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Association of Lipid Profile Components with Total Cholesterol Levels in Heart Disease and Non-Heart Patients

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Abstract

Cardiovascular diseases (CVDs) are the leading cause of morbidity and mortality worldwide, with a rapidly increasing burden in low- and middle-income countries such as Pakistan. Dyslipidemia is a major modifiable risk factor for CVD and plays a crucial role in the development and progression of atherosclerosis. This study aimed to compare lipid profile parameters between heart disease patients and non-heart individuals and to identify lipid components most strongly associated with elevated total cholesterol in District Sargodha. A cross-sectional analytical study was conducted using secondary data collected from public and private hospitals and diagnostic laboratories in Sargodha. A total of 180 lipid profile reports were included, comprising heart disease patients with confirmed cardiovascular conditions and non-heart individuals with no documented history of CVD. Data on total cholesterol, LDL, HDL, triglycerides, and VLDL were analyzed using SPSS. Descriptive statistics, independent sample t-tests, Pearson correlation, and multiple linear regression analyses were applied to assess associations and predictors. The regression model for heart disease patients was highly significant and explained 99.7% of the variance in total cholesterol levels. LDL cholesterol emerged as the strongest predictor, followed by triglycerides, HDL, and

VLDL. In non-heart patients, the model explained 90.3% of cholesterol variability, with LDL, HDL, and triglycerides as significant predictors, while VLDL showed no significant association. In conclusion, lipid abnormalities—particularly elevated LDL cholesterol—are strongly associated with total cholesterol levels, with a more pronounced effect among heart disease patients. These findings emphasize the importance of early lipid screening and targeted cholesterol management to reduce cardiovascular risk in the population.

Introduction

Cardiovascular disease (CVD) is a broad term that refers to a class of disorders involving the heart and blood vessels. It encompasses a wide range of conditions such as coronary artery disease, cerebrovascular disease (stroke), rheumatic heart disease, hypertensive heart disease, congenital heart disease, peripheral arterial disease, and heart failure. Among these, coronary artery disease and stroke are the most common and deadliest types. CVD typically develops over time and is often the result of a combination of genetic, behavioral, environmental, and metabolic risk factors. Major contributors include unhealthy diet, physical inactivity, tobacco use, and excessive alcohol consumption, which lead to conditions like hypertension, dyslipidemia, diabetes, and obesity [1].

Pathologically, most cardiovascular diseases are linked to atherosclerosis—a process in which fatty deposits accumulate on the inner walls of arteries, narrowing them and restricting blood flow. When this process occurs in the coronary arteries, it can result in angina or myocardial infarction (heart attack). If it affects arteries leading to the brain, it may cause a stroke. These events often occur suddenly and can be fatal without immediate medical attention [2].

CVD has become the leading cause of death globally, accounting for an estimated 17.9 million deaths annually, representing 32% of all global deaths (WHO, 2021). Alarmingly, more than three-quarters of these deaths occur in low- and middle-income countries, where healthcare infrastructure is often inadequate and awareness about preventive measures remains limited. South Asia, including Pakistan, is witnessing a rapid increase in cardiovascular morbidity and mortality, largely driven by urbanization, shifting dietary habits, sedentary lifestyles, and persistent poverty [3].

In addition to biological and behavioral factors, recent research highlights the significant role of psychosocial stress, environmental pollution, and socioeconomic disparities in increasing cardiovascular risk. Airborne pollutants, especially fine particulate matter (PM2.5), have been strongly associated with increased risks of heart attacks and strokes. Moreover, gender and age play critical roles in the epidemiology of CVD. For instance, men are more likely to experience heart attacks at a younger age, whereas women often present with atypical symptoms and are less likely to receive timely treatment [4].

CVD is not only a health issue but also an economic burden. It leads to premature deaths, disability, and reduced productivity, particularly among working-age adults in developing countries. The chronic nature of the disease also imposes long-term costs on healthcare systems and families. Despite its immense burden, CVD is largely preventable through lifestyle modification, early screening, and affordable medical interventions. In Pakistan, the situation is particularly worrisome due to a lack of awareness, poor healthcare access in rural regions, and insufficient public health policies targeting non-communicable diseases. Understanding the nature, causes, and distribution of cardiovascular diseases through epidemiological studies is crucial for formulating targeted interventions, especially in under-researched regions like Sargodha, Punjab [5].

