

# Implicit Gender Bias and the Use of Cardiovascular Tests Among Cardiologists

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**Background**—Physicians' gender bias may contribute to gender disparities in cardiovascular testing. We used the Implicit Association Test to examine the association of implicit gender biases with decisions to use cardiovascular tests.

**Methods and Results**—In 2014, cardiologists completed Implicit Association Tests and a clinical vignette with patient gender randomly assigned. The Implicit Association Tests measured implicit gender bias for the characteristics of strength and risk taking. The vignette represented an intermediate likelihood of coronary artery disease regardless of patient gender: chest pain (part 1) followed by an abnormal exercise treadmill test (part 2). Cardiologists rated the likelihood of coronary artery disease and the usefulness of stress testing and angiography for the assigned patient. Of the 503 respondents (9.3% of eligible; 87% male, median age of 45 years, 58% in private practice), the majority associated strength or risk taking implicitly with male more than female patients. The estimated likelihood of coronary artery disease for both parts of the vignette was similar by patient gender. The utility of secondary stress testing after an abnormal exercise treadmill test was rated as "high" more often for female than male patients (32.8% versus 24.3%,  $P=0.04$ ); this difference did not vary with implicit bias. Angiography was more consistently rated as having "high" utility for male versus female patients (part 1: 19.7% versus 9.8%; part 2: 73.7% versus 64.3%;  $P<0.05$  for both); this difference was larger for cardiologists with higher implicit gender bias on risk taking ( $P=0.01$ ).

**Conclusions**—Cardiologists have varying degrees of implicit gender bias. This bias explained some, but not all, of the gender variability in simulated clinical decision-making for suspected coronary artery disease. (*J Am Heart Assoc.* 2017;6:e006872. DOI: 10.1161/JAHA.117.006872.)

**Key Words:** angiography • gender disparities • implicit bias • stress testing

Gender differences in the use of cardiac tests in patients with suspected or confirmed coronary artery disease (CAD) have been known for decades.<sup>1–8</sup> After an abnormal cardiac stress test, women are less likely to undergo any subsequent diagnostic testing, including secondary stress testing or angiography.<sup>6–8</sup> These gender differences persist even after considering patient factors that may explain variation in care such as differences in comorbidities,

presentation, appropriateness of treatment, and patient preferences—suggesting that these differences represent *disparities*, as defined by the Institute of Medicine.<sup>7–12</sup> Despite studies documenting gender disparities in the use of cardiovascular tests, few have examined the underlying reasons for these disparities in management.

A potential reason for gender disparities in cardiovascular testing is providers' gender stereotyping and bias.<sup>11,13–16</sup>

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Accompanying Tables S1 through S3 are available at <http://jaha.ahajournals.org/content/6/12/e006872/DC1/embed/inline-supplementary-material-1.pdf>

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## Clinical Perspective

### What Is New?

- In a survey of cardiologists practicing in the United States, we detected implicit gender bias suggesting these cardiologists are more likely to view men as being strong and more likely to take risks than women.
- Despite similar estimates of coronary artery disease likelihood, cardiology physicians rated the usefulness of angiography higher for a standardized male than female patient.
- The gender difference in angiography ratings was related to cardiologists' implicit gender bias, suggesting that the perception of men being more risk tolerant may influence decisions about angiography with regard to female versus male patients with chest pain.

### What Are the Clinical Implications?

- Implicit gender bias explained some, but not all, gender differences in simulated clinical decision making, suggesting that factors beyond clinical appropriateness alone play a role.
- Gender bias may be more likely in clinical scenarios that involve more subjectivity or higher risk procedures, and bias may be less likely when explicit gender-specific recommendations exist.
- Efforts to ensure equity in care for women and men should include improving the evidence base, particularly for women, who are historically underrepresented in trials and for whom there is greater clinician uncertainty about how best to manage their conditions.

Gender stereotyping is the process by which people make assumptions about others' characteristics based on their gender, along specific trait dimensions.<sup>17</sup> Gender stereotypes have remained remarkably consistent over time, with men traditionally perceived to be stronger (both physically and mentally) and more likely to take risks compared with women and with women perceived to be more emotional and focused on caring for others than men.<sup>18–22</sup> These gender stereotypes are referred to as *bias* because they create unjust assumptions or decisions about a person.<sup>17,23</sup> Bias has been inferred in prior studies when gender differences in care persist after adjusting for many patient, physician, and health system characteristics.<sup>24–27</sup> A recent systematic review found 14 studies that examined the presence of gender bias using controlled, randomly assigned vignettes to examine the influence of patient gender on healthcare professionals' attitudes, diagnoses, and treatment decisions.<sup>12</sup> However, no study has directly measured physician gender bias using a validated measure.<sup>12</sup>

The Implicit Association Test (IAT) is a reliable and validated measure for determining implicit (unconscious) bias.<sup>17,23,28–33</sup> The IAT measures bias through speed of response (reaction

time), operating on the principle that it is easier to pair concepts that are more strongly associated in one's minds than to pair concepts less strongly associated, regardless of one's conscious beliefs or values.<sup>31</sup> The IAT has been used to measure race/ethnicity bias and has predicts behavior including physicians' treatment recommendations for hypothetical patients.<sup>28,34</sup> Although the IAT has been used to measure implicit gender bias in career and educational roles,<sup>35,36</sup> no study has examined the association between implicit gender bias and decision-making in health care.<sup>12</sup>

Accordingly, we conducted a survey of cardiology physicians to measure implicit gender bias using the IAT and to determine the extent to which it is associated with making judgments about cardiac testing for hypothetical male and female patients with similar likelihoods of obstructive CAD. We hypothesized little or no effect of physician gender bias on treatment decisions for the male patient and lower use of cardiovascular tests among gender-biased physicians for the female patient.

