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Socioeconomic inequalities and dyslipidaemia in adult population of the Ravansar Non-Communicable Disease Cohort Study: the role of sex and age

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ABSTRACT

Objectives This study represents a pioneering attempt to quantify the contribution of age, sex and socioeconomic status (SES) to the observed inequalities in lipid profile components.

Design Cross-sectional study.

Setting The data from the Ravansar Non-Communicable Disease (RaNCD) Cohort Study were used.

Participants 10 000 individuals aged 35–65 years.

Main outcome measures Principal component analysis was used to determine the SES of individuals. Using the concentration index (C-index) and curves, the study assessed socioeconomic inequalities in dyslipidaemia in different age groups and genders. Decomposition analysis was used to determine the contribution of sex, age and SES to the observed inequality in the prevalence of dyslipidaemia components between the wealthiest and poorest groups.

Results The prevalence of dyslipidaemia was 72.39% of the population and was significantly higher in women than in men (excluding hypertriglyceridaemia). Overall, no significant SES-based inequality in dyslipidaemia was observed (C-index=−0.045, p=0.116), but after adjustment for age and sex, individuals with high SES had increased odds of dyslipidaemia (OR=1.16, 95% CI: 1.03 to 1.31). Hypercholesterolaemia and hyper-low-density lipoprotein (LDL) were more common in individuals with lower SES (C-index=−0.117 and −0.105), while hypo-high-density lipoprotein (HDL) was more prevalent in individuals with higher SES (C-index=0.029), regardless of adjustment for age, sex and confounding factors. SES played a significant role in hypercholesterolaemia and hyper-LDL (322.11% and 400.14%), while sex dominated in hypertriglyceridaemia and hypo-HDL (814.05% and −615.26%) and contributed to the existing inequalities.

Conclusion The results highlight the existing inequalities in lipid profiles due to SES, sex and age. Consideration of these factors in interventions and policy decisions is critical to reduce abnormalities and inform future interventions.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study was the first to examine the quantified role of age, sex and socioeconomic status in lipid profile component inequality in the context of a population-based study.
⇒ The current sample is derived from the Ravansar Non-Communicable Disease Cohort Study which is part of the larger PERSIAN (Prospective Epidemiological Research Studies in IrAN) Cohort.
⇒ This study did not examine inequality in access to and adoption of therapeutic interventions, whereas the existing inequality in dyslipidaemia components may decrease or increase with treatment adoption.
⇒ As diet plays a central and influential role in the components of the lipid profile, the lack of this data prevented the investigation of the dietary behaviour of the participants in the different groups.

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of worldwide mortality, resulting in approximately 17.9 million deaths annually.[1] In Iran, a developing country, CVD is responsible for half of mortality and contributes to 20–23% of the total disease burden.[2] On the other hand, atherosclerosis is a major risk factor for CVD and dyslipidaemia, characterised by abnormal levels of total cholesterol (TC), triglycerides (TG), low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol, or a combination of these components has been shown contribute to the development of atherosclerosis.[3] Evidence shows that a 1% reduction in mean population levels of TC leads to a decrease in CVD mortality of approximately 2.5%.[4] Similarly, a 40 mg/dL reduction in LDL cholesterol is associated with a corresponding 22% decrease in CVD mortality and morbidity.[5]

The prevalence of dyslipidaemia varies in different regions; approximately 30–60% of the population is affected by dyslipidaemia, with hypercholesterolaemia ranging from 22.6% to 54% in Africa, Southeast Asia, Europe and the Americas.[6–9] Notably, in the Iranian population, the prevalence rates were reported as 41.6% for hypercholesterolaemia, 46.0% for hypertriglyceridaemia, 35.5% for hyper-LDL and 43.9% for hypo-HDL.[10]

In addition, considering the multifaceted nature of dyslipidaemia, it is clear that this condition is influenced by numerous factors, including age, sex, socioeconomic status (SES), level of fat intake and obesity.[11 12] SES is commonly defined as a combination of education, income level, occupational status and place of residence.[13 14] Numerous studies have been conducted to investigate the socioeconomic indicators contributing to dyslipidaemia development in the Iranian population.[10 15–17] A national study by Soleimani *et al* on urban-dwelling and rural-dwelling adults in all 31 provinces of Iran showed lower HDL levels and higher rates of hypercholesterolaemia and hypertriglyceridaemia among urban male population with lower income, lower urbanisation and lower education levels. While in women, lower levels of urbanisation and education were associated with higher rates of hypercholesterolaemia and hypertriglyceridaemia and lower income levels were associated with hypertriglyceridaemia.[15] In addition, a systematic review of 29 studies by Tabatabaei-Malazy *et al* indicated a sex-specific difference in the prevalence of dyslipidaemia such that hypercholesterolaemia, hyper-LDL and hypo-HDL were more prevalent in women and hypertriglyceridaemia was more reported in men.[10]

