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ORIGINAL RESEARCH

Triglyceride Levels and Residual Risk of Atherosclerotic Cardiovascular Disease Events and Death in Adults Receiving Statin Therapy for Primary or Secondary Prevention: Insights From the KP REACH Study

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BACKGROUND: Patients with risk factors or established atherosclerotic cardiovascular disease remain at high-risk for ischemic events. Triglyceride levels may play a causal role.

METHODS AND RESULTS: We performed a retrospective study of adults aged ≥45 years receiving statin therapy, with a low-density lipoprotein cholesterol of 41 to 100 mg/dL, and ≥1 risk factor or established atherosclerotic cardiovascular disease between 2010 and 2017. Outcomes included death, all-cause hospitalization, and major adverse cardiovascular events (myocardial infarction, stroke, or peripheral artery disease). The study sample included 373 389 primary prevention patients and 97 832 secondary prevention patients. The primary prevention cohort had a mean age of 65±10 years, with 51% women and 44% people of color, whereas the secondary prevention cohort had a mean age of 71±11 years, with 37% women and 32% people of color. Median triglyceride levels for the primary and secondary prevention cohorts were 122 mg/dL (interquartile range, 88–172 mg/dL) and 116 mg/dL (interquartile range, 84–164 mg/dL), respectively. In multivariable analyses, primary prevention patients with triglyceride levels ≥150 mg/dL were at lower adjusted risk of death (hazard ratio [HR], 0.91; 95% CI, 0.89–0.94) and higher risk of major adverse cardiovascular events (HR, 1.14; 95% CI, 1.05–1.24). In the secondary prevention cohort, patients with triglyceride levels ≥150 mg/dL were at lower adjusted risk of death (HR, 0.95; 95% CI, 0.92–0.97) and higher risk of all-cause hospitalization (HR, 1.03; 95% CI, 1.01–1.05) and major adverse cardiovascular events (HR, 1.04; 95% CI, 1.05–1.24).

CONCLUSIONS: In a contemporary cohort receiving statin therapy, elevated triglyceride levels were associated with a greater risk of atherosclerotic cardiovascular disease events and lower risk of death.

Key Words: atherosclerotic cardiovascular disease ■ mortality ■ risk stratification ■ triglycerides

Patients with risk factors for or established atherosclerotic cardiovascular disease (ASCVD) remain at high risk for incident and/or recurrent nonfatal and fatal ASCVD events.[1,2] Observational studies and randomized controlled trials have consistently demonstrated that individuals with low levels of low-density

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CLINICAL PERSPECTIVE

What Is New?

- Triglyceride levels decreased with age and were lower in non-Hispanic Black patients and higher in Hispanic and Asian/Pacific Islander patients compared with non-Hispanic White patients.
- Elevated triglyceride levels were associated with increased risk of major adverse cardiovascular events and decreased risk of death in patients with risk factors or established atherosclerotic cardiovascular disease.

What Are the Clinical Implications?

- Triglycerides function as a surrogate of atherosclerotic cardiovascular disease risk, as well as a biomarker of nutritional status, and additional risk-reduction strategies are needed to further improve outcomes.

Nonstandard Abbreviations and Acronyms

KPNC	Kaiser Permanente Northern California
MACE	major adverse cardiovascular events

lipoprotein cholesterol (LDL-C) on or off lipid-lowering therapy are at lower lifetime risk of subsequent acute myocardial infarction, ischemic stroke/transient ischemic attack, or death due to ASCVD.[3–5] However, even among patients who are treated with lipid-lowering therapies and have an LDL-C that is below the current guideline-recommended goal, residual risk for ASCVD events persists in many patients.[6,7]

There is accumulating evidence that triglyceride-rich lipoprotein cholesterol may contribute to residual risk and play a causal role in atherogenesis.[8–10] Despite this growing recognition, contemporary randomized controlled trials and meta-analyses of medications that reduce triglyceride levels (ie, fibrates, extended-release niacin, and supplements containing mixtures of omega-3 fatty acids) have not found incremental benefit in patients receiving statin therapy.[11–15] In contrast, a more recent study found that high-dose icosapent ethyl decreased the risk of various nonfatal and fatal ischemic end points in patients with elevated triglyceride levels and either diabetes with ASCVD risk factors or established ASCVD independent of baseline triglyceride levels and irrespective of the triglyceride level attained on treatment.[16–20]

The proportion of patients with ASCVD risk factors or established ASCVD who are potentially eligible for additional risk reduction strategies has not been well-defined in a real-world, ethnically diverse, and generalizable population.[21–23] Thus, the primary objective of the KP REACH (Kaiser Permanente Residual Risk by Ethnicity, Sex, and Age in a Statin-Treated Cohort) study was to better understand the extent of age-, sex-, and race/ethnicity-related variation in the distribution of triglyceride levels and the association between triglyceride levels and subsequent outcomes in a large, contemporary, and diverse population receiving statin therapy, with a well-controlled LDL-C, and with ≥1 ASCVD risk factors (ie, primary prevention cohort) or established ASCVD (ie, secondary prevention cohort).

METHODS

Source Population

Kaiser Permanente Northern California (KPNC) is a large integrated healthcare delivery system with 21 hospitals and >255 freestanding clinics where approximately 4.5 million members receive comprehensive care (ie, inpatient, emergency department, and ambulatory encounters). KPNC membership is highly representative of the local and statewide population with respect to age, sex, race/ethnicity, and socioeconomic status.[24–26] This study was approved by the KPNC institutional review board, and a waiver of informed consent was obtained due to the nature of the study.

