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Association between dairy products and dyslipidemia among the PERSIAN Guilan cohort study population

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ABSTRACT

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Dyslipidemia is a major risk factor for cardiovascular diseases, and the role of dairy intake in modulating lipid profiles remains debated. This study aimed to investigate the association between dairy product consumption and dyslipidemia prevalence among adults in the Prospective Epidemiological Research Studies (PERSIAN) Guilan Cohort study (PGCS) population. In this cross-sectional analysis, 10,520 adults aged 35–70 years were included. Demographic and lifestyle factors were recorded, and fasting blood samples were analyzed for total cholesterol, triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C). Dyslipidemia was defined as cholesterol ≥200 mg/dL, TG ≥150 mg/dL, LDL-C ≥100 mg/dL, or HDL-C ≤40 mg/dL. Dairy intake was categorized into tertiles. Dietary data were assessed using a validated and reliable Persian Food Frequency Questionnaire (FFQ). Overall, 76.4% of participants had dyslipidemia, with 40.3% having hypercholesterolemia, 43.1% hypertriglyceridemia, 29.0% high LDL-C, and 41.5% low HDL-C. Dyslipidemia prevalence showed a non-significant increasing trend with higher dairy intake (*P*=0.056). No significant trends were found for hypercholesterolemia, hypertriglyceridemia, or high LDL-C. A significant inverse trend was observed between dairy intake and low HDL-C in men (*P*=0.026); however, this association lost significance after multivariable adjustment (aOR=0.87; 95%CI: 0.73–1.02; *P*=0.093). This study revealed prevalent dyslipidemia across lipid profiles. Dairy intake showed a non-significant association with overall dyslipidemia and no associations with specific lipid abnormalities. A transient protective trend against low HDL-C in men disappeared post-adjustment, supporting no conclusive link between dairy consumption and dyslipidemia risk.

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1. Introduction

Dyslipidemia, characterized by abnormal levels of lipids in the blood, remains a significant and modifiable risk factor for cardiovascular diseases (CVD), which are among the leading causes of morbidity and mortality worldwide. The global burden of dyslipidemia is rising in parallel with shifts in dietary habits, urbanization, and sedentary lifestyles, making the identification of modifiable dietary factors crucial for prevention and management strategies [1–3].

Dairy products are widely consumed across diverse populations and represent a substantial source of dietary energy, high-quality protein, calcium, and various bioactive compounds [4,5]. Traditionally, the role of dairy intake in lipid metabolism has been contentious due to the relatively high content of saturated fats in full-fat dairy products, which are thought to raise total cholesterol and low-density lipoprotein cholesterol (LDL-C) levels [6,7]. For decades, public health guidelines have often recommended limiting the consumption of high-fat dairy products to mitigate the risk of dyslipidemia and related cardiovascular conditions [8,9].

Not all dairy products are nutritionally equivalent; they vary significantly in fat content, fermentation status, and nutrient composition, each potentially exerting distinct effects on lipid metabolism [10,11]. Moreover, recent studies have challenged the conventional view that saturated fats from dairy uniformly contribute to adverse lipid profiles. Some observational and interventional studies have reported neutral or even beneficial associations of certain dairy products particularly fermented varieties such as yogurt and cheese with lipid parameters and overall cardiovascular health [7,12–14].

Heterogeneity in the prevalence of dyslipidemia has been observed between men and women, with notable gender differences in how dyslipidemia trends with age and its associated factors, particularly among middle-aged populations [15,16]. Increases in lipid levels are often attributed to age-related metabolic changes, hormonal shifts, and lifestyle factors such as diet and physical activity [17,18].

While high-density lipoprotein cholesterol (HDL-C) levels may decrease or remain relatively stable with age, women commonly experience an increase in LDL-C and a decline in HDL-C levels after menopause, resulting in a convergence of lipid profiles between men and postmenopausal women [19–21].

These inconsistencies among studies' findings highlight the need for further investigation and consideration of potential confounding factors. Therefore, this study investigated the association between consumption patterns of dairy products and lipid profiles among the Prospective Epidemiological Research Studies (PERSIAN) Guilan Cohort study (PGCS) population.