The differences in the prevalence of individual lipid profile components and dyslipidaemia as a whole may be due to the prevailing socioeconomic inequalities between people. Inequalities can be defined as systematic disparities in health that could be mitigated by appropriate interventions, as they are due to an unequal distribution of health risks and resources.[18 19] According to a widely accepted definition, the perpetuation of avoidable and unnecessary health inequalities is considered unjustifiable.[20] Age and sex are important determinants of the emergence of these inequalities. While younger people tend to have better access to educational and health resources and a wider range of employment opportunities,[21] they often have fewer financial resources and are more affected by housing insecurity than their older peers within and across socioeconomic groups.[22] These circumstances can have a tangible impact on the lifestyle choices they make, which translates into unequal health status. In terms of sex, women in different socioeconomic groups face different educational and occupational conditions, as well as differences in work-life balance, which in turn has a significant impact on their overall health.[23]

Assessing the extent of inequalities within a society is crucial for setting targets to promote change. Although previous studies conducted in Iran and other countries have examined the association between socioeconomic factors and components of lipid profile, these studies have not comprehensively assessed the extent of inequalities in the components of lipid profile or identified the factors responsible for these inequalities. Therefore, the present study aims to improve our understanding of socioeconomic inequalities in dyslipidaemia and lipid profile components by analysing the effects of sex and age on these inequalities, as well as the contribution of age, sex and SES in the existing inequalities among participants in the Ravansar cohort study.

METHODS

Study population and measurements

For this cross-sectional study, data were used from the Ravansar Non-Communicable Disease (RaNCD) Cohort Study, which is part of the larger PERSIAN (Prospective Epidemiological Research Studies in IrAN) Cohort. The RaNCD cohort is a population-based prospective study that includes at least 10 000 individuals aged 35–65 years. More details on this cohort can be found elsewhere.[24] Trained interviewers used a pretested demographic and clinical information form of the Persian cohort questionnaire to collect the data on age, sex, smoking status, alcohol consumption, physical activity, anthropometric characteristics and comorbidities (CVD, diabetes and hypertension). The comprehensive data collection and measurement details have been described elsewhere.[25–29] Briefly, the participants were categorised into never-smokers and passive smokers and current and ex-smokers. Physical activity was measured based on physical activity over 24 hours and a 22-item questionnaire (metabolic equivalents=METs). Then METs were classified as low (24–36.5 MET/hours per day), moderate (36.6–44.4 MET/hours per day) and vigorous (≥44.5 MET/hours per day).[30] Weight and height measurements were conducted using the InBody 770 BioSpace device (Korea) and the BSM 370 (Biospace, Seoul, Korea), respectively, with 0.5 kg and 0.1 cm precision. The body mass index (BMI) was calculated using the formula weight (kg)/height^2 (m). In addition, the waist-to-height ratio (WHtR) was defined as the waist circumference (cm) divided by the height (cm).[29] Seven missing data on SES, 71 missing data on lipid profile and 136 pregnant women were excluded from the analysis and data from 9832 individuals at baseline were included in the study. All participants provided written informed consent, and the Kermanshah University of Medical Sciences Review Board approved the study.

Definition and assessment

Dyslipidaemia and its components

Dyslipidaemia was defined as hypercholesterolaemia, and/or hypertriglyceridaemia, and/or hyper-LDL, and/or hypo-HDL based on the National Cholesterol Education Program Adult Treatment Panel III classification of lipid profile.[31] Hypercholesterolaemia was defined as TC≥200 mg/dL, hypertriglyceridaemia as TG≥150 mg/

dL, hyper-LDL as LDL≥130 mg/dL and hypo-HDL as HDL<40 mg/dL in men and <50 mg/dL in women.

Socioeconomic status

Principal component analysis (PCA) was used to determine the SES of individuals. The PCA analysis considered the possession of various assets (such as freezers, washing machines, dishwashers, microwaves, vacuum cleaners, television at the household, personal computer access to the internet, motorcycle and car (based on its price), having a mobile phone, computer, laptop, access to the internet and car (based on its price) for personal use), the status of the house (owned, rented or leased, relative's house, etc), area per capita (house area per family number), rooms per capita (number of bedrooms per family number), number of books read in the last year (excluding school books, those required for a job and religious scriptures), international trips in a lifetime (never, pilgrimage only, both pilgrimage and non-pilgrimage trips), residency and education level. The asset index derived from the PCA served as a simple and efficient method for collecting data on SES. Polychoric PCA was used for this study because it includes both quantitative and qualitative variables that are highly correlated. Subsequently, all SES-related variables were transformed into a cardinal variable representing SES. Then, SES was classified into five ranks, ranging from the poorest to the richest (five groups: the poorest, poor, middle, rich and the richest).

