Metabolic and inflammatory risk reduction in response to lipid-lowering and lifestyle modification in the medically underserved individuals

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A B S T R A C T

Introduction: Medically underserved (US) populations have an increased level of atherosclerotic cardiovascular disease (ASCVD) risk, however, few studies investigated ASCVD risk reduction in US.

Methods: Of 217 subjects with ApoB ≥120 mg/dL and carotid atherosclerosis (≥15% stenosis by ultrasound) enrolled in the Carotid Plaque Composition by MRI (CPC) study between 2005 and 2011, US (n=33) was defined as those without adequate healthcare insurance, while AS (n=184) included those with adequate healthcare coverage. All subjects received atorvastatin-based lipid therapies and lifestyle intervention for 2 years. Metabolic and inflammatory risk factors were compared between AS and US.

Results: At baseline, compared to AS, US displayed higher levels of metabolic and inflammatory risk including systolic blood pressure (140±27 vs. 131±18 mmHg, p=0.04), fasting glucose (125±59 vs. 102±22 mg/dL, p=0.03) and fasting insulin (39±33 vs. 28±20 μU/dL, p=0.03) which resulted in higher insulin resistance (HOMA-IR 2.2±0.4 vs. 1.3±0.1, p=0.03), and hsCRP (5.6±1.5 vs. 2.8±0.2 mg/L, p=0.03). Over 2 years of intervention, US and AS showed similar reductions in LDL-C (-10.7% vs. -16% per year, p=0.2), triglycerides (-16.7% vs. -15.9% per year, p=0.4), and hsCRP (-0.11% vs. -0.04% per year, p=0.1). However, US continued to show significantly higher levels of fasting blood glucose (115±6.0 vs. 101±2.0 mg/dL, p=0.03) and HOMA-IR (1.9±0.2 vs. 1.5±0.1, p=0.047), and hsCRP (3.9±0.7 vs. 1.9±0.2 mg/L, p<0.001) than AS following 2 years of interventions.

Conclusions: US displayed higher ASCVD risk than AS at baseline and over 2 years despite similar reductions following the intervention. These findings highlight the unmet needs for improved intervention strategies and implementation methods for ASCVD risk reduction in US.

Clinical Trial Registration: NCT00715273 at ClinicalTrials.gov
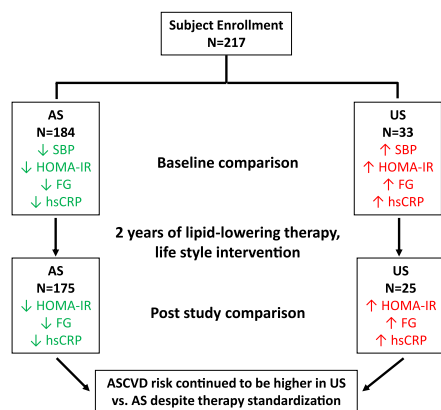
Central Illustration

1. Introduction

Atherosclerotic cardiovascular disease (ASCVD) is remains the leading cause of death in the United States, despite decreases in ASCVD rates over the past 10 years.[1] It is suggested that ASCVD has shifted from a disease of the privileged to one of the disadvantaged.[2] An estimated 7.3 million individuals living with ASCVD in the US are uninsured.[3] In addition to well-established impact of lifestyle factors on ASCVD risk, socioeconomic status and adequate healthcare coverage independently influence ASCVD risk.[4] ASCVD poses a significant health burden as an estimated 45% of individuals with ASCVD report financial hardship due to medical care costs, with the uninsured and low income displaying the highest burden.[5] Furthermore, medically underserved populations are less likely to access treatment and prevention services,[6] because ASCVD risk factors usually show no physical symptoms and are largely undetectable without regularly administered diagnostic tests.

Despite the recognition of impact of the socioeconomic status on elevated ASCVD related morbidity, mortality and financial distress, few studies examine the implementation of ASCVD risk reduction and management strategies in medically underserved populations. In our study,

we compared ASCVD-related risk reduction responses to two years of lipid and lifestyle therapies in medically underserved (US) populations compared to adequately served (AS) populations. Through this post-hoc analysis, we seek to inform future intervention methods aimed at reducing ASCVD risk equitably in individuals with varying healthcare coverage.