Study Sample

The study population included all health-plan members aged ≥45 years who were receiving statin therapy, with a well-controlled LDL-C (ie, defined as 41–100 mg/dL), and had ≥1 ASCVD risk factors (ie, primary prevention cohort) or established ASCVD (ie, secondary prevention cohort) between January 1, 2010 and December 31, 2017. ASCVD risk factors included diabetes, older age (ie, ≥55 years for men or ≥65 years for women), tobacco use, hypertension with or without treatment, reduced high-density lipoprotein cholesterol (ie, <40 mg/dL for men or <50 mg/dL for women), estimated glomerular filtration rate <60 mL/min per 1.73 m^2, retinopathy, or micro- or macroalbuminuria (ie, based on a spot sample or 24-hour urine collection). Established ASCVD was determined using *International Classification of Disease, Ninth or Tenth Revision* (*ICD-9/10*) or *Current Procedural Terminology* (*CPT*) codes for coronary artery disease (ie, defined as prior myocardial infarction, percutaneous coronary intervention, and/or coronary artery bypass grafting), ischemic stroke/transient ischemic attack, or peripheral artery disease. Index date was defined as the date all eligibility criteria were met (ie, age, statin use, target LDL-C, and ≥1 ASCVD risk factor or established ASCVD). Patients were excluded who had unknown sex, <12 months of prior membership or drug benefit,

a known noncardiovascular life-limiting diagnosis (ie, metastatic cancer, receiving chronic dialysis, and/or liver cirrhosis), prior organ transplant, or no outpatient triglyceride measured within 2 years before the index date.

Covariates

KPNC's state-of-the-art Virtual Data Warehouse served as the primary data source for subject identification and characterization.[27,28] The Virtual Data Warehouse is a standardized data resource composed of electronic data sets that is populated with individually linked demographic, administrative, outpatient pharmacy, laboratory test results, and healthcare use (ie, ambulatory visits and network and nonnetwork hospitalizations with diagnoses and procedures) data for all KPNC members. All data were abstracted at the time point closest to the index date (ie, qualification for the primary or secondary prevention cohorts).

Demographic information including age, sex, and self-reported race/ethnicity was obtained from electronic health records. Comorbid conditions were ascertained within 5 years before the index date. Laboratory results, including triglyceride levels, were all obtained from a nonemergency, ambulatory setting (ie, including fasting and nonfasting measurements) within 2 years before index date. Baseline medication use was based on dispensed prescriptions within 120 days before the index date using health-plan pharmacy databases.

Follow-Up and Outcomes

Follow-up occurred through December 31, 2018 with censoring because of disenrollment from the health plan or end of study follow-up. Disenrollment was defined as a continuous membership gap of 45 days or longer. Outcomes of interest included all-cause death, all-cause hospitalization, major adverse cardiovascular events (MACE) (ie, defined as myocardial infarction, ischemic stroke, or peripheral artery disease), and expanded MACE (ie, defined as MACE, coronary revascularization, or hospitalization for unstable angina). Myocardial infarction, ischemic stroke, and revascularization procedures (ie, coronary, cerebrovascular, and/or peripheral) were ascertained using *ICD-9/10* or *CPT* codes, including any that occurred at nonnetwork hospitals.[29–34] These diagnostic and procedural codes for end points resulting in hospitalization have been validated in multiple healthcare delivery systems, and previous studies have demonstrated a positive predictive value of ≥95% when compared against the gold standard of manual chart review and adjudication by a board-certified physician using clinical criteria. Death was comprehensively identified from health-plan administrative databases, hospitalization and billing claims databases, state death certificate files, and Social Security Administration vital status files using previously described methods.[29,35]

Statistical Analysis

All analyses were performed using SAS software version 9.4 (SAS Institute, Cary, NC), and the analyses are described separately for the primary and secondary prevention cohorts. A 0-sided P value of <0.05 was considered statistically significant. Descriptive characteristics are presented as mean with standard deviation, median with interquartile range (IQR), and frequency with percentage. Descriptive characteristics were compared using ANOVA or Wilcoxon rank sum test for continuous variables and χ^2 test for categorical variables. Rates for outcomes are presented as number of outcomes per 100 person-years with associated 95% CIs. Because there were no obvious visual cutoffs of triglyceride where a substantial increase was observed in event rates, a cutoff of ≥150 mg/dL was selected based on generally accepted clinical/laboratory criteria[11–20] to examine the associations between triglyceride levels and adverse outcomes. After confirming no violation in the proportional hazards assumption using visual inspection of the Martingale residuals and the Kolmogorov-Smirnov test, multivariable Cox regression models were performed to examine the independent association between triglyceride and each of the outcomes of interest. For both the primary and secondary prevention cohorts, adjustment was performed for age, sex, race/ethnicity, heart failure, atrial fibrillation/flutter, dyslipidemia, hypertension, diabetes, chronic kidney disease, chronic lung disease, chronic liver disease, thyroid disease, dementia, depression, smoking status, systolic blood pressure, albuminuria, LDL-C, anticoagulants, antiplatelets, antihypertensives, and lipid-lowering therapy other than statins. Finally, additional analyses were performed to assess for potential interaction between key subgroups of interest (ie, age, sex, race/ethnicity, and diabetes) and the adjusted associations between triglyceride levels and outcomes.

