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RESEARCH ARTICLE

A COMPREHENSIVE INVESTIGATION OF ATHEROSCLEROSIS IN THE 10-25 AGE GROUP THROUGH MEDICO-LEGAL AUTOPSIES

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ABSTRACT

Introduction: Atherosclerosis, a leading cause of coronary heart disease (CHD), remains a global health concern with a rising prevalence in young populations, particularly in regions like Kerala, India. Despite advancements in social indicators, Kerala faces an alarming surge in CHD cases among its youth. This study aimed to assess the prevalence and severity of atherosclerosis in coronary arteries and the aorta among individuals aged 10–25 years, shedding light on etiological factors influencing CHD.

Methods: A cross-sectional study was conducted at the Department of Forensic Medicine, Government Medical College, Thiruvananthapuram, India, involving medico-legal post-mortem examinations. Sixty-four cases aged 10-25 years were included, with data collected on personal, physical, and lifestyle parameters. Autopsy-based examinations focused on atherosclerosis in coronary arteries and the aorta, utilizing a detailed histopathological classification system.

Results: The study revealed a high prevalence of atherosclerosis, with 60.9% of cases exhibiting aortic lesions, and varying percentages observed in coronary arteries. Associations were found between atherosclerosis and age, family history of heart disease leading to death, cigarette smoking, recreational drug use, and personal history of heart disease.

Conclusion: This study underscores the concerning prevalence of atherosclerosis among young individuals and emphasizes the need for antiatherogenic preventive measures and targeted awareness programs against cigarette smoking and recreational drug abuse. It calls for novel therapeutic approaches and public health campaigns to promote lifestyle modifications and mitigate atherosclerosis-related early mortality and morbidity. Policy implications include recognizing atherosclerosis as a condition affecting young populations and advocating for comprehensive research approaches with larger sample sizes and genetic studies to identify potential genetic contributions to atherosclerosis development. Limitations include challenges in obtaining accurate lifestyle histories during autopsies and the need for larger, multicenter studies to provide deeper insights into risk factors and age-related trends.

Keywords: *Atherosclerosis; autopsy; cardiovascular risk factors; coronary artery disease; youth cardiovascular health.*

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INTRODUCTION

Heart disease, often silent until it becomes fatal, remains a global menace, with coronary heart disease (CHD) leading to morbidity and mortality. The prevalence of CHD in India, particularly in Kerala, has surged over the last six decades. Kerala, despite its social advancements, faces an alarming rise in CHD cases, notably affecting the younger population[1]. The present study aims to assess the extent and severity of atherosclerosis in coronary arteries and aorta among individuals aged 10–25 years, providing valuable insights into the etiological factors influencing CHD[2,3].

Atherosclerosis, a major contributor to CHD, involves the build-up of fats, cholesterol, and other substances in arterial walls, compromising blood flow. Prevention, especially primordial prevention, is crucial. Studying atherosclerosis in living populations is challenging, making autopsy studies essential. The lack of reliable mortality data in India underscores the importance of estimating the cardiovascular disease burden through cross-sectional studies[4,5].

The cardiovascular system comprises arteries, veins, and capillaries. Arteries, with their three layers, play a crucial role. Large elastic arteries, medium muscular vessels, and small arteries or arterioles exhibit structural variations. Arteries' embryonic development gives rise to the major vessels, including the aorta[6]. The pathophysiology of atherosclerosis involves physiological changes like diffuse intimal thickening and pathological atherosclerosis. Major risk factors include dyslipidemia, hypertension, diabetes mellitus, obesity, smoking, and psychosocial factors. The emerging risk factors encompass environmental influences, hormonal factors, physical inactivity, and iron overload. Atherosclerosis, a complex vascular disease, is initiated by hyperlipidemia, hyperglycemia, and hypertension-induced endothelial injury. This leads to platelet adhesion, recruitment of monocytes and T cells, and subsequent release of cytokines and growth factors, fostering smooth muscle cell migration and proliferation[7-10]. Foam cells in atheromatous plaques derive from macrophages and smooth muscle cells accumulating modified lipids, particularly oxidized and aggregated low-density lipoprotein (LDL). Extracellular lipids result from vessel lumen insudation, accentuated by hypercholesterolemia[11-14]. Coronary artery stenosis was classified into five grades: Grade 0 denoted normal conditions, Grade 1 represented 1 to 25% stenosis, Grade 2 indicated 26 to 50% stenosis, Grade 3 signified 51 to 75% stenosis, and Grade 4 encompassed 76 to 100% stenosis.