2. Methods

2.1. Study Population

To determine ASCVD-related metabolic and inflammatory risk and responses to lipid-lowering therapies in the US individuals comparing to their AS cohort, we analyzed data from the Carotid Plaque Composition by MRI (CPC) study,[7] a longitudinal study that monitored the change in carotid plaque morphology and composition during lipid therapy treatment. Study participants were recruited from both urban and rural regions at three locations: University of Washington in Seattle, WA, the Yakima Heart Center in Yakima, WA, and University of Southern California in Los Angeles, CA. The definition of rural and urban areas was based on 2010 RUCA codes.[8]

A total of 217 subjects with a mean age of 56 years and 60% of male were enrolled in CPC. Among these 217 study participants enrolled between 2005 and 2011, 184 were classified as AS, while 33 classified as US based on self-reported healthcare coverage. US individuals include those who reported having inadequate or a lack of healthcare insurance. AS individuals include those who reported having healthcare insurance with adequate and sufficient coverage. Specific study inclusion criteria included: 1) age <67 years for males and <70 years old for females; 2) family history of cardiovascular disease; 3) medically stable; 4) no contraindications to MRI; 5) angiographically confirmed coronary artery disease (defined as having ≥1 50% stenosis or ≥3 30% coronary lesions) or carotid disease (defined as having a ≥15% stenosis by ultrasound); 6) apolipoprotein (Apo) B ≥120 mg/dL; 7) not receiving lipid therapy >1 year prior to enrollment. All subjects received atorvastatin-based lipid therapy for 2 years and were randomized to 1 of 3 treatment groups: (1) single therapy - atorvastatin (10-80 mg per day) alone, placebos for extended release (ER) niacin and colesevelam or ezetimib; (2) double therapy – atorvastatin plus ER-niacin (2 g/day), and placebo for colesevelam or ezetimib; (3) triple therapy – atorvastatin, ER-niacin plus colesevelam (3.8 g/day) or ezetimibe (10 mg/day). The treatment target for LDL-C was ≤80 mg/dl for the single and double therapy groups and ≤60 mg/dl for the triple therapy group. The mean dose of atorvastatin received was 53 mg and 48 mg daily in the US and AS groups during the study. Additionally, subjects received dietary and lifestyle consultation using American Heart Association recommendations throughout the study period.

All study protocol and procedures received approvals of local Institutional Review Boards.

2.2. Clinical and Laboratory Measures

All subjects were followed every month for the initial 6 months of the study, and then every two months for the duration of the 2-year study period. Clinical data collected at all study visits included blood pressure, heart rate, weight, height, waist circumference, and BMI. Laboratory tests at baseline and during the study included: plasma lipids in mg/dL (total cholesterol, VLDL-C, IDL-C, LDL-C, HDL-C, triglycerides, ApoB, ApoA1, ApoE [mg/dL], and Lp(a) in nmol/L); fasting glucose levels in mg/dL, insulin in μU/dL and calculated HOMA-IR levels using a formula (HOMA-IR = fasting insulin μU/mL * fasting glucose (nmol/L) / 22.5); eGFR (mL/min/1.73m^2] was calculated based on creatinine level, age, gender and ethnicity; and white blood cell count (WBC) in k/μL and hsCRP in mg/L.

2.3. Definition of Metabolic and Inflammatory Risk

Metabolic risk was defined as hyperglycemia with fasting glucose levels > or =100 mg/dL, dyslipidemia if high apoB required by the study plus HDL-C<40 mg/dL for men and <50 mg/dL for women, and increased insulin resistance if HOMA-IR >2.9. WBC and hsCRP were used to identify inflammatory risk. In addition, we used 5 common modifiable risk factors (BMI> or =25 Kg/m^2, current smoker, type-2 diabetes mellitus, high blood pressure with SBP>140 mmHg or DBP>90 mmHg, and LDL-C>100 mg/dL) to reflect overall ASCVD risk level and room for reduction. We also collected data on treatment status for hypertension, hyperlipidemia and type-2 diabetes.