Funding and Article Preparation

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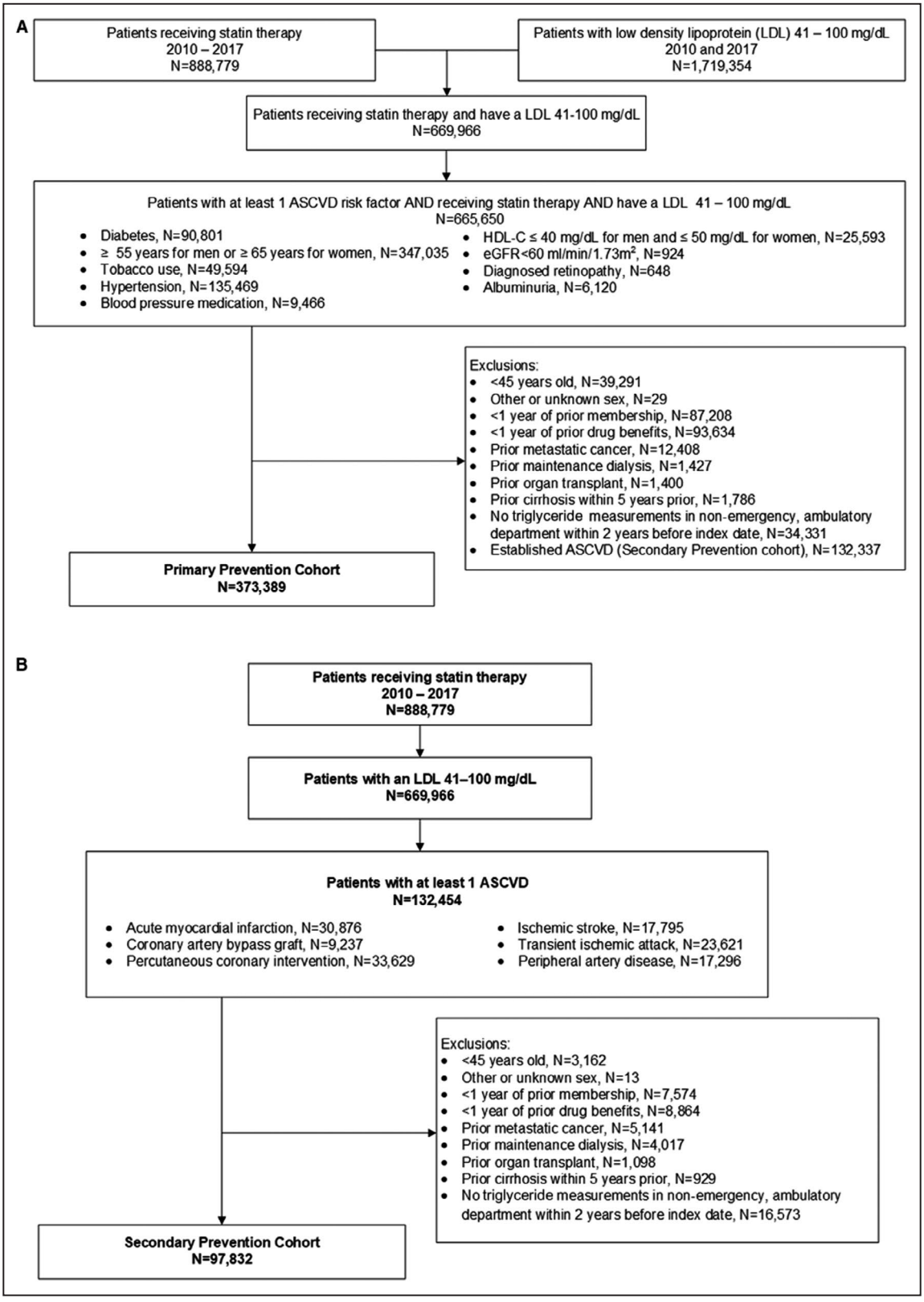

Figure 1. Assembly of the (A) primary prevention cohort and (B) secondary prevention cohort.
ASCVD indicates atherosclerotic cardiovascular disease; eGFR, estimated glomerular filtration rate; HDL, high-density lipoprotein cholesterol.

Table 1. Baseline Characteristics of the Primary and Secondary Prevention Cohorts

Characteristics	Overall primary prevention cohort n=373 389	Overall secondary prevention cohort n=97 832
Age, y, mean (SD)	64.8 (10.4)	70.5 (11.1)
Women, n (%)	189 187 (50.7)	36 600 (37.4)
Self-reported race/ethnicity		
Non-Hispanic White	210 004 (56.2)	64 972 (66.4)
Non-Hispanic Black	25 903 (6.9)	6688 (6.8)
Hispanic	56 127 (15.0)	12 270 (12.5)
Asian/Pacific Islander	72 002 (19.3)	12 798 (13.1)
Unknown	9353 (2.5)	1104 (1.1)
Tobacco use, n (%)		
Current	86 056 (23.0)	30 444 (31.1)
Former	70 757 (18.9)	27 357 (28.0)
Never	216 576 (58.0)	40 031 (40.9)
Medical history, n (%)		
Heart failure	12 059 (3.2)	12 053 (12.3)
Hypertension	315 926 (84.6)	89 795 (91.8)
Dyslipidemia	372 914 (99.9)	97 687 (99.9)
Atrial fibrillation and/or flutter	19 448 (5.2)	15 619 (16.0)
Chronic kidney disease	67 484 (18.1)	31 406 (32.1)
Albuminuria	99 534 (26.7)	40 978 (41.9)
Chronic obstructive pulmonary disease	73 375 (19.7)	25 228 (25.8)
Chronic liver disease	13 224 (3.5)	3174 (3.2)
Hyperthyroidism	13 543 (3.6)	3797 (3.9)
Hypothyroidism	53 036 (14.2)	15 192 (15.5)
Dementia	7693 (2.1)	4421 (4.5)
Depression	52 725 (14.1)	16 415 (16.8)
Diabetes	162 198 (43.4)	38 072 (38.9)
Baseline medication use, n (%)		
Aldosterone receptor antagonist	3254 (0.9)	2269 (2.3)
α-Blocker	21 681 (5.8)	9177 (9.4)
Angiotensin-converting enzyme inhibitor or angiotensin II receptor blocker	198 592 (53.2)	64 959 (66.4)
Antiarrhythmic agent	4686 (1.3)	4226 (4.3)
Anticoagulant	17 582 (4.7)	12 570 (12.9)
Antiplatelet agent (other than aspirin)	5690 (1.5)	27 621 (28.2)
β-Blocker	124 080 (33.2)	66 423 (67.9)
Calcium channel blocker	69 870 (18.7)	25 278 (25.8)
Digoxin	4909 (1.3)	3208 (3.3)
Diuretic	139 460 (37.4)	39 593 (40.5)
Hydralazine	5141 (1.4)	4267 (4.4)
Nitrate	9655 (2.6)	22 463 (23.0)
Any antihypertensive agent	264 978 (71.0)	87 517 (89.5)
Nonstatin lipid-lowering agent	18 927 (5.1)	6712 (6.9)
Bile acid binding agent	1089 (0.3)	521 (0.5)
Ezetimibe	2330 (0.6)	1232 (1.3)
Fibrate	13 310 (3.6)	3684 (3.8)
Niacin	2879 (0.8)	1607 (1.6)
PCSK-9 inhibitor	5 (0.0)	6 (0.0)
Oral diabetes medication	128 689 (34.5)	31 032 (31.7)
Insulin	29 260 (7.8)	12 900 (13.2)
Body mass index, kg/m^2, mean (SD)	29.4 (6.0)	28.4 (5.6)
Blood pressure, mm Hg, mean (SD)		
Systolic	127 (15)	127 (18)
Diastolic	73 (10)	70 (11)
Baseline laboratory values, median (IQR)		
Estimated glomerular filtration rate, mL/min per 1.73 m^2	81 (66–93)	71 (56–85)
High-density lipoprotein, mg/dL	48 (41–58)	45 (38–55)
Low-density lipoprotein, mg/dL	83 (71–93)	77 (64–89)
Total cholesterol, mg/dL	161 (144–177)	151 (133–171)
Triglycerides, mg/dL	122 (88–172)	116 (84–164)