Cardiovascular diseases (CVDs), a group of disorders of the heart and blood vessels, represent the leading cause of death globally, accounting for approximately 17.9 million deaths annually (World Health Organization [WHO], 2021). Of these, 85% are due to heart attacks and strokes. The global burden of CVDs is expected to rise to 23.6 million deaths by 2030, largely driven by aging populations, unhealthy lifestyles, and growing urbanization (Roth et al., 2020). Low- and middle-income countries (LMICs) bear a disproportionate share of this burden, with over 75% of global CVD deaths occurring in these regions (WHO, 2021). The transition from infectious to chronic diseases in LMICs reflects a significant epidemiological shift.

South Asia, home to nearly 1.9 billion people, is experiencing an alarming rise in CVD prevalence. The region is characterized by a younger onset of CVDs, higher mortality rates, and a greater burden of modifiable risk factors, such as tobacco use, unhealthy diets, and sedentary behavior [6]. Research indicates that South Asians are more susceptible to insulin resistance, abdominal obesity, and metabolic syndrome, even at lower body mass indices (GBD 2019 Diseases and Injuries. A key concern is the early age at which these diseases present; studies have found heart attacks occurring in individuals as young as 40. Compounding this issue is a lack of effective prevention programs and poor healthcare access in rural areas [7].

Pakistan is currently undergoing a health transition from infectious to non-communicable diseases. According to national estimates, CVDs account for approximately 29% of all deaths in the country. Pakistan's population faces widespread risk factors: hypertension (37%), obesity (25–30%), diabetes (14%), and a high prevalence of smoking (19%), especially among males. The Pakistan Demographic and Health Survey (2017–18) reported a worrying increase in obesity and hypertension across both rural and urban populations. Moreover, awareness, treatment, and control of these conditions remain alarmingly low. For instance, only 12% of hypertensive patients have their condition adequately controlled [8].

CVDs affect both young and old, but age remains one of the strongest predictors of cardiovascular risk. Research has shown that men in Pakistan tend to develop heart disease earlier than women, with increasing risk observed among individuals over 45 [9]. Post-menopausal women also face heightened risk due to hormonal changes, often exacerbated by poor access to care. A 2021 study by Khan et al. found that CVD prevalence among people aged 50+ was nearly double compared to those under 40, with the risk sharply rising after the age of 60. Alarmingly, younger adults in urban areas are increasingly presenting with CVD symptoms, attributed to stress, poor diet, and lack of physical activity [10].

There are marked differences in CVD risk between urban and rural populations in Pakistan. Urban areas tend to report higher rates of obesity, physical inactivity, and dyslipidemia, while rural populations face challenges such as lack of awareness, delayed diagnosis, and limited access to healthcare. A comparative study in Punjab revealed that urban residents had 30% higher rates of smoking and 40% higher obesity prevalence than their rural counterparts. However, rural populations often suffer more severe complications due to late-stage presentation and inadequate management. Furthermore, women in rural settings are particularly vulnerable due to gender-based barriers in accessing healthcare [11].

Punjab, the most populous province of Pakistan, has shown a consistent rise in cardiovascular risk factors over the last two decades. The Punjab NCD Survey (2018) highlighted that nearly one in three adults in the province has hypertension, and more than 60% fail to meet physical activity recommendations [12]. Additionally, the survey indicated a high intake of sodium-rich processed foods, particularly in urban settings. Despite having better health infrastructure than other provinces, Punjab's healthcare system struggles with resource allocation, health worker shortages in rural

districts, and lack of preventive care services [12]. Public hospitals often remain overburdened, and community-level screening programs are rare.

Sargodha, a rapidly developing district in central Punjab, has a population of approximately 4.33 million, with about 63% residing in rural areas (Pakistan Bureau of Statistics, 2017). It has seen rapid urbanization, leading to shifts in lifestyle, diet, and occupational habits. Despite this transformation, epidemiological data specific to Sargodha's CVD burden is scarce, leaving local health authorities without the evidence needed to guide effective intervention. Anecdotal reports and hospital records suggest a rise in heart-related emergencies, yet no structured research has quantified the disease burden or assessed the distribution of risk factors across age groups, gender, or rural vs. urban populations [13].

