Published in final edited form as:

Am J Kidney Dis. 2014 May ; 63(5): 753–760. doi:10.1053/j.ajkd.2013.11.014.

Potential Effects of Reclassifying CKD as a Coronary Heart Disease Risk Equivalent in the US Population

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Abstract

Background—Persons with chronic kidney disease (CKD) are at high risk for cardiovascular disease events, but are not classified as such in current U.S. cholesterol treatment guidelines. We examined potential effects of modified guidelines in which CKD was considered a “coronary heart disease (CHD) risk equivalent” for risk stratification.

Study Design—Nationally representative cross-sectional study.

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Financial Disclosure: DN and EM are employees of Merck and own stock in the company. The other authors declare that they have no other relevant financial interests.

Supplementary Material

Table S1: Population characteristics in adults with no CKD, CKD stages 1–2, and CKD stages 3–5.

Table S2: Percent of US population not meeting LDL cholesterol targets and on lipid-lowering therapy within current risk categories.

Table S3: Estimated number and proportion of adults on lipid-lowering therapy within groups.

Note: The supplementary material accompanying this article (doi: _____) is available at www.ajkd.org

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Setting & Participants—4,823 adults aged 20 years or older from the 2007–2010 National Health and Nutrition Examination Survey.

Predictors—Cardiovascular risk stratification based on current U.S. cholesterol treatment guidelines and two simulated scenarios in which CKD stages 3–5 or CKD stages 1–5 were considered a CHD risk equivalent.

Outcomes & Measurements—Proportion of persons with low-density lipoprotein (LDL) cholesterol at levels above treatment targets and above the threshold for lipid-lowering therapy initiation, based on current guidelines and the two simulated scenarios.

Results—Under current guidelines, 55.1 million adults in 2010 did not achieve target LDL cholesterol goal. Of these, 25.2 million had sufficiently elevated levels to meet recommendations for initiating lipid-lowering therapy; 12.1 million were receiving this therapy but remained above goal. When CKD stages 3–5 were considered a CHD risk equivalent, 59.2 million persons were above target LDL cholesterol goals, with 28.5 million and 13.3 million meriting therapy initiation and intensification, respectively. When CKD stages 1–5 were considered a CHD risk equivalent, 65.2 million adults were above goal, with 33.9 million and 14.4 million meriting therapy initiation and intensification, respectively.

Limitations—CKD and LDL cholesterol levels defined using a single laboratory value.

Conclusions—Many adults in the U.S. do not meet currently recommended goals for LDL cholesterol. Modifying the current cholesterol guidelines to include CKD as a CHD risk equivalent would lead to a substantial increase in both the number of persons above LDL cholesterol treatment targets as well as those recommended to initiate lipid-lowering therapy.

Keywords

chronic kidney disease; National Health and Nutrition Examination Survey (NHANES); coronary heart disease (CHD) risk equivalents; cholesterol treatment guidelines; low-density lipoprotein (LDL) cholesterol; guideline implementation; public health

Under current US cholesterol treatment guidelines,^{1,2} patients with prevalent coronary heart disease (CHD) or a “CHD risk equivalent” are classified as high risk for cardiovascular events and are recommended for aggressive cardiovascular risk reduction with lower target low-density lipoprotein (LDL) cholesterol goals. Conditions considered CHD risk equivalents include non-coronary clinical atherosclerotic disease, diabetes, an abdominal aortic aneurysm, or a combination of a 10-year Framingham CHD risk >20% and two of the following risk factors: older age, low high-density lipoprotein (HDL) cholesterol, hypertension, family history of premature CHD, and smoking.

Chronic kidney disease (CKD) is common in the U.S. and is associated with a high burden of cardiovascular disease. Both reductions in estimated glomerular filtration rate (eGFR) and increases in albuminuria are associated with increased risk of cardiovascular mortality^{3,4} and recent work suggests that CKD carries a myocardial infarction risk similar to that for diabetes.⁵ However, CKD is not considered a CHD risk equivalent in the current U.S. cholesterol treatment guidelines; this omission of CKD in cholesterol treatment guidelines has been a point of discussion for several years.^{6–8} Both the National Kidney Foundation

and the American Heart Association have recommended that patients with CKD be targeted for intensive cardiovascular risk factor control.^{6,7} In Europe, cholesterol guidelines formally recommend that adults with CKD be considered at high or very high cardiovascular risk and that LDL-cholesterol reduction be a primary therapy target in adults with moderate to severe CKD.⁹