2.4. Statistical Analysis

Descriptive statistics are presented as mean ± standard error. Normality of outcomes was assessed by Q-Q plots for the mixed models. Demographic, clinical and laboratory variables were compared between US and AS using two sample t-test with a log scale transformation for unequal variances and Chi-square analysis.

Linear mixed models with random intercept and time slope were used to compare rate of changes in LDL-C, triglycerides, and C-reactive protein (hsCRP). The underserved indicator, time and their interaction were used in fixed effects modeling. Logistic mixed model with random intercept and time slope was used to compare rates of changes in the probability of 2+ risk factors. The underserved indicator, time and their interaction were used in fixed effects in modeling. Normal quantile-quantile plots of the random effects and residuals for the mixed model revealed substantial departures from normality for triglycerides and hsCRP outcomes. Therefore, the two outcomes were also analyzed on the log scale which led to less substantial departures from normality (and, thus, more valid confidence intervals and p-values). The model for LDL-C with a random effect for time had a singular fit with a 1.00 correlation between the intercept and the time slope random effects. The random effect for the time was therefore dropped. The model for 2+ risk factors with a random effect for time failed to converge. Therefore, the random effect for the time was dropped.[9]

All analyses were performed in 2019 using R. All p-values <0.05 were considered statistically significant.

3. Results

3.1. Baseline Characteristics

As described in Table 1, compared to AS, in the US group a significantly greater percentage of subjects were female (61% vs. 37%, p=0.01) and of Hispanic origin (36% vs. 8%, p<0.001). US displayed a significantly higher prevalence of diabetes (29% vs. 11%, p=0.004) and of >=3 modifiable risk factors (39% vs. 19%, p=0.009). Overall, 28% of subjects with diagnosis of hypertension, but, didn't receive any treatment. Untreated hyperlipidemia was seen in 73% and untreated diabetes was 16%. The treatment status for these 3 modifiable risk factors did not differ significantly between the US and AS groups. No statistical differences were observed in self-reported history of vascular disease including myocardial infarction, clinical diagnosed CAD, stroke or TIA.

At baseline, systolic blood pressure was on average 9 mmHg higher in the US compared to the AS group (140±27 vs. 131±18 mmgHg, p=0.04), with no differences in diastolic blood pressure between groups. Plasma lipids were not different between groups (Table 1). However, the US group showed significantly higher levels of fasting glucose (125±59 vs. 102±22 mg/dL, p=0.03) and fasting insulin (39±33 vs. 28±20 μU/dL, p=0.03), which resulted in a significantly higher HOMA-IR (2.2±0.42 vs. 1.3±0.09, p=0.03) (Fig. 1A) than the AS group. In addition, US had a significantly higher level of hsCRP (5.6±1.5 vs. 2.8±0.2 mg/L, p=0.03) (Fig. 1B) and non-statistically significant higher count of

Table 1

Comparison in clinical, metabolic and inflammatory characteristics between US and AS groups at baseline.