IQR indicates interquartile range; and PCSK-9, proprotein convertase subtilisin/kexin type 9.

RESULTS

Cohort Assembly

A total of 888 779 patients receiving statin therapy were initially identified (Figure 1). Among this starting population, 665 650 (75%) patients had an LDL-C between 41 and 100 mg/dL and either ≥1 ASCVD risk factors or established ASCVD. After exclusions were applied, the final analytical cohort included 373 389 patients in the primary prevention cohort and 97 832 in the secondary prevention cohort. Within the secondary prevention cohort, 58% qualified based on coronary artery disease, 30% qualified based on ischemic stroke/transient ischemic attack, and 12% qualified based on peripheral artery disease.

Baseline Characteristics

The primary prevention cohort had a mean±SD age of 65±10 years, with 51% women and 41% non-White patients, including 7% non-Hispanic Black, 15% Hispanic, and 19% Asian/Pacific Islander patients (Table). The prevalence of diabetes was 43%, and 85% had hypertension, but the remaining major cardiac and noncardiac comorbidities were present in <25%

of patients. The baseline use of antihypertensives was 71%, and nonstatin lipid-lowering therapy was 5%, and most commonly included a fibrate and/or niacin.

In contrast, the secondary prevention cohort was older with a mean±SD age of 71±11 years, and included a lower proportion of women, and tended to be less ethnically diverse but still included 7% non-Hispanic Black, 13% Hispanic, and 13% Asian/Pacific Islander patients (Table). The prevalence of cardiac and noncardiac comorbidities in the secondary prevention cohort was comparatively higher and included 92% hypertension, 16% atrial fibrillation/flutter, 32% chronic kidney disease, 39% diabetes, and 26% chronic obstructive pulmonary disease. The baseline use of antihypertensives was 90%, antiplatelet agents other than aspirin was 28%, and nonstatin lipid-lowering therapy was 7%.

Triglyceride Levels

Median triglyceride levels for the primary versus secondary prevention cohorts were 122 mg/dL (IQR, 88–172 mg/dL) and 116 mg/dL (IQR, 84–164 mg/dL), respectively (Table, Figure 2). In general, for both the primary and secondary prevention cohorts, triglyceride levels decreased and the IQR narrowed with increasing age despite their being smaller sample sizes in older age groups (P<0.0001 for both comparisons) (Figure S1). Women had slightly higher median triglyceride levels than men for the primary prevention (122 [IQR, 90–169] mg/dL versus 121 [IQR, 86–175] mg/dL, P=0.04) and secondary prevention (median 119 [IQR, 87–165] mg/dL versus 114 [IQR, 82–163] mg/dL, P<0.0001) cohorts that reached the threshold for statistical significance (Figure S2). Compared with non-Hispanic White patients, non-Hispanic Black patients had lower and Hispanic and Asian/Pacific Islander patients had higher TG levels for both the primary and secondary prevention cohorts (P<0.0001) (Figure S3).

Unadjusted Outcomes and Multivariable Models

During median follow-up of 5.9 years (IQR, 3.0–8.3 years) in the primary prevention cohort, 8% died, 28% were hospitalized, 1% experienced a MACE, and 1% experienced an expanded MACE. After adjustment for potential confounders, patients in the primary prevention cohort with triglyceride levels ≥150 mg/dL were at lower risk of death and higher risk of MACE and expanded MACE compared with patients with triglyceride levels <150 mg/dL (Figure 3). These findings were largely consistent across prespecified subgroups including age, sex, race/ethnicity, and diabetes status.

During median follow-up of 4.5 years (IQR, 2.3–7.3 years) in the secondary prevention cohort, 23% died, 52% were hospitalized, 14% experienced a MACE,