2. Materials and Methods

2.1 Study design

This cross-sectional study is part of the PGCS, which began in September 2014 to September 2017 in Guilan Province, Iran, and enrolled a total of 10,520 participants [22,23]. The study protocol was approved by the Ethics Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1402.132). Written informed consent was obtained from all participants prior to enrollment. Exclusion criteria comprised failure to complete clinical evaluations, diagnosed intellectual disabilities, or voluntary withdrawal from study participation. Demographic and clinical information was collected for each participant, including age, sex, habitat, marital status, educational attainment, socioeconomic status (SES), and lifestyle factors such as smoking history, opium and alcohol consumption, and level of physical activity (categorized as low, moderate, or high). Body mass index (BMI) was classified as underweight (BMI <18.5 kg/m²), normal weight (BMI 18.5–24.99 kg/m²), overweight (BMI 25–29.9 kg/m²), or obese (BMI ≥ 30 kg/m²).

Blood lipid profiles, including cholesterol, triglycerides (TG), LDL-C, and HDL-C, were measured using Pishtaz commercial kits (Pishtaz, Iran) with a Biotechnical BT 1500 analyzer (Italy) at the PGCS central laboratory. All measurements were performed according to standard quality control protocols to ensure accuracy and precision. Dyslipidemia was defined according to the following cut-offs: total cholesterol ≥ 200 mg/dL, TG ≥ 150 mg/dL, LDL-C ≥ 100 mg/dL, and HDL-C ≤ 40 mg/dL [24]. Weekly intake of milk and other dairy products was also recorded for each participant. Dietary data were assessed using a validated and reliable Persian Food Frequency Questionnaire (FFQ) comprising 90 food items with standardized portion sizes [25]. Participants reported consumption frequencies (daily, weekly, monthly) for the preceding year, which were converted into daily consumption units. Food group intake was classified according to the Iranian Food Pyramid Guide (Ministry of Health and Medical Care), with recommended daily servings as follows: 6-11 bread/cereals, 2-4 fruits, 3-5 vegetables, 2-3 meat/legumes, and 2-3 milk/dairy. Dairy consumption was categorized into quartiles based on daily intake and analyzed as an ordinal variable.

2.2 Statistical Analysis

Categorical variables were presented as frequencies and percentages, while continuous variables were summarized as means ± standard deviations (SD). Differences in demographic and clinical characteristics between participants with and without dyslipidemia were assessed using independent t-tests for continuous variables and Chi-squared tests (or the Cochran-Armitage test for trend where appropriate) for categorical variables. Both unadjusted and multivariable-adjusted analyses were conducted to assess the association between milk and dairy product consumption and the presence of dyslipidemia. Results are reported as crude odds ratios (OR) and adjusted odds ratios (aOR) with corresponding 95% confidence intervals (95% CI). All statistical analyses were performed using SPSS software version 16, with a p-value <0.05 considered statistically significant.

3. Results

A total of 10,520 participants (4,887 men and 5,633 women) were included in the analysis. The mean cholesterol level among participants was 192.8 ± 39.0 mg/dL, with a median of 191 mg/dL (IQR: 166–217). The mean TG, LDL-c, and HDL-c levels were 160.3 ± 103.3 mg/dL, 112.8 ± 32.1 mg/dL, and 48.4 ± 11.0 mg/dL, respectively. Overall, 40.3% of participants had hypercholesterolemia, 43.1% had hypertriglyceridemia, 29.0% had high LDL-c, and 41.5% had low HDL-c. While 23.6% of individuals had none of these lipid abnormalities, about one-third (30.7%) had two components, 24.9% had one, 15.5% had three, and 5.3% had all four dyslipidemia components, resulting in an overall dyslipidemia prevalence of 76.4% in this study (Table 1,2).

The overall prevalence of dyslipidemia was 75.3% (low dairy intake), 76.6% (moderate dairy intake), and 77.3% (high dairy intake). Although the prevalence increased with higher dairy intake, this trend did not reach statistical significance (*P*=0.056). Similar non-significant trends were seen in men (*P*=0.071) and women (*P*=0.376) (Table 3 and Figure 1). The prevalence of hypercholesterolemia was 40.0% in the lowest tertile, 39.9% in the middle tertile, and 41.0% in the highest tertile of dairy intake. The Cochran-Armitage test for trend did not indicate a statistically significant association in the total population (*P*=0.381).

