Journal of Clinical Lipidology (2016) 10, 568–576

Journal of Clinical Lipidology

Prevalence, awareness, treatment, and control of high low-density lipoprotein cholesterol in Brazil: Baseline of the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil)

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KEYWORDS:
Dyslipidemia;
Statins;
Coronary heart disease;
Epidemiology;
Risk factors;
Cardiovascular

BACKGROUND AND OBJECTIVES: Dyslipidemia is a pivotal risk factor for coronary heart disease (CHD). The purpose of this study was to identify the profile of dyslipidemia in a Brazilian population, according to high low-density lipoprotein (LDL-C) levels. We used the classification of the 2004 update of National Cholesterol Education Program Adult Treatment Panel III (ATP-III).

METHODS: Of the 15,105 men and women aged 35 to 74 years enrolled in the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil), we included 14,648 subjects (97%). They had data to categorize them according to the NCEP-ATP-III criteria. We compared 4 categories: "0–1" risk factors, "2 or more risk factors", "CHD or CHD risk equivalent", and "CHD at very high risk". The sociodemographic determinants used were sex, age, ethnicity, income, education, and health insurance. Poisson regression was used to estimate the prevalence ratios for cholesterol (LDL-C), frequency, awareness, treatment, and control of high LDL-C.

The ELSA-Brasil baseline study was supported by the Brazilian Ministry of Health (Science and Technology Department) and the Brazilian Ministry of Science and Technology (Financiadora de Estudos e Projetos and CNPq National Research Council; grants 01 06 0010.00 RS, 01 06 0212.00 BA, 01 06 0300.00 ES, 01 06 0278.00 MG, 01 06 0115.00 SP, and 01 06 0071.00 RJ).

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Submitted September 10, 2015. Accepted for publication December 27, 2015.

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http://dx.doi.org/10.1016/j.jacl.2015.12.029

RESULTS: The frequencies of high LDL-C, awareness, treatment, and control were 45.5%, 58.1%, 42.3%, and 58.3%, respectively. After adjustment for sociodemographic determinants, the prevalence ratios for high LDL-C were significantly higher for men, blacks, older subjects, and subjects with lower levels of education. Low frequency of awareness, treatment, and uncontrolled values of LDL-C was observed among men, mixed race and blacks, poorer, less educated, and those who did not have private health insurance.

CONCLUSIONS: The prevalence of high LDL-C was elevated in this Brazilian population, with low rates of awareness, treatment and control, and remarkable socioeconomic disparity.
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Coronary heart disease (CHD) is a leading cause of morbidity and mortality worldwide.[1] There is a paradox when comparing the findings of epidemiologic and clinical trials with the practice of preventive cardiology. On one hand, a high level of blood low-density lipoprotein cholesterol (LDL-C) was recognized several decades ago to be a pivotal risk factor for the initiation and progression of atherosclerosis to CHD,[2] and clinical trials in the 1990s proved the efficacy and safety of lipid-lowering agents for secondary and primary CHD prevention.[3,4] On the another hand, a large proportion of adults with high LDL-C remained under diagnosed and under treated worldwide.[5–16]

An evaluation of total cholesterol since 1980, spanning several countries and involving three million subjects revealed a slight decline in the rates of prevalence of high LDL-C. This phenomenon occurred in countries where blood lipids are regularly monitored. However, in some regions, such as Latin America, surveys have shown flattening temporal trends for LDL-cholesterol serum levels. These results may be due to a lack of data in these countries or to a real phenomenon secondary to genetic or environmental factors.[17]

The Brazilian Longitudinal Study of Adult Health (ELSA-Brasil), involving 15,105 men and women aged 35 to 74 years, is an opportunity to add more information about lipid profile in Latin America. Our aim was to describe the demographics and socioeconomic determinants of prevalence, awareness, treatment, and control of LDL-C at baseline of the ELSA-Brasil (2008 to 2010).[18–23]

Methods

Study recruitment

ELSA-Brasil addresses the incidence of cardiovascular diseases and significant associated risk factors. The design and preliminary findings of this study are detailed available elsewhere.[18,19] Briefly, 15,105 civil servants aged 35–74 years from 6 cities in Brazil (Belo Horizonte, Porto Alegre, Rio de Janeiro, Salvador, São Paulo, and Vitória) were enrolled between August 2008 and December 2010 for baseline examination. All 6 participating centers approved the ELSA-Brasil protocol, and all subjects granted informed consent.