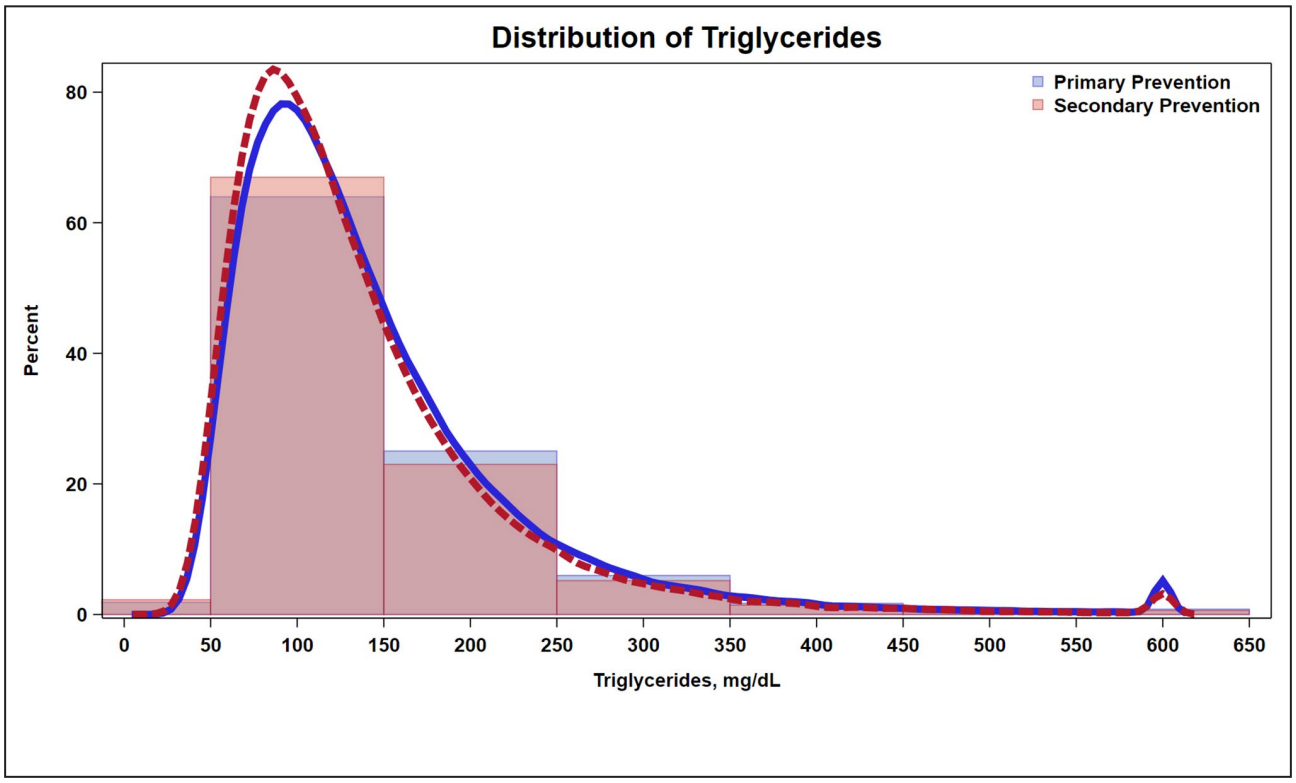

Figure 2. The distribution of triglycerides for the primary and secondary prevention cohorts.
Blue and red lines are smoothed density curves of the bars that represent primary prevention and secondary prevention.

and 24% experienced an expanded MACE. After adjustment for potential confounders, patients in the secondary prevention cohort with triglyceride levels ≥150 mg/dL were at lower risk of death and higher risk of all-cause hospitalization, MACE, and expanded MACE compared with patients with triglyceride levels <150 mg/dL (Figure 4). Again, these findings were largely consistent across prespecified subgroups including age, sex, race/ethnicity, and diabetes status.

DISCUSSION

We found that approximately three-quarters of studied primary and secondary prevention patients receiving statin therapy had a well-controlled LDL-C (ie, 41–100 mg/dL). Secondary prevention patients tended to be older, men, less racially/ethnically diverse, had a higher prevalence of comorbidities, and experienced substantially higher rates of morbidity and mortality than primary prevention patients. In general, triglyceride levels decreased with age and were lower in non-Hispanic Black patients and higher in Hispanic and Asian/Pacific Islander patients compared with non-Hispanic White patients. Finally, elevated triglyceride levels were associated with increased risk of MACE and expanded MACE and decreased risk of all-cause death in both the primary and secondary prevention cohorts.

Only ~30% to 35% of statin-treated patients in our population had a triglyceride level ≥150 mg/dL and would therefore be potentially eligible for currently available additional cardioprotective medications and emerging pharmacotherapies intended for this target population. However, patients remained at high residual risk of ASCVD events despite achieving a well-controlled LDL-C on statin therapy and a relatively low prevalence of hypertriglyceridemia, underscoring the importance of a global assessment of ASCVD risk. As expected, despite treatment with statins, patients with established ASCVD have a substantially higher rate of ASCVD events compared with those with only ASCVD risk factors. Thus, in the absence of strong risk-enhancing features (ie, clinical characteristics, biomarkers, and/or imaging findings), there may be more limited opportunity for further risk reduction in the setting of primary prevention given the low background ischemic event rate seen in a contemporary on-treatment population.[36]

Among patients receiving statin therapy with a well-controlled LDL-C, the median triglyceride level was lower and the distribution narrower compared with historical cohorts, which tend to be younger,