The goal of this study was to evaluate the potential population-level impact of defining CKD as a CHD risk equivalent in cholesterol guidelines in a U.S. nationally representative population-based sample. We simulated two scenarios: one in which CKD stages 3–5 was considered a CHD risk equivalent, and a second in which CKD stages 1–5 was considered a CHD risk equivalent. We then estimated the proportion of U.S. adults failing to meet LDL cholesterol treatment targets under each of these scenarios, as well as the proportion with sufficiently elevated LDL levels that they would be recommended for the initiation or intensification of lipid-lowering therapy (LLT), comparing our results with those estimated using the current cholesterol guidelines.

Methods

Study Population

The 2007–2010 NHANES was a cross-sectional, multistage, stratified, clustered probability sample of the U.S. civilian non-institutionalized population conducted by the National Center for Health Statistics (NCHS).¹⁰ Our study sample included 4,823 adults aged 20 years or older who attended the mobile examination center visit and were fasting for at least 9 hours prior to their examination and blood draw (the “morning fasting subsample”), and who were not pregnant, or missing urinary albumin or creatinine measurements. The NHANES was approved by the NCHS Research Ethics Review Board and all participants provided informed consent.^{11–13}

Assessment of CKD and Definitions

Serum creatinine was measured in serum samples using the Jaffe rate method. Urinary albumin and creatinine were measured using an enzymatic method in random urine samples collected during the mobile examination center visit.^{14,15} We used the 2009 CKD-EPI (CKD Epidemiology Collaboration) creatinine equation to estimate the glomerular filtration rate (eGFR).¹⁶ Urinary albumin-creatinine ratio (ACR) was calculated from urinary albumin divided by urinary creatinine and was expressed in mg/g. We defined CKD stages 1–5 as the presence of decreased eGFR (GFR categories G3a–G5) or moderately to severely increased ACR (albuminuria categories A2 or A3) and CKD stages 3–5 as the presence of decreased eGFR (GFR categories G3a–G5) at any level of albuminuria (A1–A3).^{6,17} We did not account for the persistence of albuminuria based on repeated ACR measurements, which may lead to overestimates in the overall prevalence of CKD.

Cardiovascular Risk Stratification and LDL Cholesterol Goals Based on Current Guidelines

We approximated current national cholesterol guidelines^{1,2} by stratifying participants into five categories of cardiovascular risk; these risk categories, their specific target LDL cholesterol goals, and the LDL cholesterol levels at which to consider LLT are summarized

in Table 1. We defined CHD risk factors and CHD risk equivalents as follows: CHD risk factors included current smoking (self-report), low HDL cholesterol level (<40 mg/dL), older age (45 years or older in men, 55 years or older in women), hypertension (systolic blood pressure $\geq$ 140 mmHg, diastolic blood pressure $\geq$ 90 mmHg, or self-reported physician diagnosis of hypertension), a family history of premature CHD (self-report of a heart attack in a close relative before age 50), and high HDL cholesterol level ($\geq$ 60 mg/dL) (a negative risk factor).^{1,2} The CHD risk equivalents included (1) diabetes (hemoglobin A1c $\geq$ 6.5%, a self-reported physician diagnosis, or self-reported use of insulin or anti-diabetic pills), (2) a history of stroke based on self-report, and (3) the presence of 2 or more risk factors with a ten-year risk of a CHD event $\geq$ 20%, calculated based on the Framingham Risk Score.

Alternative Guideline Scenarios

Two different modifications to the current national cholesterol guidelines were evaluated (Table 1). The first classified CKD stages 3–5 as a CHD risk equivalent (scenario 1); the second classified CKD stages 1–5 as a CHD risk equivalent (scenario 2). Under the two simulated scenarios, adults with CKD classified under current guidelines in one of the three lowest risk stratification groups (moderately high, moderate, or lower risk) were reclassified as high risk. Adults with CKD classified as high risk under current guidelines would be reclassified as very high risk were they also to have prevalent CVD.

