

Cholesterol medication adherence and its determinants in community dwelling older adults in India: Evidence from the Longitudinal Ageing Study in India (2017–2018)

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ABSTRACT

INTRODUCTION Amidst rising cardiovascular disease rates globally, hypercholesterolemia emerges as a critical factor, especially in rapidly urbanizing nations like India. This study determines the prevalence of hypercholesterolemia among older adults in India, and ascertains its sociodemographic, lifestyle, and clinical determinants. We also ascertained the adherence to cholesterol lowering therapies and their determinants among previously diagnosed patients with hypercholesterolemia.

METHODS We conducted a cross-sectional analysis of secondary data from the Longitudinal Ageing Study in India (LASI Wave 1: 2017–2018) involving 66606 participants aged ≥ 45 years including 2310 participants with high cholesterol. Multivariable logistic regression was employed to analyze determinants of high cholesterol and medication adherence, which was assessed by whether participants self-reported taking regularly cholesterol-lowering medication.

RESULTS The weighted prevalence of (self-reported) high cholesterol was 2.28% (95% CI: 2.07–2.51). On adjusted analysis, participants of a higher socio-economic status

(AOR=2.02; 95% CI: 1.40–2.92), urban residence (AOR=1.80; 95% CI: 1.46–2.22), obese (AOR=4.94; 95% CI: 2.80–8.70), with comorbidities such as diabetes (AOR=2.41; 95% CI: 1.52–3.83) and hypertension (AOR=3.41; 95% CI: 2.18–5.32), had significantly higher odds of having high cholesterol. Medication adherence among those with high cholesterol was suboptimal, with nearly 40% not taking medications regularly. The factors associated with higher odds of non-adherence included being underweight (AOR=3.66; 95% CI: 1.49–9.01), tobacco use (AOR=1.59; 95% CI: 1.01–2.50), and the absence of diabetes or hypertension comorbidity (AOR=1.53; 95% CI: 1.08–2.17).

CONCLUSIONS Nearly four in ten patients in India take medications regularly for their condition, indicative of non-adherence in a substantial proportion of previously diagnosed patients. Tailored interventions are needed for raising awareness, early screening and managing high cholesterol, with healthcare providers focusing on lipid management and comprehensive care, regardless of comorbidities.

INTRODUCTION

Hyperlipidemia is a major risk factor for coronary and cardiovascular disease, a leading and increasing cause of morbidity and mortality worldwide due to ongoing epidemiological and demographic transition, secondary to ageing¹. Hypercholesterolemia is a type of hyperlipidemia, characterized by elevated levels of low-density lipoprotein cholesterol (LDL-C), and is a major contributor to atherosclerosis and coronary artery disease². Globally, nearly 18 million deaths are attributed to cardiovascular

diseases each year, with hyperlipidemia playing a pivotal role³. In India, the burden of hypercholesterolemia has been steadily rising especially in the older population with recent estimates suggesting that approximately 24% of the Indian adult population has elevated cholesterol levels, rendering them increasingly vulnerable to coronary and cardiovascular diseases^{4,5}. Factors such as increasing urbanization, dietary transition towards high-fat and processed foods, sedentary lifestyles, and increasing stress levels are risk factors associated with high cholesterol levels^{6,7}. Furthermore,

genetic predispositions among certain Indian ethnicities make them particularly susceptible to high cholesterol levels⁸.

The strict adherence to therapies, as per standard treatment guidelines of hyperlipidemia, reduces the occurrence of cardiovascular events with high cost-effectiveness^{9,10}. Medication adherence has been defined by the World Health Organization as the 'the degree to which use of medication by the patient corresponds with the prescriber's instructions' and includes the stages of initiation, implementation, and persistence^{11,12}. Primary non-adherence signifies the inability of the patient to obtain regular drug refills, usually for chronic disease, due to challenges in drug access especially related to drug affordability.

Medication non-adherence to cholesterol lowering therapies is a major public health challenge worldwide with only an estimated 50% of the patients requiring the therapy being adherent to treatment¹³. In the lower middle-income countries, overall adherence to hypercholesterolemia is significantly lower, as a smaller fraction of patients are initiated on treatment. Furthermore, even among patients initiated on cholesterol lowering therapies, the rates of adherence tend to fall within a year signifying poor persistence with therapy¹⁴. Non-adherence to cholesterol-lowering therapies is associated with a heightened cardiovascular risk profile, characterized by elevated levels of low-density lipoprotein cholesterol (LDL-C) and a greater tendency for atherosclerotic progression, thereby increasing the incidence of myocardial infarctions, strokes, and other severe cardiovascular events, ultimately compromising both patient well-being and healthcare system resources^{15,16}.

Although India has the largest global cohort of patients with diabetes (DM) and hypertension (HTN) who are at high risk of cardiovascular events especially when comorbid with uncontrolled hyperlipidaemia¹⁷, there is limited information on access and adherence to cholesterol lowering therapies in this vulnerable population with most existing studies being single-centered clinic-based studies and having small sample sizes¹⁸⁻²⁰. Given its considerable impact on public health, understanding the prevalence and determinants of hypercholesterolemia among older adults in India is crucial for designing effective preventive and therapeutic interventions. Additionally, exploring the medication adherence is essential to identify barriers to healthcare access and utilization, facilitating the development of targeted strategies to improve health outcomes.

In this study, we utilized data from a nationally representative dataset with the objectives of determining the prevalence of hypercholesterolemia among older adults in India and ascertaining its sociodemographic, lifestyle, and clinical determinants. Furthermore, we also ascertained adherence to cholesterol lowering therapies and its determinants among previously diagnosed patients with hypercholesterolemia.

