

# Association of Clinician Knowledge and Statin Beliefs With Statin Therapy Use and Lipid Levels (A Survey of US Practice in the PALM Registry)



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**Guideline implementation requires clinician knowledge but may be influenced by pre-existing beliefs and biases. We assessed the association of these clinician factors with lipid management following the release of the 2013 American College of Cardiology/American Heart Association cholesterol guidelines. In the PALM registry, 774 clinicians completed a survey to assess their knowledge of the 2013 American College of Cardiology/American Heart Association guidelines, belief in statin benefit, and statin safety concerns. The association of these factors with statin use, statin dosing, and low-density lipoprotein cholesterol (LDL-C) levels were assessed in the 6,839 patients treated by these clinicians between May and November 2015. Overall, 63.9% of clinicians responded to at least 3 out of 4 hypothetical scenarios in concordance with guideline recommendations (good tested knowledge), 88.4% reported belief in statin benefit, and 15.4% raised concerns about statin safety. Belief in statin benefit was more prevalent among cardiologists, who represented 48.8% of the clinicians surveyed, and concerns regarding statin safety were higher among noncardiologists and clinicians in an academic setting. Guideline knowledge was not associated with a difference in statin use (74.1% vs 73.8%,  $p = 0.84$ ) and achievement of LDL-C level  $<100$  mg/dl (54.7% vs 52.4%,  $p = 0.07$ ). However, patients treated by clinicians who reported belief in statin benefit were more likely to receive guideline-recommended statin intensity (41.9% vs 36.9%,  $p = 0.03$ ), whereas patients treated by clinicians expressing statin safety concerns were less likely receive statins of at least guideline-recommended intensity (36.8% vs 42.5%,  $p = 0.001$ ) and to achieve an LDL-C  $<100$  mg/dl (44.1% vs 56.1%,  $p < 0.001$ ); the latter persisted after multivariable adjustment (odds ratio 0.75, 95% confidence interval 0.63 to 0.89). In conclusion, clinician beliefs regarding benefits and risks of statins were significantly associated with guideline adherence and patients' achieved LDL-C levels, whereas clinician knowledge of guideline recommendations was not. © 2019 Elsevier Inc. All rights reserved. (Am J Cardiol 2019;123:1011–1018)**

The treatment of hyperlipidemia with low-density lipoprotein cholesterol (LDL-C)-lowering therapy is an important part of primary and secondary prevention of atherosclerotic cardiovascular disease (ASCVD). Numerous studies have shown an improvement in patient outcomes and a mortality reduction associated with LDL-C-lowering therapy.<sup>1–10</sup> The extent to which clinician knowledge and beliefs regarding statin therapy is associated with their treatment practices and degree of guideline adherence is unknown. The Patient and Provider Assessment of Lipid Management (PALM)

Registry was designed to evaluate lipid management practices after the release of the 2013 American College of Cardiology/American Heart Association (ACC/AHA) cholesterol guideline in a large cohort of cardiology, endocrinology, and primary care outpatient clinics in the United States.<sup>11</sup> In this study, we examine clinician knowledge and perceived benefits and risks of statin therapy as well as their association with guideline adherence and lipid management of enrolled PALM patients.

## Methods

The PALM registry involved 153 outpatient cardiology, endocrinology, and primary care practices across the United States. Detailed rationale, design, inclusion, and exclusion details for the PALM registry have been previously published.<sup>12</sup> Sites were selected to be geographically representative, with a mix of urban and rural, and teaching and nonteaching practices. After institutional review board approval, clinicians able to prescribe lipid-lowering therapy at participating sites completed a web-based clinician survey. Sites were required to have  $>80\%$  of participating

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clinicians with a completed survey before site activation for patient enrollment.