Table 1. Demographical and clinical characteristics of individuals with and without dyslipidemia among PERSIAN Guilan cohort study population.

Variables		With dyslipidemia (n=7977) n (%)	Without dyslipidemia (n=2542) n (%)	*P* value
Age (year)	35-44	2641 (76.5)	813 (32.8)	0.432
	45-54	2895 (77.0)	863 (34.8)	
	≥55	2502 (75.6)	806 (32.5)	
Gender	Male	3440 (70.4)	1447 (58.3)	<0.001
	Female	4598 (81.6)	1035 (41.7)	
Marital status	Single	221 (72.5)	84 (3.4)	0.339
	Married	7283 (76.4)	2244 (90.4)	
	Widow/Widower	441 (77.9)	125 (5.0)	
	Divorced	93 (76.2)	29 (1.2)	
Educational status	Illiterate	1306 (75.1)	432 (17.4)	0.012
	Under diploma	2496 (75.4)	816 (32.9)	
	Diploma	3736 (77.3)	1096 (44.2)	
	University degree	500 (78.4)	138 (5.6)	
Habitat	Urban	3445 (74.7)	1168 (47.1)	<0.001
	Rural	4593 (77.8)	1314 (52.9)	
SES	Lowe	2591 (73.9)	916 (36.9)	<0.001
	Moderate	2675 (76.3)	831 (33.5)	
	High	2772 (79.0)	735 (29.6)	
BMI (kg/m^2)	<20	75 (53.2)	66 (2.7)	<0.001
	20≤BMI<25	1895 (6.0)	851 (34.3)	
	25≤ BMI<30	3298 (78.6)	900 (36.3)	
	30≤	2770 (80.6)	665 (6.8)	
Physical activity	Low	2799 (79.8)	708 (28.5)	<0.001
	Middle	2679 (76.4)	828 (32.3)	
	High	2560 (73.0)	47 (38.2)	
History of smoking	Yes	6104 (76.9)	1832 (73.8)	0.031
	No	1934 (74.8)	650 (26.2)	
Opium consumption	Yes	7475 (76.3)	2319 (93.4)	0.453
	No	563 (77.5)	163 (6.6)	
Alcohol consumption	Yes	7037 (77.1)	2088 (84.1)	<0.001
	No	1001 (71.8)	394 (15.9)	

BMI: Body mass index; SES; Socioeconomic status. *Chi-squared tese; P-value<0.05 was considered a significant level.

Table 2. Descriptive statistics and prevalence of dyslipidemia and its components among participants of the PERSIAN Guilan cohort study population.

Dyslipidemia component	Men (N=4,886) n (%)	Women (N=5,633) n (%)	Total (N=10,520) n (%)
No dyslipidemia components	1,447 (29.6)	1,035 (18.4)	2,482 (23.6)
1 component	1,076 (22.0)	1,545 (27.4)	2,621 (24.9)
2 components	1,526 (31.2)	1,707 (30.3)	3,233 (30.7)
3 components	730 (14.9)	896 (15.9)	1,626 (15.5)
4 components	108 (2.2)	450 (8.0)	558 (5.3)
Overall dyslipidemia	3,440 (70.4)	4,598 (81.6)	8,038 (76.4)

Table 3. Prevalence of dyslipidemia components by dairy intake tertiles (Chi-square / Cochran-Armitage test).