METHODS

Study design and participants

We performed a secondary data analysis of data from the Longitudinal Ageing Study in India (LASI), specifically focusing on Wave 1 (2017–2018). LASI is a nationally representative cross-sectional survey that aims to assess the health, economic, and social well-being of the older population in India. Data were collected from 73396 participants aged ≥ 45 years, as well as their spouses (of any age) across Indian states and union territories. LASI employed a comprehensive multistage stratified cluster sampling design to ensure the data collected were nationally representative of the older population in India. The first stage involved selecting Primary Sampling Units (PSUs), which were villages in rural areas and Census Enumeration Blocks (CEBs) in urban areas. These PSUs were chosen based on a probability proportional to size sampling method to ensure that larger PSUs had a higher chance of being selected, maintaining the representativeness of the sample. In the second stage, within each selected PSU, households were systematically chosen. Finally, in the third stage, individuals aged ≥ 45 years were selected from these households. Additionally, all spouses of the selected individuals, regardless of their age, were included in the survey to provide a comprehensive understanding of the household dynamics and health status.

Data were collected by trained field investigators through face-to-face interviews using a structured questionnaire. The questionnaire included sections on demographic information, health status, lifestyle factors, medical history, and medication usage. In addition to the questionnaire, physical measurements such as height, weight, and blood pressure were taken to provide objective health indicators. Biomarkers, including blood samples, were also collected to measure levels of glucose, cholesterol, and other critical health markers. More details on sampling, survey design and data collection tools are reported in the national report of LASI²¹. The present study includes a total sample size of 66606 individuals aged ≥ 45 years.

LASI was approved by an ethical committee of the Indian Council of Medical Research (ICMR) and was conducted in accordance with the relevant guidelines and regulations. Informed consent was obtained from all participants prior to their participation in the study. Since the LASI Wave I dataset is an anonymous publicly available dataset with no identifiable information about the participants, no separate ethical approval was required for the present secondary data analysis.

Outcome variables

Presence of high cholesterol (HC) was assessed through self-reported information. Participants were asked whether (yes or no) they had ever been diagnosed with high cholesterol by a healthcare professional. Medication adherence was assessed among those having high cholesterol using a single

item: ‘Do you regularly take medications to help lower your cholesterol?’ with patients reporting ‘no’ to the question considered as non-adherent and those reporting ‘yes’ considered as adherent.

Covariates

Several covariates were considered in the analysis, including age (45–59, 60–69, 70–79 and ≥80 years), sex (male or female), education level (no/up to primary, up to secondary school, high school, and college or higher), monthly per capita expenditure (MPCE) quintiles (poorest to richest), marital status (never married, currently married/cohabiting, and separated/widowed/others), residence (urban or rural), religion (Hindu, Islam or others), tobacco use (yes or no), alcohol consumption (yes or no), body mass index (BMI, kg/m²) (classified as per Asian classification as underweight: <18.5, normal weight: 18.5–22.9, overweight: 23.0–24.9 and obese: ≥25.0)²², and presence of comorbidities such as DM (yes or no) and HTN (yes or no). Presence of DM, HTN and chronic heart diseases were assessed using separate self-reported questions: ‘Has any health professional ever diagnosed you with the following chronic conditions or diseases: diabetes or high blood sugar (yes or no), hypertension or high blood pressure (yes or no), and chronic heart diseases (yes or no)’.

Statistical analysis

Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population. The prevalence of high cholesterol was calculated as the proportion of participants who self-reported a diagnosis of high cholesterol. Proportions of treatment seeking behavior were reported for those having HC, DM-HC comorbidity, HTN-HC comorbidity and chronic heart disease-HC comorbidity.

Bivariate analyses were performed to assess the association between presence of high cholesterol and various demographic and clinical variables. Multivariable logistic regression analysis was conducted to examine the association between high cholesterol and participant characteristics. Adjusted analysis was conducted wherein variables found to be significantly associated ($p < 0.05$) with the outcome were included in the final adjusted model. Adjusted odds ratios (AORs) and their respective 95% confidence intervals (CIs) were reported to quantify the strength of the associations.

Similarly, a multivariable logistic regression was conducted to assess the predictors associated with medication adherence among those with high cholesterol. Two separate adjusted models were constructed after conducting unadjusted analysis. Model 1 included all variables in the adjusted model, while Model 2 included only those variables that were found to be significantly associated ($p < 0.05$) with the outcome.

Model assumptions such as multicollinearity were

Table 1. Socio-economic and demographic characteristics of the study population (N=66606)

Characteristics	n (weighted %)
Age (years)	
45–59	34704 (49.77)
60–69	19211 (29.39)
70–79	9250 (15.17)
≥80	3441 (5.67)
Sex	
Male	31039 (45.94)
Female	35567 (54.06)
Education level	
Not educated/up to primary	16359 (46.51)
Up to secondary school	12290 (32.97)
High school	2852 (9.11)
College or higher	3752 (11.41)
Marital status	
Never married	868 (1.19)
Currently married/cohabiting	49946 (73.86)
Separated/widowed/other	15786 (24.95)
Religion	
Hinduism	48710 (81.96)
Islam	7804 (11.51)
Other	10083 (6.53)
MPCE quintile	
Poorest	13180 (20.86)
Poorer	13403 (21.24)
Middle	13371 (20.49)
Richer	13410 (19.42)
Richest	13239 (17.99)
Residence	
Rural	43238 (68.53)
Urban	23365 (31.47)
BMI (kg/m²)	
Underweight	11001 (21.39)
Normal weight	22227 (37.49)
Overweight	9116 (14.03)
Obese	17568 (27.09)
Tobacco consumption	
No	41999 (62.83)
Yes	24022 (37.17)
Alcohol use	
No	54188 (84.89)
Yes	11853 (15.11)
DM-HTN comorbidity	
None	43827 (68.01)
Only DM	3320 (4.47)
Only HTN	14028 (19.65)
DM-HTN comorbidity	5244 (7.88)

MPCE: monthly per capita expenditure. BMI: body mass index. DM: diabetes. HTN: hypertension.