From May 27, 2015 to November 12, 2015, PALM enrolled 7,904 patients with atherosclerotic vascular disease, current statin therapy use, LDL-C  $\geq 130$  mg/dl, diabetes, chronic kidney disease, or 10-year atherosclerotic cardiovascular disease risk  $\geq 7.5\%$ . All participants provided informed consent to participate. On the day of enrollment, each participant underwent phlebotomy for core lab lipid measurement. Chart abstractions assessed current lipid-lowering therapy use and dosing. This analysis includes all physicians and advanced practice providers with a completed survey, resulting in 774 clinicians. Patients evaluated by these clinicians and who had complete lab data were included for analysis of patient-level data, leading to a final patient population of 6,839 patients. In these patients, 5,312 met a guideline indication for primary or secondary prevention statin therapy and were included in analyses evaluating the use of statin therapy and guideline-directed statin dosing.

Clinician surveys included questions regarding clinician and practice characteristics. We used 4 hypothetical patient scenarios to assess clinician knowledge of the 2013 ACC/AHA guidelines. Scenarios included asymptomatic primary prevention patients with: (1) high ( $\geq 7.5\%$ ) ASCVD risk and high LDL-C ( $\geq 130$  mg/dl); (2) diabetes; (3) low ( $< 7.5\%$ ) ASCVD risk and high LDL-C (130-189 mg/dl); and (4) high ( $\geq 7.5\%$ ) ASCVD risk and low LDL-C ( $< 130$  mg/dl). Detailed descriptions of each scenario are shown in Table 1. For each scenario, clinicians were asked to choose the likelihood of prescribing statin treatment; good guideline knowledge was defined as  $\geq 3$  of 4 scenarios answered in accordance with guideline recommendations.

The survey also assessed clinician beliefs in statin benefits and risks by asking clinicians to respond with their level of agreement on statements, such as "statins are very effective in reducing risk of heart attack or stroke" or "I worry that the risks of statin therapy may be under-reported or underappreciated" (answer choices: strongly disagree, disagree, neutral, agree, strongly agree). Table 2 summarizes the questions and the scoring used to categorize degree of belief or concern.

For each enrolled patient, retrospective review of medical records allowed for collection of detailed sociodemographic characteristics and medical history. Current and previous treatment with lipid-lowering therapy was recorded. For statin medications, dosing intensity was also

noted. Lipid testing results within the 2 years before enrollment, including the highest LDL-C measured, were collected. On the day of enrollment, all patients underwent phlebotomy. Core lab lipid panels with analysis of total cholesterol, direct LDL-C, high-density lipoprotein cholesterol, and triglyceride levels were completed at LabCorp (Burlington, North Carolina).

Treatment with guideline-recommended statin dosing intensity was defined according to the 2013 ACC/AHA lipid management guidelines.<sup>11</sup> Patients with known ASCVD, LDL-C  $\geq 190$  mg/dl, or diabetes with 10-year ASCVD risk score of  $\geq 7.5\%$  and age 40 to 75 years are recommended to be treated with high-intensity statin therapy. Patients without indication for high-intensity statin and age 40 to 75 years with diabetes and 10-year ASCVD risk  $< 7.5\%$  or without diabetes and 10-year ASCVD risk  $\geq 7.5\%$  are recommended to be treated with at least moderate-intensity statin therapy. Finally, treatment with at least moderate-intensity statin therapy was indicated for patients with clinical ASCVD and age  $> 75$  years.

First clinician characteristics such as specialty, board certification, number of years in practice, and type of practice were summarized using percentage. Next, we described overall clinician knowledge of the ACC/AHA cholesterol guidelines based on summed responses to the 4 hypothetical patient scenarios in the clinician survey (Table 2). Similarly, clinician belief in statin benefit and concern regarding statin safety were evaluated based on summed responses. We then assessed whether clinician characteristics (specialty, board certification, years in practice, and type of practice) associated with guideline knowledge, belief in statin benefit, and concern regarding statin risk using percentage and compared using the chi-square test.