Data collection

Trained personnel with strict quality control carried out the interviews and examinations at each site. The questionnaire addressed sociodemographic variables, lifestyle, morbidity, diet, and medicines under use. Smoking status was defined as never, former, or current. The level of education was categorized as elementary, high school, or college. Annual household income was analyzed in tertiles. All subjects described their previous medical diagnoses of coronary heart disease (stable angina, myocardial infarction and/or coronary revascularization), stroke, and other cardiovascular diseases. All prescriptions and over-the-counter pill bottles were examined to confirm what medications had been taken during the 15-day period preceding the interview.

Trained nurses measured the subjects' weight, height, and waist circumference and performed standardized physiological examinations. Body mass index was calculated by dividing the patient's weight in kilograms by their height in square meters. Hypertension was defined in terms of 3 criteria: systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or the use of medication to control hypertension (in the interview: "Are any of the drugs you have taken in the past two weeks for high blood pressure?").[20,21] Diabetes was defined as a report of a previous medical diagnosis of diabetes, the use of medication for diabetes, or meeting a diagnostic cut-off for diabetes according to fasting or 2-hour plasma glucose levels, obtained as part of a 75-g oral glucose tolerance test or the glycated hemoglobin test.[22]

Subject awareness of the presence of high LDL-C was defined by an affirmative response to the question "Have you ever been told by a doctor l that your blood cholesterol was high?" Use of lipid-lowering treatment was defined by listing of lipid-lowering agents by subjects which confirmed a medical diagnosis of high cholesterol. A description of lipid-lowering drugs is given in Appendix 1.

Measurement of lipids

Blood samples collected from each subject after overnight fasting were refrigerated immediately, transported in cold storage to a certified central laboratory (Hospital Universitário, São Paulo, Brazil)., Total cholesterol (TC) was measured using a cholesterol oxidase enzymatic method and high-density lipoprotein cholesterol by homogeneous, colorimetric methods, without using the precipitation method. Triglyceride (TG) levels were measured by the glycerol-phosphate peroxidase method according to Trinder (enzymatic colorimetric). LDL-C was calculated using the Friedewald's formula: [LDL-C (mg/dL) = TC (mg/dL) − {HDL-C (mg/dL) + TG (mg/dL)/5}] if the TG level was low (≤400 mg/dL), and measured directly by a homogeneous, enzymatic, colorimetric method without precipitation. All these examinations were performed using the ADVIA 1200 Siemens analyzer.[23] Appendix 2 shows the mean and standard deviations for total cholesterol and its fractions and triglycerides to age and use of lipid-lowering agents.

To determine the proportion of high-cholesterol awareness, treatment and control, the criteria for 2004 updated NCEP ATP-III guidelines were applied.[24,25] In ELSA-Brasil, CHD is defined as symptomatic ischemic heart disease, including myocardial infarction, stable or unstable angina, and history of coronary artery procedures. CHD risk equivalent was defined as the presence of at least one of the following: diabetes, previous stroke or a 10-year risk for hard CHD > 20% estimated by the Framingham equations in the ATP-III. CHD risk factors were age ≥55 years for women and ≥45 years for men, current smoking, high blood pressure, family history of early CHD (history of myocardial infarction or angina before the age of 60 years among parents), and low HDL-cholesterol (<40 mg/dL). HDL cholesterol ≥60 mg/dL was considered protective and offset the presence of one these risk factors.[24,25]

Four mutually exclusive categories of CHD risk were created:

(1) 0-1 major CHD risk factors;
(2) Two or more major CHD risk factors;
(3) CHD or CHD risk equivalent;
(4) CHD at very high risk including who reported both CHD and diabetes, current smoking, and metabolic syndrome.

High LDL-C was defined as the use of lipid-lowering agents or the following cut-off values, according these categories:

(1) "0 or 1 risk factor": LDL-C ≥ 160 mg/dL:
(2) "2 or more risk factors" depending on the estimated 10-year CHD risk. If the calculated risk was lower than 10%, the value of undesirable LDL-C was≥ 130 mg/dL. However, when the 10-year CHD risk was between 10% and 20%, the cut-off value was LDL-C ≥ 100 mg/dL.
(3) CHD or risk equivalent: LDL-cholesterol ≥ 100 mg/dL.
(4) CHD at very high risk: LDL-cholesterol ≥ 70 mg/dL.