Key mechanisms involve lipid accumulation in the arterial intima, smooth muscle cell migration, platelet and fibrin deposition, and an augmented vasoconstrictor response. Atherosclerosis undergoes diverse morphologic stages, from fatty streaks in youth to atheromatous plaques in advanced age[15-22].

1. Fatty streaks and dots: Common in youth, appearing as yellow circumscribed areas.
2. Gelatinous lesions: Greyish areas with increased mucoid ground substance, prominent in proximal coronary segments after the second decade.
3. Atheromatous plaques: Fully developed lesions, selective in different locations, with a central core and fibrous cap.
4. Fatty plaques: Intermediate lesions, exhibiting mixed white or yellow appearance.
5. Fibrous plaques: Complicated lesions with clinical significance, prone to ulceration, fissuring, and thrombosis.

Complications include calcification, ulceration, intimal hemorrhage, and superimposed thrombosis. Secondary changes occur in the tunica media and adventitia, marked by fibrous tissue increase and altered vascularity.[23-28].

In the detailed classification system developed by the American Heart Association (AHA), atherosclerotic plaques are categorized into eight types based on histopathological features[29-34].

1. Type 1: Minimal change, isolated foamy cells in the intima.
2. Type 2: Fatty streaks, numerous foamy cells often in layers.
3. Type 3: Extracellular lipids without a defined lipid core (pre-atheroma or intermediate lesion).
4. Type 4: Atheroma or fibro plaque, well-defined lipid core with a normal intima covering the luminal surface.
5. Type 5: Fibroatheroma, well-defined lipid core with a fibrous cap, with or without calcification.
6. Type 6: Fibroatheroma with fibrous cap defect like haemorrhage or thrombosis.
7. Type 7: Presence of prominent calcification.
8. Type 8: Presence of prominent fibrous tissue change.

METHODS

This study, conducted at the Department of Forensic Medicine, Government Medical College, Thiruvananthapuram, Kerala, India, involved medico-legal post-mortem examinations. The study, adopted a cross-sectional design, focusing on cases aged 10-25 years brought for medico-legal autopsy at the mortuary wing. The study's primary objective was to investigate atherosclerosis in coronary arteries and aorta among 10–25-year-olds at autopsy. Secondary objectives include identifying factors associated with atherosclerosis. The study included cases meeting inclusion criteria (age 10-25) with consent, excluding those with decomposition changes, heart/aorta injuries, unknown/ unclaimed bodies, or lacking consent. Consecutive sampling was applied. Sample size (n=64) was calculated based on prevalence (p=60%), precision (d=20%), and confidence level (α=0.05). Informed consent from relatives facilitated data collection, including personal/family history, external features, and anthropometric measurements. Autopsy followed routine protocols, emphasizing aorta and coronary examination. Tissue samples preserved in 10% formalin underwent histopathological examination. Fixation, dehydration, clearing, impregnation with paraffin, embedding, and sectioning were standard procedures. Haematoxylin and eosin staining aided microscopic examination. Study tools comprised instruments for tissue collection, reagents, paraffin block-making tools, stains, slides, cover slips, and a microscope. Atherosclerosis was identified through both gross and microscopic examination. Grossly, atheromatous plaques appeared as white to yellowish lesions, varying in size and raised on the surface. Microscopically, the cut section revealed a luminal surface with a firm, white fibrous cap and a central core of yellow to yellow-white, soft material, known as atheroma, housing various cellular components like smooth muscle cells, macrophages, and lipid-laden foam cells. In accordance with the detailed histopathological classification system established by the American Heart Association, atherosclerotic plaques were systematically categorized into eight distinct types in this study, facilitating a comprehensive assessment of disease progression and severity to enhance our understanding of cardiovascular pathology. A structured pro forma recorded details. Variables included age, sex, monthly income, body mass index (BMI), abdominal girth, diet, oil consumption, tea/coffee, smoking, alcohol, recreational drug use, personal/family medical history, comorbidities, death cause, and heart weight. Data were collected from the reliable relatives of the deceased. Data were entered into Microsoft Excel spreadsheet software and analyzed using SPSS Statistics version 26.0. Descriptive statistics provided insights into the study variables, enabling a comprehensive understanding of the medico-legal cases under consideration.