Statistical analysis

Descriptive statistics was performed using the mean (standard deviation=SD) and number (percentage). The different variables in both sexes and according to age groups were compared using t-test and χ^2 test. The concentration index (C-index) and a concentration curve were used to assess socioeconomic inequality in dyslipidaemia by sex and age. The concentration index was calculated using the normalised Wagstaff *et al* formula with the 'conindex' command.[32] The concentration curve was obtained by plotting the cumulative percentage of dyslipidaemia and its components on the y-axis against the cumulative percentage of the ratio of the poorest to the richest socioeconomic groups plotted on the x-axis. When the curve is above the diagonal line, the C-index takes negative values, indicating a concentration of dyslipidaemia in low-SES groups. On the other hand, when the curve is below the line of equality, positive values of the C-index indicate the concentration of the outcome in high SES groups.[33 34] In addition to the C-index, logistic regression was performed to examine the association between SES and the prevalence of dyslipidaemia and its components. Odds Ratio (OR) and 95% confidence intervals (CI) were reported. Decomposition analysis was used to determine the contributions of sex, age and SES to the differences in the prevalence of dyslipidaemia components between the poorest and richest groups based on the study by Mosquera *et al*[35] and a probit regression model was used to estimate the marginal effects of socioeconomic determinants on the health variable. Weighted means of the dyslipidaemia components and concentration indices for each determinant were calculated. The elasticity of the dyslipidaemia components considering the determinants was also calculated. The unique contribution of each determinant was quantified to understand its role in explaining SES inequalities in dyslipidaemia components. Data analysis was performed using Stata V.14 software, and a significance level of p<0.05 was used.

Patient and public involvemen

RESULTS

The mean age of the 9832 participants was 47.36±8.27 years. 51.96% (5109) of participants were women (sex ratio: 1.08 women/men). 59.74% of participants resided in urban areas. More than 90% of individuals were married. The frequency of current and ex-smokers is found to be higher in men than in women, with a prevalence of 36.96% in men. Alcohol consumption was lower in women and individuals ≥50 years, with a total frequency of 4.88%. Individuals with low physical activity were more common among men and individuals ≥50 years, with a total frequency of 30.34%. In addition, mean anthropometric indices were higher among women. About 25.74% of participants reported at least one comorbidity, and the frequency was higher among women and those ≥50 years (table 1).

Prevalence of dyslipidaemia by sex and age group

The prevalence of dyslipidaemia was 72.39%, and the prevalence of hypercholesterolaemia, hypertriglyceridaemia, hyper-LDL and hypo-HDL were 31.58%, 31.56%, 25.49% and 49.18%, respectively. The prevalence of dyslipidaemia and all its components was significantly higher in women than in men (except hypertriglyceridaemia). The prevalence of dyslipidaemia was 70.46% in persons <50 years and 75.50% in persons ≥50 years (table 1). Online supplemental figure 1 shows the stratification of TC, TG, LDL and HDL by SES and age groups for men and women. TC levels increased with age, and women with higher SES tended to have lower TC levels compared with men. In women, TG levels increased with age. In addition, TG levels were generally higher in men and individuals with high SES, particularly in individuals <50 years. LDL levels in women showed higher values in lower SES for two age groups. Men generally had lower LDL levels than women, especially at lower SES, and also individuals ≥50 years. Across all age groups, men had lower HDL levels than women and HDL levels decreased with increasing SES (online supplemental figure 1).

Prevalence of dyslipidaemia and its components in men and women and age groups by socioeconomic status

Dyslipidaemia was found to be most prevalent in women and individuals ≥50 years of age with low SES. Conversely, the highest prevalence of dyslipidaemia in men and individuals aged <50 years was found in those with high SES.

Table 1 Frequency and distribution of different variables by sex and age group

Variables	Total (9832) N (%)	Male (4723) N (%)	Female (5109) N (%)	P value*	<50 years (6069) N (%)	≥50 years (3763) N (%)	P value*
Age (year)†	47.36 (8.27)	47.01 (8.08)	47.68 (8.43)	**0.001**	–	–	–
Sex (male)	4723 (48.04)	–	–	–	3002 (49.46)	1721 (45.73)	**<0.001**
Education (year)†	5.41 (4.82)	7.47 (4.95)	3.50 (3.81)	**<0.001**	6.94 (4.65)	2.94 (4.01)	**<0.001**
Marital status							
Single	417 (4.24)	94 (1.99)	323 (6.32)	**<0.001**	398 (6.56)	19 (0.50)	**<0.001**
Married	8871 (90.23)	4590 (97.18)	4281 (83.79)		5483 (90.34)	3388 (90.03)	
Other	414 (5.53)	39 (0.83)	505 (9.88)		188 (3.10)	356 (9.46)	
Residency							
Urban	5874 (59.74)	2921 (61.85)	2953 (57.30)	**<0.001**	3781 (62.30)	2093 (55.62)	**<0.001**
Rural	3958 (40.26)	1802 (38.15)	2156 (42.20)		2288 (37.70)	1670 (44.38)	
Socioeconomic status							
The poorest	1944 (19.77)	464 (9.82)	1480 (28.97)	**<0.001**	905 (14.91)	1039 (27.61)	**<0.001**
Poor	1958 (19.91)	723 (15.31)	1235 (24.17)		1095 (18.04)	863 (22.93)	
Middle	1969 (20.03)	931 (19.71)	1038 (20.32)		1242 (20.46)	727 (19.32)	
Rich	1976 (20.10)	1117 (23.65)	859 (16.81)		1331 (21.93)	645 (17.14)	
The richest	1985 (20.19)	1488 (31.51)	497 (9.73)		1496 (24.65)	489 (12.99)	
Smoking status							
Non-smoker and passive smoker	7767 (79.43)	2961 (63.04)	4806 (94.57)	**<0.001**	5029 (83.26)	2738 (73.23)	**<0.001**
Current and ex-smokers	2012 (20.57)	1736 (36.96)	276 (5.43)		1011 (16.74)	1001 (26.77)	
Alcohol consumption							
Yes	480 (4.88)	478 (10.12)	2 (0.04)	**<0.001**	354 (5.83)	126 (3.35)	**<0.001**
No	9352 (95.12)	4245 (89.88)	5107 (99.96)		5715 (94.17)	3637 (96.65)	
Physical activity (MET hour/day)							
Low	2983 (30.34)	1646 (34.85)	1337 (26.17)	**<0.001**	1759 (28.98)	1224 (32.53)	**0.001**
Moderate	4656 (47.36)	1445 (30.59)	3211 (62.85)		2951 (48.62)	1705 (45.31)	
High	2193 (22.30)	1632 (34.55)	561 (10.98)		1359 (22.39)	834 (22.16)	
Anthropometry†							
Body mass index, kg/m^2	27.45 (4.75)	26.29 (4.20)	28.51 (4.98)	**<0.001**	27.57 (4.75)	27.24 (4.74)	**0.001**
Waist circumference, cm	97.28 (10.51)	96.20 (9.69)	98.27 (11.13)	**<0.001**	96.56 (10.44)	98.44 (10.53)	**<0.001**
Waist-to-height ratio	0.59 (0.07)	0.56 (0.05)	0.63 (0.07)	**<0.001**	0.59 (0.07)	0.61 (0.07)	**<0.001**
Comorbidities (yes)							