Sampling and statistical analysis

We calculated the number of ELSA-Brasil subjects with high LDL-C overall, by CHD risk categories, and by sociodemographic variables (sex, age, ethnicity, income, education, and private health insurance). Awareness was calculated based on the number of subjects with high LDL-C, who also had a previous medical diagnosis of high cholesterol. The number of participants under lipid-lowering therapy was determined in those who knew of their diagnosis of high cholesterol and had been referred for treatment. Treatment was considered effective when those subjects under lipid-lowering therapy obtained optimal LDL-C levels according to their CHD risk category, as recommended by the NCEP/ATP-III guidelines.[24,25]

We applied a generalized linear model using Poisson regression with a robust estimator, to estimate the prevalence ratios of high LDL-C, awareness of the diagnosis, treatment and control, first for the NCEP-ATP-III categories ("0–1 cardiovascular risk factor", "2 or more cardiovascular risk factors", "CHD-risk equivalent," and "CHD at very high risk") and then for the sociodemographic variables. The latter were sex, age (35–44; 45–54; 55–64; 65–74 years), ethnicity (white, mixed race, black, Asian, indigenous), income (tertiles of annual family income), level of education (elementary, high-school, college), and health insurance status (yes/no).

Results

Of the 15,105 subjects, 15,096 had a full lipid profile for quantification of LDL-C. Figure 1 shows the distribution of LDL-C levels considering the use or not of lipid-lowering drugs revealing a normal distribution. LDL-C >190 mg/dL was observed in 5% of this sample. Lipid-lowering agents, mostly statins (Appendix 1), were used by 1975 (13.1%) of subjects, and the average LDL-C for the whole sample was 131.1 mg/dL (95% confidence interval (CI) = 130.4–131.6). The mean values in subjects under lipid-lowering agents were 114.6 mg/dL (95%

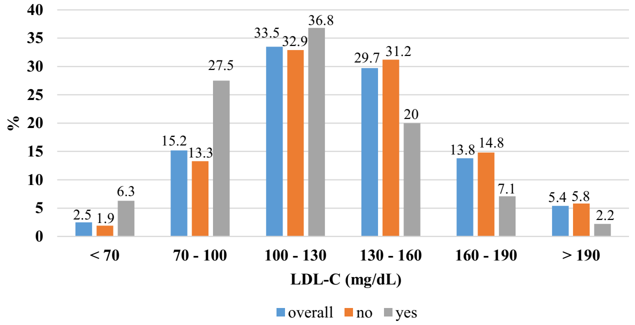

Figure 1 Distribution of values for LDL-Cholesterol, according the use of lipid-lowering agents among subjects of the baseline of the ELSA-Brasil (2008–10).

CI = 113.3–116.2), significantly lower than in those who did not use medications, 133.5 (95% CI = 132.9 to 132.4).

To evaluate the prevalence, awareness, treatment, and control of high LDL-C, we restricted the analysis to subjects whose had complete data on NCEP-ATP-III criteria variables criteria, reducing the sample size to 14,648 subjects (97%). Almost two-thirds of the subjects had "0-1" risk factor, 10% presented "2 or more risk factors", and 22% were classified as CHD or CHD risk equivalent. Finally, 2.7% were classified as having CHD at very high risk.

Table 1 General characteristics of the subjects of the ELSA-Brasil study (2008–10)

Characteristics	N	%
Sex		
Men	6607	43.8
Women	8041	56.2
Age (y)		
35–44	3286	22.4
45–54	5826	39.8
55–64	4084	27.9
65–74	1452	9.9
Ethnicity		
White	7525	51.4
Mixed race	4101	28
Black	2330	15.9
Asian	364	2.5
Indigenous	153	1
Annual family income (tertiles)		
Bottom	4836	33.0
Middle	4666	31.9
Top	5076	34.7
Education		
Elementary	1846	12.6
High school	5108	34.9
College	7694	52.5
Private health insurance		
No	4653	31.8
Yes	9994	68.2
Body mass index (kg/m^2)		
<25	5447	37.2
25 to 29.9	5854	40
≥30	3341	22.8
Diabetes		
No	11,852	80.9
Yes	2796	19.1
Hypertension		
No	9521	65
Yes	5117	34.9
Smoking		
Never	8361	57.1
Former	4371	29.8
Current	1915	13.1
Self-reported CHD		
No	13,758	93.9
Yes	873	6
Family history CHD		
No	12,277	83.8
Yes	2250	15.4

Table 1 shows the general characteristics of the study subjects, who were more frequently women, aged <65 years, white, with higher education and private health insurance. Two-thirds of the ELSA-Brasil subjects were overweight and/or obese; one-fifth had the diagnoses of diabetes, one-third hypertensive, and 13% current smokers. The frequency of self-reported CHD was 6%.