Dyslipidemia component	Dairy intake tertile	Total (N=10,520) n/N (%)	*P* Trend	Men (N=4,887) n/N (%)	*P* Trend	Women (N=5,633) n/N (%)	*P* Trend
Hypercholesterolemia	Low	1403/3507 (40.0)		638/1629 (39.2)		765/1878 (40.7)	
	Moderate	1398/3506 (39.9)	0.381	622/1629 (38.2)	0.074	776/1877 (41.3)	0.642
	High	1439/3507 (41.0)		688/1629 (42.2)		751/1878 (40.0)	
Hypertriglyceridemia	Low	1520/3507 (43.3)		714/1629 (43.8)		806/1878 (42.9)	
	Moderate	1502/3506 (42.8)	0.904	745/1629 (45.7)	0.379	757/1877 (40.3)	0.321
	High	1515/3507 (43.2)		739/1629 (45.4)		776/1878 (41.3)	
High LDL-C	Low	998/3507 (28.5)		455/1629 (27.9)		543/1878 (28.9)	
	Moderate	1018/3506 (29.0)	0.357	434/1629 (26.6)	0.074	584/1877 (31.1)	0.694
	High	1033/3507 (29.5)		501/1629 (30.8)		532/1878 (28.3)	
Low HDL-C	Low	1466/3507 (41.8)		424/1629 (26.0)		1042/1878 (55.5)	
	Moderate	1483/3506 (42.3)	0.286	421/1629 (25.8)	0.026	1062/1877 (56.6)	0.718
	High	1422/3507 (40.5)		369/1629 (22.7)		1053/1878 (56.1)	
Overall Dyslipidemia	Low	2642/3507 (75.3)		1129/1629 (69.3)		1513/1878 (80.6)	
	Moderate	2686/3506 (76.6)	0.056	1135/1629 (69.7)	0.071	1551/1877 (82.6)	0.376
	High	2710/3507 (77.3)		1176/1629 (72.2)		1534/1878 (81.7)	