Number of subjects	Total n=217	US n=33	AS n=184	p-value
Age (years)	56.3±0.54	56.3±0.61	56.7±1.07	0.359
Male gender, n (%)	128 (59%)	13 (39%)	115 (63%)	**0.013**
Hispanic/Latino, n (%)	27 (12%)	12 (36%)	15 (8%)	**<0.001**
Current Smoking, n (%)	42 (19%)	9 (27%)	33 (18%)	0.211
BMI, kg/m^2	29.8±5.9	30.6±4.6	29.7±6.0	0.139
History of MI, n (%)	82 (38%)	15 (44%)	67 (36%)	0.324
Established CAD, n (%)	104 (48%)	89 (48%)	15 (45%)	0.758
History of stroke or TIA, n (%)	13 (6%)	3 (9%)	10 (5%)	0.415
Hypertension, n (%)	129 (59%)	21 (62%)	108 (59%)	0.595
Untreated hypertension, n (%)	36 (28%)	6 (29%)	30 (28%)	0.941
Hyperlipidemia, n (%)	188 (87%)	27 (82%)	161 (87%)	0.377
Untreated hyperlipidemia, n (%)	138 (73%)	16 (59.3%)	122 (75.8%)	0.072
Diabetes, n (%)	31 (14%)	10 (29%)	21 (11%)	**0.004**
Untreated diabetes, n (%)	5 (16%)	1 (10%)	4 (19%)	0.522
With ≥3 modifiable risk factors	48 (22%)	13 (39%)	35 (19%)	**0.009**
Systolic blood pressure, mmHg	133±1.4	140±4.7	131±1.4	**0.041**
Diastolic blood pressure, mmHg	80±1.0	82±2.7	80±1.0	0.301
Total cholesterol, mg/dL	219±3.5	216±10	220±3.7	0.380
VLDL-C, mg/dL	31±2.1	41±8.0	29±2.0	0.092
IDL-C, mg/dL	19±0.9	22±3.3	18±0.8	0.130
LDL-C, mg/dL	145±3.1	134±7.1	147±3.4	0.059
HDL-C, mg/dL	43±0.8	42±2.7	43±0.9	0.332
Triglycerides, mg/dL	190±9.2	216±21.0	185±10.2	0.094
ApoB, mg/dL	120±2.1	118±5.3	121±2.2	0.302
ApoA1, mg/dL	135±1.6	134±5.2	135±1.7	0.411
ApoE, mg/dL	4.8±0.2	5.5±0.8	4.7±0.1	0.183
Lp(a), nmol/L	71±5.9	67±15	72±6.5	0.396
Fasting glucose, mg/dL	106±2.2	125±10.9	102±1.6	**0.025**
Insulin level, µU/dL	30±1.5	39±5.7	28±1.5	**0.034**
HOMA-IR	1.5±0.1	2.2±0.4	1.3±0.1	**0.031**
eGFR[b], mL/min/1.73m^2	86±1.6	86±1.8	85±2.8	0.396
HsCRP, mg/L	3.2±0.3	5.6±1.5	2.8±0.2	**0.032**
WBC, k/µL	6.6±0.1	6.9±0.3	6.5±0.2	0.075

AdS, adequately served; ApoA1, apolipoprotein A-1; ApoB, apolipoprotein B; ApoE, apolipoprotein E; CAD, coronary artery disease; eGFR, estimated glomerular filtration rate; HDL-C, high density lipoprotein cholesterol; HOMA-IR, homeostatic model assessment of insulin resistance; HsCRP, high sensitivity C-reactive protein; IDL-C, intermediate density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; Lp(a), lipoprotein(a); MI, myocardial infarction; TIA, transient ischemic attack; UnS, underserved; VLDL-C, very low density lipoprotein cholesterol; WBC, white blood count.
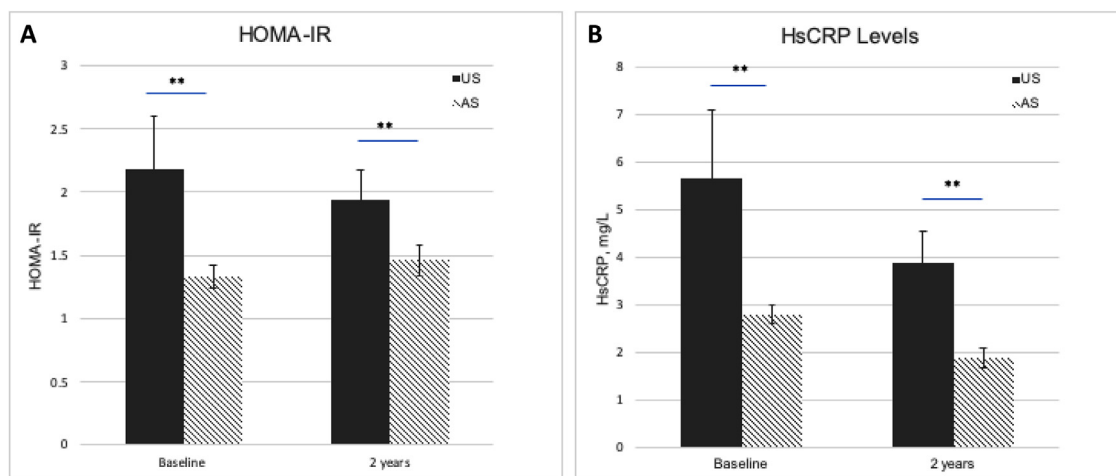
Fig. 1. A: Comparison of HOMA-IR between US and AS groups at baseline and 2 years of intensive lipid-lowering therapy. US showed significantly higher HOMA-IR than AS at baseline in mean±SE (2.2±0.42 vs. 1.3±0.09, p=0.03) and at 2 years of study therapy (1.9±0.23 vs. 1.5±0.12, p=0.047). **: p<0.05. B: Comparison of hsCRP levels between US and AS groups at baseline and 2 years of intensive lipid-lowering therapy. US displayed significantly higher levels of hsCRP than AS at both baseline in mean±SE (5.6±1.5 vs. 2.8±0.2 mg/L, p=0.03) and 2 years of lipid-lowering therapy (3.9±0.7 vs. 1.9±0.2 mg/L, p<0.001). **: p<0.05.