Figure 2 shows the proportions of prevalence, awareness, treatment, and medication-controlled LDL-C for this sample. According to ATP-III, 45.5% presented high LDL-C, and 58.1% are aware of this condition. Among subjects with high LDL-C, 42.3% were using lipid-lowering agents and 58.3% of subjects using drugs reached the targets recommended by the NCEP-ATP-III. Table 2 shows that the frequencies are different among risk categories. The prevalence rates of high LDL-C increased 4 times from 25% for the category "0-1 risk factor" to 96% for CHD at very high risk. More than the half of the subjects with high LDL-C were aware of this condition; the highest proportion was for those with "0-1 risk factors" and the lowest was for those with "2 or more risk factors". Of the subjects who reported a medical diagnosis of high cholesterol, 40% was the proportion for all categories under treatment, except for people with "CHD at very risk" category with a 60% of participants under lipid-lowering agents. The proposed ATP-III goals for LDL-C were reached in 60% of lipid-lowering agent users. However, the rates declined sharply, from 80% of subjects with "0-1 risk" to only 10% of those with CHD at very high risk.

Table 3 shows the prevalence, awareness, treatment and control of elevated LDL-C levels according to the sociodemographic variables. Overall, the prevalence of high LDL-C was 45.5% with a significantly higher prevalence among men (50%) compared to women (42%). The frequency of high-LDL-cholesterol increased with age-strata, from 24% for the youngest age group to 67% for the oldest age group. The prevalence of high LDL-C did not differ among ethnicities, but there was slight higher prevalence among blacks. No differences were observed between white and mixed race subjects. The socioeconomic variables revealed an inverse association between the prevalence of high LDL-C

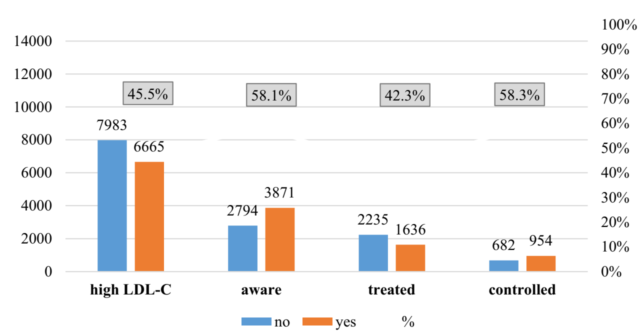

Figure 2 Number and proportion of subjects with High LDL-C, Aware, Treated and Controlled at the baseline of ELSA-Brasil study (2008–10).

Table 2 Proportion values (percentage) and 95% confidence intervals (95% CIs) for high LDL-C, awareness, treatment, and control in the Brazilian Longitudinal Study of Adult Health (2008–2010), according to NCEP-ATP-III risk categories

	0–1 risk factor		≥2 risk factors		CHD/risk equivalent		CHD high-risk	
		Proportion (%)		Proportion (%)		Proportion (%)		Proportion (%)
	N	95% CI	N	95% CI	N	95% CI	N	95% CI
High LDL	9629	25.8 (25.4–26.2)	1359	72.0 (70.8–73.2)	3261	86.5 (85.9–87.1)	399	96.0 (95.0–97.0)
Aware	2482	68.4 (67.5–69.3)	978	46.0 (44.4–47.6)	2822	52.8 (51.9–53.7)	383	60.6 (58.1–63.1)
Treated	1698	40.5 (39.3–41.7)	450	41.3 (39.0–43.6)	1491	42.5 (41.2–43.8)	232	55.2 (51.9–58.5)
Controlled	688	88.2 (87.0–89.5)	186	48.4 (44.7–52.1)	634	38.6 (36.7–40.6)	128	9.4 (6.8–12.0)

and level of education, and in contrast, a direct association with levels of income. No differences were found whether the subject had private health insurance. The awareness of high LDL-C levels was more frequent among women, people aged >55 years, those with higher incomes, higher levels of education, and with private health insurance. Awareness rates were highest among Asians and lowest among blacks; there were no differences between whites and mixed race subjects. Treatment rates followed the same pattern of high LDL-C awareness. The proportion of people under treatment reaching the LDL-C target was greater among women, white and Asians, more educated, richer and own private health insurance. Furthermore, we analyzed these variables altogether applying Poisson regression to obtain prevalence ratios.