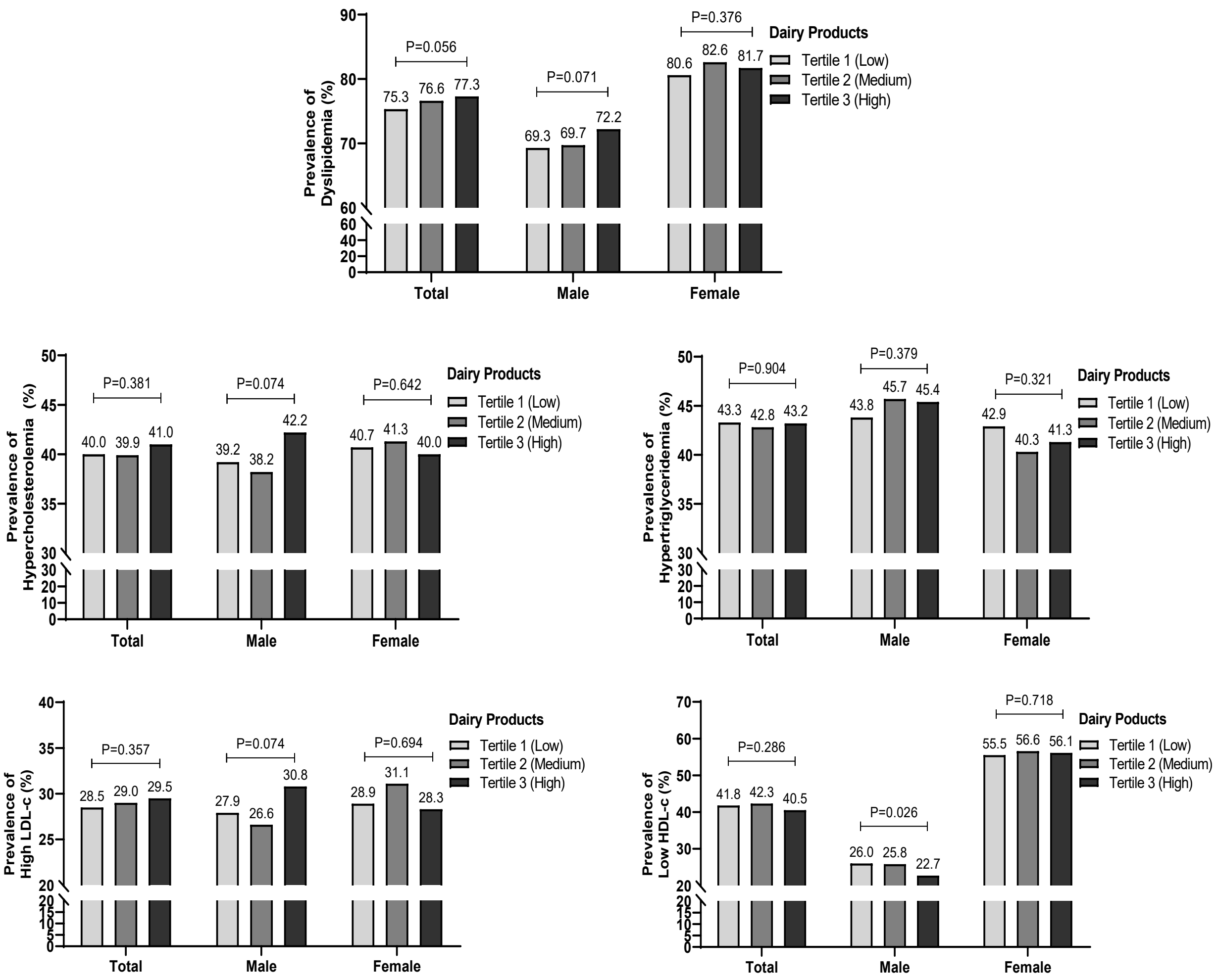

Figure 1. Figures illustrate the prevalence of hypercholesterolemia, hypertriglyceridemia, high LDL-c, low HDL-c, and overall dyslipidemia according to dairy intake levels in the total study population and stratified by sex among participants of the PERSIAN Guilan Cohort Study. P-values were calculated using the Cochran–Armitage trend test.

Among men, the prevalence increased with higher intake but did not reach statistical significance (P=0.074). No significant trend was observed in women (P=0.642). The prevalence of hypertriglyceridemia was similar across tertiles: 43.3% (low), 42.8% (moderate), and 43.2% (high). No significant trend was found in the overall sample (P=0.904) or sex-specific analyses (P=0.379 for men; P=0.321 for women) (Table 3 and

Figure 1). For elevated LDL-C, prevalence was 28.5% (low), 29.0% (moderate), and 29.5% (high), with no significant trend overall (*P*=0.357). The trend in men approached significance (*P*=0.074) but was not statistically significant. No association was found in women (*P*=0.694). In the total population, low HDL-C prevalence slightly decreased across tertiles (41.8% low, 42.3% moderate, 40.5% high), with no significant overall trend (*P*=0.286). Among men, a significant inverse trend was found (*P*=0.026), indicating that higher dairy intake was associated with a lower prevalence of low HDL-C. No significant trend was observed in women (*P*=0.718) (Table 3 and Figure 1).

Logistic regression analysis illustrated that in men, higher dairy intake was associated with lower odds of low HDL-C in the unadjusted model (OR=0.83; 95% CI: 0.71–0.98; *P*=0.025), indicating a protective effect; however, this association was attenuated and lost statistical significance after adjustment (aOR=0.87; 95% CI: 0.73–1.02; *P*=0.093). No other significant associations were observed in sex-specific analyses. Regarding overall dyslipidemia, individuals in the highest tertile of dairy intake had slightly higher, but non-significant, odds compared to the lowest tertile in both unadjusted (OR=1.11; 95% CI: 1.00–1.24; *P*=0.056) and adjusted models (aOR=1.09; 95% CI: 0.98–1.23; *P*=0.119) (Table 4).

4. Discussion

In this large population-based PGCS from northern Iran, we observed a notably high prevalence of dyslipidemia (76.4%) , affecting over three-quarters of adults surveyed. This high burden aligns with previous reports from Iran and other middle-income countries, where lifestyle transitions, dietary patterns, and increasing obesity contribute to widespread lipid disorders [26,27]. A study by Sarrafzadegan et al. in the Isfahan Cohort reported a dyslipidemia prevalence of 35.1%- 71.7% in adults, which is consistent with our findings and underscores the ongoing public health challenge posed by adverse lipid profiles in Iranian populations [28]. The variations observed in serum lipid levels across different regions can be attributed to a combination of factors, including ethnic and genetic predispositions, socioeconomic and cultural characteristics, and lifestyle differences among the subjects under study, as well as variances in the diagnostic criteria employed [29,30].