Table 2. Distribution of factors associated with self-reported high cholesterol (HC)

Characteristics	No HC (N=64123) n (weighted %)	Have HC (N=2310) n (weighted %)	OR (95% CI)	AOR ^a (95% CI)
Age (years)				
45–59 ®	33487 (97.95)	1126 (2.05)	1	1
60–69	18403 (97.17)	765 (2.83)	1.39 (1.14–1.70) *	1.12 (0.88–1.44)
70–79	8887 (98.04)	336 (1.96)	0.96 (0.76–1.20)	0.82 (0.52–1.32)
≥80	3346 (97.64)	83 (2.36)	1.15 (0.45–2.95)	1.60 (0.27– 9.57)
Sex				
Male ®	29967 (97.74)	972 (2.26)	1	-
Female	34156 (97.7)	1338 (2.3)	1.01 (0.83–1.24)	
Education level				
Not educated/up to primary ®	15643 (97.21)	678 (2.79)	1	1
Up to secondary school	11536 (96.14)	711 (3.86)	1.40 (1.15–1.70) *	1.02 (0.79–1.31)
High school	2663 (96.79)	176 (3.21)	1.16 (0.83–1.60)	0.80 (0.57–1.12)
College or higher	3449 (93.64)	285 (6.36)	2.37 (1.57–3.57) **	1.43 (0.85–2.39)
Marital status				
Never married ®	844 (98.59)	22 (1.41)	1	-
Currently married/cohabiting	48049 (97.63)	1769 (2.37)	1.69 (0.81–3.57)	
Separated/widowed/other	15228 (97.95)	519 (2.05)	1.46 (0.67–3.18)	
Religion				
Hinduism ®	47220 (98.04)	1365 (1.96)	1	1
Islam	7320 (97.09)	469 (2.91)	1.49 (1.19–1.88) *	1.39 (1.01–1.92) *
Other	9578 (94.81)	476 (5.19)	2.73 (2.21–3.38) **	2.37 (1.84–3.06) **
MPCE quintile				
Poorest ®	12897 (98.76)	243 (1.24)	1	1
Poorer	13068 (98.17)	303 (1.83)	1.48 (0.99–2.19)	1.33 (0.91–1.93)
Middle	12969 (98.14)	371 (1.86)	1.51 (0.99–2.28)	1.40 (0.87–2.23)
Richer	12854 (97.6)	531 (2.4)	1.95 (1.49–2.55) **	1.37 (0.95–1.97)
Richest	12335 (95.63)	862 (4.37)	3.63 (2.79–4.72) **	2.02 (1.40–2.92) **
Residence				
Rural ®	42221 (98.7)	936 (1.3)	1	1
Urban	21902 (95.55)	1374 (4.45)	3.55 (2.94–4.28) **	1.80 (1.46–2.22) **
BMI (kg/m²)				
Underweight ®	10928 (99.48)	74 (0.52)	1	1
Normal weight	21867 (99)	354 (1)	1.94 (1.26–3.00) *	1.98 (1.22–3.20) *
Overweight	8733 (97.12)	381 (2.88)	5.68 (3.66–8.81) **	4.21 (2.50–7.09) **
Obese	16274 (94.75)	1292 (5.25)	10.62 (6.92–16.29) **	4.94 (2.80–8.70) **
Tobacco consumption				
No ®	40241 (97.23)	1752 (2.77)	1	1
Yes	23484 (98.6)	533 (1.4)	0.50 (0.41–0.60) **	0.87 (0.69–1.10)
Alcohol use				
No ®	52244 (97.7)	1934 (2.3)	1	-
Yes	11497 (97.89)	355 (2.11)	0.92 (0.74–1.14)	
DM-HTN comorbidity				
None ®	43330 (99.08)	500 (0.92)	1	1
Only DM	3110 (96.17)	210 (3.83)	4.27 (2.95–6.18)**	2.41 (1.52–3.83)**
Only HTN	13182 (95.63)	844 (4.37)	4.90 (3.59–6.67)**	3.41 (2.18–5.32)**
DM-HTN comorbidity	4488 (92.06)	756 (7.94)	9.26 (6.63–12.91)**	4.57 (2.85–7.33)**

^a AOR: adjusted odds ratio; adjusted for age, education level, religion, MPCE quintile, residence, BMI, tobacco consumption and DM-HTN comorbidity. MPCE: monthly per capita expenditure. BMI: body mass index. DM: diabetes. HTN: hypertension. HC: high cholesterol. ® Reference categories. *p<0.05, **p<0.001.