We then linked each surveyed clinician to the patients they treated in PALM. Patient characteristics were presented using frequency for categorical variables and were presented as median (25th and 75th percentiles) for continuous variables. The associations between clinician knowledge, beliefs, or concern (explanatory variables) with patient treatment (response variables) were examined in multivariable analyses. Treatment outcomes of interest included (1) statin use, (2) statin dosing at or exceeding guideline-recommended statin intensity, and (3) achievement of LDL-C  $< 100$  mg/dl, respectively. For each outcome, we performed multivariable logistic regression modeling with generalized estimating equations to account

Table 1  
Percent concordance with ACC/AHA guidelines for each hypothetical scenario

Patient scenario	Patient characteristics	Co-morbidities	Lipid data TC, LDL-C, HDL-C (mg/dl)	10-year ASCVD risk	Guideline-recommended statin use (intensity)	% Clinicians recommend statin	% Clinicians recommend high- intensity statin*
1	54 M	Active smoker, HTN	221, 150, 41	17.3%	Yes ( $\geq$ M)	93%	66%
2	45 F	DM, HTN	220, 140, 50	6.1%	Yes ( $\geq$ M)	85%	64%
3	40 F	No co-morbidities	220, 165, 30	4.4%	No	40%	44%
4	70 F	No co-morbidities	180, 110, 40	10.1%	Yes ( $\geq$ M)	38%	52%

ASCVD = atherosclerotic cardiovascular disease; DM = diabetes; HDL-C = high-density lipoprotein cholesterol; HTN = hypertension; LDL-C = low-density lipoprotein cholesterol; M = moderate intensity statin; TC = total cholesterol.

\* Among clinicians who responded as being likely or highly likely to recommend a statin.

Table 2  
Scoring of clinician survey responses

Domains	Questions	Responses	% clinicians	Summed responses
Guideline knowledge	Hypothetical patient scenarios	Q1	92.9%	63.9% <sup>1</sup>
		Q2	84.6%	
		Q3	59.8%	
		Q4	38.1%	
Belief in statin benefit	Statins are very effective in reducing risk of heart attack or stroke	Strongly disagree (−2)	1.3%	88.4% <sup>2</sup>
		Disagree (−1)	0.9%	
		Neutral (0)	5.1%	
		Agree (+1)	46.3%	
		Strongly agree (+2)	46.4%	
	Statins prolong life	Strongly disagree (−2)	1.4%	
		Disagree (−1)	6.1%	
		Neutral (0)	23.4%	
		Agree (+1)	41.5%	
		Strongly agree (+2)	27.6%	
Concern regarding statin safety	Statins are extremely safe medications	Strongly disagree (+2)	1.0%	15.4% <sup>3</sup>
		Disagree (+1)	8.7%	
		Neutral (0)	22.1%	
		Agree (−1)	50.5%	
		Strongly agree (−2)	17.7%	
	I worry that the risks of statin therapy may be underreported or underappreciated <sup>4</sup>	Strongly disagree (−2)	16.6%	
		Disagree (−1)	39.8%	
		Neutral (0)	26.5%	
		Agree (+1)	16.2%	
	Statins are unnecessary and may be of risk in adults with already low (<70 mg/dl) LDL-C levels	Strongly agree (+2)	0.9%	
		Strongly disagree (−2)	7.4%	
		Disagree (−1)	37.6%	
		Neutral (0)	31.2%	
Agree (+1)		20.0%		
		Strongly agree (+2)	3.8%	

1) Clinicians who answered 3/4 questions in accordance with guidelines defined as good clinical knowledge.

2) Summed score >0 defined as belief in statin benefit.

3) Summed score >0 defined as concerned regarding statin safety.

4) Scale reversed for scoring to ensure that a positive score corresponds to concern for statin safety.

LDL-C = low-density protein cholesterol.

for clustering of observations among patients treated by the same hospital. Each model adjusted for differences in patient case mix. Variables for adjustment were chosen to be inclusive of clinically relevant patient characteristics which could impact statin treatment and LDL-C, including patient age, gender, race, body mass index, smoking history, hypertension, diabetes, prior ASCVD, family history of ASCVD, chronic kidney disease, insurance status, highest level of education, annual household income and clinician variables including years in practice, subspecialty, and teaching versus nonteaching practice. Missing data for most of the covariates were rare (<2.5%), except for the patient survey data such as education and income. Education was missing at 7.3%. The income variable had 8.8% of missing, 4.1% answered “I do not know” and 23.8% answered “I prefer not to answer this question” which were treated each as missing and we imputed these 36.6% of patients. Multiple imputation was used and 5 imputed data sets were generated. The results of how good guideline knowledge, belief in statin benefit, or concern regarding statin safety associated with treatment outcomes were

presented as the odds ratio with 95% confidence intervals which were combined and carried out from the 5 imputed data sets.