Table 4 discloses the prevalence ratios adjusted for age, sex, ethnicity, income, education, and health insurance status were obtained to estimate social determinant associations with the prevalence, awareness, treatment, and control, according to ATP-III classification. The prevalence ratios of high LDL-C increased through the ordinal categories of the ATP-III classification. The awareness ratios showed an inverse association with CHD risk groups. The treatment ratios were only higher among subjects with CHD at very high risk. Finally, the control of the LDL-C for subjects using lipid-lowering agents was markedly

Table 3 Proportion values (percentage) and 95% Confidence Interval (95% CI) for High LDL-C, Awareness, Treatment, and Control in the Brazilian Longitudinal Study of Adult Health (2008-2010) according to sociodemographic variables

	Prevalence		Awareness		Treatment		Control	
	N	PR 95% CI	N	PR 95% CI	N	PR 95% CI	N	PR 95% CI
Sex								
Men	6607	50.4 (49.8–51.0)	3332	52.9 (52.0–53.8)	1763	40.2 (39.0–41.4)	709	53.3 (51.4–55.2)
Women	8041	41.5 (41.0–42.0)	3333	63.2 (62.4–64.0)	2108	44.0 (42.9–45.1)	927	62.1 (60.5–63.7)
Age								
35–44	3286	24.1 (23.4–24.8)	792	43.3 (41.5–45.1)	343	20.7 (18.5–22.9)	71	63.4 (57.7–69.1)
45–54	5826	41.7 (41.1–42.3)	2430	55.4 (54.4–56.4)	1346	34.6 (33.3–35.9)	466	56.9 (54.6–59.2)
55–64	4084	60.3 (59.5–61.1)	2464	62.1 (61.1–63.1)	1530	46.3 (45.0–47.6)	709	57.7 (55.8–59.6)
65–74	1452	67.4 (66.2–68.6)	979	66.6 (65.1–68.1)	652	59.8 (57.9–61.7)	390	60.3 (57.8–62.8)
Ethnicity								
White	7525	44.8 (44.2–45.4)	3373	60.6 (59.8–61.4)	2043	48.0 (46.9–49.1)	980	63.1 (61.6–64.6)
Mixed	4101	44.9 (44.1–45.7)	1841	55.3 (54.1–56.5)	1018	34.1 (32.6–35.6)	347	53.9 (51.2–56.6)
Black	2330	47.4 (46.4–48.4)	1104	55.1 (53.6–56.6)	608	33.6 (31.73–5.5)	204	42.2 (38.7–45.7)
Asian	364	45.6 (43.0–48.2)	166	62.0 (58.2–65.8)	103	63.1 (58.3–67.9)	65	63.1 (57.1–69.1)
Indigenous	153	52.9 (48.9–56.9)	81	56.8 (51.3–62.3)	46	34.8 (27.8–41.8)	16	56.3 (43.9–68.7)
Income (tertiles)								
Bottom	4836	44.3 (43.6–45.0)	2143	53.2 (52.1–54.3)	1140	30.9 (29.5–32.3)	352	43.8 (41.2–46.4)
Middle	4668	44.9 (44.2–45.6)	2097	57.6 (56.5–58.7)	1208	41.0 (39.6–42.4)	495	56.8 (54.6–59.0)
Top	5076	47.1 (46.4–47.8)	2392	62.8 (61.8–63.8)	1503	52.0 (50.7–53.3)	782	66.0 (64.3–67.7)
Education								
Elementary	1846	57.7 (56.6–58.8)	1065	54.3 (52.8–55.8)	578	38.1 (36.1–40.1)	220	41.4 (38.1–44.7)
High-school	5108	44.8 (44.1–45.5)	2289	54.7 (53.7–55.7)	1253	37.0 (35.6–38.4)	464	50.0 (47.7–52.3)
College	7694	43.0 (42.4–43.6)	3311	61.6 (60.8–62.4)	2040	46.7 (45.6–47.8)	952	66.3 (64.8–67.8)
Health insurance								
No	4653	46.8 (46.1–47.5)	2178	51.1 (50.0–52.2)	1114	36.0 (34.6–37.4)	401	45.6 (43.1–48.1)
Yes	9994	44.9 (44.4–45.4)	4486	61.5 (60.8–62.2)	2757	44.8 (43.9–45.7)	1235	62.4 (61.0–63.8)

Table 4 Adjusted prevalence ratios (PRs) and 95% confidence interval (95% CI) for High LDL, Awareness, Treatment, and Control for NCEP-ATP-III categories and by sociodemographic variables among subjects of the ELSA-Brasil (2008–10)