Health literacy plays a critical role in cardiovascular disease prevention and management. Research has consistently shown that individuals with **higher education levels are more likely to engage in preventive behaviors**, understand risk factors, and adhere to medical advice [14]. In Sargodha and many parts of rural Punjab, **low literacy levels**, particularly among women, result in **poor awareness about blood pressure, cholesterol, and diabetes**—all key indicators of CVD risk. There is a dire need to incorporate **community-based awareness campaigns,** culturally sensitive education programs, and accessible informational resources in local languages [15].

Despite the growing burden, **CVDs are not prioritized adequately in Pakistan's national health agenda**. Although some urban tertiary hospitals offer cardiac care units, **primary care centers in rural areas are poorly equipped to diagnose or manage CVDs (**Nishtar et al., 2019)**.** Programs such as the **Prime Minister's Health Card** have improved access to tertiary care for some, but **screening, prevention, and early diagnosis remain largely unaddressed**, particularly in smaller districts like Sargodha. There is a pressing need to **integrate CVD prevention into the Basic Health Units (BHUs)** and Rural Health Centers (RHCs) infrastructure [16].

Emerging evidence also suggests that **environmental factors such as air pollution and extreme temperatures** can exacerbate cardiovascular risk. Sargodha, being an agricultural and industrial hub, experiences **periodic spikes in air pollution**, especially during crop burning and harvest seasons. Studies have linked exposure to fine particulate matter (PM2.5) with an increase in **acute myocardial infarctions and strokes** [17]. Climate change may also influence vector-borne diseases and food security, indirectly affecting cardiovascular health through malnutrition and stress.

MATERIALS AND METHODS

Study Design

This research was conducted as a cross-sectional analytical study aimed at comparing lipid profile parameters between patients with heart disease and individuals without heart disease. In addition, the study sought to identify factors associated with elevated cholesterol levels among the population of District Sargodha. Data were analyzed at a single point in time to assess differences in lipid parameters between the two groups and to explore possible associations with dyslipidemia.

Study Setting

The study was carried out in District Sargodha and its adjoining areas. Lipid profile reports were collected from several public and private hospitals and diagnostic laboratories, including DHQ Hospital Jauharabad, DHQ Teaching Hospital Sargodha, Rubina Shaheen Hospital Jauharabad, Zainab Hospital Jauharabad, Doctors Lab Sargodha, Lahore Medical Lab, and Khan Lab. These healthcare facilities were selected because they are major centers providing cardiology care and diagnostic services to a large and diverse patient population in the region.

Study Duration
Data collection for this study was completed over a period of four months. This duration was considered sufficient to obtain an adequate number of lipid profile reports from both heart patients and non-heart patients for meaningful statistical analysis.

Study Population
The study population consisted of two groups: heart patients and non-heart patients. The heart patient group included individuals with a documented history of cardiovascular disease, such as myocardial infarction, ischemic heart disease, or other clinically diagnosed cardiac conditions. Their diagnoses were confirmed through hospital medical records. The non-heart patient group served as the control group and comprised individuals with no known history of cardiovascular disease. These participants were selected through random sampling of routine lipid profile reports obtained from diagnostic laboratories.

Sample Size
A total of 180 lipid profile samples were included in the study, comprising reports from both heart patients and non-heart patients. The sample size was determined based on the availability of eligible records from multiple hospitals and diagnostic laboratories. This number was considered adequate to allow meaningful statistical comparison between the two groups and to assess differences in lipid profile parameters.

Sampling Technique
A non-probability convenient sampling technique was employed for this study. Lipid profile reports were obtained from hospital medical records and laboratory databases according to predefined inclusion and exclusion criteria. This approach allowed efficient access to relevant data within the available time frame and resources.

Inclusion Criteria
For heart patients, the study included individuals aged 18 years or older with a confirmed diagnosis of cardiovascular disease, such as myocardial infarction, ischemic heart disease, or other clinically validated cardiac events. Only patients with complete lipid profile results, including total cholesterol, LDL, HDL, triglycerides, and VLDL, were included. The non-heart patient group consisted of individuals aged 18 years or older with no known history of cardiovascular disease and with complete lipid profile reports available for analysis.

Exclusion Criteria
Patients were excluded from the study if they had incomplete or missing lipid profile data. Individuals with chronic liver or kidney disease were also excluded due to the potential effects of these conditions on lipid metabolism. Pregnant females were excluded because of physiological alterations in lipid levels during pregnancy. In addition, patients receiving high-dose lipid-lowering medications with incomplete or unclear treatment records were not included in the analysis.