Table 3. Distribution of factors associated with adherence to cholesterol lowering drugs in patients with high cholesterol (self-reported)

Characteristics	On regular treatment for HC		OR (95% CI)	Model 1	Model 2
	Yes (N=1445) n (weighted %)	No (N=863) n (weighted %)		AOR (95% CI)	AOR (95% CI)
Age (years)					
45–59 ®	646 (55.98)	479 (44.02)	1	-	-
60–69	498 (63.18)	267 (36.82)	0.74 (0.51–1.07)	0.76 (0.51–1.11)	
70–79	240 (65.56)	95 (34.44)	0.67 (0.43–1.04)	0.61 (0.3–1.25)	
≥80	61 (77.21)	22 (22.79)	0.38 (0.08–1.76)	0.12 (0.02–0.81) *	
Sex					
Male ®	605 (61.14)	367 (38.86)	1	-	-
Female	840 (61.05)	496 (38.95)	1.00 (0.70–1.45)	1.08 (0.72–1.63)	
Education level					
Not educated/up to primary ®	438 (61.46)	240 (38.54)	1	1	-
Up to secondary school	454 (60.09)	256 (39.91)	1.06 (0.72–1.56)	1.05 (0.68–1.62)	
High school	103 (62.07)	73 (37.93)	0.97 (0.56–1.70)	1.37 (0.69–2.73)	
College or higher	183 (69.02)	102 (30.98)	0.72 (0.37–1.38)	0.98 (0.54–1.78)	
Marital status					
Never married ®	11 (45.38)	11 (54.62)	1	1	-
Currently married/cohabiting	1097 (60.6)	670 (39.4)	0.54 (0.15–1.95)	0.39 (0.08–1.92)	
Separated/widowed/other	337 (63.29)	182 (36.71)	0.48 (0.13–1.84)	0.38 (0.07–2.02)	
Religion					
Hinduism ®	855 (62.74)	509 (37.26)	1	1	-
Islam	305 (60.54)	164 (39.46)	1.10 (0.71–1.69)	1.11 (0.64–1.93)	
Other	285 (53.78)	190 (46.22)	1.45 (0.99–2.12)	1.53 (0.99–2.39)	
MPCE quintile					
Poorest ®	147 (52.79)	96 (47.21)	1	1	-
Poorer	184 (60.21)	118 (39.79)	0.74 (0.36–1.53)	1 (0.49–2.06)	
Middle	241 (62.19)	130 (37.81)	0.68 (0.32–1.43)	0.78 (0.38–1.59)	
Richer	344 (64.31)	186 (35.69)	0.62 (0.36–1.07)	0.73 (0.37–1.46)	
Richest	529 (61.83)	333 (38.17)	0.69 (0.41–1.16)	0.79 (0.41–1.55)	
Residence					
Rural	535 (49.71)	401 (50.29)	2.19 (1.57–3.05) **	1.33 (0.87–2.02)	1.89 (1.32–2.70) **
Urban ®	910 (68.37)	462 (31.63)	1	1	1
BMI (kg/m²)					
Underweight	34 (31.71)	40 (68.29)	3.79 (1.71–8.37) *	3.66 (1.49–9.01) *	2.62 (1.24–5.56) *
Normal weight	219 (54.85)	135 (45.15)	1.45 (0.94–2.23)	1.38 (0.84–2.27)	1.28 (0.83–1.97)
Overweight	242 (62.6)	139 (37.4)	1.05 (0.66–1.66)	1.03 (0.63–1.68)	1.02 (0.63–1.64)
Obese ®	811 (63.74)	480 (36.26)	1	1	1
Tobacco consumption					
No ®	1114 (63.35)	638 (36.65)	1	1	1
Yes	316 (53.61)	216 (46.39)	1.50 (1.03–2.17) *	1.59 (1.01–2.5) *	1.40 (0.95–2.07)

Continued

Table 3. Continued

Characteristics	On regular treatment for HC		OR (95% CI)	Model 1	Model 2
	Yes (N=1445) n (weighted %)	No (N=863) n (weighted %)		AOR (95% CI)	AOR (95% CI)
Alcohol use					
No [®]	1222 (61.49)	711 (38.51)	1	1	-
Yes	209 (57.85)	146 (42.15)	1.16 (0.77-1.77)	1.07 (0.63-1.82)	
Diabetes-hypertension (DM-HTN)					
None	253 (56.93)	246 (43.07)	1.62 (0.90-2.90)	2.04 (1.2-3.45) *	1.55 (0.89-2.72)
Only DM	132 (64.52)	78 (35.48)	1.18 (0.69-2.02)	1.13 (0.57-2.26)	1.34 (0.73-2.45)
Only HTN	502 (58.3)	341 (41.7)	1.53 (1.08-2.17) *	1.4 (0.9-2.19)	1.42 (0.98-2.08)
DM-HTN comorbidity [®]	558 (68.16)	198 (31.84)	1	1	1
HCP visit in last 12 months					
No [®]	181 (52.67)	133 (47.33)	1	1	-
Yes	1247 (62.21)	722 (37.79)	0.68 (0.44-1.03)	0.67 (0.41-1.09)	

Model 1: full model, all variables. Model 2: only significant variables with p<0.05 in unadjusted analysis. ^a AOR: adjusted odds ratio; adjusted for age, education level, religion, MPCE quintile, residence, BMI, tobacco consumption and DM-HTN comorbidity. MPCE: monthly per capita expenditure. BMI: body mass index. DM: diabetes. HTN: hypertension. HCP: healthcare professional. HC: high cholesterol. [®] Reference categories. *p<0.05, **p<0.001.

checked for each multivariable regression analysis using variance inflation factors (VIFs). Model diagnostics, including goodness-of-fit tests, were performed to validate the final models. We used appropriate sampling weights throughout the analysis to account for the survey design. A significance level of 5% was used to determine statistical significance throughout the analysis. All statistical analyses were conducted using Stata version 15.1 (StataCorp, USA).