## Methods

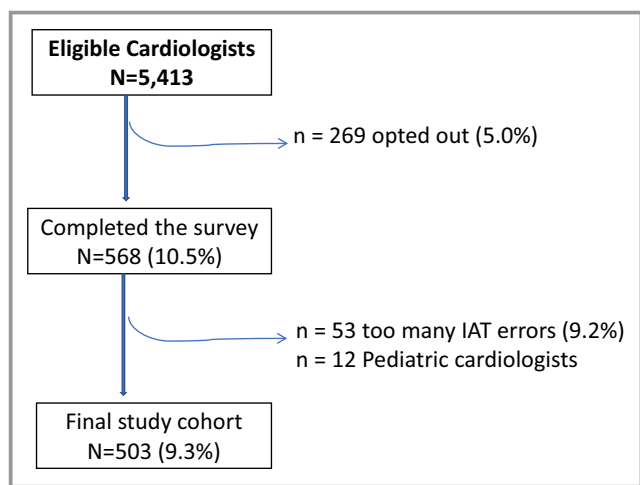
### Study Design

This between-subjects randomized experimental study was performed in a cohort of practicing US cardiologists. Eligible cardiologists were invited by e-mail with a link to a secure, web-based survey. Privately, and at their own pace, the participating cardiologists completed informed consent, read the case vignette and answered the case questions, completed 2 measures of implicit gender bias (IATs) in random order, and answered sociodemographic questions (age, race, gender, practice type, specialty).

Participants were told that the purpose of the study was to better understand provider approaches to clinical decision-making. The focus on gender was not immediately disclosed to avoid sensitizing participants to guard against bias. After the case questions were completed, participants were fully informed about the purpose of the study but were not allowed to change their prior answers. Next, participants completed the IATs and demographic questions. Participants were e-mailed a \$25 gift card on survey completion. The survey instrument was administered by Project Implicit, a nonprofit research collaboration at Harvard University (<https://implicit.harvard.edu/implicit/>). The Colorado Multiple Institutional Review Board at the University of Colorado School of Medicine approved the study.

### Study Population

Participants were located through state cardiology foundations or, for states without this option, Research Now, a



**Figure 1.** Flowchart of the study population. IAT indicates Implicit Association Test.

marketing company that maintains an “opt-in” survey panel of cardiology physicians.<sup>37</sup> Recruitment for the national survey took place from March to November 2014. All cardiology physicians identified by either method were e-mailed up to 4 invitations to participate. Participants who saw only pediatric

patients were excluded from the analysis because the study vignettes portrayed adult patients.

An invitation to participate was e-mailed to 5413 cardiology physicians throughout the United States with valid e-mail addresses; of these, 269 (5.0%) opted out and 568 (10.5% of those eligible) completed the entire survey. Of completed surveys, 12 were excluded for being pediatric cardiologists, and 53 were excluded for having an invalid IAT score (based on high errors rates).<sup>29</sup> The characteristics of those included versus excluded for IAT errors were not statistically different (Table S1). The final sample for analysis included 503 (9.3% of eligible) cardiology physicians (Figure 1).

Participants were mostly male (87%), white (62%), in private practice (58%), and noninvasive cardiologists (52%). The median age was 45 years (range: 28–89 years), and the median number of years in practice was 12 (range: 1–55 years). The characteristics of the participants who were randomly assigned a male or female case patient did not differ significantly (Table 1). The demographics of the study population are similar to members of large cardiology organizations.<sup>38</sup> The American College of Cardiology, for example, reports that 12% of physician members are, compared with 13% of our study sample.<sup>39–41</sup>

**Table 1.** Cardiology Physician Participant Characteristics by Vignette Patient Gender

	All Participants (N=503)	Male Patient (n=259)	Female Patient (n=244)	P Value*
Age, y				
Median (range)	45 (28–89)	45 (29–71)	45 (28–89)	0.65
Male, n (%)	436 (86.9)	225 (51.6)	211 (48.4)	0.99
Race/ethnicity, n (%)				
White	310 (62.3)	154 (49.7)	156 (50.3)	0.57
Asian	132 (26.5)	71 (53.8)	61 (46.2)	
Other <sup>†</sup>	61 (12.1)	34 (55.7)	27 (44.3)	
Specialty, n (%)				
General/noninvasive	264 (52.5)	140 (53.0)	124 (47.0)	0.85
Interventional	165 (32.8)	84 (50.9)	81 (49.1)	
Electrophysiology	40 (8.0)	19 (47.5)	21 (52.5)	
Other <sup>‡</sup>	34 (6.8)	16 (47.1)	18 (52.9)	
Years in practice				
Median (range)	12 (1–55)	12 (1–45)	12 (1–55)	0.40
Practice setting, n (%)				
Academic/university	207 (41.2)	101 (48.8)	106 (51.2)	0.31
Private practice	291 (57.9)	158 (53.4)	138 (56.5)	

\*Wilcoxon or  $\chi^2$  test.