RESULTS

The study included 64 subjects aged 10-25 years, with a mean age of 20.02 (SD 3.15) years. The majority (50%) fell within the 21-25 age group. Out of the subjects, 76.6% were males and 23.4% were females. Males dominated across all age groups. The most common cause of death was hanging (45.4%), followed by road traffic accidents (35.9%). 46.9% had a heart weight of less than 250 g, 43.8% had 250-300 g, and 9.3% had more than 300 g.

In this study, a comprehensive assessment of atherosclerosis prevalence in the aorta and coronary arteries was conducted. Aorta findings revealed 39% with fatty dots, 29.7% with fatty streaks, and 1.6% with fatty plaques. Coronary artery analysis indicated variations in occlusion grades, with the left anterior descending artery (LAD) showing 10.9% with grade 1 occlusion. Additionally, type I and type II lesions were observed in the aorta and coronary arteries (Figures 1, 2, and 3). Overall, 60.9% had aortic atherosclerosis, 59.4% exhibited LAD atherosclerosis, 48.4% had atherosclerosis in the right coronary artery, and 31.2% in the circumflex artery.

High-income subjects constituted 65.6%, while low-income subjects were 34.4%. The majority had a normal BMI (67.2%), with 31.2% underweight and 1.6% overweight. All subjects had a normal abdominal girth. 84.4% had <80 cm, and 15.6% had 80-99 cm. All subjects were non-vegetarians. Coconut oil was predominant (92.2%), followed by sunflower oil (4.7%) and mixed oil (3.1%). All subjects consumed tea/coffee. Alcohol consumption was reported by 18.7%, while 17.2% had a history of cigarette smoking. Ganja abuse was reported by 6.3%. Most subjects had no personal history of illness (95.3%). A small percentage had a history of bronchial asthma (3.1%) or heart disease (1.6%). 18.7% had a family history of heart disease, and 73.5% had a family history of comorbidities. 6.3% reported a family history of death due to heart disease.

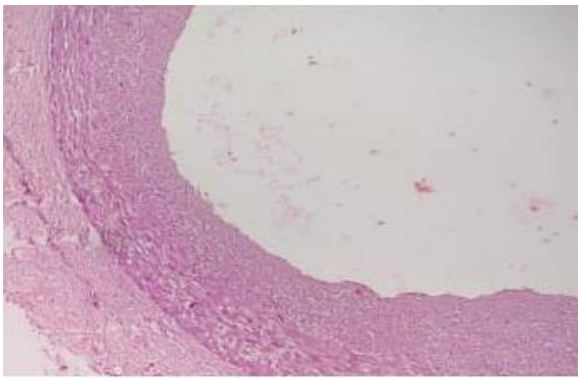

Figure 1: AHA type II lesion in LAD (H&E,100x)

