



# Gender bias in clinical decision making emerges when patients with coronary heart disease symptoms also have psychological symptoms<sup>☆</sup>

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## ABSTRACT

**Background:** Delayed treatment may contribute to women's relatively higher morbidity and mortality from coronary heart disease (CHD). We tested whether disparities in treatment may be due to bias in diagnosis and treatment recommendations for women with psychological symptoms.

**Methods:** Fourth year medical students ( $N = 225$ ) from 13 U.S. medical schools were randomly assigned to make clinical decisions (CHD risk judgments, diagnosis, treatment recommendations) about one of four experimental vignette patients (male or female; with symptoms of depression and anxiety or without). Vignettes were presented as text via an online survey platform.

**Results:** The female patient with psychological symptoms was perceived to be at lowest risk for CHD. Perceptions of risk partly mediated lower likelihood of recommending the female patient with psychological symptoms be seen in an emergency department, take medication, or receive nutrition or exercise advice relative to the male patient with psychological symptoms.

**Conclusions:** There was a gender bias in CHD clinical decision-making when patients had concurrent psychological symptoms.

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## Introduction

Cardiovascular disease (CVD) is the leading cause of death in the U.S.<sup>1</sup> Nearly a third of the population will be diagnosed with at least one type of CVD in their lifetime,<sup>1</sup> with coronary heart disease (CHD) accounting for the greatest proportion (45%) of CVD deaths.<sup>1</sup> Women have greater morbidity and poorer prognoses once diagnosed with CHD than men.<sup>1–4</sup> This may be due, in part because women are more likely to have a delay in diagnosis than men.<sup>5–7</sup> In some instances, delay may be due to gender bias in clinical diagnostic decision making. Gender bias in clinical decision making has been demonstrated in vignette-based factorial experiments, including among medical students.<sup>8–13</sup> For example, compared to male patients, physicians are more likely to misattribute middle-aged female patients' CHD symptoms to gastrointestinal conditions or mental health conditions.<sup>13</sup>

In addition to influencing providers' diagnosis, gender bias may influence providers' treatment recommendations. In a vignette study

of fictional patients experiencing CHD symptoms, physicians were less likely to order diagnostic tests and prescribe CHD medications for female than male patients.<sup>8</sup> Physicians may be less certain about diagnosing younger females with a cardiac diagnosis than younger males, and in turn may be relatively less likely to order cardiac diagnostic testing, prescribe treatment medications, and may delay follow-up visits for female patients.<sup>9,10</sup> In another vignette-based study, physicians were more likely to assign a lower CVD risk to female patients than males with similar risk profiles, and patients with lower perceived risk were less likely to receive treatment recommendations such as exercise and nutrition advice.<sup>14</sup> Emergency room nurses were less likely to judge a female vignette patient with cardiac symptoms in need of urgent triage, admission to intensive care or to consider a cardiac diagnosis than her male counterpart, although only in younger patients.<sup>15</sup> Findings from observational studies also indicate that women are less likely to undergo treatment procedures and be referred to rehabilitation for CVD.<sup>16–18</sup>

Women with comorbid CHD and psychological symptoms may be uniquely at risk for misdiagnosis and suffer increased morbidity from CHD as a result of gender bias. Physicians may differentially apply information about disease prevalence depending on patient gender.<sup>12</sup> For example, if a female patient presents with psychological distress, the association between being female and higher incidence of

*Abbreviation:* CHD, coronary heart disease; CVD, cardiovascular disease; ED, emergency department

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depression may be so strong that the clinician fails to consider other diagnoses. In contrast, because males have a higher prevalence of CHD, cardiac symptoms might carry more weight in clinical decision-making. Furthermore, psychological distress may be interpreted as a symptom of CHD in men, while CHD symptoms may be interpreted as symptoms of psychological issues in women.

Providers may encounter female patients with psychological symptoms quite frequently. Depression and anxiety are more common among females than males in the general population and among cardiac patients.<sup>19–22</sup> Both depression and anxiety increase the risk for CHD, especially when they occur together,<sup>23</sup> and more than half of all CVD patients experience some level of depression or anxiety.<sup>19</sup> Despite the frequency with which providers are likely to be making clinical decisions about females with CHD and comorbid depression and anxiety, the potential for gender bias to influence these decisions has not fully been examined.

The purpose of the present study was to test whether medical students demonstrate gender bias in clinical decision-making when patients present with depression and anxiety symptoms along with atypical CHD symptoms. We described patients with atypical symptoms (e.g., sharp chest pain sometimes on exertion, shortness of breath, fatigue, and nausea) because women are more likely to present with what have been called atypical symptoms.<sup>24</sup> By doing so we hope to replicate a typical clinical decision making scenario involving female patients with CHD. Studying clinical decision making in medical students offers the opportunity to examine biases that may be more strongly influenced by medical training or lay stereotypes, as opposed to clinical experience. Results will inform interventions during medical training.

We used a patient vignette paradigm to test whether patient sex and concurrent psychological symptoms interact to influence medical students' clinical decision-making. We hypothesized that medical students would be more likely to give a non-cardiac diagnosis, perceive lower CHD risk, and would be less likely to recommend diagnostic testing, referrals, and treatments for a female patient experiencing symptoms of depression and anxiety compared to a male patient with the same symptoms. However, we did not expect sex differences for patients without psychological symptoms. We also reasoned that bias in diagnosis or perceptions of CHD risk would result in bias in clinical recommendations. We hypothesized that there would be an indirect effect of patient sex on clinical recommendations through diagnosis and or risk perception, but only among patients with psychological symptoms.