<sup>†</sup>Includes black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, Hispanic, those who picked multiple race/ethnicities, and those who declined to answer.

<sup>‡</sup>Includes heart failure/transplant, adult congenital cardiology, cardiothoracic surgery, and those who declined to answer.

## Case Vignette

The vignette had 2 parts for the same patient (Table S2). Part 1 described a patient presenting with chest pain who, according to the information provided, would have an intermediate pretest likelihood of obstructive CAD for a male or female patient.<sup>42</sup> Part 2 described the same patient returning with continued episodes of chest pain and an abnormal exercise treadmill test (ETT; Duke Treadmill Score 5), again suggesting an intermediate likelihood of obstructive CAD regardless of gender. For accuracy and clinical validity, the case scenarios were reviewed by a panel of 10 cardiologists with both clinical and research experience.

At the end of each part of the case description, participants rated the likelihood (low, intermediate, or high) that the patient's symptoms were related to obstructive CAD and their certainty (low, intermediate, or high) of this estimate. Finally, participants were asked to rate the usefulness (1 indicates "option has no use for this case," 10 indicates "option is of utmost importance for this patient") of stress testing and coronary angiography for that patient.

The survey instrument randomly assigned participants to review the exact same case with either a male or female patient. Patient gender was identified by an accompanying picture and the usage of appropriate pronouns. The patient photos were matched between genders for perceived age, attractiveness, likeability, and representativeness of gender.<sup>43</sup>

## Measures of Gender Bias

We developed 2 web-based IATs to measure implicit gender bias on strength and risk taking. These 2 dimensions are known gender stereotypes (both more strongly associated with men than women) that our research team and consulting panel of cardiologists believed to be most likely to influence decisions to use cardiac procedures.<sup>18–22</sup>

The IAT measures implicit bias through the speed with which an individual accurately sorts concepts and is based on the assumption that concepts will be sorted more quickly when they are more tightly associated.<sup>31</sup> The strength IAT, for example, asked each participant to sort images and words under 2 conditions. Condition 1, comprising pictures of men and words synonymous with *strength* (eg, "robust" or "powerful"), required one response, whereas pictures of women and words synonymous with *weakness* (eg, "delicate" or "mild") required a different response. Condition 2, comprising pictures of women and strong words, required one response, whereas pictures of men and weak words required a different response. Participants were told to respond as quickly as possible, without sacrificing accuracy. Differences in the speed of correct responses in each condition serve as a proxy for how tightly the concepts are associated in the participant's mind.<sup>31</sup> Faster responses in

condition 1 than condition 2 indicate a stereotypical association of men with strength and women with weakness—the greater the time differences between the 2 conditions, the stronger the implicit association.<sup>44</sup> The risk-taking IAT was procedurally the same, except that it measured implicit gender bias on "takes risk versus avoids risk."

We identified words that had been rated as the best synonyms for the target concepts (Table S3). We chose 6 pictures of men and women from a facial stimuli database that were rated by a panel of 10 physicians to be similar in age, attractiveness, likability, and representative of their gender category.<sup>43</sup> The ordering of the concept pairings in the 2 sorting conditions was randomized across participants.

## IAT Scoring

Implicit gender bias was assessed using standard IAT D scores, which account for variations in respondents' average speed.<sup>29</sup> IAT D scores are computed as the mean difference in response latency of trial blocks divided by the overall standard deviation. The IAT-D score has a possible range of  $-2$  to  $+2$ . The higher the D score, the higher the implicit gender bias of associating strength or risk taking with men more than women, with negative numbers indicating a reversal in bias. For descriptive purposes, IAT D scores were categorized into standard classifications (no, slight, medium, or high bias).<sup>29</sup> Break points for slight ( $D=0.15$ ), medium ( $D=0.35$ ), and high ( $D=0.65$ ) were selected conservatively according to psychological conventions for effect size. Because the IAT is a performance-based measure, a high error rate ( $>30\%$  of responses) indicates intentional inattention (eg, random responding) or misunderstanding task instructions. Based on standard practices in IAT research, participants with error rates  $>30\%$  were excluded.<sup>29</sup> Participants were informed before each IAT that if they made too many errors, the test would not provide results.

## Pretesting, Pilot Testing, and Validation of Survey Measures

Using guidelines for pretesting questionnaires, we conducted interviews with 10 cardiologists to determine their reaction to and understanding of the web-based survey.<sup>45</sup> We asked half of the respondents to think aloud while they were completing the case scenario questionnaire and IAT measures. The interviewer probed the respondents about how they were interpreting each question and whether their responses were adequately covered by the response options provided. The survey was modified based on these initial interviews. For the other half of the interviews, participants completed the modified web-based survey under usual conditions. On completion of the survey, the interviewer probed participants

about specific questions and response sets. We ended the pretesting with more general questions about general content of the survey, ease of completion, comfort with instructions, and any other concerns. These interviews informed final revisions of the survey.