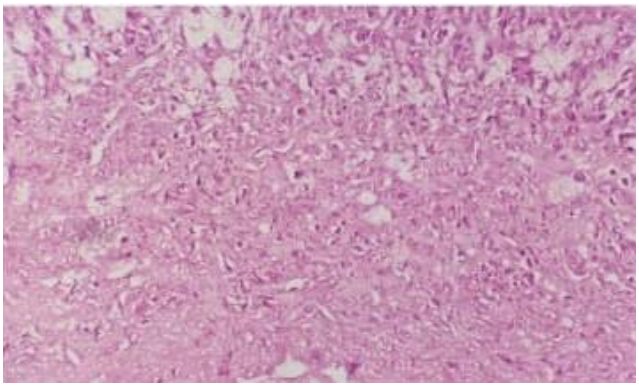

Figure 2: AHA type II lesion with numerous foam cells in LAD (H&E, 400x)

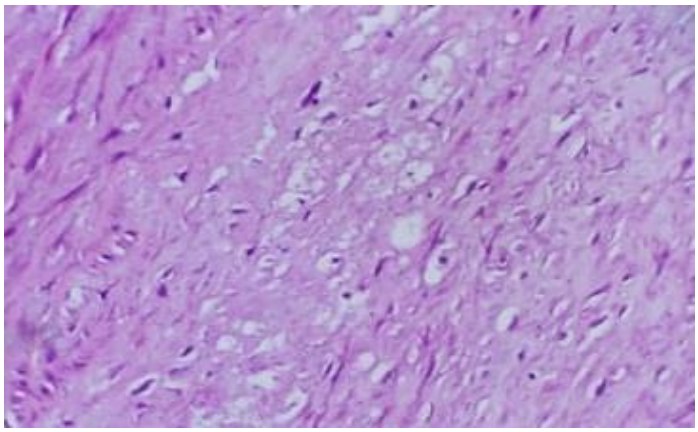

Figure 3: AHA type II lesion with numerous foam cells in the aorta (H&E, 400x)

Table 1: Associations of age with atherosclerosis in the aorta

		Atherosclerosis in Aorta						Total		X^2	df	P
		Normal		Type 1		Type 2						
		N	%	N	%	N	%	N	%			
Age	10-15	3	37.5	3	37.5	2	25	8	100	**13.71**	**4**	**0.008**
	16-20	15	62.5	5	20.8	4	16.7	24	100			
	21-25	7	21.8	6	18.8	19	59.4	32	100			
	Total	25	39.1	14	21.8	25	39.1	**64**	**100**			

Table 2: Associations of sex with atherosclerosis in the aorta

		Atherosclerosis in Aorta						Total		X^2	df	P
		Normal		Type 1		Type 2						
		N	%	N	%	N	%	N	%			
Sex	Male	19	38.8	10	20.4	20	40.8	49	100	**0.38**	**2**	**0.829**
	Female	6	40	4	26.7	5	33.3	15	100			
	Total	25	39.1	14	21.8	25	39.1	64	100			

Table 3: Associations of type of oil with atherosclerosis in aorta

		Atherosclerosis in Aorta						Total		X^2	df	P
		Normal		Type 1		Type 2						
		N	%	N	%	N	%	N	%			
Type of oil	Coconut	23	39	11	18.6	25	42.4	59	100	**9.53**	**4**	**0.049**
	Sunflower	2	66.7	1	33.3	0	0	3	100			
	Mixed	0	0	2	100	0	0	2	100			
	Total	25	39.1	14	21.8	25	39.1	64	100			

Table 4: Association of monthly income and body mass index with atherosclerosis in aorta (n=64)

		Atherosclerosis of Aorta						**Total**		**χ^2**	**Df**	**P**
		Normal		Type I		Type II						
		N	%	N	%	N	%	N	%			
Monthly income	BPL	6	27.3	4	18.2	12	54.5	22	100	3.45	2	0.177
	APL	19	45.2	10	23.8	13	31	42	100			
	Total	25	39	14	22	25	39	64	100			
BMI ($kg/m^{2)}$	<18.5	7	35	6	30	7	35	20	100	2.63	4	0.621
	18.5-24.9	17	39.5	8	18.6	18	41.9	43	100			
	>25	1	100	0	0	0	0	1	100			
	Total	25	39.1	14	21.9	25	39.1	64	100			