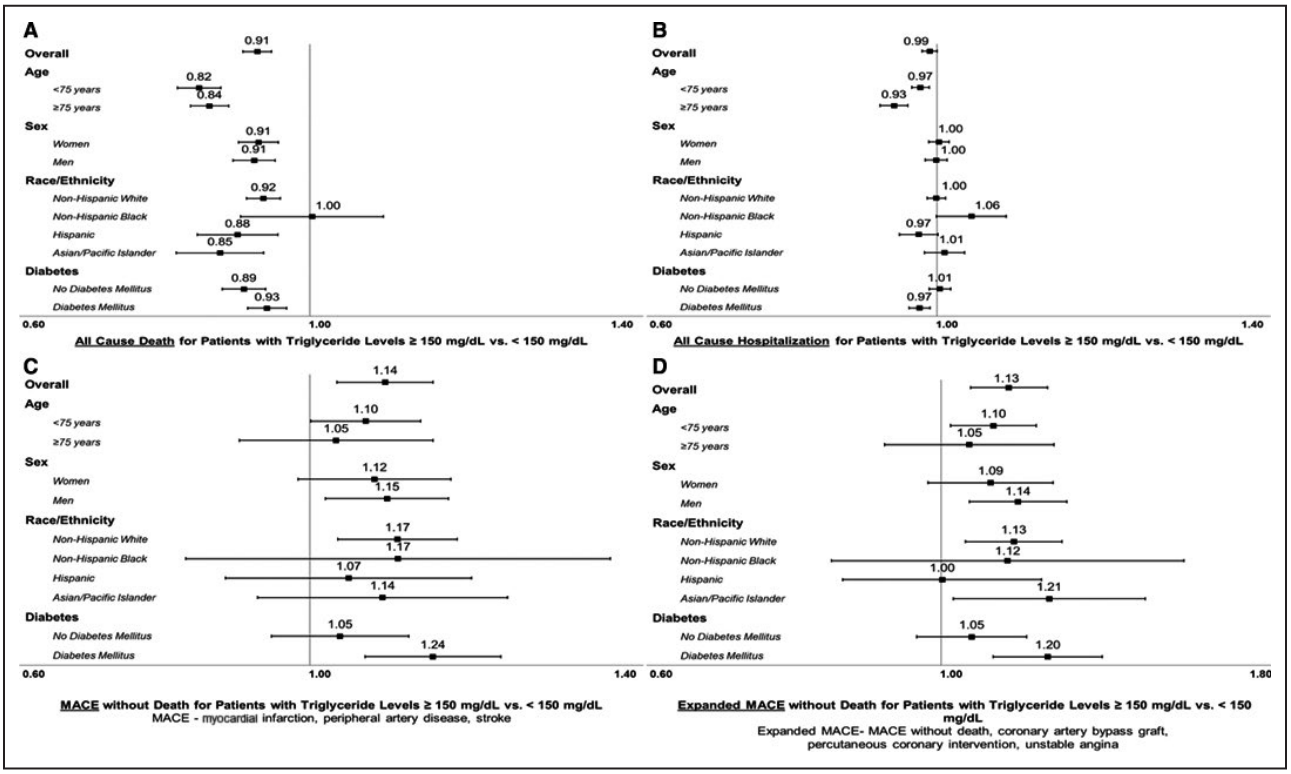

Figure 3. Adjusted hazard ratios (95% confidence limits) of those with triglyceride levels ≥150 mg/dL vs <150 mg/dL for the outcomes of (A) death due to any cause, (B) all-cause hospitalization, (C) major adverse cardiovascular events (MACE), and (D) expanded MACE overall and for prespecified subgroups for the primary prevention cohort.
The squares represent the adjusted hazard ratios and the bars represent the confidence intervals.

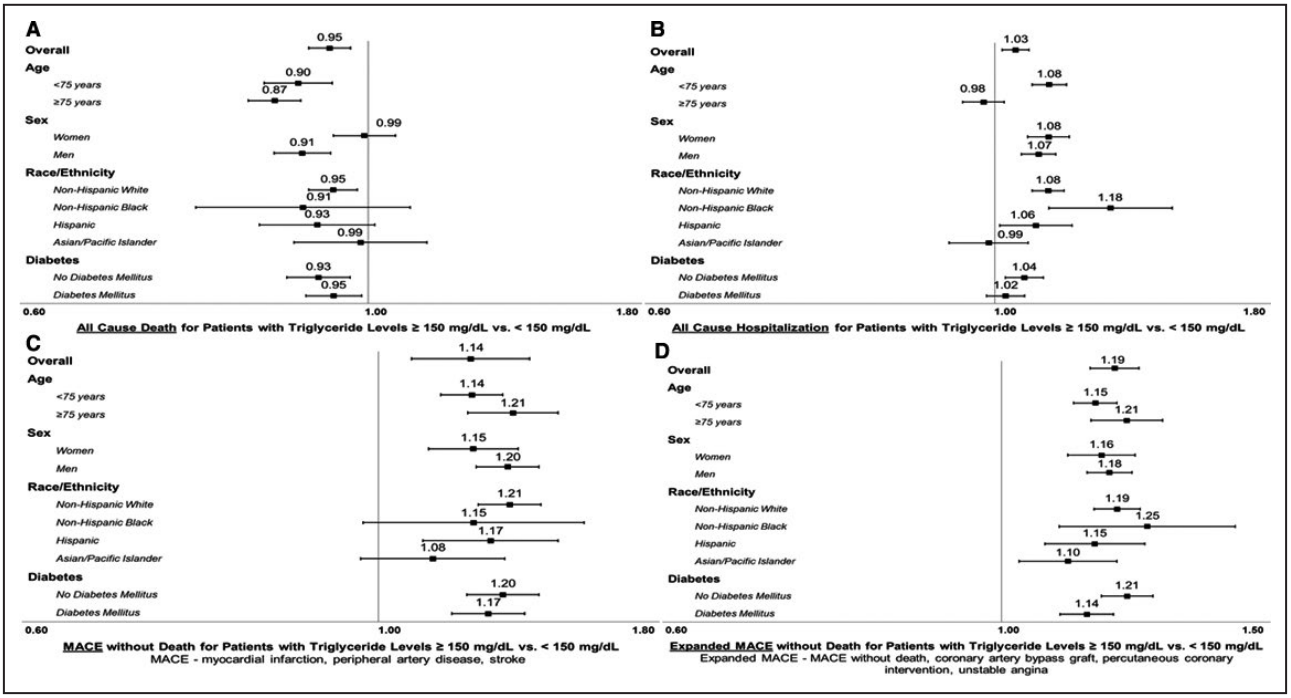

Figure 4. Adjusted hazard ratios (95% confidence limits) of those with triglyceride levels ≥150 mg/dL vs <150 mg/dL for the outcomes of (A) death due to any cause, (B) all-cause hospitalization, (C) major adverse cardiovascular events (MACE), and (D) expanded MACE overall and for prespecified subgroups for the secondary prevention cohort.
The squares represent the adjusted hazard ratios and the bars represent the confidence intervals.