RESULTS

Participant characteristics

A total of 66606 participants with mean age of 60.32 years (SD=10.80) were included in the analysis, of which 2310 participants reported having high cholesterol. Demographic characteristics of the study sample are summarized in Table 1. The majority of the participants were female (54.06%), currently married/cohabiting (73.86%), and resided in rural areas (68.53%). An estimated 4.5% of the participants had only DM, 19.7% had HTN, and 7.9% had DM-HTN comorbidity. The weighted prevalence of self-reported high cholesterol was 2.28% (95% CI: 2.07-2.51) and age-adjusted prevalence was 2.30% (95% CI: 1.44-3.68).

Determinants of high cholesterol

Multivariable logistic regression analysis was performed to assess the determinants of high cholesterol (Table 2). After adjusting for covariates that were found to be significant in the unadjusted analysis, it was found that participants with high cholesterol were more likely to belong to the richest quintiles (AOR=2.02; 95% CI: 1.40-2.92), reside in urban

areas (AOR=1.80; 95% CI: 1.46-2.22), be obese (AOR=4.94; 95% CI: 2.80-8.70), have DM (AOR=2.41; 95% CI: 1.52-3.83), HTN (3.41; 95% CI: 2.18-5.32) and DM-HTN (AOR=4.57; 95% CI: 2.85-7.33) comorbidities. There were no significant differences in the sex, marital status, or alcohol consumption between those with and without high cholesterol.

Medication adherence for high cholesterol

Among participants with self-reported high cholesterol, only 61.09% (95% CI: 56.74-65.27) reported currently taking medicines for their condition (Table 3). Upon full model adjusted analysis (Model 1), we found that participants who were underweight (AOR=3.66; 95% CI: 1.49- 9.01), tobacco users (AOR=1.59; 95% CI: 1.01-2.50) and with no DM/HTN comorbidities (AOR=1.53; 95% CI: 1.08-2.17) were more likely to not take treatment for high cholesterol compared to their counterparts. In Model 2, after adjusting for covariates found to be significant in the unadjusted analysis, being a rural resident (AOR=1.89; 95% CI: 1.32-2.70) and underweight (AOR=2.62, 95% CI: 1.24-5.56) were the significant predictors of receiving no treatment for HC.

Table 4 reports the medication adherence among those with additional comorbidities of DM, HTN and chronic heart disease. The proportion of individuals currently not on treatment for HC was found to be 32.62% among DM-HC comorbid patients, 37.55% among HTN-HC comorbid patients and 24.98% among chronic heart disease-HC patients. However, upon adjusted logistic regression analysis, we found no significant predictors of medication adherence among these participants with comorbidities.

Table 4. Medication adherence for cholesterol lowering treatment in patients with high cholesterol and other chronic comorbidities

Characteristics	DM-HC comorbid (N=966)		HTN-HC comorbid (N=1599)		Chronic heart disease-HC comorbid (N=409)	
	Not on regular treatment for HC (N=276) n (weighted %)	On regular treatment for HC(N=690) n (weighted %)	Not on regular treatment for HC (N=539) n (weighted %)	On regular treatment for HC (N=1060) n (weighted %)	Not on regular treatment for HC (N=79) n (weighted %)	On regular treatment for HC (N= 330) n (weighted %)
Age (years)						
45–59	126 (36.19)	272 (63.81)	261 (41.06)	412 (58.94)	24 (24.8)	102 (75.2)
60–69	97 (29.96)	251 (70.04)	193 (37.45)	390 (62.55)	32 (24.32)	122 (75.68)
70–79	46 (28.58)	140 (71.42)	73 (32.62)	207 (67.38)	20 (30.0)	84 (70.0)
≥80	7 (40.16)	27 (59.84)	12 (19.85)	51 (80.15)	3 (6.899)	22 (93.1)
Sex						
Male	132 (30.51)	296 (69.49)	210 (36.06)	432 (63.94)	53 (29.8)	183 (70.2)
Female	144 (34.64)	394 (65.36)	329 (38.69)	628 (61.31)	26 (17.31)	147 (82.69)
MPCE quintile						
Poorest	31 (38.12)	75 (61.88)	64 (42.74)	111 (57.26)	13 (35.89)	43 (64.11)
Poorer	36 (34.95)	86 (65.05)	75 (44.57)	128 (55.43)	14 (25.29)	42 (74.71)
Middle	40 (44.09)	114 (55.91)	89 (42.74)	176 (57.26)	8 (23.3)	60 (76.7)
Richer	60 (26.14)	165 (73.86)	118 (32.13)	253 (67.87)	18 (23.14)	72 (76.86)
Richest	109 (29.32)	250 (70.68)	193 (33.99)	392 (66.01)	26 (21.6)	113 (78.4)
TOTAL	276 (32.62)	690 (67.38)	539 (37.55)	1060 (62.45)	79 (24.98)	330 (75.02)

MPCE: monthly per capita expenditure. HTN: hypertension. HC: high cholesterol.

DISCUSSION

Early diagnosis and prompt initiation of guideline-based treatment for hyperlipidemia and hypercholesterolemia is necessary to improve health outcomes in patients at high-risk of adverse cardiovascular events. The present study observed self-reported high cholesterol prevalence of only 2.3% amongst older adults suggestive of a significant degree of underreporting due to lack of awareness and screening in healthcare facilities. Nevertheless, these findings align with prior studies that have reported a relatively lower prevalence of high cholesterol in India compared to some Western countries^{23,24}. While the prevalence in India appears lower than in some Western countries, the absolute numbers of affected individuals in India are substantial given the country’s large population, underscoring the need for continued surveillance, awareness, and diagnostic and treatment interventions to address the public health challenge of hypercholesterolemia²⁵.