Variables Collected
The primary dependent variable in this study was total cholesterol level. Independent variables included lipid profile components such as LDL, HDL, triglycerides, and VLDL, as well as demographic and clinical factors including age, gender, diabetes status, smoking status, hypertension, family history of cardiovascular disease, and

body mass index where available. The purpose of collecting these variables was to determine which lipid parameters and demographic or clinical factors were most strongly associated with elevated cholesterol levels and cardiovascular disease.

Data Collection Procedure

Lipid profile reports were obtained from hospital record rooms and laboratory information systems. Relevant data were manually extracted and entered into a structured data collection sheet designed for the study. Patient confidentiality and anonymity were strictly maintained throughout the data collection process. For heart patients, the diagnosis of cardiovascular disease was verified through physician notes, electrocardiogram findings, discharge summaries, and hospital records. Data for non-heart patients were collected from randomly selected routine laboratory samples with no documented history of cardiac illness.

Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS). Descriptive statistics were used to summarize the data, including calculation of means, standard deviations, and frequency distributions for lipid profile components and demographic variables. Inferential statistical tests were applied to assess differences and associations between variables. Independent sample t-tests and analysis of variance (ANOVA) were used to compare total cholesterol, LDL, HDL, triglycerides, and VLDL levels between heart patients and non-heart patients. Pearson correlation analysis was performed to examine the relationships between total cholesterol levels and other variables such as age, LDL, triglycerides, diabetes status, smoking status, and related clinical factors. Multiple linear regression analysis was conducted to identify the strongest predictors of elevated cholesterol levels among the studied variables. In addition, binary logistic regression analysis was optionally applied to evaluate which lipid profile parameter best predicted the presence of heart disease. A p-value of ≤ 0.05 was considered statistically significant for all analyses.

Ethical Considerations

Ethical approval and permission were obtained from the administrations of the respective hospitals and diagnostic laboratories prior to data collection. Patient confidentiality and privacy were strictly maintained, as no personal identifiers were recorded and only relevant laboratory values and clinical information were used for analysis. Since the study was based on secondary data obtained from existing records, there was no direct patient involvement, contact, or intervention during the course of the research.

RESULTS

Multiple linear regression analysis was conducted to evaluate the effect of lipid profile components on total cholesterol levels among heart disease patients and non-heart (random) patients. In heart disease patients, the regression model was found to be highly significant ($F = 2651.152$, $p < 0.001$), explaining approximately 99.7% of the variance in total cholesterol levels. All lipid parameters showed a significant positive association with cholesterol. LDL cholesterol emerged as the strongest predictor ($B = 1.047$, $\beta = 0.765$, $p < 0.001$), followed by triglycerides ($B = 0.179$, $\beta = 0.295$, $p < 0.001$), HDL cholesterol ($B = 0.803$, $\beta = 0.144$, $p < 0.001$), and VLDL cholesterol ($B = 0.134$, $\beta = 0.033$, $p = 0.035$). These findings indicate that increases in each lipid component are associated with higher cholesterol levels among heart disease patients, with LDL cholesterol exerting the greatest influence.

In non-heart (random) patients, the regression model was also statistically significant ($F = 126.753$, $p < 0.001$), explaining approximately 90.3% of the variance in total cholesterol. LDL cholesterol remained the most influential predictor of cholesterol levels ($B = 0.957$, $\beta = 0.800$, $p < 0.001$), followed by HDL cholesterol ($B = 0.825$, $\beta = 0.389$, $p < 0.001$) and triglycerides ($B = 0.183$, $\beta = 0.252$, $p < 0.001$). In contrast to heart disease patients, VLDL cholesterol did not show a significant association with total cholesterol in non-heart patients ($B = 0.017$, $\beta = 0.006$, $p = 0.911$). Collinearity diagnostics indicated acceptable levels, with variance inflation factor values below the recommended threshold.

A comparison between the two groups demonstrated that lipid profile components explain cholesterol levels more strongly in heart disease patients than in non-heart patients. While LDL cholesterol, HDL cholesterol, and triglycerides were significant predictors in both groups, VLDL cholesterol was a significant contributor only among heart disease patients. The higher proportion of explained variance in heart patients suggests that cholesterol levels in this group are more directly determined by lipid abnormalities, whereas cholesterol levels in non-heart patients may be influenced by additional non-lipid factors.