Continued

Table 1 Continued

Variables	Total (9832) N (%)	Male (4723) N (%)	Female (5109) N (%)	P value*	<50 years (6069) N (%)	≥50 years (3763) N (%)	P value*
Cardiovascular disease	1676 (17.05)	583 (12.34)	1093 (21.39)	**<0.001**	494 (8.14)	1182 (31.41)	**<0.001**
Diabetes	854 (8.69)	385 (8.15)	469 (9.18)	0.071	335 (5.52)	519 (13.79)	**<0.001**
Hypertension	1550 (15.76)	689 (14.59)	861 (16.85)	**0.002**	475 (7.83)	1075 (28.57)	**<0.001**
Dyslipidaemia and its components (yes)							
Dyslipidaemia	7117 (72.39)	3239 (68.58)	3878 (75.91)	**<0.001**	4276 (70.46)	2841 (75.50)	**<0.001**
Hypercholesterolaemia	3105 (31.58)	1336 (28.29)	1769 (34.63)	**<0.001**	1588 (26.17)	1517 (40.31)	**<0.001**
Hypertriglyceridaemia	3103 (31.56)	1710 (36.21)	1393 (27.27)	**<0.001**	1838 (30.29)	1265 (33.62)	**0.001**
Hyper-LDL	2506 (25.49)	1113 (23.57)	1393 (27.27)	**<0.001**	1268 (20.89)	1238 (32.90)	**<0.001**
Hypo-HDL	4835 (49.18)	2025 (42.88)	2810 (55.00)	**<0.001**	3065 (50.50)	1770 (47.04)	**0.001**

Hypercholesterolaemia was defined as TC≥200; hypertriglyceridaemia was defined as TG≥150 mg/dL; hyper-LDL was defined as LDL≥130 mg/dL; hypo-HDL was defined as HDL<40 mg/dL in men and <50 mg/dL in women.
*Based on χ^2 test. Bold values are significant.
†Mean (SD) and p value based on t-test.
HDL, high-density lipoprotein ; LDL, low-density lipoprotein ; MET, metabolic equivalent; TC, total cholesterol ; TG, triglycerides .

Both men and women of low SES had a higher prevalence of hypercholesterolaemia and hyper-LDL, while the prevalence of hypertriglyceridaemia were higher in men of high SES and in every age group, but higher in women of low SES. Hypo-HDL prevalence increased with increasing socioeconomic level, but decreased in the richest individuals (table 2).

Socioeconomic inequality in dyslipidaemia and its components by sex and age based on SES

Regarding SES, the concentration index for the prevalence of dyslipidaemia was 0.058 in men (95% CI: 0.024, 0.093; p=0.001), −0.027 in women (95% CI: −0.063, 0.008; p=0.136) and −0.020 in the entire participant population (95% CI: −0.045, 0.004; p=0.116). The CI indicates statistical significance only for men. Furthermore, considering age groups, the concentration index for the prevalence of dyslipidaemia was 0.011 in individuals <50 years old (95% CI: −0.020, 0.042; p=0.488) and −0.039 in those aged 50 years or older (95% CI: −0.081, 0.002; p=0.063). The results indicate that there is no significant inequality in dyslipidaemia by age group (figure 1).

The concentration index for the prevalence of hypercholesterolaemia, hypertriglyceridaemia, hyper-LDL and hypo-HDL was −0.117 (95% CI: −0.141 to −0.093; p<0.001), 0.044 (95% CI: 0.020, 0.068; p<0.001), −0.105 (95% CI: −0.131 to −0.080; p<0.001), 0.029 (95% CI: 0.007, 0.051; p=0.010), respectively. In addition, the concentration index for hypercholesterolaemia and hyper-LDL was significantly negative according to sex, indicating that the prevalence of these conditions is higher in individuals with lower SES in both men and women. The C-index for hypo-HDL was significantly positive by sex, suggesting that the prevalence of hypo-HDL is higher in individuals with higher SES in both men and women. The C-index for hypertriglyceridaemia was significantly positive in men and negative in women, indicating that the prevalence of hypertriglyceridaemia is higher in individuals with higher SES in men and individuals with lower SES in women.