We piloted the survey among 53 cardiologists who were not part of the pretesting or the national study. Pilot survey participants had characteristics (82% men, 63% noninvasive cardiologists), case responses, and mean IAT scores (risk-taking IAT score: 0.45 [SD: 0.54]; strength IAT score: 0.60 [SD: 0.42]) similar to those of the larger national sample. Among this pilot sample, internal consistency of the IATs using Pearson correlation coefficients was adequate (strong IAT:  $r=0.65$ ,  $P<0.01$ , Cronbach  $\alpha=0.79$ ; risk-taking IAT:  $r=0.68$ ,  $P<0.01$ , Cronbach  $\alpha=0.81$ ) and comparable to other commonly used IATs.<sup>46</sup> Eleven of the pilot participants repeated the IATs  $\approx 30$  days after the initial survey; test-retest reliability using Pearson correlation coefficients was high (strong IAT:  $r=0.68$ ,  $P=0.02$ ; risk-taking IAT:  $r=0.78$ ,  $P<0.01$ ). Survey responses from the pilot participants were not included in the final study cohort reported in this article.

## Statistical Analyses

Demographic characteristics of the participating cardiologists were described. Based on the distribution of responses, the case management ratings were categorized as low/intermediate (1–7) or high (8–10) agreement. Case management responses were compared for the female and male patients. Physician factors associated with patient gender differences in case responses were explored. The association of cardiologists' demographic factors, including age, gender, race, years in practice and specialty, and IAT scores, were also assessed.

Next, we examined the relationship between patient gender and the participants' ratings (high versus low/intermediate) for either stress testing or angiography using logistic regression analysis. To test the extent to which implicit gender bias influenced differences in management of male and female patients, we included an interaction term for patient gender and physician IAT D score (modeled as a continuous variable). Multivariable models examining this interaction included the physicians' specialty and estimated likelihood of CAD. The analysis was conducted using SAS 9.4 software (SAS Institute).

## Results

### Implicit Gender Bias

Among the 503 participants, the mean risk-taking IAT score was 0.42 (SD: 0.41), and mean strength IAT score was 0.66 (SD: 0.40), consistent with gender bias that males take more

risks and are stronger than females (Figure 2). When categorized by extent of bias, 74.7% and 89.9% of the physicians had some implicit gender bias on risk taking and strength, respectively; 32.4% and 57.6% had high implicit bias on risk taking and strength, respectively (Figure 2).

In unadjusted analysis, female cardiologists had less implicit gender bias on both risk taking and strength; younger age and nonwhite race of the physician were also associated with less implicit gender bias on strength. After adjustment, female cardiologists still showed significantly less implicit gender bias on risk taking or strength than male cardiologists (risk-taking bias:  $D=-0.17$ ,  $P<0.01$ ; strength bias:  $D=-0.21$ ,  $P<0.01$ ). Nonwhite race and age were no longer significant after adjustment (Table 2).

### Case Responses

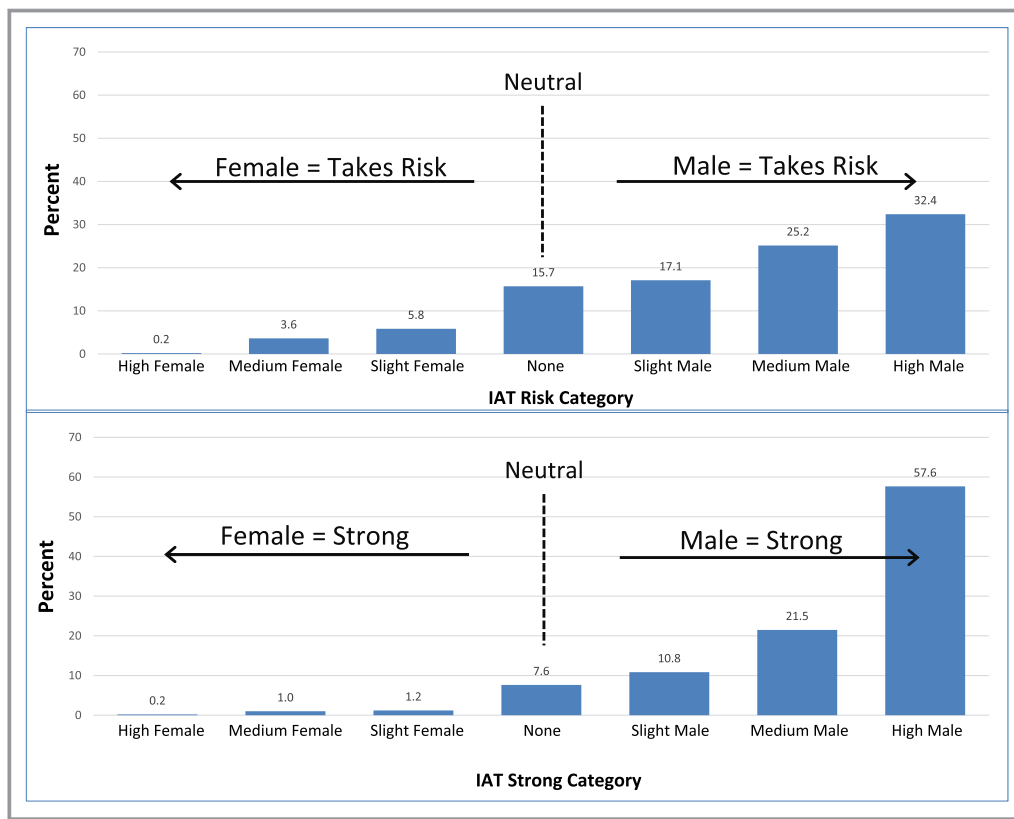
For a patient with symptoms suggesting CAD (part 1), the majority of cardiologists estimated the likelihood of obstructive CAD as intermediate or low in equal proportions for the male and female patients; however, respondents were less certain of their CAD estimates for the female patient (Table 3). More than 90% agreed that stress testing would be highly useful for the patient with symptoms suggestive of CAD regardless of patient gender, although a larger percentage rated angiography as highly appropriate for the male versus the female patient (19.7% versus 9.8%,  $P<0.01$ ).