BPL – Below poverty line, APL – Above poverty line

Table 5: Association of diet with atherosclerosis in aorta (n=64)

		Atherosclerosis in aorta								X^2	df	P
		Normal		Type I		Type II		Total				
		N	%	N	%	N	%	N	%			
Diet	Pure Vegetarian	0	0	0	0	0	0	0	0	-	-	-
	Non vegetarians	25	39.1	14	21.8	25	39.1	64	100			
	Total	25	39.1	14	21.8	25	39.1	64	100			

Table 6: Associations of cigarette smoking, alcohol consumption, recreational drugs, personal history and history of heart disease in family with atherosclerosis in aorta (n=64)

		Atherosclerosis in Aorta								X^2	df	P
		Normal		Type I		Type II		Total				
		N	%	N	%	N	%	N	%			
Cigarette smoking	No	21	39.6	12	22.6	20	37.7	53	100	0.25	2	0.884
	Yes	4	36.4	2	18.2	5	45.5	11	100			
	Total	25	39.1	14	21.9	25	39.1	64	100			
Alcohol consumption	No	20	38.5	12	23.1	20	38.5	52	100	0.23	2	0.889
	Yes	5	41.7	2	16.7	5	41.7	12	100			
	Total	25	39.1	14	21.9	25	39.1	64	100			
Recreational drugs	No	22	36.7	14	23.3	24	40	60	100	2.56	2	0.278
	Yes	3	75	0	0	1	25	4	100			
	Total	25	39.1	14	21.9	25	39.1	64	100			
Personal history	Normal	25	41	13	21.3	23	37.7	61	100	3.22	4	0.522
	Heart disease	0	0	0	0	1	100	1	100			
	asthma	0	0	1	50	1	50	2	100			
	Total	25	39.1	14	21.9	25	39.1	64	100			
History of heart disease in the family	No	21	40.4	11	21.2	20	38.5	52	100	0.22	2	0.898
	Yes	4	33.3	3	25	5	41.7	12	100			
	Total	25	39.1	14	21.9	25	39.1	64	100			

DISCUSSION

The study investigated atherosclerosis in coronary arteries and the aorta among individuals aged 10-25 years through autopsy, involving 64 cases at the Department of Forensic Medicine, Government Medical College, Thiruvananthapuram. Data on income, diet, smoking, alcohol, drugs, and personal/family history were collected and compared with existing research. While most studies focused on CHD prevalence and mortality, primordial prevention methods were underexplored. The prevalence of atherosclerosis in the study group's aorta was 60.9%, in LAD 59.4%, RCA 48.4%, and CA 31.2% (Table 1).

Comparisons with other citations revealed higher percentages, possibly due to Kerala's elevated CHD prevalence. Aged below 40, atherosclerosis prevalence was 40.8%. While our initial analysis suggested no significant association between sex and atherosclerosis, it's important to reconsider this finding in light of the sample demographics, which predominantly comprise males (Table 2). Further investigation may be warranted to elucidate any potential sex-specific differences in atherosclerosis risk. Similarly, although BMI did not exhibit a significant association with atherosclerosis in our study, the high proportion of individuals with normal or less than normal BMI in the sample raises questions about the role of BMI in this context. Future research could explore the impact of BMI on atherosclerosis risk in more detail, considering potential confounding factors (Table 4).

Regarding dietary factors, the observed correlation between types of oil used and aorta atherosclerosis (Tables 3, 5). This could involve investigating specific components or cooking methods associated with different oils to better understand their impact on cardiovascular health.

Personal history, family history of heart disease, and death due to heart disease in the family demonstrated varied associations (Table 6). Cause of death data highlighted suicides (45.3%), emphasizing the need for mental health awareness. Heart weight, unrelated to atherosclerosis, differed from studies associating certain cardiovascular diseases with increased heart weight. Atherosclerosis in the aorta is associated with its gross appearance ($p<0.001$), an unexplored correlation. Limitations included a small sample size, potentially affecting statistical significance. Overall, the study delved into atherosclerosis prevalence and risk factors in a young population, contributing insights for primordial prevention strategies.