	High LDL-C		Awareness		Treatment		Control	
	N	PR (95% CI)	N	PR (95% CI)	N	PR (95% CI)	N	PR 95% CI
ATP III category								
0–1 RF	9496	1.00 (reference)	2438	1.00 (reference)	1673	1	676	1.00 (reference)
≥2 RF	1339	1.54 (1.50–1.59)	961	0.81 (0.78–0.84)	442	1.01 (0.96–1.06)	184	0.51 (0.44–0.60)
CHD/RE	3197	1.78 (1.75–1.81)	2768	0.85 (0.82–0.87)	1465	1.01 (0.97–1.05)	623	0.43 (0.39–0.48)
CHD HR	393	1.94 (1.90–1.99)	377	0.91 (0.86–0.96)	227	1.13 (1.06–1.21)	124	0.11 (0.06–0.18)
Sociodemographics variables								
Sex								
men	6493	1.00 (reference)	3263	1.00 (reference)	1726	1.00 (reference)	694	1.00 (reference)
women	7932	0.92 (0.90–0.93)	3281	1.10 (1.07–1.12)	2081	1.02 (0.99–1.05)	913	1.20 (1.10–1.31)
Age (y)								
35–44	3254	1.00 (reference)	782	1.00 (reference)	337	1.00 (reference)	71	1.00 (reference)
45–54	5755	1.19 (1.16–1.21)	2399	1.12 (1.08–1.17)	1333	1.15 (1.09–1.21)	458	0.88 (0.73–1.06)
55–64	3996	1.43 (1.40–1.46)	2408	1.19 (1.14–1.24)	1499	1.27 (1.21–1.34)	694	0.87 (0.72–1.04)
65–74	1420	1.52 (1.48–1.57)	955	1.24 (1.18–1.30)	638	1.44 (1.36–1.53)	384	0.89 (0.74–1.08)
Ethnicity								
White	7505	1.00 (reference)	3364	1.00 (reference)	2038	1.00 (reference)	978	1.00 (reference)
Mixed	4087	1.01 (0.99–1.03)	1834	0.97 (0.94–1.00)	1015	0.91 (0.87–0.94)	346	0.94 (0.84–1.05)
Black	2320	1.03 (1.01–1.06)	1101	0.97 (0.93–1.01)	607	0.92 (0.88–0.96)	203	0.76 (0.64–0.91)
Asian	362	1.00 (0.95–1.05)	165	0.99 (0.92–1.06)	102	1.14 (1.04–1.25)	65	0.98 (0.81–1.18)
Indigenous	151	1.03 (0.95–1.12)	80	1.00 (0.89–1.12)	45	0.91 (0.80–1.04)	15	0.96 (0.64–1.45)
Income								
	4796	1.00 (reference)	2122	1.00 (reference)	1130	1.00 (reference)	348	1.00 (reference)
	4624	1.03 (1.01–1.05)	2067	1.01 (0.97–1.04)	1192	1.08 (1.04–1.12)	488	1.08 (0.93–1.26)
	5005	1.04 (1.01–1.06)	2355	1.02 (0.98–1.06)	1485	1.14 (1.09–1.20)	771	1.13 (0.96–1.33)
Education								
Elementary	1811	1.00 (reference)	1043	1.00 (reference)	565	1.00 (reference)	215	1.00 (reference)
High school	5050	0.98 (0.95–1.00)	2265	1.01 (0.97–1.05)	1242	1.01 (0.96–1.06)	457	1.13 (0.94–1.36)
College	7564	0.94 (0.91–0.96)	3236	1.03 (0.99–1.08)	2000	1.00 (0.94–1.05)	935	1.31 (1.08–1.58)
Insurance								
No	4584	1.00 (reference)	2144	1.00 (reference)	1098	1.00 (reference)	393	1.00 (reference)
Yes	9841	0.99 (0.97–1.01)	4400	1.08 (1.04–1.11)	2709	1.02 (0.98–1.06)	1214	1.17 (1.03–1.33)

lower among those with more than 2 risk factors and with CHD risk equivalent.

After adjustment for all variables, the prevalence ratios for high LDL-C were significantly greater for men, those aged >45 years, and slightly higher for blacks, those with higher incomes, and with lower levels of education. Awareness of high LDL-C was independently associated with woman, older, white or Asian and having private health insurance. The treatment ratios were higher among women, older subjects, Asians, and those with higher incomes. A greater proportion of uncontrolled values of LDL-C were observed among men, mixed race, and black subjects, those with lower incomes, lower levels of education, and who did not have private health insurance.