When age group was considered, the C-index was negative for hypercholesterolaemia and hyper-LDL, but statistically significant for hypercholesterolaemia in both age groups and for hyper-LDL only in individuals ≥50 years. The C-index was significantly positive for hypertriglyceridaemia only in individuals <50 years and for hypo-HDL only in individuals 50 years or older (figure 2).

Association of dyslipidaemia and its components with SES

The univariable logistic regression analysis showed no significant association between dyslipidaemia and SES level. However, after adjustment for sex and age, the odds of dyslipidaemia was higher in individuals with high SES than in individuals with low SES (OR=1.16; 95% CI: 1.03 to 1.31). In addition, both the univariable and multivariable models showed that the odds of hypercholesterolaemia and hyper-LDL were significantly lower in those with higher SES than in those with lower SES (between 20% and 38% for hypercholesterolaemia and between

Table 2 Prevalence of dyslipidaemia and its components in men and women and age groups by socioeconomic status

Variables	SES group	Total (%)	Male (%)	Female (%)	<50 years (%)	≥50 years (%)
Dyslipidaemia	The poorest	73.04	64.22	75.81	68.50	76.99
	Poor	72.98	65.00	77.65	70.50	76.12
	Middle	72.52	67.45	77.07	71.01	75.10
	Rich	72.72	71.35	74.50	71.67	74.88
	The richest	70.68	70.29	71.83	70.05	72.59
	P for trend	0.116	**<0.001**	0.077	0.430	0.058
Hypercholesterolaemia	The poorest	39.91	32.54	42.22	30.82	47.83
	Poor	33.40	29.87	35.46	25.93	42.87
	Middle	29.35	26.20	32.17	24.07	38.37
	Rich	29.45	29.63	29.22	27.12	34.26
	The richest	25.94	26.47	24.34	24.39	30.67
	P for trend	**<0.001**	**0.029**	**<0.001**	**0.010**	**<0.001**
Hypertriglyceridaemia	The poorest	28.65	31.03	27.90	24.53	32.22
	Poor	31.00	34.71	28.82	28.40	34.29
	Middle	31.38	35.33	27.84	30.67	32.59
	Rich	33.14	37.51	27.47	32.15	35.19
	The richest	33.55	38.10	19.91	33.15	34.76
	P for trend	**<0.001**	**0.003**	**0.009**	**<0.001**	0.270
Hyper-LDL	The poorest	31.58	28.44	32.56	23.64	38.49
	Poor	27.01	23.37	29.14	21.00	34.64
	Middle	24.12	23.41	24.75	19.00	32.87
	Rich	24.64	25.24	23.86	22.61	28.83
	The richest	20.20	20.96	17.90	19.18	23.31
	P for trend	**<0.001**	**0.008**	**<0.001**	0.071	**<0.001**
Hypo-HDL	The poorest	44.13	32.97	47.63	47.07	41.57
	Poor	50.35	36.09	58.70	51.78	48.55
	Middle	51.85	44.79	58.18	52.97	49.93
	Rich	50.96	45.47	58.09	50.63	51.62
	The richest	48.51	46.10	55.73	49.46	45.60
	P for trend	**0.009**	**<0.001**	**<0.001**	0.727	**0.006**

Bold values are significant.
HDL, high-density lipoprotein; LDL, low-density lipoprotein; SES, socioeconomic status.

19% and 34% for hyper-LDL). Conversely, the OR for hypo-HDL was significantly higher in individuals with lower SES than in individuals with higher SES (ranging from 13% to 39%). Furthermore, in the multivariable model adjusted for sex and age, the odds of hypertriglyceridaemia were higher in individuals with higher SES than in individuals with lower SES, while this association was found to be inversely significant after adjustment for other variables, indicating a 16% lower prevalence of hypertriglyceridaemia in individuals with high SES (online supplemental table 1).

Decomposition of dyslipidaemia components

The concentration index for the predictor variables (CI_k) indicates a disproportionate concentration of women among the poor for all dyslipidaemia components, as shown by the negative values. In addition, individuals aged <50 years were mainly concentrated among the rich, as shown by the positive CI_k values. The positive marginal effect for women for hypercholesterolaemia and for women and persons <50 years for hypo-HDL implies that the determinant has a positive association with the outcome and a higher probability of hypercholesterolaemia and hypo-HDL. The results of the decomposition analysis showed that SES was the largest contributor to the observed inequalities in hypercholesterolaemia (322.11%), hyper-LDL (400.14%) and hypo-HDL (473.07%), whereas in hypertriglyceridaemia, sex was the largest contributor to the observed inequalities