CONCLUSION

This research investigated the prevalence of atherosclerosis in coronary arteries and the aorta among individuals aged 10-25 years through medico-legal autopsies conducted at the Department of Forensic Medicine, Government Medical College, Thiruvananthapuram. Among the 64 subjects included, the majority were aged 21-25 years. High-income individuals were prevalent, with coconut oil being the most commonly used cooking oil. Notable findings include a high prevalence of atherosclerosis in the aorta (60.9%), left anterior descending artery (LAD) (59.4%), right coronary artery (RCA) (48.4%), and circumflex artery (CA) (31.2%). Grade 1 occlusion was noted in 10.9% of LAD cases. Statistical analysis revealed associations between atherosclerosis and age, type of oil consumed, death due to heart disease in the family, cigarette smoking, recreational drug use, and a history of heart disease. The study highlights the prevalence of atherosclerosis in young individuals and advocates for antiatherogenic preventive measures, including awareness programs against cigarette smoking and recreational drug abuse from primary school levels. Additionally, it suggests new therapeutic approaches, preventive measures, and public health campaigns to promote lifestyle modifications and mitigate atherosclerosis-related early mortality and morbidity. Policy implications underscore the importance of recognizing atherosclerosis as a condition affecting young individuals and recommend targeted awareness programs and

public health campaigns to address the issue. Lastly, the study suggests future research directions, including multicentre approaches with larger sample sizes and genetic studies to identify potential genetic contributions to atherosclerosis development in young individuals.

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None.

CONFLICTS OF INTEREST
The author declared no conflicts of interest.

ETHICAL ISSUES
Ethical clearance was obtained from the Human Ethics Committee, Government Medical College, Thiruvananthapuram, Kerala, India (HEC No. 13/44/MCT).

SOURCES OF SUPPORT
None

AUTHOR CONTRIBUTIONS
AVA: Conception of the work; acquisition, analysis, of data for the work; drafting the work or; and final approval of the version to be published. **NG:** Analysis and interpretation of data for the work; drafting the work and revising it critically for important intellectual content; and final approval of the version to be published. **UM:** Supervision of the work; and final approval of the version to be published.

REFERENCES

1. Gupta R, Mohan I. Trends in coronary heart disease epidemiology in India. *Annals of Global Health*. 2016;82(2):307-315. https://doi.org/10.1016/j.aogh.2016.04.002.

2. Krishnan MN, Zachariah G, Venugopal K, *et al*. Prevalence of coronary artery disease and its risk factors in Kerala, South India: A community-based cross-sectional study. *BMC Cardiovascular Disorders*. 2016;16:12. https://doi.org/10.1186/ s12872-016-0189-3.

3. Pillay AK, Naidoo DP. Atherosclerotic disease is the predominant etiology of acute coronary syndrome in young adults. *Cardiovascular Journal of Africa*. 2018;29(1):36-42. https://doi.org/10.5830/CVJA-2017-035.

4. Mayo Clinic. *Atherosclerosis/arteriosclerosis: Patient care and health information/conditions and improvement*. 2020. Available from: https://www.mayoclinic.org/diseases-conditions/arteriosclerosis-atherosclerosis/diagnosis-treatment/drc-20350575.

5. Tuzcu EM, Kapadia SR, Tutar E, *et al*. High prevalence of coronary atherosclerosis in asymptomatic teenagers and young adults. *Circulation*. 2001;103:2705-2710. http://dx.doi.org/10.1161/01.CIR.103.22.2705.