For the patient with an abnormal ETT and continued symptoms of chest pain despite medications (part 2), respondents rated the likelihood of CAD as high at similar rates for the male and female patients (83.0% versus 79.5%,  $P=0.31$ ) but again were less certain of this estimate for the female patient (Table 3). Respondents were more likely to rate the usefulness of a secondary stress test as intermediate to low (75.7% versus 67.2%,  $P=0.04$ ) and angiography as high (73.7% versus 64.3%,  $P=0.03$ ) for the male versus the female patient (Table 3).

For both parts of the case, factors independently associated with a higher angiography rating included male patient gender, higher estimated likelihood of CAD, and higher certainty of this estimate (all  $P<0.05$ ). Physician factors independently associated with higher angiography ratings included having a procedural specialty (interventional, cardiothoracic surgery, or electrophysiology) and fewer years in practice (all  $P<0.05$ ).

### Implicit Gender Bias and Case Responses

In unadjusted analysis, gender differences in angiography ratings for parts 1 and 2 of the case varied significantly by physician implicit bias (an interaction effect of patient gender and physician IAT scores). Physicians with more gender bias



**Figure 2.** Cardiology physicians' gender bias regarding risk taking and strength. IAT indicates Implicit Association Test.

on risk taking (Figure 3A) or strength (Figure 3B) rated angiography as more useful for men than for women ( $P < 0.05$  for both unadjusted interactions). After adjustment for perceived likelihood of CAD and physician specialty, physicians' gender bias on risk taking remained a significant predictor of gender differences in angiography ratings in patients with symptoms suggestive of CAD (adjusted  $P = 0.01$  for interaction); however, gender bias on strength was no longer significant in patients with an abnormal stress test (adjusted  $P = 0.12$ ). Implicit gender bias did not significantly relate to gender differences in stress test ratings in either part of the case (all  $P > 0.05$  for interactions; data not shown).

## Discussion

In this survey of cardiology physicians practicing throughout the United States, most participants exhibited implicit gender bias suggesting they viewed men as stronger or more likely to take risks than women. Hypothetical female and male patients were also evaluated differently; in an identical case presentation with symptoms and a stress test suggestive of CAD, participating cardiologists were less likely to rate angiography as highly useful for a female patient compared with a male patient. Importantly, this gender difference in

case management was associated with implicit gender bias: cardiologists who associated risk taking more with men than with women were more likely to view angiography as highly useful for male versus female patients. Implicit gender bias was not significantly associated with differences in angiography recommendations among patients with an abnormal ETT or in the use of stress testing. Consequently, implicit gender bias—as measured in this study—may influence some clinical decisions but not others.

To our knowledge, this study is the first to directly measure implicit gender bias among physicians and the first to relate such bias with clinical decision-making.<sup>12</sup> Research shows that people commonly use a person's social identity (eg, gender) as a mechanism to organize, simplify, or supplement the torrent of information that must be dealt with in everyday situations.<sup>47,48</sup> Implicit biases are common and operate in a relatively unintentional, automatic manner.<sup>49,50</sup> Our study is the first to demonstrate that  $>70\%$  of the participating cardiologists associated strength and risk taking with men more than women. Prior studies have shown that the majority of physicians have implicit race/ethnicity bias at rates similar to community samples.<sup>12,46,51–53</sup> Physicians may be especially vulnerable to the use of implicit biases in clinical settings characterized by time pressure, brief encounters, and