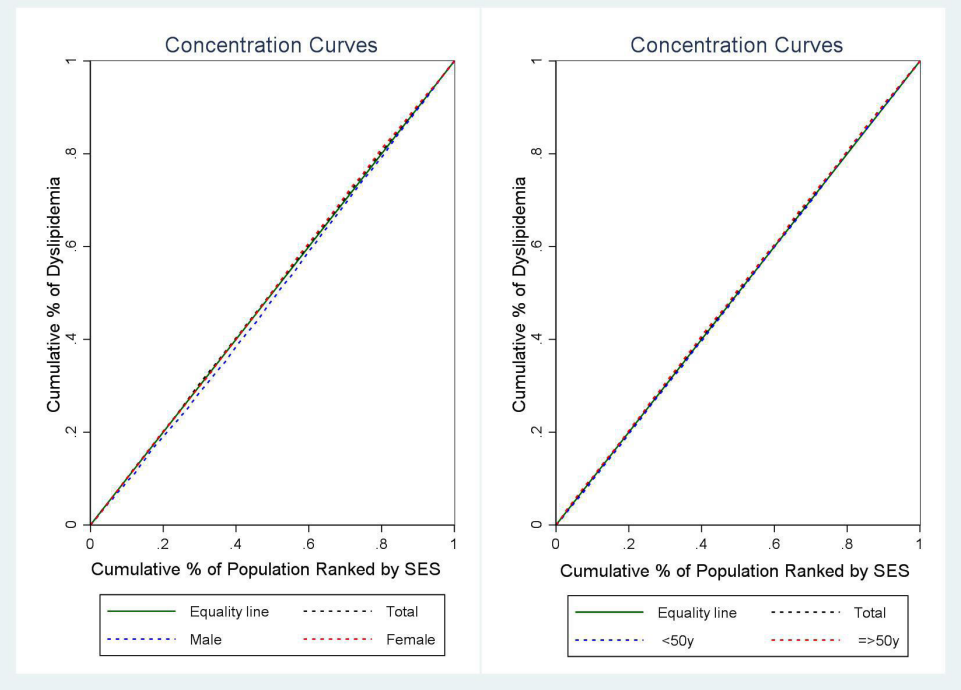

Figure 1 Concentration curve of dyslipidaemia based on SES by sex and age group. SES, socioeconomic status.

(814.05%). In addition, sex acts as an equalising factor in hypo-HDL (−615.26%). This means that, on average, women have a more even SES distribution than men, leading to a reduction in overall SES inequality (table 3).

DISCUSSION

Our results showed distinct patterns that are both sex-specific and age-specific. This indicates that the effects observed in our study vary between different sexes and across age groups. While hypertriglyceridaemia and hypo-HDL had a higher prevalence in men aged ≥50 years and women aged <50 years, respectively, dyslipidaemia and other components of the lipid profile were significantly more prevalent in women aged ≥50 years than in their peers. Socioeconomic inequality was reflected in a higher prevalence of hypercholesterolaemia and hyper-LDL in lower-SES individuals and a higher prevalence of hypo-HDL in higher-SES individuals, whether or not age, sex and other confounders were taken into account. Dyslipidaemia was associated with higher SES only in the age-adjusted and sex-adjusted analysis. Sex was found to be the most important factor contributing to inequalities in hypertriglyceridaemia and hypo-HDL, exceeding the influences of SES and age. In contrast, SES was more strongly associated with hypercholesterolaemia and hyper-LDL. Of note, age had the least influence on all lipid profile components.

The prevalence of dyslipidaemia and lipid abnormalities in plasma may vary by region, population and over time due to changes in lifestyle and health practices. Our results show that approximately 72.39% of the population studied had at least one abnormality in lipid profile components, with a significantly higher prevalence in women than in men. This sex disparity extends to all lipid profile components, with the exception of TG. In addition, women had a higher incidence of comorbidities, particularly CVD, which may be due to a higher rate of the aforementioned abnormalities. The exact mechanisms contributing to these sex differences are not yet fully understood, but are likely influenced by hormonal, genetic and lifestyle factors.[36] Our findings are consistent with existing research suggesting a correlation between unfavourable anthropometric indices such as BMI, waist circumference and WHtR in women, justifying the observed higher rates of plasma lipid abnormalities. Considering participant characteristics in our study, it is noticeable that women participants had lower educational attainment, lower SES and lower engagement in physical activity compared with their men counterparts. Research shows that lower levels of education and lower social status can negatively impact health literacy, access to healthcare and the ability to make informed decisions related to well-being, such as dietary choices and health-related behaviours.[37] In addition, the observed gender disparities in access to physical activity equipment and resources in Iran may contribute to these findings.[38] These findings highlight the need for targeted interventions to mitigate the effects of dyslipidaemia and associated cardiovascular risks, particularly in vulnerable populations.