Definition of Dyslipidemia and Lipid-Lowering Medication Use

We defined dyslipidemia as (1) serum LDL cholesterol level above goal based on National Cholesterol Education Program Adult Treatment Panel III (ATP III) criteria and the modified ATP III guidelines,^{1,2} or (2) self-reported use of LLT. Use of therapy was self-reported as part of the home visit questionnaire; type of therapy was assessed during the home visit, where medication bottles for prescription medications used in the 30 days prior to the home visit were reviewed. We classified LLT type into three groups: (1) statin monotherapies, (2) statin combination therapies (statins in combination with non-statin antihyperlipemic agents), and (3) other (non-statin) lipid therapies. We assessed the reliability of self-reported LLT use by comparing it to prescription medication use collected from medication containers for drugs used in the past 30 days at the NHANES (National Health and Nutrition Examination Survey) household visit. The concordance between these two definitions was high (total agreement = 92.3%; $\kappa=0.75$).

Statistical Analyses

Analyses were performed using weights for the morning fasting subsample that account for oversampling in the complex survey design, non-response, and post-stratification adjustment to produce nationally representative estimates.^{10,18} Standard errors were obtained using Taylor series linearization following NCHS analytic guidelines.¹⁰ We calculated the proportion of adults with LDL cholesterol levels above goal based on current guidelines, scenario 1, and scenario 2. Among those with LDL cholesterol above goal, we estimated the proportion of adults who were sufficiently above target levels that they met recommendations for initiation of drug therapy, as well as the proportion of adults who were already on LLT such that intensification of therapy might be appropriate. Prevalence estimates derived from NHANES analyses were applied to 2010 U.S. Census results to

estimate the numbers of U.S. adults in each category of CVD risk. Finally, among those with dyslipidemia, we estimated the proportion using different types of LLT by CKD status. Statistical analyses were performed using Stata version 11.1 (StataCorp LP, <http://www.stata.com/>).

Results

Current Risk Classification, Stratified by CKD Status

Population characteristics are presented in Table 2 and Table S1 (provided as online supplementary material). The prevalence of CKD stages 1–5 was 13.3%; adults with CKD were older, more likely to be female and more likely to use LLT when compared to all adults. A total of 53.7% of those with CKD had albuminuria in the absence of reduced eGFR and 40.7% had an eGFR of 30–59 mL/min/1.73 m². Under current national cholesterol guidelines, a high proportion of adults with CKD were classified as either high or very high risk (Table 3); indeed, an estimated 14.1 million (46.9%) adults with CKD stages 1–5 fell within the two highest risk categories. The proportion of adults with CKD categorized as either moderate high or moderate risk was low (18.3%), and 34.8% of adults with CKD were classified as lower risk (Table 3). This was in contrast to the overall adult population, where only 18.6% were classified as high or very high risk and more than 60% were classified as lower risk (Table 3). The percent of the US population not meeting LDL cholesterol targets and on lipid-lowering therapy within current risk categories in adults with no CKD, CKD stages 1–2, and CKD stages 3–5 are presented in Table S2.

Proportion of US Population Above LDL Targets

Current guidelines—Under current guidelines, 24.4% (55.1 million) of the overall U.S. population in 2010 did not achieve their target LDL cholesterol goal. Of these, 25.2 million had sufficiently high LDL levels to meet recommendations for initiating LLT; 12.1 million were already on lipid-lowering therapy but merited intensification of treatment. Among those with CKD, 34.6% (10.4 million) did not achieve target LDL cholesterol goals; 4.6 million and 4.2 million, respectively merited initiation or intensification of therapy (Figure 1).

Alternative guideline scenarios—Under scenario 1 (where CKD stages 3–5 were included as a CHD risk equivalent), the proportion of U.S. adults above target LDL cholesterol goals increased to 26.3% (59.2 million); this includes an additional 3.3 million who would be recommended to initiate LLT and 1.1 million who might benefit from more intensive treatment. Under scenario 2 (where CKD stages 1–5 were included as a CHD risk equivalent), the proportion of adults in the overall population who did not meet target LDL cholesterol goals increased to 28.9% (65.2 million), including an additional 8.7 million who would be recommended to initiate therapy and 1.9 million who may benefit from more intensive therapy.