**Table 2.** Physician Factors Associated With Implicit Gender Bias

Measure	Risk-Taking IAT*				Strength IAT*			
	Unadjusted		Adjusted†		Unadjusted		Adjusted†	
	Estimate	P Value	Estimate	P Value	Estimate	P Value	Estimate	P Value
Intercept	...	...	0.45	<0.01	...	...	0.79	<0.01
Age, y	0.01	0.27	...	0.65	0.01	<0.01	...	0.07
<35	−0.05	0.43	−0.02	0.75	−0.13	0.04	−0.08	0.24
35–45	−0.03	0.55	−0.02	0.79	−0.13	0.02	−0.09	0.11
46–60	0.04	0.50	0.06	0.54	0.01	0.93	0.02	0.78
>60	Ref.	...			Ref.	...	...	...
<b>Gender</b>								
Female	−0.18	<0.01	−0.17‡	<0.01	−0.24	<0.01	−0.21	<0.01
Male	Ref.	...	Ref.	...	Ref.	...	Ref.	...
Race/ethnicity		0.19		0.67		<0.01		0.06
Asian	−0.05	0.25	−0.05	0.42	−0.10	0.01	−0.07	0.11
Other	−0.10	0.12	−0.02	0.58	−0.17	<0.01	−0.13	0.04
White	Ref.	...	...	...	Ref.	...	Ref.	...
Years in practice§		0.29		...		<0.01		...
0–5	−0.07	0.19	−0.02	...	−0.19	<0.01	...	...
6–15	−0.04	0.43	0.003	...	−0.13	<0.01	...	...
16–24	0.03	0.59	0.04	...	−0.08	0.18	...	...
≥25	Ref.	...	...	...	Ref.	...	Ref.	...
<b>Cardiology specialty</b>								
Invasive	0.05	0.21	0.02	0.56	−0.01	0.96	−0.03	0.38
Noninvasive	Ref.	...	...	...	Ref.	...	...	...

IAT indicates Implicit Association Test; Ref., reference value.

\*A positive IAT score is associated with a higher implicit association with males and risk taking or strength, and a negative score is associated with higher implicit association with females and risk taking or strength.

†Adjusted models include age, gender, race/ethnicity, and specialty.

§Age and years in practice are highly correlated ( $P<0.0001$ ); only age was retained in the multivariable linear regression model.

the need to manage very complex situations—the type of situations in which implicit bias is more likely to be applied.<sup>17,50</sup> Demonstrating the presence of bias among physicians and other healthcare professionals is an important step in understanding the potential role of bias in clinical decision-making.

Women with angina have a lower prevalence of obstructive CAD at angiography compared with men, and lower angiography referral in women may not necessarily be inappropriate.<sup>54</sup> Similarly, it is not surprising that men were perceived as stronger or more likely to take risks than women because these perceptions align with societal stereotypes.<sup>18–20</sup> What is unique about our findings is the demonstration that implicit gender stereotypes (bias) were related to some clinical decisions; those with the most bias that women are less likely to take risks than men were the least likely to rate

angiography as useful in women. Our findings suggest that factors beyond clinical appropriateness alone play a role. The inappropriate application of prior knowledge or assumptions about differences between populations can result in “knowledge-mediated bias.”<sup>27,48,55</sup> In other words, an assumption that all women with symptoms of angina or an abnormal stress test do not have obstructive CAD or are more risk avoidant, resulting in lower angiography rates in women, could result in significant health disparities.

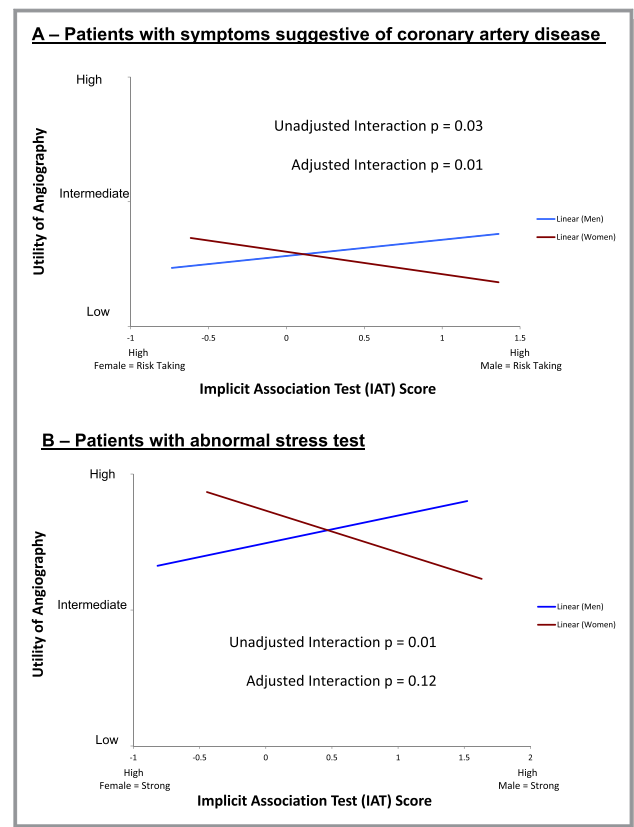
Our study demonstrated that implicit gender bias was associated with differences in some simulated clinical decisions but not others. Gender-based variation in recommendations for angiography among patients with chest pain was related to implicit gender bias on risk taking. This same bias was not significantly associated with observed differences in rated usefulness of secondary stress testing or angiography