The multivariable logistic regression analysis revealed several determinants associated with high cholesterol among Indian older adults. Notably, participants from non-Hindu religious groups were more likely to have high cholesterol, a finding corroborating evidence from previous studies conducted elsewhere^{26,27}. This suggests potential variations

in dietary (such as vegetarianism) and lifestyle patterns among different religious groups as influencing factors, warranting further investigation into dietary practices and cultural factors that may contribute to this phenomenon²⁸.

Socio-economic status played a significant role in high cholesterol prevalence, as participants in the richest quintiles were more likely to have high cholesterol, a finding that could be linked to dietary choices and better access to healthcare resources. Evidence from previous studies also supports this view²⁹. Additionally, residence in urban areas was associated with a higher likelihood of high cholesterol, which may be attributed to urbanization-related lifestyle changes, including unhealthy dietary habits and reduced work and leisure time physical activity³⁰.

The strong association between obesity and high cholesterol is consistent with the well-established linkage between excess body weight and dyslipidaemia³¹. Furthermore, individuals with comorbid conditions, such as DM, HTN, or both, had a substantially increased risk of high cholesterol, signifying the necessity of addressing these comorbidities collectively to mitigate cardiovascular risk¹⁷.

Among participants with self-reported high cholesterol, nearly four in ten patients reported not taking medications regularly for their condition, indicative of non-adherence in

a substantial proportion of previously diagnosed patients with high cholesterol. Patients having DM, HTN, or obesity were more likely to be adherent to treatment possibly due to increased frequency of contact with the health-system, self-perception of increased risk, and prioritization of treatment in the high-risk groups. Tobacco users were more likely to be non-adherent to treatment for high cholesterol, similar to previous evidence, suggestive of poor self-care practices³². Interestingly, individuals without comorbidities of DM or HTN were less likely to seek treatment for high cholesterol possibly due to reduced risk perception. Consequently, individuals with multiple chronic health conditions in India may be more likely to receive more comprehensive care, including lipid-lowering medications, while those with high cholesterol as a standalone condition may be undertreated, suggestive of the need for sensitization of healthcare providers to also initiate and prioritize lipid management in these patients³³. Finally, a substantial proportion of individuals with self-reported high cholesterol and DM, HTN, and heart disease were not adherent to treatment, despite the presence of these multiple risk factors suggestive of either poor treatment seeking behavior by patients, or therapeutic inertia by clinical providers.

Strengths and limitations

The study strengths include the large sample size from a nationally representative survey conducted by trained field workers with standardized instruments. However, there are certain major study limitations. First, cholesterol status was assessed from self-report which possibly contributed to lower estimation of the burden of hypercholesterolemia. Furthermore, the survey did not distinguish between different types of cholesterol, such as LDL (low-density lipoprotein), HDL (high-density lipoprotein), or total cholesterol, limiting our ability to analyze specific cholesterol-related health risks. This could be due to the low awareness of hypercholesterolemia among the Indian population³⁴, which may have led this large population-based survey to exclude inquiries about different types of cholesterol among the participants. Second, medication adherence in the participants was assessed using a single item question that could not differentiate non-adherence from non-initiation of prescribed medications due to absence of screening or therapeutic inertia amongst healthcare providers, primary non-adherence due to challenges of drug accessibility and financial constraints, or secondary non-adherence from patient related factors such as carelessness and forgetfulness. Third, the survey did not inquire on the specific nature of the cholesterol lowering therapy and it is possible that a small but significant proportion of participants were on alternative or traditional medicine, a question that should be incorporated in future rounds of the survey.

Implications

The findings of this study have several implications for the

public health system and healthcare management practices in India. First, despite the relatively lower prevalence of high cholesterol compared to some Western countries, the absolute number of affected individuals in India is substantial. This highlights the need for continued awareness campaigns, early screening, and appropriate management of high cholesterol, particularly among older adults³⁵. Efforts to address high cholesterol should account for the sociodemographic and clinical determinants identified in this study. Tailored interventions for different sociodemographic groups, urban and rural populations, and individuals with comorbidities may help improve adherence and overall management of high cholesterol¹⁰. Healthcare providers should prioritize lipid management, even in the absence of other comorbidities, and ensure that underweight individuals and tobacco users receive adequate attention and guidance regarding their cholesterol levels. Furthermore, standard treatment guidelines for lipid management should be implemented in Indian health settings to ensure early detection and management of patients at risk of complications from hyperlipidemia.

CONCLUSIONS

A very low prevalence of self-reported high cholesterol among older adults in India suggests underestimation of the problem due to ineffective clinical screening. Only six in ten individuals with a previous diagnosis of cholesterol are adherent to cholesterol lowering therapies, suggestive of the need to strengthen health systems and awareness generation to reduce the risk of cardiovascular complications in this medically vulnerable population.