6. Standring S. *Gray's Anatomy*. 41st ed. Elsevier; 2016.

7. Moore KL, Agur AMR, Dalley AF. *Clinically Oriented Anatomy*. 7th ed. Wolters Kluwer Health; 2017.

8. Reddy KS, Shah B, Varghese C, Ramadoss A. Responding to the threat of chronic diseases in India. *The Lancet*. 2005:1746-1751. https://doi.org/10.1016/s0140-6736(05)67343-6.

9. Jafar TH. The growing burden of chronic kidney diseases in Pakistan. *New England Journal of Medicine*. 2006;354:995-997. https://doi.org/10.1056/NEJMp058319.

10. Kearney PM, Whelton M, Reynolds K, *et al*. Global burden of hypertension: Analysis of worldwide data. *The Lancet*. 2005 Jan 15;365(9455):217-23. https://doi.org/10.1016/S0140-6736(05)17741-1.

11. Teo KK, Ounpuu S, Hawken S, Pandey M, Valentin V, Hunt D. Tobacco use and risk of myocardial infarction in 52 countries: The INTERHEART study. *The Lancet*. 2006;368:567-571. https://doi.org/10.1016/S0140-6736(06)69249-0.

12. Yusuf S, Hawken S, Ounpuu S, *et al*. Effects of potentially modifiable risk factors associated with myocardial infarction in 52 countries (The INTERHEART Study): Case-control study. *The Lancet*. 2004 Sep;364(9438):937-52. https://doi.org/10.1016/S0140-6736(04)17018-9.

13. Rastogi T, Vaz M, Spiegelman D, *et al*. Physical activity and risk of coronary heart disease in India. *International Journal of Epidemiology*. 2004 Aug;33(4):759-67. https://doi.org/10.1093/ije/dyh042.

14. Bhanvadia VM, Desai NJ, Agarwal NM. Study of coronary atherosclerosis by modified American Heart Association classification of atherosclerosis. *Journal of Clinical and Diagnostic Research*. 2013 Nov;7(11):2494–2497. https://doi.org/10.7860/JCDR/2013/6828.3588.

15. Murray CJL, Lopez AD. *The global burden of disease: A comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020*. Harvard University; 1996. Available from: https://digitallibrary.un.org/record/195443?ln=en.

16. Anand SS, Yusuf S, Vuksan V, *et al*. Differences in risk factors, atherosclerosis, and cardiovascular diseases between ethnic groups in Canada: The study of health assessment and risk in ethnic groups. *The Lancet*. 2000 Jul 22;356(9226):279-84. https://doi.org/10.1016/s0140-6736(00)02502-2.

17. R Gupta. Burden of coronary heart diseases in India. *Indian Heart Journal*. 2005 Nov-Dec;57(6):632-8.

18. Leeder S, Raymond S, Greenberg H, Lui H, Esson K. *A race against time: The challenge of cardiovascular disease in developing economie*s. Columbia University; 2004:561-564. Available from: https://www.earth.columbia.edu/news/2004/images/raceagainsttime_FINAL_051104.pdf.

19. Thankappan KR, Shah B, Mathur P, *et al*. Risk factor profile for chronic non-communicable diseases: Results of a community-based study in Kerala, India. *Indian Journal of Medical Research*. 2010 Jan;131:53-63.

20. Sugathan TN, Soman CR, Sankaranarayanan K. Behavioural risk factors for non-communicable diseases among adults in Kerala, India. *Indian Journal of Medical Research*. 2008 Jun;127(6):555-63.

21. Ng N, Stenlund H, Bonita R, Hakimi M, Wall S, Weinehall L. Preventable risk factors for non-communicable diseases in rural Indonesia: prevalence study using WHO step approach. *Bulletin of the World Health Organization*. 2006 Apr;84(4):305-13. https://doi.org/10.2471/blt.05.023721.

22. Ming HV, Byass P, Huong DL, Chuc NTK, Wall S. Risk Factors for Chronic Diseases among Rural Vietnamese Adults and the Association of These Factors with Sociodemographic Variables. Findings from the WHO STEPS Survey in Rural Vietnam, 2005. *Preventing Chronic Disease*. 2007 Apr;4(2):A22.