**Table 3.** Responses to the Management Questions According to Patient Gender in Vignette

	Male Patient (n=259), %	Female Patient (n=244), %	P Value
<b>Part 1: patient with symptoms suggestive of CAD</b>			
<b>Likelihood of CAD</b>			
High	41.3	38.5	0.52
Intermediate/low	58.7	61.5	
<b>Certainty of estimate</b>			
High	53.7	44.3	0.04
Intermediate/low	46.4	55.7	
<b>Stress test rating</b>			
High	90.1	90.6	0.82
Intermediate/low	10.0	9.4	
<b>Angiography rating</b>			
High	19.7	9.8	<0.01
Intermediate/low	80.3	90.2	
<b>Part 2: patient with abnormal stress test</b>			
<b>Likelihood of CAD</b>			
High	83.0	79.5	0.31
Intermediate/low	17.0	20.5	
<b>Certainty of estimate</b>			
High	86.1	79.1	0.04
Intermediate/low	13.9	20.9	
<b>Secondary stress test rating</b>			
High	24.3	32.8	0.04
Intermediate/low	75.7	67.2	
<b>Angiography rating</b>			
High	73.7	64.3	0.03
Intermediate/low	26.3	35.6	

CAD indicates coronary artery disease.

after an abnormal ETT. Explanations for this heterogeneity include the possibility that gender bias may be more relevant in clinical scenarios that involve more subjectivity or higher risk procedures. In a patient with chest pain, the clinician must subjectively interpret the patient’s symptoms to determine risk, whereas an ETT provides a more objective assessment of risk. It is also possible that physicians viewed proceeding directly to angiography in a patient with symptoms of CAD as a higher risk first step, rendering gender biases about the patient’s risk acceptance more relevant. Nevertheless, once presented with an abnormal stress test, angiography was felt to be useful regardless of a patient’s assumed risk acceptance. Gender bias may be less relevant when gender-specific recommendations exist. A consensus statement on women and diagnostic cardiovascular testing



**Figure 3.** The strength of angiography rating varied according to case patient gender and physician implicit gender bias. The x-axis represents physician gender bias based on Implicit Association Test scores, and the y-axis represents the extent to which angiography was rated as useful for the case vignette by the physician. The relationship between gender bias and angiography rating is indicated when the case patient was male (blue line) and female (red line). In unadjusted analysis, significant interactions were seen between gender bias and case gender; those with higher implicit gender bias on risk taking (A) or strength (B) rated angiography as less useful in women than men (unadjusted  $P < 0.05$  for interaction for both). After adjustment for perceived likelihood of coronary artery disease and physician specialty, the interaction between risk-taking bias and patient gender on angiography usefulness remained significant (adjusted  $P = 0.01$  for interaction in panel A); however, the interaction with strength bias was no longer significant (adjusted  $P = 0.12$  in panel B).

recommends a secondary stress test after an abnormal ETT, which may explain the higher rating of secondary stress testing for women than men in our study.<sup>56</sup> Finally, it is possible that other gender biases, beyond risk taking and strength, may contribute to disparities in care. Taken together, our findings suggest that although implicit gender bias exists, it does not explain all gender differences in the use of cardiac testing among patients being evaluated for CAD.

Another important contribution to the literature is our inclusion of cardiologists’ estimated likelihood of CAD and their certainty of this estimate. Others have appropriately



criticized claims of gender disparities in care when physicians' estimates of risk were not included.<sup>57</sup> Our participants estimated the likelihood of obstructive CAD in hypothetical male and female patients similarly but felt less certain of these estimates for the female patient. Other studies have similarly shown that physician certainty of cardiac diagnoses varied by patient gender and influenced clinical decisions.<sup>58,59</sup> Consequently, efforts to reduce gender disparities in management may need to focus on increasing physician certainty of evaluating suspected CAD in female patients.

Our study provides evidence of the presence of physician gender bias, raising the question of whether implicit bias is modifiable.<sup>34</sup> The first step in minimizing any potential negative effects of implicit bias is increasing awareness. Awareness of unwanted implicit stereotypes and being motivated to counteract them—or creating structures that minimize their effects—may help ensure that implicit bias does not overtly influence behavior.<sup>34,60</sup> Implicit bias is modifiable in experimental settings using counterstereotyping exercises; however, these methods have not been applied in a clinical setting.<sup>61</sup> Furthermore, changing bias among all healthcare professionals is an ambitious task. Efforts to ensure equity in care for women and men may be better spent by improving the evidence base, particularly for women, who are historically underrepresented in trials and for whom there is greater clinician uncertainty about management. Finally, using decision support to guide management based on evidence appropriate to a patient's objective clinical data rather than clinicians' implicit stereotypes may reduce some disparities in care related to bias.