REFERENCES

1. Nelson RH. Hyperlipidemia as a risk factor for cardiovascular disease. *Prim Care*. 2013;40(1):195-211. doi:[10.1016/j.pop.2012.11.003](https://doi.org/10.1016/j.pop.2012.11.003)
2. Borén J, Chapman MJ, Krauss RM, et al. Low-density lipoproteins cause atherosclerotic cardiovascular disease: pathophysiological, genetic, and therapeutic insights: a consensus statement from the European Atherosclerosis Society Consensus Panel. *Eur Heart J*. 2020;41(24):2313-2330. doi:[10.1093/eurheartj/ehz962](https://doi.org/10.1093/eurheartj/ehz962)
3. World Health Organization. Cardiovascular diseases. Accessed June 15, 2024. <https://www.who.int/health-topics/cardiovascular-diseases>
4. Aïdoud A, Gana W, Poitau F, et al. High prevalence of geriatric conditions among older adults with cardiovascular disease. *J Am Heart Assoc*. 2023;12(2):e026850. doi:[10.1161/JAHA.122.026850](https://doi.org/10.1161/JAHA.122.026850)
5. Anjana RM, Unnikrishnan R, Deepa M, et al. Metabolic non-communicable disease health report of India: the ICMR-INDIAB national cross-sectional study (ICMR-INDIAB-17). *Lancet Diabetes Endocrinol*. 2023;11(7):474-489. doi:[10.1016/S2213-8587\(23\)00119-5](https://doi.org/10.1016/S2213-8587(23)00119-5)
6. Ibrahim MA, Asuka E, Jialal I. Hypercholesterolemia. *StatPearls*

- Publishing; 2024. Accessed June 15, 2024. <https://www.ncbi.nlm.nih.gov/books/NBK459188/>
7. Crichton GE, Alkerwi A. Physical activity, sedentary behavior time and lipid levels in the Observation of Cardiovascular Risk Factors in Luxembourg study. *Lipids Health Dis.* 2015;14:87. doi:[10.1186/s12944-015-0085-3](https://doi.org/10.1186/s12944-015-0085-3)
 8. Paththinige CS, Sirisena ND, Dissanayake V. Genetic determinants of inherited susceptibility to hypercholesterolemia - a comprehensive literature review. *Lipids Health Dis.* 2017;16(1):103. doi:[10.1186/s12944-017-0488-4](https://doi.org/10.1186/s12944-017-0488-4)
 9. Malik C, Khanna S, Jain Y, Jain R. Geriatric population in India: demography, vulnerabilities, and healthcare challenges. *J Family Med Prim Care.* 2021;10(1):72-76. doi:[10.4103/jfmpc.jfmpc_1794_20](https://doi.org/10.4103/jfmpc.jfmpc_1794_20)
 10. Bosworth HB, Ngouyombo B, Liska J, Zullig LL, Atlani C, Beal AC. The importance of cholesterol medication adherence: the need for behavioral change intervention programs. *Patient Prefer Adherence.* 2018;12:341-348. doi:[10.2147/PPA.S153766](https://doi.org/10.2147/PPA.S153766)
 11. Chaudri NA. Adherence to long-term therapies evidence for action. *Ann Saudi Med.* 2004;24(3):221-222. doi:[10.5144/0256-4947.2004.221](https://doi.org/10.5144/0256-4947.2004.221)
 12. Basu S, Garg S, Sharma N, Singh MM. Improving the assessment of medication adherence: challenges and considerations with a focus on low-resource settings. *Ci Ji Yi Xue Za Zhi.* 2019;31(2):73. doi:[10.4103/tcmj.tcmj_177_18](https://doi.org/10.4103/tcmj.tcmj_177_18)
 13. Gatwood J, Bailey JE. Improving medication adherence in hypercholesterolemia: challenges and solutions. *Vasc Health Risk Manag.* 2014;10:615-625. doi:[10.2147/VHRM.S56056](https://doi.org/10.2147/VHRM.S56056)
 14. Gibson TB, Fendrick AM, Gatwood J, Chernew ME. Gaps in treatment, treatment resumption, and cost sharing. *American Journal of Pharmacy Benefits.* 2012;4:e159-e165.
 15. Rodriguez F, Maron DJ, Knowles JW, Virani SS, Lin S, Heidenreich PA. Association of statin adherence with mortality in patients with atherosclerotic Cardiovascular Disease. *JAMA Cardiol.* 2019;4(3):206-213. doi:[10.1001/jamacardio.2018.4936](https://doi.org/10.1001/jamacardio.2018.4936)
 16. Chowdhury R, Khan H, Heydon E, et al. Adherence to cardiovascular therapy: a meta-analysis of prevalence and clinical consequences. *Eur Heart J.* 2013;34(38):2940-2948. doi:[10.1093/eurheartj/ehz295](https://doi.org/10.1093/eurheartj/ehz295)
 17. Petrie JR, Guzik TJ, Touyz RM. Diabetes, hypertension, and cardiovascular disease: clinical insights and vascular mechanisms. *Can J Cardiol.* 2018;34(5):575-584. doi:[10.1016/j.cjca.2017.12.005](https://doi.org/10.1016/j.cjca.2017.12.005)
 18. Umarje S, James NM, Dave P, Raut A, Pandey N. Impact of adherence, patient perception, and knowledge to statin therapy - a cross-sectional study. *Indian J Endocrinol Metab.* 2021;25(3):206-210. doi:[10.4103/ijem.ijem_120_21](https://doi.org/10.4103/ijem.ijem_120_21)
 19. Alwhaibi M, Altoaimi M, AlRuthia Y, et al. Adherence to statin therapy and attainment of LDL cholesterol goal among patients with type 2 diabetes and dyslipidemia. *Patient Prefer Adherence.* 2019;13:2111-2118. doi:[10.2147/PPA.S231873](https://doi.org/10.2147/PPA.S231873)
 20. Oommen AM, Nand K, Abraham VJ, George K, Jose VJ. Prevalence of statin use among high-risk patients in urban and rural Vellore, Tamil Nadu: a population-based cross-sectional study. *Indian J Pharmacol.* 2017;49(2):201-204. doi:[10.4103/ijp.IJP_747_16](https://doi.org/10.4103/ijp.IJP_747_16)
 21. Government of India. Ministry of Health and Family Welfare. Longitudinal Ageing Study in India (LASI): Wave-1: India Report. Accessed June 15, 2024. <https://main.mohfw.gov.in/newshighlights-33> www.iipsindia.ac.in/sites/default/files/LASI_India_Report_2020_compressed.pdf
 22. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet.* 2004;363(9403):157-163. doi:[10.1016/S0140-6736\(03\)15268-3](https://doi.org/10.1016/S0140-6736(03)15268-3)
 23. Lotufo PA, Santos RD, Sposito AC, et al. Self-reported high-cholesterol prevalence in the Brazilian population: analysis of the 2013 National Health Survey. *Arq Bras Cardiol.* 2017;108(5):411-416. doi:[10.5935/abc.20170055](https://doi.org/10.5935/abc.20170055)
 24. Morales-Villegas EC, Yarleque C, Almeida ML. Management of hypertension and dyslipidemia in Mexico: evidence, gaps, and approach. *Arch Cardiol Mex.* 2023;93(1):077-087. doi:[10.24875/ACM.21000330](https://doi.org/10.24875/ACM.21000330)
 25. Grundy SM, Stone NJ, Bailey AL, et al. 2018: AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APhA/ASPC/NLA/PCNA guideline on the management of blood cholesterol: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circulation.* 2019;139(25):e1082-e1143. doi:[10.1161/CIR.0000000000000625](https://doi.org/10.1161/CIR.0000000000000625)
 26. McKeigue PM, Shah B, Marmot MG. Relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians. *Lancet.* 1991;337(8738):382-386. doi:[10.1016/0140-6736\(91\)91164-p](https://doi.org/10.1016/0140-6736(91)91164-p)
 27. Hirode G, Vittinghoff E, Bharmal NH, Kandula NR, Kanaya AM. The association of religious affiliation with cholesterol levels among South Asians: the Mediators of Atherosclerosis in South Asians Living in America study. *BMC Cardiovasc Disord.* 2019;19(1):75. doi:[10.1186/s12872-019-1045-z](https://doi.org/10.1186/s12872-019-1045-z)
 28. Shridhar K, Dhillon PK, Bowen L, et al. The association between a vegetarian diet and cardiovascular disease (CVD) risk factors in India: the Indian Migration Study. *PLoS One.* 2014;9(10):e110586. doi:[10.1371/journal.pone.0110586](https://doi.org/10.1371/journal.pone.0110586)
 29. Espírito Santo LR, Faria TO, Silva CSO, et al. Socioeconomic status and education level are associated with dyslipidemia in adults not taking lipid-lowering medication: a population-based study. *Int Health.* 2022;14(4):346-353. doi:[10.1093/inthealth/ihz089](https://doi.org/10.1093/inthealth/ihz089)
 30. de Groot R, van den Hurk K, Schoonmade LJ, de Kort WLAM, Brug J, Lakerveld J. Urban-rural differences in the association between blood lipids and characteristics of the built environment: a systematic review and meta-analysis. *BMJ Glob Health.* 2019;4(1):e001017. doi:[10.1136/bmjgh-2018-001017](https://doi.org/10.1136/bmjgh-2018-001017)
 31. Feingold KR. Obesity and Dyslipidemia. In: Feingold KR, Anawalt B, Blackman MR, et al, eds. Accessed September 16,