In the present study, the overall prevalence of dyslipidemia was higher among females than males. This pattern is consistent with several other studies [31,32], although some research has reported the opposite trend, with higher rates in men [33,34], while others have found no significant difference in prevalence between the sexes [35,36]. Studies that align with our findings have suggested that the higher prevalence in women may be related to hormonal changes, particularly the decline in estrogen levels before and after menopause, which can adversely affect lipid metabolism [33,37]. In this context, estrogen replacement therapy has been recommended by some experts as a potential strategy to reduce cardiovascular risk in postmenopausal women [38,39]. In our study, hypertriglyceridemia was more common among men, whereas elevated cholesterol and LDL-c levels, as well as lower HDL-c levels, were more prevalent in women. Similar distributions of dyslipidemia components have been reported in a study conducted in Slovakia [40]. Several observational and interventional studies have suggested that higher dairy consumption particularly of low-fat or fermented dairy products may be associated with improved lipid profiles, including lower levels of total cholesterol, LDL-C, and triglycerides, and modest increases in HDL-C [41,42].

Table 4. Association between dairy intake and dyslipidemia components (logistic regression).

Outcome	Dairy intake tertile	Crude OR (95% CI)	*P*	Adjusted OR (95% CI)*	*P*
Hypercholesterolemia (Total)	Low	1 (ref)		1 (ref)	
	Moderate	0.99 (0.90–1.09)	0.911	0.98 (0.89–1.08)	0.680
	High	1.04 (0.95–1.15)	0.381	1.03 (0.93–1.13)	0.618
Hypercholesterolemia (Men)	Low	1 (ref)		1 (ref)	
	Moderate	0.96 (0.83–1.10)	0.565	0.91 (0.79–1.05)	0.188
	High	1.14 (0.99–1.31)	0.075	1.07 (0.93–1.23)	0.367
Hypercholesterolemia (Women)	Low	1 (ref)		1 (ref)	
	Moderate	1.03 (0.90–1.17)	0.705	1.03 (0.91–1.18)	0.618
	High	0.97 (0.85–1.10)	0.642	0.98 (0.86–1.12)	0.761
Hypertriglyceridemia (Total)	Low	1 (ref)		1 (ref)	
	Moderate	0.98 (0.89–1.08)	0.672	0.99 (0.90–1.09)	0.783
	High	0.99 (0.90–1.09)	0.904	0.95 (0.86–1.05)	0.297
High LDL-C (Total)	Low	1 (ref)		1 (ref)	
	Moderate	1.03 (0.93–1.14)	0.592	1.01 (0.91–1.13)	0.781
	High	1.05 (0.95–1.16)	0.357	1.03 (0.93–1.15)	0.542
Low HDL-C (Total)	Low	1 (ref)		1 (ref)	
	Moderate	1.02 (0.93–1.12)	0.673	1.01 (0.91–1.11)	0.904
	High	0.95 (0.86–1.04)	0.286	0.92 (0.83–1.03)	0.139
Overall Dyslipidemia (Total)	Low	1 (ref)		1 (ref)	
	Moderate	1.07 (0.96–1.20)	0.211	1.05 (0.94–1.18)	0.388
	High	1.11 (1.00–1.24)	0.056	1.09 (0.98–1.23)	0.119

* Adjusted for age, sex, marital status, education, residence, wealth index, BMI, physical activity, smoking, opium, alcohol, and lipid-lowering medication. OR: Odds Ratio; CI: Confidence Interval; Ref: Reference group.

Such beneficial effects are often attributed to the inclusion of dairy as part of an overall healthy dietary pattern, emphasizing low-fat and nutrient-rich options like yogurt, kefir, and low-fat milk [13,43]. We observed that while overall dyslipidemia prevalence showed a slight upward trend with increasing dairy intake, this association did not reach statistical significance. The lack of a clear protective or detrimental effect of dairy on overall dyslipidemia risk is in line with evidence from large meta-analyses.

A meta-analysis by Guo et al. found that dairy consumption was not significantly associated with total cholesterol levels but was modestly associated with higher HDL-C and lower TG. However, these effects tend to vary by type of dairy product and fat content, which were not specifically examined in our analysis but could be relevant modifiers [41]. Regarding specific lipid fractions, our study found no significant associations between dairy intake and hypercholesterolemia, hypertriglyceridemia, or elevated LDL-C in the total population or sex-specific subgroups. Evidence indicated that habitual dairy intake does not meaningfully increase total cholesterol or LDL-C when consumed as part of a mixed diet [41,44]. Some studies suggest fermented dairy products, such as yogurt, may exert lipid-lowering effects, whereas high-fat dairy could have neutral or slightly adverse impacts depending on consumption levels and population background [45,46].