Certain limitations should be considered in the interpretation of our findings. First, we used case scenarios and not real patient encounters to measure gender differences in clinical decisions. Although decision-making in clinical vignettes may not match in-person encounters, vignettes have the benefit of eliminating the influence of variation in patient behavior, preferences, and patient-provider interaction.<sup>25</sup> Furthermore, our study is the first to directly measure physician gender bias instead of inferring it based on observed gender differences in care, as has been done in prior work. Future studies should evaluate whether measured gender bias is associated with clinical decisions in actual patient encounters. Another limitation of our study is the low response rate and our convenience-sampling approach. Our respondents may not reflect the rates of gender bias among a larger population of practicing cardiologists in the United States or internationally; however, response bias would not be expected to influence the interaction between physician gender bias and patient gender in predicting decision-making. In other words, we have no a priori reason to suspect that factors related to nonresponse would differentially affect this relationship (ie, those less likely to respond would be more or less likely to be

influenced by gender bias). Furthermore, our respondents represent >500 cardiologists practicing throughout the United States, and their demographics are similar to those of members of large cardiology organizations.<sup>38–41</sup> Finally, compared with surveys among the general population, physician surveys have lower average response rates, and response bias has been shown to be minimal.<sup>62–64</sup>

## Conclusions

In summary, we conducted the first study to demonstrate the existence of implicit gender bias among cardiology physicians. Our findings also suggest that hypothetical women and men with suspected CAD are managed differently and that implicit gender bias is associated with some of these differences. Consequently, although implicit gender bias exists, it does not appear to explain all gender differences in the use of cardiac tests among patients being evaluated for CAD. Additional research is needed to better understand why women and men may receive different care when they have similar clinical characteristics.

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## Disclosures

Dr Masoudi is the Chief Science Officer for the NCDR. All other authors report no conflicts in relation to this article.

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# **SUPPLEMENTAL MATERIAL**

**Table S1. Cardiology physician participant characteristics of those included versus excluded for erroneous IAT responses.**

	<b>Included</b>	<b>Excluded</b>	<b>p-value*</b>
	<b>N=503</b>	<b>N=53</b>	
<b><u>Age,</u></b>			
Median (range)	45 (28, 89)	44 (28, 83)	.88
<b><u>Male</u></b>	436 (86.9%)	46 (86.8%)	.99
<b><u>Race/ethnicity</u></b>			
<b>Caucasian</b>	310 (62.3%)	30 (56.6%)	.27
<b>Asian</b>	132 (26.5%)	13 (24.5%)	
<b>Other</b>	56 (11.2%)	10 (18.9%)	
<b><u>Specialty</u></b>			
<b>General/Non-invasive</b>	261 (51.9%)	29 (54.7%)	.92
<b>Interventional</b>	165 (32.8%)	18 (34.0%)	
<b>Electrophysiology</b>	40 (8.0%)	3 (5.7%)	
<b>Other</b>	34 (6.8%)	3 (5.7%)	
<b><u>Years in practice,</u></b>			
Median (range)	12, (1, 55)	13 (1, 50)	.39
<b><u>Practice setting</u></b>			
<b>Academic/University</b>	207 (41.2%)	24 (45.3%)	.56
<b>Private Practice</b>	291 (57.9%)	29 (54.8)	

\*Wilcoxon or chi-square test

**Table S2. Terms for Gender Bias Implicit Association Tests:**

**Dimension: Takes Risks- Avoids Risks**

Takes Risks

1. Courageous
2. Bold
3. Daring
4. Reckless
5. Aggressive
6. Risky

Avoids Risks

1. Sensible
2. Careful
3. Passive
4. Cautious
5. Tentative
6. Timid

**Dimension: Strength - Weakness**

Strong

1. Tough
2. Robust
3. Vigorous
4. Strong
5. Powerful
6. Forceful

Weak

1. Dainty
2. Soft
3. Tender
4. Mild
5. Delicate
6. Sensitive

## Table S3. Case vignettes

### [CASE PICTURE]

#### Part 1 – Patient with symptoms suggestive of CAD (Female example)

A 65 year-old patient shown in this picture is referred by her primary physician for evaluation of chest discomfort. She has been experiencing a burning sensation in her chest for 4 weeks that has been occurring with increasing frequency. There is no radiation of the pain and no associated shortness of breath. The discomfort has occurred with exertion, but not reproducibly so, and lasts anywhere from 5 minutes to an hour per episode. An antacid has provided no relief. She bowls once a week and can walk up a flight of stairs. Her history is pertinent for hypertension, smoking, and a father who died of a heart attack at age 65. Her only medication is hydrochlorothiazide.

#### Physical Exam:

- Blood pressure is 135/75 mm Hg, heart rate is 90 bpm, BMI is 32
- Remainder of exam is unremarkable

#### Lab Values:

- Total cholesterol -230 mg/dL, HDL-25 mg/dL, LDL-145 mg/dL, Triglycerides-190 mg/dL
- Glucose (fasting) -105 mg/dL
- Creatinine - 0.9 mg/dl

EKG: normal sinus rhythm, no Q waves and no ST-segment abnormalities.

#### Part 2 – Patient with an abnormal ETT

Now, assume that before seeing this patient, her PCP had started medications and obtained an exercise stress test with ECG monitoring. She is now on aspirin, Imdur 30 mg daily, Atorvastatin 40 mg daily and Toprol XL 50 mg daily. Her heart rate is 65 bpm and blood pressure is 120/70 mm Hg. She is still experiencing intermittent chest discomfort.

During her stress test, she exercised into Stage III of a standard Bruce protocol with total exercise duration of 6 ½ minutes (7 METs estimated peak workload). She had a normal hemodynamic response to exercise and stopped exercise due to fatigue. She had non-limiting, right-sided chest pain with exercise. Her ECG revealed 1.5 mm of horizontal to down sloping ST depression in the inferior and lateral leads that resolved within 2 minutes of recovery.