All statistical analyses were performed at the Duke Clinical Research Institute using SAS version 9.4 (Cary, North Carolina). All p values are 2-sided, and  $p < 0.05$  was considered statistically significant.

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## Results

In 774 clinicians surveyed in the PALM Registry, 48.8% were cardiologists, 3.1% were endocrinologists, 30.2%

Table 3  
Guideline knowledge, belief in statin benefit, and concerns regarding statin risk based on clinician characteristics

Clinician-reported	Cardiologists	Noncardiologists	Board certified	Not board certified	>10 years in practice	≤10 years in practice	Academic	Nonacademic
Guideline knowledge	66.8%	61.3%	63.5%	66.4%	62.6%	66.5%	65.7%	63.5%
p value		0.11		0.58		0.28		0.56
Belief of statin benefit	91.5%	85.5%	89.6%	80.8%	90.8%	83.6%	85.9%	89.4%
p value		<b>0.009</b>		<b>0.009</b>		<b>0.003</b>		0.17
Concern regarding statin safety	10.1%	20.3%	15.1%	17.3%	14.5%	17.2%	20.2%	13.3%
p value		<b>&lt;0.001</b>		0.55		0.32		<b>0.02</b>

Guideline knowledge: ≥3/4 scenario questions answered in accordance with guidelines.  
 Belief of statin benefit: sum score >0.  
 Concern regarding statin safety: sum score >0.

were primary care clinicians, and 13.4% were not board certified. The majority (66.7%) reported practicing >10 years, with 29.7% overall in teaching practices.

Table 1 shows clinician responses to the 4 hypothetical patient scenarios aimed at evaluating their knowledge of the ACC/AHA cholesterol guidelines. The greatest discordance with guidelines was in the scenario of the young patient with high LDL-C and the older patient with high ASCVD risk. The majority of clinicians answered at least 3 of the 4 questions in concordance with guideline recommendations (Table 2). Table 2 also shows the clinician responses to the statements regarding statin benefit and risks. Most clinicians reported a belief in statin benefit, while a small number raised concerns about the safety of statin medications or an under-reporting of statin side effects.

There was no significant difference in guideline knowledge when clinicians were stratified by specialty, board

certified status, years in practice, and type of practice (Table 3). Compared with noncardiologists, those specialized in cardiology were more likely to believe in statin benefit, as were board certified clinicians and those with >10 years in practice. Clinicians not specializing in cardiology and those practicing in academic settings were significantly more likely to have concerns regarding statin safety.

Baseline characteristics of the 6,839 patients treated by the clinicians in our study are presented in supplemental Table 1. In the patients who met a guideline indication for statin therapy, there was no difference in statin use or guideline-adherent statin dosing between patients treated by clinicians with and without good guideline knowledge (Figure 1). Patients seen by clinicians with higher belief in the benefit of statin medications were, however, more likely to be treated with the statin doses at or above the guideline-recommended intensity. Conversely, patients who were seen by clinicians with concerns about statin safety were

