and other significant risk factors should gain more attention in any integrated and comprehensive intervention strategy aiming at prevention, control, early detection and prompt proper management. In the meantime reduction of obesity rates by increasing the public awareness of importance of adopting healthy eating habits, and increasing physical activity are of paramount importance to reduce dyslipidemia incidences.

6. Acknowledgements

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7. Authors' Contributions

Al-Hamdan conceived, designed, overviewed data collection and implemented the study and provided critical academic insight. Al-Kabbaa wrote the first draft and subsequent revisions of the manuscript; Saeed provided academic inputs, contributed to the first draft of the article and revisions; Hamza and El Taher helped in handling the data and analyses and overlooked biochemical measurements. Abdulshakour helped in data collection and analysis and helped in data analyses. All authors jointly conceived, designed and overviewed data collection, provided statistical inputs and participated in writing of the article. All authors have read and approved the final manuscript.

8. Study Limitations

The study is cross-sectional and hence it is difficult to assess properly etiological factors of dyslipidemia. The study included only subjects in age group 15 - 6 years of age. Other factors which could be associated with dyslipidemia such as drugs were not included.

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