predominantly primary prevention, and treatment naïve (ie, low prevalence of statin use).[37,38] In addition, there was not a clinically significant between-group difference in median triglyceride levels in patients treated for primary versus secondary prevention. Increasing age was associated with lower median triglyceride levels but is a well-established risk factor for ASCVD events, suggesting that triglyceride levels may be less informative in guiding medical decision-making in older adults. This study also confirms that non-Hispanic Black patients receiving statin therapy have substantially lower triglyceride levels compared with non-Hispanic White patients.[39,40] Of note, although Black patients are more likely to present with lower triglyceride levels in combination with a higher high-density lipoprotein cholesterol, they are known to experience disproportionately higher rates of diabetes, hypertension, and ASCVD.[39,40] In contrast, we observed higher triglyceride levels in Hispanic and Asian/Pacific Islander patients receiving statin therapy, which has previously been hypothesized to explain the earlier onset and greater burden of ASCVD-related morbidity and death in these groups.[41,42]

Most importantly, this study highlights the critical importance of interpreting triglyceride levels in the context of background lipid-lowering therapy (ie, on versus off treatment) and with respect to the outcome of interest (ie, all cause versus ASCVD related). Notably, we found that elevated triglyceride levels were associated with a greater risk of initial and/or recurrent ASCVD events in both the primary and secondary prevention cohorts, and that the effect was largely consistent across prespecified subgroups including age, sex, race/ethnicity, and diabetes status. In contrast, despite ASCVD being a leading cause of death nationally, we found that elevated triglyceride levels were associated with a lower risk of all-cause mortality in both the primary and secondary prevention cohorts. In this older population receiving statin therapy, it is likely that in addition to playing a putative causal role in atherogenesis and risk of clinical ASCVD events, lower triglyceride level may reflect poorer nutritional status. In aggregate, these data are congruent with current guideline recommendations suggesting that medical decision-making for existing and emerging cardioprotective medications should be based on a global assessment of ASCVD risk including, but not limited to, individual lipoprotein components as well as the overall lipid profile.

Our study had several limitations. First, triglyceride levels were obtained from outpatient, nonemergency-department settings within the previous 2 years and included both fasting and nonfasting lipid panels. Although this baseline measurement was not collected on the assigned index date (ie, qualification for the primary or secondary prevention cohorts) or at a standardized time point, only ~5% to 10% of patients

had to be excluded from the final analytical cohort for a missing baseline triglyceride level, enhancing the generalizability of this study. Second, race/ethnicity was self-reported and certain subgroups (ie, Native American patients) were underrepresented, but ~30% to 40% of the final analytical cohorts included people of color, which is highly representative of the diverse Northern California population. Third, patients were required to be receiving statin therapy on the index date, but the multivariable models were not adjusted for longitudinal data based on serial pharmacy dispensing. However, it is not clear that pharmacy prescription data are a reliable indicator for medication adherence. Fourth, data on cause of death were not available, and therefore the relationship between triglyceride levels and cause-specific mortality could not be assessed. However, cause of death is notoriously difficult to ascertain, and this study included a range of outcomes including ASCVD events. Finally, because the study was focused on patients receiving statin therapy with a well-controlled LDL-C, our findings may not be applicable to patients off treatment and/or with a poorly controlled LDL-C.

In a diverse and contemporary cohort of patients receiving statin therapy for primary or secondary prevention and having a well-controlled LDL-C, ~65% to 70% of patients had a triglyceride level within normal limits (ie, triglyceride <150 mg/dL). Elevated triglyceride levels were associated with increased risk of initial and/or recurrent ASCVD events and decreased risk of all-cause mortality in both the primary and secondary prevention cohorts, suggesting that triglyceride function as both a surrogate of ASCVD risk as well as a biomarker of nutritional status. In conclusion, additional ASCVD risk reduction strategies are needed to further improve clinical outcomes, particularly among the high-risk subset of patients with established ASCVD.

ARTICLE INFORMATION

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Disclosures

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Supplementary Material

Figures S1–S3

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SUPPLEMENTAL MATERIAL

Figure S1. The distribution of triglycerides for the (A) primary prevention cohort and (B) secondary prevention cohort stratified by age group.