Type of Lipid-Lowering Therapy Currently in Use, by CKD Status

Among U.S. adults with dyslipidemia, 45.2% (35.4 million) were already on LLT in 2010. This therapy was more common in those with CKD (no CKD, 41.2%; CKD stages 1–2,

60.7%; CKD stages 3–5, 61.7%; Figure 2); however, the distribution of the type of therapy was similar across the persons with and without CKD, with statin monotherapy the most common treatment regimen (no CKD, 76.8%; CKD stages 1–2, 85.8%; CKD stages 3–5, 77.8%; Figure 2). For statin monotherapy and statin combination therapy, target LDL-cholesterol goal achievement was 75.7% and 71.5% in those without CKD, 67.4% and 65.1% in those with CKD stages 1–2, and 62.2% and 56.6% in those with CKD stages 3–5, respectively. For all other LLT, LDL cholesterol goal achievement was 48.9% in those without CKD, 67.8% in those with CKD stages 1–2, and 15.7% in those with CKD stages 3–5. The proportions of adults treated with LLT by dyslipidemia status and by cardiovascular risk category under current cholesterol guidelines are presented in Table S3. Both in adults with dyslipidemia and in adults with high/very high risk, LLT use tended to be higher among adults with CKD than those without CKD.

Discussion

Under current cholesterol guidelines, 55.1 million adults in the U.S. population did not achieve LDL-cholesterol goals, and almost half met the criteria for LLT initiation. If cholesterol guidelines were expanded to include CKD stages 1–5 as a CHD risk equivalent, these numbers would increase to 65.2 and 33.9 million adults, respectively. Currently, a higher proportion of adults with CKD than those without do not meet target LDL-cholesterol levels, suggesting that LDL cholesterol control in adults with CKD remains a concern whether or not CKD is considered a CHD risk equivalent. Expanding guidelines to include CKD as a CHD risk equivalent may raise awareness of CHD risk among CKD patients. Given the demonstrated efficacy and safety of LLT in CKD populations,^{19–21} this could have a large public health impact in reducing the cardiovascular burden among those with CKD and a potential economic impact for health care providers though increases in LLT use in adults with CKD.

Earlier work from NHANES III (1988–1994) showed that updating current cholesterol guidelines to include CKD as a CHD risk equivalent would change LLT recommendations in a large proportion of adults with CKD.²² When included as a CHD risk equivalent, the percentage of adults with CKD stage 3 (eGFR, 30–60 mL/min/1.73 m²) meeting recommendations for LLT initiation increased from 61.4% to 87.7%, or an additional 2 million adults.²² Using the current U.S. population, we observed that the percentage of adults with CKD stages 1–5 meeting recommendations for LLT initiation would increase from 27.2% to 62.4% if CKD stages 1–5 were considered a CHD risk equivalent. This suggests that lipid control in adults with CKD has improved, consistent with trends in the overall U.S. population²³ as well as with our prior work in NHANES 2007–2010.²⁴ Nevertheless, there remains substantial room for improvement as more than one quarter of adults with CKD did not achieve target LDL-cholesterol goals and would be considered for lipid lowering based on current cholesterol guidelines—even more so if CKD is considered a CHD risk equivalent.

Some have raised concerns that including CKD as a CHD risk equivalent in cholesterol guidelines will increase pharmacologic therapy in patients with moderate CKD in the absence of diabetes or prevalent CVD,²⁵ and that this healthier subset of adults with CKD is

not well represented in clinical trials of statin use. In our study, we did observe that those with CKD were predominately of earlier stages and that 34.8% of adults with CKD were classified as lower risk under current cholesterol guidelines based on established risk factors. Whether earlier stages of CKD are associated with sufficiently high risk to be a CHD risk equivalent or to improve risk stratification beyond traditional risk factors are also important considerations. In patients with high CVD risk, while moderate declines in eGFR and increases in ACR are associated with cardiovascular events, the addition of eGFR and ACR to traditional cardiovascular risk factors did not improve risk reclassification.²⁶ Similarly in patients with hypertension, model discrimination and risk classification did not improve when CKD (defined using creatinine-based eGFR) was added to Framingham risk factors.²⁷ For the purpose of cholesterol control, the majority of participants in these studies were high risk based on current guidelines and may not reflect risk classification among adults with CKD in our general population-based sample. Certainly, the risk associated with CKD increases with lower eGFR and higher ACR;^{3,4} appropriate thresholds for CVD risk when considering initiating treatment for risk factor control continue to be debated. Nonetheless, several existing guidelines already recommend that adults with CKD be classified in the highest risk groups for CVD.^{6,7} Reclassifying CKD as a CHD risk equivalent in cholesterol guidelines would simply align the ATP III to existing guidelines.