Table 2

Comparison in metabolic risk factors between US and AS groups following two-years of lipid-lowering therapy.

	Total	US	AS	p-value
Completion, n (%)	175 (81%)	25 (76%)	150 (82%)	0.4
Treated with double therapy, n (%)	59 (34%)	6 (24%)	53 (35%)	0.267
Treated with triple therapy, n (%)	58 (33%)	7 (28%)	51 (34%)	0.555
BMI, Kg/m^2	29.9±0.4	30.8±1.2	29.8±0.4	0.226
Systolic Blood pressure, mmHg	126±1.32	129±4.60	126±1.38	0.229
Diastolic Blood pressure, mmHg	78±0.8	80±2.9	78±0.8	0.321
Total cholesterol, mg/dL	154±3.8	155±4.2	155±7.3	0.456
Triglycerides, mg/dL	127±10.4	145±14.3	125±11.6	0.292
LDL-C, mg/dL	86±1.9	89±6.9	85±1.9	0.292
HDL-C, mg/dL	51±1.3	47±3.5	52±1.5	0.097
VLDL-C, mg/dL	19±3.3	21±2.7	19±3.7	0.315
IDL-C, mg/dL	9±0.5	11±1.9	9±0.5	0.084
ApoB, mg/dL	75±1.6	79±5.0	75±1.7	0.190
Lp(a), nmol/L	57±7.0	39±15.9	59±7.7	0.110
Fasting glucose, mg/dL	103±1.9	115±6.0	101±2.0	**0.025**
Insulin, μU/dL	32±1.6	37±3.8	31±1.7	0.102
HOMA-IR	1.5±0.1	1.9±0.2	1.5±0.1	**0.047**
eGFR, mL/min/1.73m^2	85±1.3	85±1.4	82±3.9	0.252
HsCRP, mg/L	2.1±0.2	3.9±0.7	1.9±0.2	**<0.001**
WBC, k/μL	6.5±0.2	6.8±0.4	6.4±0.2	0.168

Table 3

Annualized rates of change in lipids and hsCRP between the US and AS patients.

	US(rate per year; 95% CI)	AS(rate per year; 95% CI)	Difference, US-AS (Est. 95% CI)	p-value
LDL-C, mg/dL	-16.0 (-18.9, -13.1)	-10.7 (-18.2, -3.2)	5.3 (-2.8, 13.3)	0.201
Triglycerides, mg/dL	-15.9 (-23.5, -8.2)	-16.7 (-36.3, 2.8)	-0.9 (-20.6, 23.4)	0.935
HsCRP, mg/L	-0.042 (-0.073, -0.011)	-0.114 (-0.192, -0.034)	-0.071 (-0.156, 0.014)	0.099
>=2 risk factors (Yes vs. No)	HR=0.31 (0.21-0.43)	HR=0.57 (0.23-1.40)	HR=0.57 (0.23-1.40)	0.199

Note: Linear mixed and logistic mixed model.[9]

WBC (6.9±0.3 vs. 6.5±0.2 k/μL, p=0.07). The 2 groups showed a similar eGFR (Table 1).