Discussion

The dyslipidemia profile evaluated by high LDL-C at the baseline of ELSA-Brasil reveals several significant findings. First, the prevalence of high LDL-C is common and high in Brazil, and to the best of our knowledge, this is the first large study to evaluate the profile of high cholesterol in Brazil accurately. Second, the prevalence, awareness, treatment, and control proportions rates are differentiated by demographics and socioeconomic factors, with less favorable values among men, blacks, and those with lower levels of education. Third, the awareness, treatment, and control rates are relatively low among subjects with "2 or more risk factors" and those with "CHD equivalent risk". Fourth, the control of LDL-C was quite low for the categories "CHD equivalent" and "CHD at very high risk".

Our initial results must be compared with other baseline descriptions of high LDL-C in similar cohorts as The Atherosclerosis Risk in Communities (ARIC),[5] the Cardiovascular Health Study (CHS),[6] the Multi-Ethnic Study of Atherosclerosis,[10] the Genetic Epidemiology Network of Arteriopathy (GENOA),[7] and the Hispanic Community Health Study/Study of Latinos (HCHS/SOL).[16] Comparison among cohort studies must be done with caution because the definition of high cholesterol was different in each study. The measure of cholesterol varied (total cholesterol vs LDL-C), and the NCEP-ATP-III, a seminal guideline, was released until after the ARIC and CHS first visits.[5,6]

Awareness and treatment rates were lower in blacks compared to whites with were also identified in the ARIC study of 15,739 individuals aged 45–64 years during the baseline examination (1987 to 1989).[5] In the study by Lemaitre et al., higher treatment rates were found among women compared to men, in elderly subjects.[6]

More recently, Multi-Ethnic Study of Atherosclerosis involving 6814 subjects aged 45 to 84 years who were free of clinical CVD at baseline (2000–2002), showed an overall prevalence of high LDL-C of 29.3%, a treatment rate of 54.0% and a control rate of 75.2% (797 of 1060) of subjects with treated dyslipidemia.[10] These data reveal a lower prevalence of high LDL-cholesterol, but better treatment and control rates compared to ELSA-Brasil. The GENOA study compared 1286 blacks in Jackson, and 1070 whites in Rochester, to determine dyslipidemia patterns among people with hypertension. The results showed higher prevalence and treatment rates among whites, but the control rates were higher among Blacks.[7] Finally, among Hispanic/Latino adults in the "HCHS/SOL, which had 16,207 subjects aged 18 to 74 years, it was identified that half of the subjects was aware of having high LDL-C, one-third was receiving treatment, and two-thirds had reached their LDL-C with the same NCEP-ATP-III goals. Men had a higher prevalence of LDL-C than women, a lower rate of treatment, but a better rate of control, compared to women.[16]

Although, the methods applied in the "Hispanic Community Health Study/Study of Latinos" (HCHS/SOL) were a little bit different from those of ELSA-Brasil, this study has more similarity with ours. The awareness, treatment, and control rates for men and women aged 45–64 years were relatively similar between these 2 studies.[16] One common characteristic of most of those cohorts, including ELSA-Brasil, is that the prevalence of high LDL-C is greater among men than women; however, the control rates were inverse in relation to sex, with more women having desirable levels of LDL-C in ELSA-Brasil, as opposed to the situation in the HCHS/SOL, which had more men under control than women. In relation to race, the lower rates of treatment and control among blacks among ELSA-Brasil participants could be associated with unfavorable conditions; however, this association was kept after adjustment for income and private health insurance.

Among several surveys addressing dyslipidemia management, some were performed among populations with a different ethnicity distribution than ELSA-Brasil.[8,9,11,14,15] The survey that partially presents a racial pattern that most closely matches that of ELSA-Brasil was the US. National Health and Nutrition Examination Survey (NHANES 2009-2011). During the NHANES visit in 2009-10, the prevalence of high LDL-C, awareness, treatment, and control were 37.8%, 61.5%, 70.0%, and 63.6%, respectively. The prevalence of high LDL-C was higher in ELSA-Brasil subjects than in the NHANES survey, but the rates of awareness, treatment, and control were significantly higher in the NHANES survey. One reason for this difference is that the definition of diabetes in ELSA-Brasil includes the oral glucose tolerance test and glycated hemoglobin quantification, in contrast to the NHANES, in which diabetes was defined as a fasting plasma glucose level $\geq$126 mg/dL or self-reported history of diabetes with concurrent anti-diabetic medication use. This difference of definition yielded a higher prevalence of diabetes in ELSA-Brasil (19.8%) compared to NHANES (10.6%). Consequently, the distribution of subjects according to NCEP-ATP-III was different, comparing these 2 studies. The proportions of those who had "2 or more risk factors" were 10% vs 20%, in the ELSA-Brasil and NHANES studies, respectively. The category "CHD equivalent" was found in 22% of ELSA-Brasil compared to 13% of NHANES. Despite this aspect, the treatment and control of people with high LDL-C was lower in a selected sample of civil servants evaluated in ELSA-Brasil than in a survey representing the general population of the United States.