It is also important to consider potential concerns that may limit the acceptance of updated LLT guidelines in adults with CKD, such as potential adverse events related to statin use (for example, myalgia or rhabdomyolysis) or the mixed results for statins and CVD events in large randomized trials of patients with CKD.^{19,28,29} We did observe a higher proportion of adults with CKD not achieving LDL-cholesterol goals in spite of a higher percentage reporting current LLT. It may be that clinicians recognize the higher CVD risk associated with CKD, but that they have ongoing concerns with the safety of LLT in this population, leading to under-dosing. A recent meta-analysis incorporating 80 trials does suggest that statin use is relatively safe in CKD and that it decreases the risk of cardiovascular events in CKD patients not on dialysis.²¹ Revised guidelines that consider CKD a CHD risk equivalent and incorporate this evidence supporting the safety and efficacy of statin use in CKD could have a meaningful effect on cardiovascular risk factor control in adults with CKD.

Our study has limitations that should be considered. Current clinical definitions of CKD are based on the persistence of reduced eGFR and albuminuria over a period of three or more months,⁶ whereas we defined CKD based on single measurements of eGFR and urinary ACR, leading to potential misclassification of CKD status. There is also potential misclassification related to national cholesterol guideline risk categories, because data on some CHD risk equivalents, such as clinical atherosclerotic disease (e.g. peripheral arterial disease or abdominal aortic aneurysm), were not available in NHANES 2007–2010. Finally, our estimates for meeting cholesterol treatment goals are based on LDL-cholesterol targets described in ATP III, and the strength of the evidence supporting such targets may be debated.

A major strength of our study is the use of a large, nationally representative sample with rigorous and standardized measurement of kidney measures, lipids and other traditional

cardiovascular risk factors. Our analyses update prior literature by reporting estimates using the most recent data available (NHANES 2007–2010), applied to the 2010 U.S. population. We also considered the impact of including both milder and more severe stages of CKD in cholesterol guidelines, combining measures for both reduced eGFR and albuminuria, as each factor is independently associated with substantial excess cardiovascular disease risk.^{3,30}

In conclusion, adults with CKD represent a group with high cardiovascular risk. We found that reclassifying CKD as a CHD risk equivalent in national cholesterol guidelines would lead to an increase of 4.1 to 10.1 million U.S. adults not meeting target LDL-cholesterol goals, of which over 50% would meet recommendations for LLT initiation to reduce the risk of future cardiovascular disease events.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Support: This study was supported by the National Kidney Foundation (grant to Johns Hopkins) and Merck Sharp and Dohme Corp, a subsidiary of Merck & Co Inc, Whitehouse Station, NJ (professional service agreement to the National Kidney Foundation). MCF was supported in part by a National Institutes of Health/National Heart, Lung and Blood Institute Cardiovascular Epidemiology Training Grant (T32HL007024). MG receives support from the National Institute of Diabetes and Digestive and Kidney Diseases (grant K08DK092287). The NHANES is funded by the NCHS, Centers for Disease Control and Prevention, Department of Health and Human Services.

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Figure 1.

Percent and estimated number of U.S. adults in 2010 above LDL cholesterol goals under current cholesterol guidelines, guidelines that consider CKD stages 3–5 a “CHD risk equivalent” (scenario 1), and guidelines that consider CKD stages 1–5 a “CHD risk equivalent” (scenario 2).

Figure 2. Prevalence and type of lipid-lowering therapy use in U.S. adults with dyslipidemia by chronic kidney disease (CKD) status. Error bars represent standard errors.

Table 1

Cardiovascular risk category classifications with corresponding LDL-C targets and levels at which to consider LLT

Risk Category	LDL-C Goal	LDL-C level to consider LLT	Current Guidelines	Scenario 1	Scenario 2
Very High Risk	<70 mg/dL	100 mg/dL	Established CVD and 1 severe or poorly controlled risk factors**	Very high risk under current guidelines with CKD stages 3–5 as severe risk factor	Very high risk under current guidelines with CKD stage 1–5 as severe risk factor
High Risk	<100 mg/dL	100 mg/dL	CHD/CHD risk equivalents§	CKD stages 3–5 or high risk under current guidelines	CKD stages 1–5 or high risk under current guidelines
Moderately High Risk	<130 mg/dL	130 mg/dL		2 risk factors§§, 10-y hard CHD risk 10%–20%	
Moderate Risk	<130 mg/dL	160 mg/dL		2 risk factors§§, 10-y hard CHD risk <10%	
Lower Risk	<160 mg/dL	190 mg/dL		0 or 1 risk factor§§	

Note: Current guidelines based on modified Adult Treatment Panel III criteria for risk categorization and LDL-C goals and LDL-C level to consider LLT.² Scenario 1 represents a modification of current national cholesterol guidelines with CKD stages 3–5 as a CHD risk equivalent; scenario 2 represents a modification of current national guidelines with CKD stages 1–5 as a CHD risk equivalent. Conversion factor for LDL-C and HDL-C in mg/dL to mmol/L, $\times 0.02586$.