3.2. Metabolic and Inflammatory Risk Following Lipid-lowering Therapy

After 2 years of lipid therapy, plasma lipids were effectively decreased among all study participants and were not different between the US and AS groups (Table 2). However, US continued to display significantly higher levels of fasting blood glucose (115±6.0 vs. 101±2.0 mg/dL, p=0.03) and HOMA-IR (1.9±0.23 vs. 1.5±0.12, p=0.047) (Fig. 1A) than AS. Also, hsCRP levels continued to be statistically higher in US (3.9±0.7 vs. 1.9±0.2 mg/L, p<0.001) (Fig. 1B). Furthermore, the US group displayed a non-significant lower study completion rate compared to AS over 2 years (76% vs. 82%, p=0.4) and lower percentages of subjects stayed on double or triple combination lipid therapies (Table 2).

Table 3 demonstrates the annualized rates of changes in LDL-C, triglycerides, hsCRP and the number of subjects with >=2 modifiable risk factors. On average per year, the US group displayed a 5.3% greater decrease in LDL-C (p=0.2), 0.9% greater increase in triglycerides (p=0.4), and 0.07% greater increase in hsCRP (p=0.1) compared to the AS group. Given the study provided intensive lipid therapy on dyslipidemia, 2 or more modifiable risk factors, instead of 3 or more, was used to compare risk following the intervention between the 2 groups; this showed a non-statistically significant difference in change of this ASCVD risk status between US and AS (Table 3).

Detailed data on response of metabolic and inflammatory risk factors to 2 years of lipid-lowering by medically served status and therapy groups are presented in supplemental Table.

In addition, the US group showed a trend of progression over 2 years in maximum carotid wall thickness (4.4% vs. -1.3%, p=0.2) and percent wall volume (0.08% vs. -0.5%, p=0.057) compared to regression in the AS group.

4. Discussion

To address ASCVD risk reduction responses in populations with inadequate access to medical care, we compared changes in ASCVD-related metabolic and inflammatory risk between US and AS individuals in response to two-years of lipid lowering pharmacological therapy and lifestyle intervention in the CPC study. We found: (1) US individuals displayed higher levels of metabolic and inflammatory risk including systolic blood pressure, fasting glucose and fasting insulin which resulted in higher insulin resistance, and hsCRP at baseline compared to AS (Table 1). (2) US group had similar reductions in LDL-C, triglycerides and hsCRP over 2 years of intensive lipid-lowering therapy and lifestyle intervention compared to AS (Fig. 1 and Table 3). (3) Despite similar responses to the study therapies, US continued to show significantly higher levels of fasting blood glucose, insulin resistance and hsCRP than AS following the two-year intervention (Fig. 1 and Table 2).

Undoubtably, access to adequate healthcare improves reduces cardiovascular disease risk and improves outcomes[6]. Upon Medicaid expansion provided by the Affordable Care Act (ACA), cardiovascular-related mortality in non-elderly patients decreased 2 years after implementation by 4.3 deaths per 100,000 compared to incidences 3 years prior to implementation in expansion states [10]. Reduced access to care, reduced health literacy, and decreased compliance to lifestyle-based interventions increase cardiovascular disease risk in medically underserved populations [11]. Findings from the Framingham Heart Study and the National Health and Nutrition Examination Surveys (NHANES) highlight the importance of health insurance coverage on ASCVD risk and risk reduction. Within NHANES survey participants, uninsured adults displayed higher LDL and lower HDL cholesterol levels and were less likely to control hypercholesterolemia compared to those on public or private insurance [12]. Among adults ages 19 to 64 years enrolled in the Framingham Heart Study, uninsured men also dis-