The only study-addressing LDL-C treatment that included Brazilian patients was the Lipid Treatment Assessment Project 2 (LTAP-2), which evaluated a sample of 361 Brazilian patients under treatment at different lipid clinics.[26] The overall success of LDL-C reduction in the LTAP-2 was slightly better than observed among ELSA-Brasil subjects. However, the proportion of people with CHD disease-presenting controlled cholesterol levels in our study was substantially lower than in patients enrolled in the LTAP-2, considering that the percentage of treated persons in ELSA-Brasil was very low. This comparison shows the difference frequently observed between tertiary care units in contrast to an unselected population with high LDL-C. Moreover, physicians involved in LTAP-2 were more successful at achieving treatment goals than those not working at a lipid clinic. On the other hand, the results of ELSA-Brasil are showing the "real world" of lipid reduction treatment.

Some aspects must be considered when comparing the ELSA-Brasil findings with those of other countries.[5–16] Although access to the cholesterol test is relatively easy for ELSA-Brasil subjects, statins, by contrast, were not available free of charge from Brazilian National Health System and/or on private health insurance until few years ago during the ELSA-Brasil baseline. This fact, no doubt, explains the apparent association between LDL-C control and level of income. The program of the National Health System to cardiovascular prevention launched 15 years ago focused on diagnose and to control of hypertension and diabetes. This program provided medicines for both hypertension and diabetes, free of charge in primary care units or pharmacies but not for dyslipidemia control. The reason was that using statins, and applying NCEP-ATP-III recommendations could have added billions of dollars in cost to the National Health System. Fortunately, as the 2013 generic statins are available at primary care units and subsidized at drugstores by the National Health System.

Recent review of the cardiovascular disease new policy will permit to reduce the burden of dyslipidemia because CHD surpassed stroke as the main cause of death in Brazil.[27] To exemplify, we detected, among ELSA-Brasil subjects during the baseline that for hypertension, rates of awareness (80.2%), treatment (76.8%), and control (69.4%) were much higher than for high LDL-C. Moreover, of the 35.8% of subjects in ELSA-Brasil who had diagnostic of hypertension, 53.3 had the disease under control.[21,22] In contrast, of the 45.5% ELSA-Brasil subjects with high LDL-C, only 14% had desirable LDL-C cholesterol levels.

This study has several limitations that deserve comment. ELSA-Brasil enrolled university employees, most of them with employment stability and tenure track, a high educational achievement, and with greater access to good medical care. They were, therefore, not representative of the Brazilian population as a whole, but worse results to be expected in the general population. Nevertheless, self-reported conditions in ELSA-Brasil were similar to those obtained in a periodic surveillance survey carried out annually in the 27 state capitals of Brazil.[19] Moreover, as the prevalence of high cholesterol has been inversely related to educational attainment, it is likely to be an underestimation of the prevalence of high LDL-C, due to the underrepresentation of those with less formal education. Finally, this article does not address the impact of the ACC/AHA 2013 guidelines compared to the NCEP/ATP-III guidelines.[28] There are two reasons for this; first, our aim was to compare the Brazilian situation with other places, and the NCEP/ATP-III is still the best reference for this purpose. Second, the ACC/AHA guidelines must be evaluated against the Brazilian guidelines, which are slightly different from those of the NCEP/ATP-III, providing distinct medical decisions.[29]

Conclusion

The prevalence of high LDL-cholesterol is relatively high in Brazil compared to other populations, with undesirable rates of awareness, treatment, and control, particularly among those at very high risk of cardiovascular death. Moreover, there is an apparent inverse association between healthy lipid profile identified by LDL-C and socioeconomic status.

Acknowledgment

The authors thank the ELSA-Brasil subjects who agreed to participate in this study. The authors also thank the ELSA-Brasil research team for their contributions.

Two authors declare the following potential conflicts of interest: PAL honoraria received for speakers activities from Abbot and Abbvie. RDS honoraria received for consultation and speaker activities from Astra Zeneca, Amgen, Biolab, Boehringer-Ingelheim, Eli-Lilly, Genzyme, Jansen, Pfizer, Praxis, Sanofi/Regeneron, and Torrent.

Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jacl.2015.12.029.

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