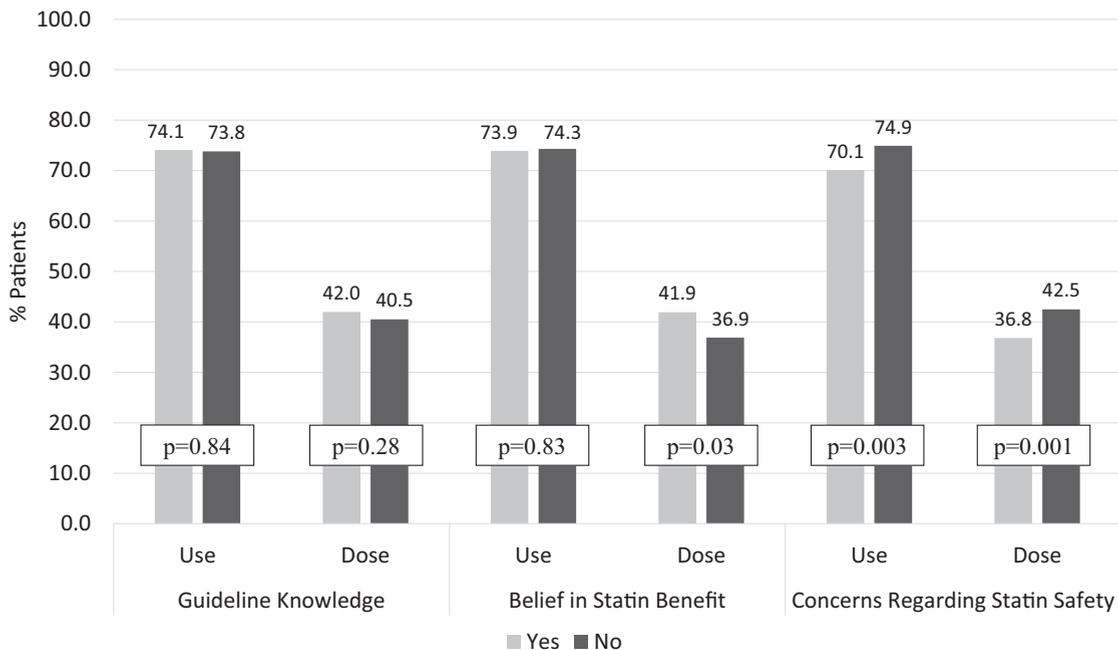


Figure 1. Statin use and guideline-concordant statin dosing among patients with a guideline indication for statin therapy  
 Belief in benefit—reported statins effective in reducing atherosclerotic cardiovascular disease (ASCVD) risk and prolonging life.  
 Dose—percent of patients with statin dosing at or above guideline-recommended statin intensity.  
 Guideline knowledge—answered ≥3 of 4 knowledge questions related to guideline recommendations correctly.  
 Safety concerns—reported worry about statin therapy risks and that statin therapy risks are under-reported.  
 Use—percent of patients in which statin is used.

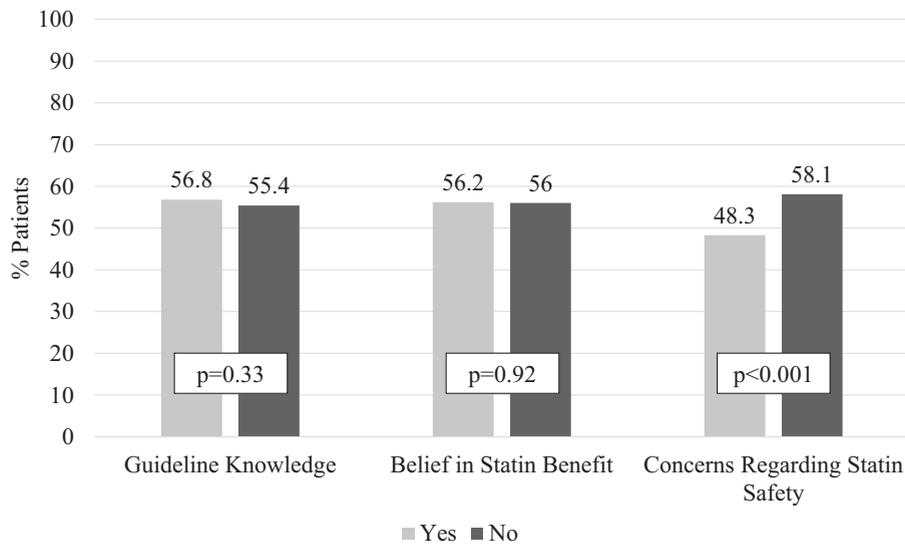


Figure 2. Achievement of LDL-C <100 mg/dl among patients with a guideline indication for statin therapy  
LDL-C = low-density lipoprotein cholesterol.

significantly less likely to be treated with a statin and more likely to be on a statin dose lower than the guideline-recommended intensity (Figure 1). Similarly, patients who were seen by clinicians with concerns about statin safety were significantly less likely to achieve an LDL-C level of <100 mg/dl (Figure 2).