played higher levels of LDL cholesterol, despite no statistical differences in 10-year Framingham risk score or metabolic syndrome. Following treatment in this cohort, uninsured men and women were less likely to achieve blood pressure control (odds ratio: 0.19 and 0.31, respectively) and men were less likely to achieve control of hyperlipidemia (odds ratio 0.17) [25]. Similar reports are observed in minority-specific populations, where Latino/Hispanic adults without health insurance display elevated fasting blood glucose and HbA1c levels compared to those with health insurance [13]. These findings are of concern as disease burden is also elevated in uninsured groups. For example, the microvascular complications of type 2 diabetes are higher in those without adequate healthcare coverage [14]. In addition, lack of healthcare coverage is highest among minority groups [15]. In our study, 8% of AS vs. 36% of US were classified as Hispanic/Latino origin, respectively. The difference in ethnic distribution between AS and US groups in our study may have contributed to observed differences in baseline ASCVD risk[16,17].[ ] Hispanics and African-Americans have been reported to show higher levels of metabolic risk [18]. and display elevated hsCRP levels relative to Whites after adjusting for socioeconomic factors[19]

A likely contributing factor contributing to increased ASCVD risk and reduced ASCVD control in uninsured groups is access to care [12]. A handful of studies in the United States have shown that interventions targeting risk reduction are effective in medically underserved populations. The WISEWOMAN project investigated the effects of an ASCVD risk reduction program in uninsured woman and observed a combined physical activity and nutritional intervention reduced the incidence of death during the monitoring period [20]. In another study examining the effects of a pharmacist-led diabetes management program, medically underserved minorities displayed improvements in HbA1C, triglyceride and BMI [21]. In a more recent study, nurse management, but not a telehealth intervention, reduced Framingham risk scores in medically underserved rural and urban populations [22]. Our study demonstrated that US group has similar responses to intensive lipid-lowering and lifestyle interventions compared to their AS cohorts. Together these findings suggest interventions targeting ASCVD risk reduction are effective in medically underserved populations, but more comprehensive interventions including lifestyle intervention and medical therapies for management of blood pressure, lipids and diabetes and effective implementation strategies to achieve maximum reduction in ASCVD risk are needed.

Moreover, our study also demonstrated that despite similar responses to the study therapies, US continued to show significantly higher levels of fasting blood glucose, insulin resistance and hsCRP than AS following 2 years of lipid-lowering and lifestyle interventions. The higher baseline risk may require more aggressive treatment regimens to equitably reduce ACSVD risk. In a diabetes management study of medically underserved individuals, those with higher baseline glucose displayed more difficulty in determining insulin requirements to manage their blood glucose levels [23]. It is therefore important to establish baseline physiological, socioeconomic and behavioral risk factors to develop targeted interventions. Future studies are needed to examine the targeted interventions and longer duration for the US populations.

5. Limitations

The definitions of US and AS in our study were based on self-reported healthcare coverage which is subjective. Despite a sample size of 217 subjects at baseline, the number in the US cohort is small in proportion to AS. Nevertheless, the smaller US cohort displayed a significant different risk profile and similar response to therapy compared to AS. In addition, the 7 AHA cardiovascular health factors, including smoking, nutrition, physical activity, body weight, blood pressure, cholesterol, and blood sugar, were not collected completely [24]. Future large prospective interventional trials are needed for implementing established effective ASCVD risk reduction strategies in the US populations.

6. Conclusions

The medically underserved individuals displayed an increased AS-CVD risk and demonstrated similar improvements in lipids and inflammatory risk as response to intensive lipid-lowering therapy. Despite similar improvements, the medically underserved group continued to display elevated ASCVD risk with higher levels of fasting glucose and hsCRP following therapy compared to the adequately served. These findings highlight unmet needs, warranting more comprehensive ASCVD risk reduction and targeted implementation strategies to successfully reduce ASCVD risk among the underserved populations.

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Authorship statement

Michael Chu and Gina Many wrote the manuscript. Daniel Isquith and Susan McKeeth performed data collection. Jayne Williamson performed life style modifications. Moni B Neradilek performed statistical analysis. Patrick Colletti supported the study activities conducted at USC. Xue-Qiao Zhao was responsible for overall study design, funding and interpretation of the study results. All authors read and approved the final manuscript.

Declaration of Competing interest

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ajpc.2021.100227.

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