CKD, chronic kidney disease; CHD, coronary heart disease; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; LLT, lipid-lowering therapy.

** History of cardiovascular disease based on self-report in addition to 1 of following risk factors: current smoking, diabetes, and/or metabolic lipid abnormalities (serum triglycerides ≥ 200 mg/dL, non-HDL-C ≥ 130 mg/dL, or HDL-C < 40 mg/dL)

§ History of CHD based on self report or CHD risk equivalents: diabetes (hemoglobin A1c $\geq 6.5\%$, a self-reported physician diagnosis, or self-reported use of insulin or anti-diabetic pills), history of stroke based on self-report, or 2 risk factors with a 10-year risk of a CHD event $\geq 20\%$

§§ CHD risk factors were defined as follows: current smoking (self-report), low HDL-C (< 40 mg/dL), older age (≥ 45 years in men, ≥ 55 years in women), hypertension (systolic blood pressure ≥ 140 mmHg, diastolic blood pressure ≥ 90 mmHg, or self-reported physician diagnosis of hypertension), a family history of premature CHD (self-report of a heart attack in close relative before age 50 years), and high HDL-C (≥ 60 mg/dL, a negative risk factor)

Table 2

Population characteristics by CKD status

	Overall	CKD stages 3–5	CKD stages 1–5
No. of NHANES participants *	4823	398	849
Age (y)	46.8 (0.4)	71.0 (0.9)	60.7 (0.8)
Female sex	51.0% ± 0.8%	60.1% ± 2.6%	57.1% ± 2.0%
Race **			
Non-Hispanic white	69.3% ± 2.3%	82.2% ± 2.2%	68.9% ± 2.3%
Non-Hispanic black	11.0% ± 1.1%	8.6% ± 1.4%	10.9% ± 1.5%
Mexican American	8.4% ± 1.2%	2.7% ± 0.9%	7.9% ± 1.7%
Other Hispanic	5.1% ± 0.9%	3.1% ± 0.8%	4.5% ± 0.9%
Smoking status			
Current	20.2% ± 0.8 %	7.7% ± 1.4%	15.4% ± 1.1%
Former	24.8% ± 1.1%	34.0% ± 2.8%	27.9% ± 1.8%
Never	55.0% ± 1.3%	58.3% ± 3.2%	56.6% ± 1.8%
eGFR (mL/min/1.73 m ²)	95.7 (0.6)	46.9 (0.7)	73.1 (1.3)
Urinary ACR (mg/g)	6.3 [4.2–11.3]	13.3 [6.1–50.7]	45.1 [23.2–103.5]
Diabetes	10.5% ± 0.5%	29.8% ± 2.6%	29.6% ± 1.8%
Dyslipidemia	34.8% ± 1.0%	62.8% ± 2.9%	53.0% ± 2.1%
Current LLT [^]	15.8% (0.7%)	39.7% (2.7%)	32.5% (1.6%)
Lipid measurements			
Receiving LLT			
Total cholesterol (mg/dL)	186.1 (1.0)	181.0 (4.2)	184.1 (3.1)
LDL-C (mg/dL)	106.1 (1.5)	98.3 (3.1)	101.0 (2.3)
HDL-C (mg/dL)	51.2 (0.5)	51.9 (1.4)	51.3 (0.8)
Non-HDL-C (mg/dL)	136.6 (1.6)	131.5 (4.1)	134.8 (2.9)
Triglycerides (mg/dL)	128 [91–188]	140 [99–220]	126 [91–212]
Not receiving LLT			
Total cholesterol (mg/dL)	197.6 (1.0)	196.7 (4.8)	197.8 (3.1)
LDL-C (mg/dL)	118.0 (0.8)	114.2 (3.7)	114.4 (2.6)
HDL-C (mg/dL)	54.1 (0.4)	54.5 (1.4)	54.2 (0.8)
Non-HDL-C (mg/dL)	142.7 (0.9)	141.3 (4.1)	142.4 (2.8)
Triglycerides (mg/dL)	96 [67–141]	111 [89–163]	105 [75–163]

Note: US population aged 20 years or older, NHANES 2007–2010. Estimate values are given as weighted mean ± standard error, weighted proportion ± standard error, or weighted median [interquartile range]. Conversion factors for units: HDL-C and LDL-C in mg/dL to mmol/L, ×0.02586; triglycerides in mg/dL to mmol/L, ×0.01129.