After multivariable adjustment, there remained no difference in statin use, statin dosing, or achievement of LDL-C <100 mg/dl between patients treated by clinicians with good guideline knowledge versus those without (Table 4). Patients seen by clinicians with a greater belief in the benefit of statin medications were also no more likely to be treated with statin medications, guideline-adherent statin dose, and to achieve an LDL-C <100 mg/dl after multivariable adjustment. Patients cared for by clinicians with concerns for statin safety were significantly less likely to be treated to an LDL-C <100 mg/dl.

## Discussion

This analysis of the PALM registry examined how clinician beliefs in statin therapy and knowledge of the 2013 ACC/AHA cholesterol guidelines may influence patient treatment. Although most clinicians believed in the benefit of statin treatment, 15% expressed concerns about safety. Cardiologists were more likely to believe in statin benefit; primary care clinicians were more likely to express concern about statin side effects. Pre-existing clinician concerns regarding safety may play a significant role in treatment decisions, resulting in higher LDL-C levels in their patients. In contrast, guideline knowledge was not significantly associated with treatment decisions or LDL-C levels achieved in unadjusted and adjusted analyses.

The 2013 ACC/AHA blood cholesterol management guideline represented a transition in recommendations to

Table 4  
Outcomes after multivariable adjustment based on clinician knowledge, belief in statin benefit, and concern regarding statin safety

	Outcome	Adjusted odds ratio*	95% confidence interval	Adjusted p value
Guideline knowledge	Statin use	0.89	0.73–1.08	0.23
	Statin dose	1.04	0.81–1.34	0.77
	LDL-C <100 mg/dl	1.03	0.90–1.19	0.67
Belief in statin benefit	Statin Use	0.92	0.64–1.34	0.68
	Statin Dose	1.06	0.77–1.45	0.73
	LDL-C <100 mg/dl	0.95	0.72–1.24	0.70
Concern regarding statin safety	Statin use	0.97	0.71–1.33	0.85
	Statin dose	1.00	0.80–1.25	0.99
	LDL-C <100 mg/dl	0.75	0.63–0.89	0.001

**Use**—Patients in which statin is used at the clinic visit.

**Dose**—Patients with statin dosing at or above guideline-recommended statin intensity.

**Guideline Knowledge**—Clinician answered  $\geq 3$  of 4 knowledge questions related to guideline recommendations correctly.

**Belief in Benefit**—Reported statins effective in reducing atherosclerotic cardiovascular disease (ASCVD) risk and prolonging life.

**Safety Concerns**—Reported worry about statin therapy risks and that statin therapy risks are under-reported.

\* **Variables used for risk adjustment:** Age, gender, race, body mass index, smoking status, hypertension, diabetes, previous atherosclerotic cardiovascular disease (ASCVD), family history of ASCVD, chronic kidney disease, insurance status, practice in training hospital, clinician years in practice (<10 years vs  $\geq 10$  years) and clinician cardiologist versus not cardiologist.

patient treatment based on overall patient ASCVD risk.<sup>11,13</sup> The PALM registry and other studies have shown that >25% of statin-eligible patients were not treated with a statin or were dosed below the recommended intensity.<sup>14,15</sup> This study demonstrates persistent undertreatment in which less than half of patients received guideline-recommended intensity of statin therapy. Hypothesized reasons for undertreatment have included cost factors, patient concerns, and under-recognition of patients who would benefit from statin therapy.<sup>16</sup> However, little is known about how clinician knowledge and biases may impact treatment.

PALM is unique in capturing clinician characteristics, knowledge, and beliefs in a large cohort of the US clinicians. The majority of clinicians surveyed demonstrated good knowledge of the 2013 ACC/AHA guidelines, as exemplified by alignment of hypothetical treatment decisions with the guideline recommendations. However, there was heterogeneity in these responses. The vast majority of clinicians chose to treat the patient with high risk and high cholesterol and the patient with diabetes. However, many chose not to treat the older patient with low cholesterol but high ASCVD risk for whom guidelines would recommend a risk discussion regarding statin therapy. Conversely, a significant proportion of clinicians chose to treat the patient with elevated LDL-C but low ASCVD risk, a scenario where the 2013 ACC/AHA guidelines again suggest discussion with the patient regarding possible initiation of a statin. Variations in statin prescribing have been reported between specialties, possibly attributed to differing guidelines.<sup>11,17–19</sup> Other studies have shown gaps in clinician understanding of the 4 statin benefit groups.<sup>20,21</sup> However, our study showed that clinician guideline knowledge was not the limiting factor.