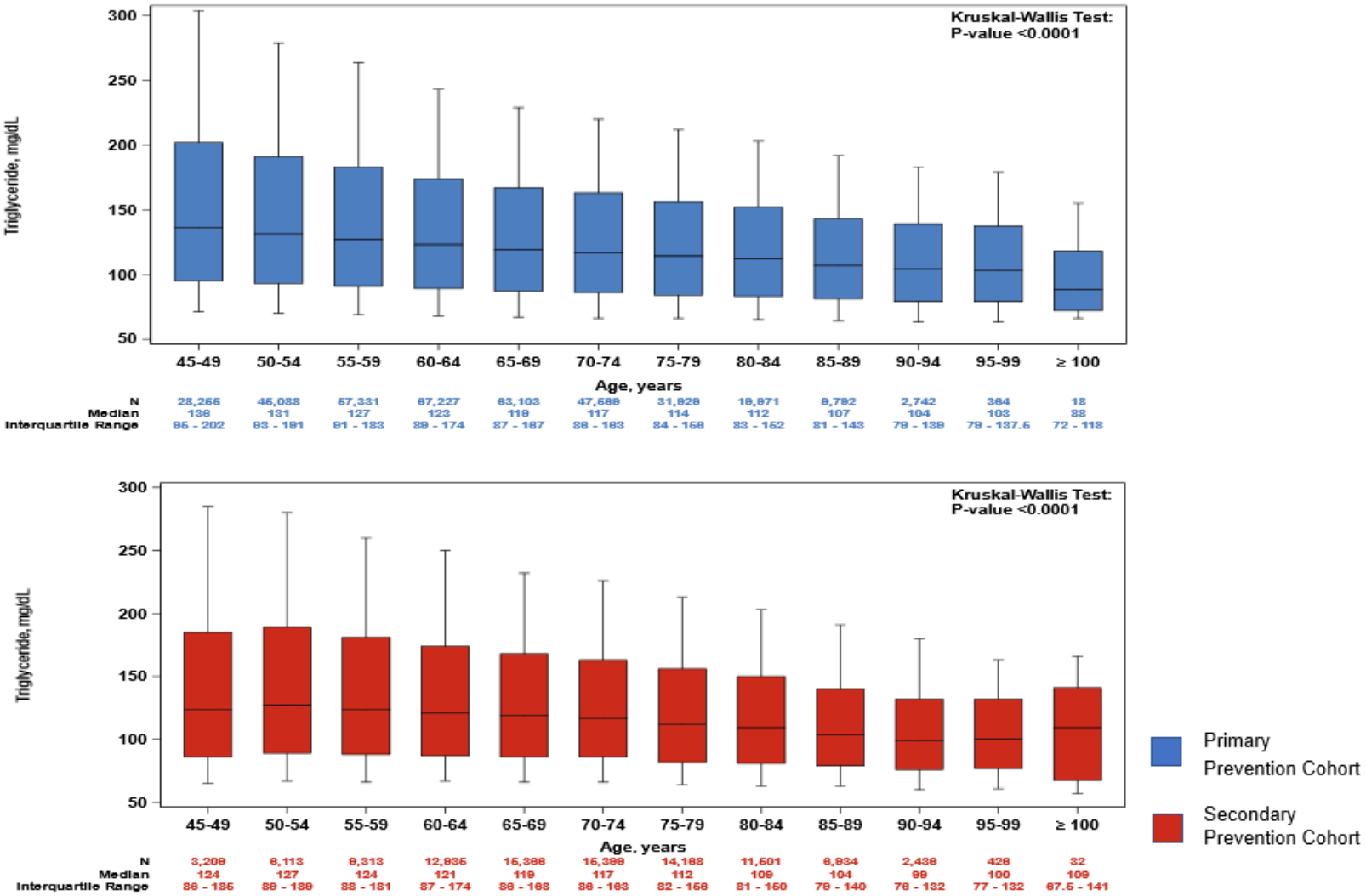

Figure S2. The distribution of triglycerides for the (A) primary prevention cohort and (B) secondary prevention cohort stratified by sex.

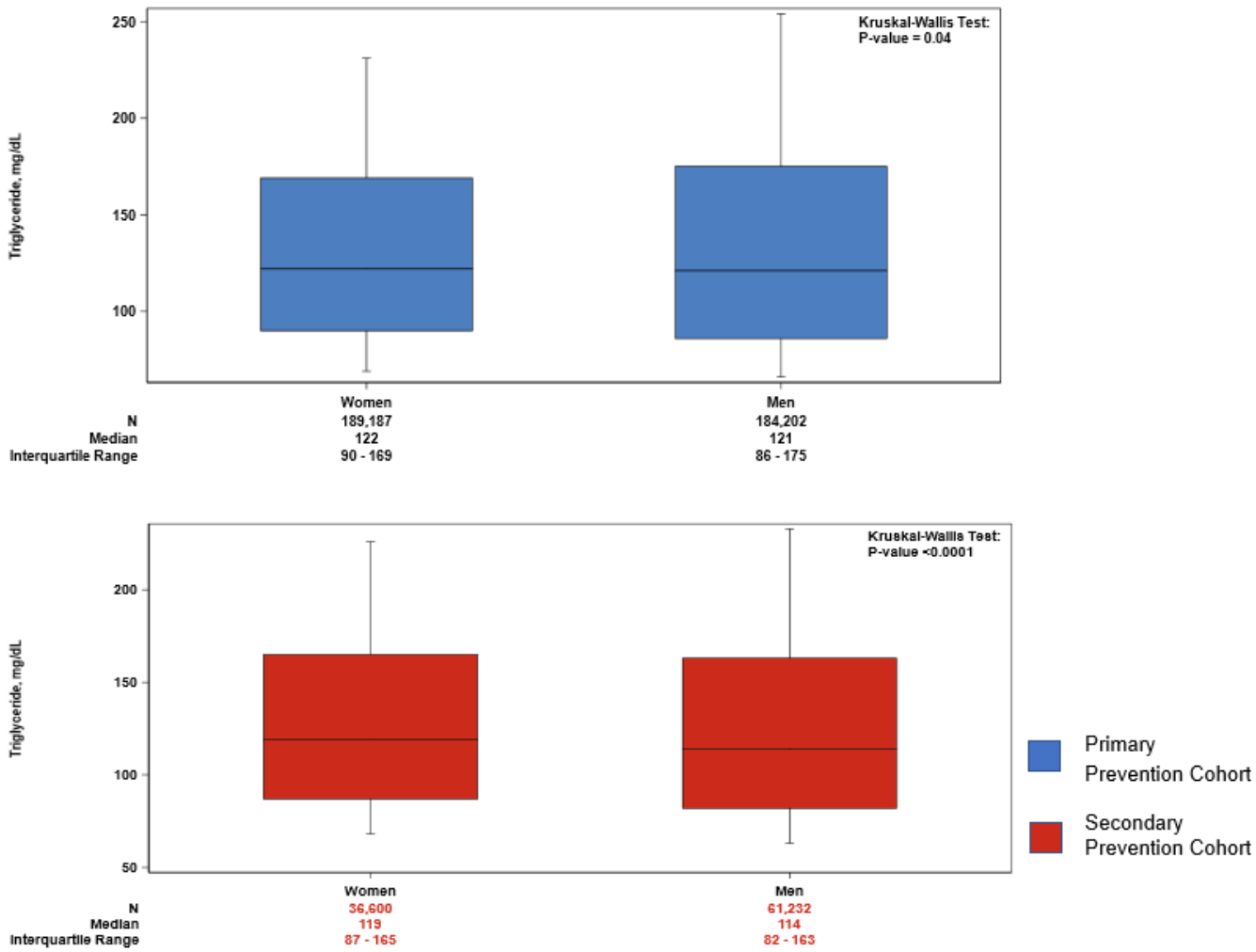

Figure S3. The distribution of triglycerides for the (A) primary prevention cohort and (B) secondary prevention cohort stratified by self-reported race/ethnicity.