Abbreviations: ACR, albumin-creatinine ratio; eGFR, estimated glomerular filtration rate; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; LLT, lipid-lowering therapy; NHANES, National Health and Nutrition Examination Survey.

* Corresponds to 2010 population estimates of 225.5 million adults (overall), 14.5 (95% confidence interval, 13.0–16.0) million adult with CKD stages 3–5, and 30.5 (95% confidence interval, 28.6–32.3) million adults with CKD stages 1–5; determined by applying weighted prevalences from the NHANES 2007–2010 to the 2010 U.S. Census population data.

** Column percentages do not sum to 100% because other race not reported.

^ Based on self-report.

Table 3

Percent of U.S. population not meeting LDL-C targets and receiving LLT within risk categories in current cholesterol guidelines.

	Overall	CKD Stages 3–5	CKD Stages 1–5
Overall (all risk categories)			
2010 No. in millions (%)	225.5 (100%)	13.9 (100%)	30.0 (100%)
% not at target LDL-C	24.4 (0.9)	41.6 (2.9)	34.6 (1.7)
% receiving LLT	15.8 (0.7)	39.7 (2.7)	32.5 (1.6)
Very High Risk (target 70 mg/dL)			
2010 No. in millions (%)	8.8 (3.9%)	2.2 (15.6%)	3.7 (12.4%)
% not at target LDL-C	78.1 (2.9)	73.5 (7.2)	71.6 (5.2)
% receiving LLT	48.5 (3.9)	57.7 (5.6)	55.5 (4.9)
High Risk (target 100 mg/dL)			
2010 No. in millions (%)	33.3 (14.7%)	5.7 (40.8%)	10.4 (34.5%)
% not at target LDL-C	58.5 (2.2)	54.4 (4.5)	55.5 (2.9)
% receiving LLT	40.5 (2.0)	48.7 (0.4)	46.9 (3.5)
Moderate High Risk (target 130 mg/dL)			
2010 No. in millions (%)	14.1 (6.2%)	1.4 (10.0%)	2.8 (9.4%)
% not at target LDL-C	39.8 (3.0)	15.6 (4.6)	21.9 (3.4)
% receiving LLT	26.6 (2.8)	35.3 (9.8)	37.3 (7.9)
Moderate Risk (target 130 mg/dL)			
2010 No. in millions (%)	28.4 (12.6%)	1.5 (10.9%)	2.7 (8.9%)
% not at target LDL-C	32.8 (3.0)	19.2 (7.8)	23.3 (7.3)
% receiving LLT	16.5 (2.1)	28.2 (10.0)	20.2 (5.7)
Lower Risk (target 160 mg/dL)			
2010 No. in millions (%)	141.0 (62.5%)	3.1 (22.7%)	10.4 (34.8%)
% not at target LDL-C	10.3 (0.7)	19.4 (4.3)	8.7 (2.3)
% receiving LLT	6.9 (0.8)	20.4 (5.3)	12.6 (2.5)

Note: US adults aged 20 years or older, NHANES 2007–2010. Based on the third report of the Adult Treatment Panel (ATP III) of the National Cholesterol Education Program and modified ATP III guidelines.^{1,2} Risk stratification definitions: Very high risk: history of cardiovascular disease in addition to current smoking, diabetes, and/or adverse triglyceride (≥ 200 mg/dL), non-HDL-C (≥ 130 mg/dL), or HDL-C (<40 mg/dL) measurements; high risk: history of CHD or a CHD risk equivalent; moderate high risk: 2 risk factors with a 10%–20% 10-year hard CHD risk; moderate risk: 2 risk factors with $<10\%$ 10-year hard CHD risk; lower risk: 0 or 1 risk factor. Conversion factors for units: HDL-C and LDL-C in mg/dL to mmol/L, $\times 0.02586$; triglycerides in mg/dL to mmol/L, $\times 0.01129$.

CKD, chronic kidney disease; CHD, coronary heart disease; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; LLT, lipid-lowering therapy.