DISCUSSION

The present study examined the relationship between lipid profile components and total cholesterol levels among heart disease patients and non-heart (random) patients. The findings demonstrate that lipid parameters play a central role in determining cholesterol levels in both groups; however, their influence is substantially stronger in heart disease patients. This difference highlights the varying biological and metabolic behavior of cholesterol in diseased versus non-diseased populations [18,19,20].

In heart disease patients, the regression model explained nearly all the variability in total cholesterol (99.7%), indicating that cholesterol levels in this group are predominantly driven by lipid abnormalities. LDL cholesterol emerged as the most influential predictor, consistent with existing literature identifying LDL as the primary atherogenic lipid responsible for plaque formation and progression of cardiovascular disease [21,22]. The strong positive association observed in this study supports the well-established role of LDL cholesterol as a major determinant of elevated cholesterol in heart patients [23].

Triglycerides and HDL cholesterol also showed significant positive associations with total cholesterol in heart disease patients. Although HDL is traditionally considered protective against cardiovascular disease, its positive contribution to total cholesterol is expected, as total cholesterol is mathematically composed of HDL along with other lipid fractions [24,25]. The significant effect of triglycerides further reflects altered lipid metabolism commonly observed in cardiac patients, where elevated triglyceride levels contribute to increased cholesterol through enhanced VLDL production [26,27,28].

An important finding of this study is the significant role of VLDL cholesterol in heart disease patients, which was not observed in non-heart patients. This suggests that VLDL may be more metabolically active or clinically relevant in individuals with established heart disease [29]. Elevated VLDL is often associated with insulin resistance and dyslipidemia, conditions frequently present in cardiac patients, thereby strengthening its contribution to cholesterol elevation in this group.

In contrast, the regression model for non-heart patients explained a smaller proportion of cholesterol variability (90.3%), indicating that cholesterol levels in this group are influenced by additional factors beyond the measured lipid components. Although LDL cholesterol remained the strongest predictor, its effect was slightly weaker than that observed in heart disease patients. HDL cholesterol and triglycerides also

significantly influenced cholesterol levels, suggesting that these lipid fractions contribute to cholesterol elevation even in individuals without diagnosed heart disease [30]. Notably, VLDL cholesterol did not show a significant association with cholesterol in non-heart patients. This finding implies that VLDL may not be a critical determinant of cholesterol levels in relatively healthy individuals and becomes more relevant in pathological conditions such as heart disease [31,32].

Overall, the findings suggest that cholesterol levels in heart disease patients are more predictable and strongly driven by lipid abnormalities, whereas cholesterol levels in non-heart patients are more heterogeneous and likely influenced by lifestyle factors, genetic predisposition, diet, physical activity, age, and other metabolic conditions. These results emphasize the importance of aggressive lipid management, particularly LDL cholesterol control, in heart disease patients, while also underscoring the need for broader lifestyle-based interventions in non-heart populations.

REFERENCES

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Supplementary Tables

Table 1: The mean lipid profile values showed elevated total cholesterol, triglycerides, and LDL cholesterol with comparatively lower HDL cholesterol and a mean VLDL level

	Mean	Std. Error of Mean
cholesterol	205.46	6.785
Triglycerides	162.51	8.599
LDL cholesterol	130.957	1.2051
HDL cholesterol	41.717	5.0866
VLDL cholesterol	32.494	1.7202

Table 2: The descriptive statistics indicate positively skewed lipid distributions, with mean values of total cholesterol, triglycerides , LDL , HDL , and VLDL , wide ranges, and high kurtosis—particularly for cholesterol, HDL, and VLDL—suggesting substantial variability and the presence of extreme values in the study population.

	cholesterol	triglyceride	LDL	HDL	VLDL
Mean	191.95	189.02	104.2	51.2	41.75
Median	186	163	102	45	35
Mode	159	128	110	46	27
Std. Deviation	60.982	83.678		28.792	51.02
Skewness	1.76	1.096		4.527	2.075
Std. Error of Skewness	0.311	0.311		0.311	0.311
Kurtosis	8.658	1.175		22.215	9.257
Std. Error of Kurtosis	0.613	0.613		0.613	0.613
Range	449	398		191	329
Minimum	37	48		24	28
Maximum	486	446		215	357