In our study, over 15% of clinicians continue to have concerns regarding the safety of statin medications, despite data suggesting that statin intolerance is unreliably reproduced when in a blinded setting.<sup>22</sup> These concerns directly translate to differences in use and appropriate dosing of statin therapy. The largest observed differences were found between clinicians with and without concerns regarding the safety of statins. Patients treated by clinicians with concerns regarding statin safety were less likely to achieve an LDL-C <100 mg/dl in both unadjusted and adjusted analyses, suggesting lower-intensity lipid-lowering efforts. PALM showed no association between clinician-perceived benefit of statin therapy and treatment practices.

Statin medications have been approved for commercial use in the United States for more than 30 years. This study shows that uptake of one of the most studied cardiovascular medication groups, with clear treatment benefit, remains hampered by underlying clinician beliefs rather than a lack of guideline knowledge. Clinically, this translates to large groups of patients receiving suboptimal care, for primary and secondary prevention of ASCVD. Although current health system-based initiatives are testing interventions to increase clinician awareness of treatment eligibility, broader initiatives to address clinicians' underlying beliefs and biases are needed. These results suggest the need for additional research and education to assure clinicians of statin safety in order to improve the care of our patients by maximizing guideline adherence in prescribing.

Our study should be evaluated taking note of several important limitations. First, given the observational and cross-sectional design of our study, rationale for clinician treatment decisions regarding statin therapy were not available for evaluation. Thus, we were unable to fully capture treatment motivations, including clinician-patient risk discussions or previous statin intolerance. Additionally, as many patients see several physicians for their care, the clinician completing the survey may not represent the individual who made primary decisions regarding statin therapy. Next, in patients receiving therapy with a statin medication at the time of the survey, the baseline LDL-C, before lipid lowering therapy, was not consistently available. Similarly, ASCVD risk, which was used to inform guideline-recommended eligibility and dose of statin therapy, was calculated in patients with and without statin therapy. Calculating ASCVD risk in the patients on statin therapy may underestimate true risk, and thus may underestimate the guideline statin recommendation. Finally, we defined clinician knowledge based on answers to 4 hypothetical scenarios addressing key take-home messages from the 2013 ACC/AHA guidelines. Although a more extensive knowledge check may have been informative, it was not feasible in this large, multicenter study.

Clinician characteristics, including specialty, years in practice, and setting of practice, may influence belief in the benefit of statin medications and concern regarding statin safety. These beliefs in the benefit of statin therapy and safety of statin medications play a significant role in management of patient blood lipid levels with statin use, appropriate dosing based on guideline recommendations, and achievement of LDL-C <100 mg/dl. Conversely, clinician guideline knowledge was not significantly associated with treatment decisions. Interventions specifically targeting these underlying clinician beliefs and ongoing discussions of the benefit-to-risk ratio of statin medications will be important to continue improving the guideline-directed care of patients.

### Author Agreement

This manuscript contains original research and is not under consideration elsewhere. None of the paper's contents have been previously published. All investigators have read and approved the manuscript. All of our investigators meet the criteria for authorship.

### Author Contributions

All authors have been involved in the study design, analysis, and manuscript revision. All investigators read and approved the final manuscript. Dr. Lowenstern is the guarantor who accepts full responsibility for the work and the conduct of the study, had access to the data, and controlled the decision to publish.

**A Lowenstern:** Dr. Lowenstern had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Dr. Lowenstern contributed to the conception and design of the study, the data interpretation, the manuscript drafting, and the critical revision of the manuscript.

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## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at <https://doi:10.1016/j.amjcard.2018.12.031>.

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