The current study revealed a modest but significant inverse association between higher dairy intake and low HDL-C among men in crude models. This aligns with previous observations that dairy foods, particularly those rich in bioactive peptides, calcium, and certain fatty acids, may beneficially influence HDL-C levels (7,47). A study by Nestel et al. demonstrated that dairy-derived saturated fats might raise HDL-C levels compared to non-dairy sources [48]. However, this apparent benefit in our study did not persist after adjusting for confounders, implying that factors such as physical activity, BMI, or other lifestyle habits may confound the relationship between dairy intake and HDL-C. Notably, sex differences were observed in the association between dairy intake and low HDL-C, with the trend being significant only in men. This could reflect differences in dietary patterns, hormonal influences on lipid metabolism, or cultural factors affecting both dairy consumption and other health behaviors in men versus women. A similar sex-specific pattern was reported by previous studies [41,44].

Our findings suggest that in this population, dairy consumption does not exert a major influence on dyslipidemia risk, except for a potential minor benefit for HDL-C among men, which did not hold after adjustment. This reinforces conclusions from global evidence that the impact of dairy on lipid health is nuanced and likely depends on product type, fat content, serving size, and broader dietary context [44,49]. Moreover, given the high prevalence of dyslipidemia overall, broader interventions targeting multiple lifestyle factors, such as total diet quality, physical activity, and weight management, are likely to be more effective strategies for improving lipid health in this region [45,50].

This large population-based cohort (n=10,520) employed standardized protocols for lipid measurements and utilized a validated Persian Food Frequency Questionnaire for culturally relevant dietary assessment. Rigorous inclusion of demographic, lifestyle, and socioeconomic variables, alongside multivariable-adjusted analyses, strengthened the reliability of dyslipidemia risk evaluations. The study further benefits from adherence to Iranian dietary guidelines and robust quality control in laboratory procedures.

However, this study has several limitations that should be acknowledged. First, its cross-sectional design precludes establishing causal relationships between dairy intake and dyslipidemia. Second, dietary intake was based on self-reported frequency, which may be subject to recall bias and did not differentiate between dairy subtypes (e.g., low-fat vs. full-fat, fermented vs. non-fermented). Third, potential residual confounding cannot be ruled out despite adjustment for several demographic and lifestyle variables. Lastly, since the study population was from a single province in northern Iran, the findings may not be generalizable to other regions or populations with different dietary patterns and metabolic profiles. Future research should further clarify the role of specific dairy subtypes and consider genetic and metabolic diversity that may modify individual responses to dairy intake. Longitudinal analyses and intervention trials within Iranian populations would be particularly valuable to determine whether culturally tailored dietary guidance could optimize the benefits of dairy products without increasing dyslipidemia risk.

This large population-based study showed a high prevalence of dyslipidemia across all lipid components. Although higher dairy intake was linked to a slight, non-significant increase in overall dyslipidemia, no meaningful associations were found for hypercholesterolemia, hypertriglyceridemia, or elevated LDL-C. A modest protective trend for low HDL-C was observed in men, but disappeared after adjustment. Overall, dairy consumption was not significantly related to dyslipidemia risk, highlighting the need for further studies to better understand this relationship.

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Authors' contributions

Supervision, Concept and design: FJ, HAB, MM, MN, FMG. Methods, Data collection, and Analysis:

NM, HAB, SM, MM, MN. Manuscript drafting: NM, SM, MM, MN. Critical revision: FJ, FMG. All authors read and approved the final version of the manuscript.

Conflict of interest

No potential conflict of interest was reported by the authors.

Ethical declarations

This study desgin was approved by the ethics committees of the Guilan University of Medical Sciences [IR.GUMS.REC.1402.132]. The methods were carried out in agreement with the principles and propositions established in the Declaration of Helsinki for all human or animal subjects. Written informed consent was obtained from all participants prior to enrollment.

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