Consistent with the studies conducted on the prevalence of dyslipidaemia and plasma lipid abnormalities in different age groups, the current study showed that except for a significant prevalence of hypo-HDL in individuals younger than 50 years with the older age group, dyslipidaemia and other lipid profile components are more prevalent in the older age group.[39–41] The literature

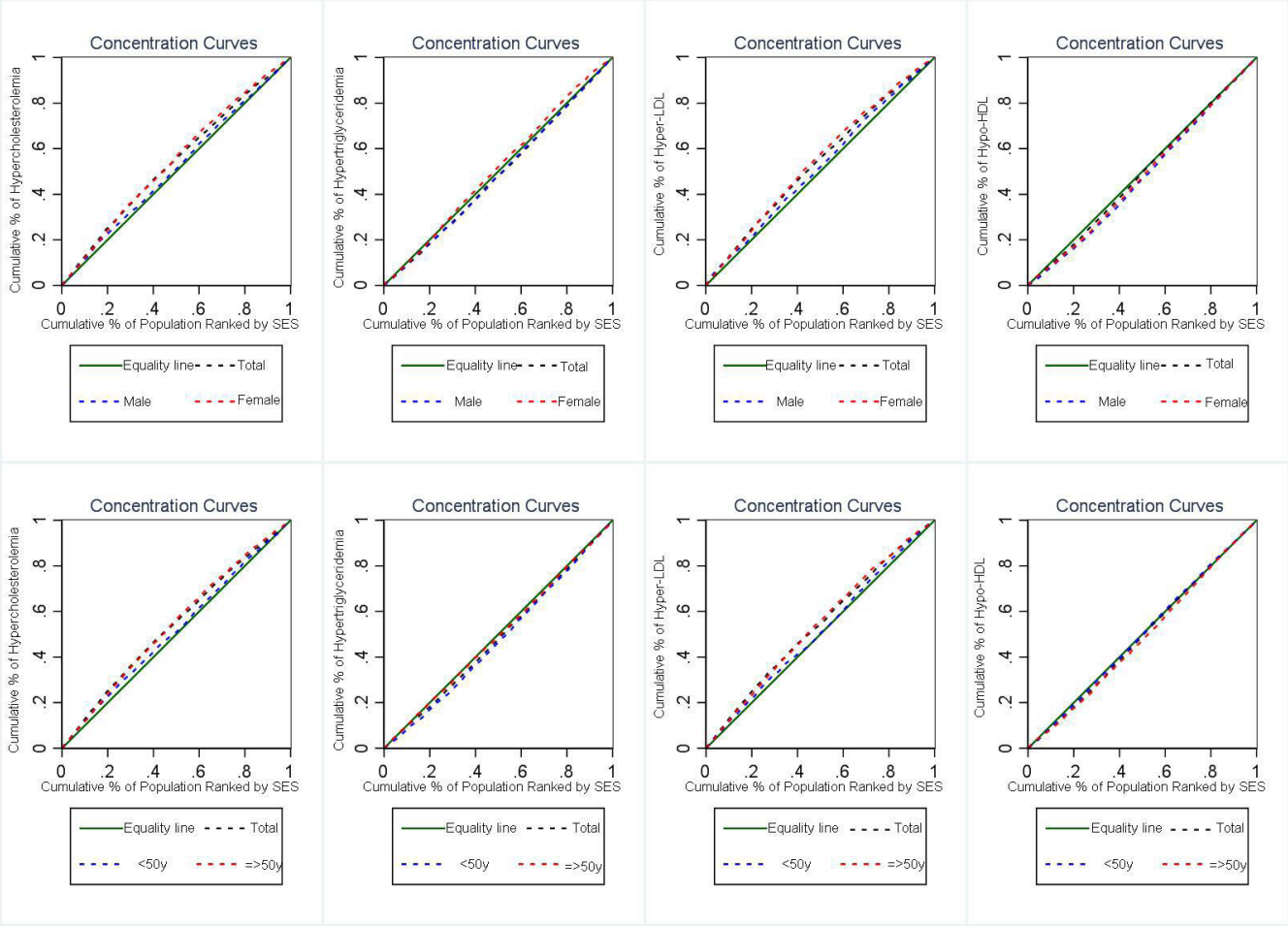

Figure 2 Distribution of mean of total cholesterol, triglycerides, low-density lipoprotein (LDL) and high density lipoprotein (HDL) by socioeconomic status in men and women for age group. SES, socioeconomic status.

suggests that ageing plays a crucial role in the increase of lipid profile components, which is due to a decrease in metabolic rate and changes in body fat distribution.[42 43] In addition, in women, hormonal fluctuations, especially in the postmenopausal phase, which is characterised by a decrease in oestrogen levels, contribute to an increase in LDL and a decrease in HDL.[44] Furthermore, ageing provides a prolonged period for the cumulative effects of unhealthy lifestyle habits, including unhealthy dietary habits, physical inactivity and smoking.[45] These factors are known to influence the components of the lipid profile. The elderly population, characterised by a higher prevalence of disease, higher medication use and particular age-related characteristics, requires increased attention in the study of factors associated with lipid abnormalities in plasma.