2023. <http://www.ncbi.nlm.nih.gov/books/NBK305895/>
32. Lopes J, Santos P. Determinants of non-adherence to the medications for dyslipidemia: a systematic review. *Patient Prefer Adherence*. 2021;15:1853-1871. doi:[10.2147/PPA.S319604](https://doi.org/10.2147/PPA.S319604)
33. Yang CC, Jick SS, Testa MA. Who receives lipid-lowering drugs: the effects of comorbidities and patient characteristics on treatment initiation. *Br J Clin Pharmacol*. 2003;55(3):288-298. doi:[10.1046/j.1365-2125.2003.01724.x](https://doi.org/10.1046/j.1365-2125.2003.01724.x)
34. Guptha S, Gupta R, Deedwania P, et al. Cholesterol lipoproteins and prevalence of dyslipidemias in urban Asian Indians: a cross sectional study. *Indian Heart J*. 2014;66(3):280-288. doi:[10.1016/j.ihj.2014.03.005](https://doi.org/10.1016/j.ihj.2014.03.005)
35. World Heart Federation. Improving Prevention and Control of Raised Cholesterol. Accessed June 15, 2024. <https://world-heart-federation.org/resource/whf-cholesterol-white-paper/>

CONFLICTS OF INTEREST

The authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none was reported.

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ETHICAL APPROVAL AND INFORMED CONSENT

LASI was approved by an ethical committee of the Indian Council of Medical Research (ICMR) and was conducted in accordance with the relevant guidelines and regulations. Informed consent was obtained from all participants prior to their participation in the study. Since the LASI Wave I dataset is an anonymous publicly available dataset with no identifiable information about the participants, no separate ethical

approval was required for the present secondary data analysis.

DATA AVAILABILITY

The data supporting this research are available from the IIPS upon permission (<https://www.iipsindia.ac.in/lasi>).

AUTHORS' CONTRIBUTIONS

VM: data analysis, writing of first draft. SB: concepts, writing, reviewing and editing of manuscript. Both authors read and approved the final version of the manuscript.

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