23. Centers for Disease Control and Prevention. Prevalence of Fruit and Vegetable Consumption and Physical Activity by Race/Ethnicity - United States, 2005. *Morbidity and Mortality Weekly Report*. 2007. Available from: https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5613a2.htm.

24. Ong KL, Cheung BMY, Man YB, Lau CP, Lam KSL. Prevalence, awareness, treatment, and control of hypertension among United States adults 1999-2004. *Hypertension*. 2007 Jan;49(1):69-75. https://doi.org/10.1161/01.HYP.0000252676.46043.18.

25. Cowie CC, Rust KF, Byrd-Holt DD, *et al*. Flegal K. Prevalence of diabetes and impaired fasting glucose in adults in the US population: National Health and Nutrition Examination Survey 1999-2002. *Diabetes Care*. 2006 Jun;29(6):1263-8. https://doi.org/10.2337/dc06-0062.

26. Xin X, He J, Frontini MG, Ogden LG, Motsamai OI, Whelton PK. Effects of alcohol reduction in blood pressure: A meta-analysis of randomized control trial. *Hypertension*. 2001 Nov;38(5):1112-7. https://doi.org/10.1161/hy1101.093424.

27. Van't Veer P, Jansen MC, Klerk M, Kok FJ. Fruits and vegetables in the prevention of cancer and cardiovascular disease. *Public Health Nutrition*. 2000 Mar;3(1):103-7. https://doi.org/10.1017/s1368980000000136.

28. Khaw K, Sharp SJ, Finikarides L, *et al*. Randomized trial of coconut oil, olive oil, or butter on blood lipids and other cardiovascular risk factors in healthy men and women. *BMJ Open*. 2018 Mar 6;8(3):e020167. https://doi.org/10.1136/bmjopen-2017-020167.

29. Korrapati D, Jeyakumar SM, Putcha UK, *et al*. Coconut oil consumption improves fat-free mass, plasma HDL-cholesterol and insulin sensitivity in healthy men with normal BMI compared to peanut oil. *Clinical Nutrition*. 2019 Dec;38(6):2889-2899. https://doi.org/10.1016/j.clnu.2018.12.026.

30. Pletcher MJ, Kiefe CI, Sidney S, Carr JJ, Lewis CE, Hulley SB. Cocaine and coronary calcification in young adults: The Coronary Artery Risk Development in Young Adults (CARDIA) Study. *American Heart Journal*. 2005;150(5):921-926. https://doi.org/10.1016/j.ahj.2005.04.016

31. Huang Y, Li Y, Zheng S, Yang X, Wang T, Zeng J. Moderate alcohol consumption and atherosclerosis: Meta-analysis of effects on lipids and inflammation. *Wiener klinische Wochenschrift*. 2017 Nov;129(21-22):835-843. https://doi.org/10.1007/s00508-017-1235-6.

32. Chevli PA, Aladin AI, Kanaya AM, Kandula NR, Malaver D, Herrington DM. Alcohol consumption and subclinical atherosclerosis among South Asians: Findings from the Mediators of Atherosclerosis in South Asians Living in America (MASALA) study. *Nutrition, Metabolism and Cardiovascular Diseases*. 2020 Jan 3;30(1):123-131. https://doi.org/10.1016/j.numecd.2019.07.021.

33. Lloyd-Jones DM, Nam B, D'Agostino Sr RB, *et al*. Parental cardiovascular disease as a risk factor for cardiovascular disease in middle-aged adults: a prospective study of parents and offspring. *JAMA*. 2004 May 12;291(18):2204-11. https://doi.org/10.1001/jama.291.18.2204.

34. Mahmood SS, Levy D, Vasan RS, Wang TJ. The Framingham Heart Study and the epidemiology of cardiovascular disease: A historical perspective. *The Lancet*. 2014 Mar 15;383(9921):999-1008. https://doi.org/10.1016/S0140-6736(13)61752-3.