In this study, the socioeconomic distribution showed that 51.16% of men and 26.54% of women belonged to the rich groups. Socioeconomic differences were always evident in the prevalence of hypercholesterolaemia, hyper-LDL and hypo-HDL, regardless of the influence of confounding factors; thus, hypercholesterolaemia and hyper-LDL were more common in lower SES individuals, whereas hypo-HDL was more common in higher SES individuals. Despite the absence of socioeconomic inequality in dyslipidaemia in women, which may be due to the significant and high prevalence of hypo-HDL (55%); socioeconomic inequalities in lipid profile components such as hypercholesterolaemia, hypertriglyceridaemia and hyper-LDL were mainly found in poor participants. Among men, the prevalence of hypercholesterolaemia and hyper-LDL was significantly higher in participants with lower SES. However, there was a shift in the overall prevalence of dyslipidaemia towards higher SES individuals, as the prevalence of hypertriglyceridaemia and hypo-HDL was higher in both the overall male population and in the rich group. One possible reason for the observed patterns could be the difference in access to health resources and lifestyle factors, which is associated with different SES in men. Specifically, higher SES in men may facilitate access to unhealthy behaviours, which include a diet of unhealthy and processed foods and high alcohol consumption and tobacco use.[46] In contrast, lower SES in men may be associated with a work environment that emphasises physical activity, while sedentary work habits are prevalent among higher SES individuals.[15]

Table 3 Decomposition results for inequality in dyslipidaemia components

Dyslipidaemia components	Marginal effect*	Elasticity	CI_k	Contribution	%	Summed %
Hypercholesterolaemia						
Age <50	−0.490	−0.959	0.094	−0.090	10.76	10.76
Female	0.018	0.030	−0.196	−0.006	7.170	7.170
Poor	−0.250	−0.158	−0.399	0.063	−75.26	322.11
Middle	−0.407	−0.257	0.000	0.000	0.030	
Rich	−0.387	−0.245	0.400	−0.098	116.36	
The richest	−0.468	−0.296	0.800	−0.237	280.98	
Hypertriglyceridaemia						
Age <50	0.000	0.000	0.094	0.000	−0.060	−0.060
Female	−0.795	−1.309	−0.196	0.256	814.05	814.05
Poor	−0.043	−0.027	−0.399	0.011	34.860	−457.15
Middle	−0.108	−0.068	0.000	0.000	−0.020	
Rich	−0.129	−0.082	0.400	−0.032	−104.10	
The richest	−0.241	−0.152	0.800	−0.122	−387.89	
Hyper-LDL						
Age <50	−0.511	−1.238	0.094	−0.117	146.07	146.07
Female	−0.044	−0.092	−0.196	0.017	−22.081	−22.081
Poor	−0.175	−0.138	−0.399	0.055	−68.785	400.14
Middle	−0.322	−0.253	0.000	0.000	0.032	
Rich	−0.273	−0.214	0.400	−0.085	106.92	
The richest	−0.462	−0.363	0.800	−0.290	361.98	
Hypo-HDL						
Age <50	0.194	0.244	0.094	0.023	132.45	132.45
Female	0.518	0.547	−0.196	−0.107	−615.26	−615.26
Poor	0.231	0.094	−0.399	−0.0377	−215.98	473.07
Middle	0.313	0.127	0.000	0.000	0.074	
Rich	0.269	0.109	0.400	0.043	251.47	
The richest	0.234	0.095	0.800	0.076	437.51	

*Marginal effects from the probit model; adjusted for body mass index, waist-to-height ratio, physical activity, smoking status, alcohol consumption and comorbidities.
CI_k, concentration index for the predictor variables; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

With regard to women's health, a high socioeconomic level may manifest itself in greater participation in health management practices. This can include the inclusion of organic food in the diet and active participation in health-related events.[47] However, it is necessary to acknowledge the complexity of these relationships and to exercise caution when generalising health behaviours between different sexes and strata with different SES, as the determinants of health status are multifaceted (including individual choices, socioeconomic influences and access to resources) and collectively shape the complex landscape of health outcomes.

The study showed that SES makes the largest contribution to existing inequalities, while age makes the smallest contribution. Moreover, the effects of sex and SES cancel each other out for most inequalities in the dyslipidaemia components (except hypercholesterolaemia). These results indicate that the implementation of preventive and therapeutic measures to improve the components of the lipid profile requires separate interventions. For example, for hypercholesterolaemia and hyper-LDL, planning and implementing interventions for low-SES groups is more effective than sex-specific interventions, whereas for hypo-HDL and hypertriglyceridaemia, planning for women and men, respectively, is preferable to planning based on groups with different SES.

Strength and limitations

Although previous studies conducted in Iran and other countries have mainly investigated the relationship between socioeconomic factors and lipid profile components, this study was the first to examine the

quantified role of age, sex and SES in lipid profile component inequality. However, this study also had limitations. This study did not examine inequality in access to and adoption of therapeutic interventions, whereas the existing inequality in dyslipidaemia components may decrease or increase with treatment adoption. In addition, it should be noted that information on participants' nutritional status was not available. As diet plays a central and influential role in the components of the lipid profile, the lack of this data prevented the investigation of the dietary behaviour of the participants in the different groups. Another limitation of the study is the reliance on self-reported data for some questions and variables. The generalisability of the results is limited to communities with similar cultural and socioeconomic characteristics.

In conclusion, our results emphasise the importance of existing inequalities in lipid profile components among participants, with SES, sex and age contributing significantly. Consequently, strategic planning of interventions and preventive measures based on the contribution of these determinants is necessary in a population where 7 out of 10 individuals have abnormalities in at least one component. Policy decisions based on this method and monitoring the results of implemented measures can provide information on the change in the status of inequalities. This approach facilitates a comprehensive understanding of the impact of policy and enables future planning of practical measures.

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