## Materials and methods

### Sample

One hundred and fifty-six medical schools in the United States were contacted to request permission to send an email to their students inviting them to participate in a study on clinical decision-making. Thirteen schools (8%) agreed, 23% declined, and 69% did not respond to the invitation. Students were eligible to participate in the study if they were fourth year medical students and had taken part in at least one clinical rotation as part of their medical training. Response rates for medical students ranged from 5–18%. To ensure data quality, data for any participants who failed 3 or more of the 7 attention checks ( $n = 1$ ) were dropped from the analyses.<sup>25</sup> The final sample included 225 medical students. All participants received a \$5.00 gift card. Study procedures were Institutional Review Board approved.

### Procedure

All study procedures were conducted via an online survey platform. First, participants completed basic demographic and screening information questions. Next, to reduce demand bias, each participant read and answered questions about a foil vignette of a patient with non-cardiac symptoms (i.e. symptoms of vertigo). Third, participants were randomly assigned to one of four experimental vignette conditions (either a male or female patient, and either a patient with or without symptoms of depression and anxiety). All experimental vignettes consisted of a text-based description of a patient at intermediate risk for CHD and experiencing atypical CHD symptoms. Patient sex and whether they had anxiety and depression varied by experimental condition. After reading the vignette, the participant completed questions about their primary diagnosis, recommendations for further diagnostic testing, referrals and/or treatment, and their perception about the patient's risk for CHD. Lastly, the participant completed a set of items measuring their knowledge of CHD, and depression and anxiety.

### Experimental stimuli: vignette

Experimental vignettes are provided in the Supplemental Material. Vignettes were adapted from a previous vignette study<sup>26</sup> and were based on known symptoms of, and risk factors for CHD and recommendations by a cardiologist and a primary care provider. The vignette description consisted of patients' age, sex, insurance status, history of present illness including symptoms, past medical history, social history, medications, diagnostic test results, vitals, and labs. The patient was described as presenting with atypical chest pain (i.e. sharp pain, sometimes occurs after exertion, sometimes occurs after meals), shortness of breath, shoulder and back pain, fatigue, and nausea. Patients all had normal electrocardiogram results and the following intermediate CHD risk factor profile: total cholesterol of 260 mg/dL, HDL cholesterol of 25 mg/dL, non-smokers, blood pressure of 144/83 mm/Hg. Participants either read about a male or female patient. Due to females having a lower risk for CHD than males,<sup>27</sup> we specified a 14 year age difference between the male (54 years old) and female (68 years old) patients; all patients were still at intermediate risk for CHD (13.1% 10-year ASCVD risk for females and 15.6% for males). Participants read about a patient experiencing either depression and anxiety symptoms (experiencing depression and anxiety symptoms vs. not) or no psychological symptoms. In the depression and anxiety condition, the patient complains of a racing heart, poor appetite, weight loss, trouble sleeping, feeling anxious, and not being interested in anything. Symptoms of depression and anxiety were not mentioned in the control condition.

### Measures

#### Outcomes

**Primary non-cardiac diagnosis.** Each participant answered an open-ended item asking, "What would be your main diagnosis for this person?"<sup>12</sup> Responses were coded as (cardiac (0) or non-cardiac (1)).

**Certainty of primary diagnosis.** Participants were asked to indicate how certain they were of their primary diagnosis (totally uncertain (0) – totally certain (100)).<sup>13</sup>

**Medical students' perceived patient CHD risk.** We asked participants, "What do you think is the patient's risk for heart disease?" (low risk (1)/intermediate risk (2)/high risk (3)/don't know (4)). "Don't know" ( $n = 2$ ) responses were excluded from these analyses.

**Certainty of patient CHD risk assessment.** Participants indicated how certain they were of their CHD risk assessment for the patient (very uncertain (1) – very certain (4)).

Further diagnostic testing, referrals, and treatment recommendations. Adapted from Chiaramonte and Friend, participants indicated if they would recommend each of 8 diagnostic tests, referrals, or treatment (blood test, ultrasound, stress test, referral to a cardiologist, referral to an emergency department (ED), medication recommendation, nutritional advice, exercise advice) on a 7-point response option ranging from extremely unlikely (1) to extremely likely (7).<sup>12</sup>

### Covariates

**CHD knowledge.** CHD knowledge was measured using an adapted version of the perception and knowledge of heart disease measure by Mosca et al.<sup>28</sup> Participants answered 7 multiple choice and true/false/don't know items (e.g., "Women are less likely to get heart disease after menopause than before"). Correct responses were summed.

**Depression and anxiety knowledge.** We assessed medical students' depression and anxiety knowledge using the (1) definition, (2) the size of the problem and presentation and (3) symptoms subscales of a multiple choice knowledge of depression test,<sup>29</sup> to which we added 3 questions to assess knowledge of anxiety for a total of 14 multiple choice items (e.g., "Which is not a common symptom of clinical depression?"). Correct responses were summed.

**Demographics.** Participants self-reported age, sex, race/ethnicity (collapsed into non-Hispanic White versus other), and what medical school they were attending.

### Statistical analyses

Statistical analyses were performed using Stata 14<sup>30</sup> and SPSS 24.0.<sup>31</sup> We used multivariable logistic regression to test whether patient sex or depression and anxiety symptoms, or, as hypothesized, the interaction between the two were associated with a non-cardiac primary diagnosis. We used multivariable linear regressions to test whether patient sex or depression and anxiety symptoms or, as hypothesized, the interaction between the two were associated with certainty of primary diagnosis, perceived patient CHD risk and certainty of risk, and clinical recommendations. We used separate models to test main effects and the interaction between patient sex and symptoms of depression and anxiety. In all models we controlled for participant age, sex, race/ethnicity, medical school, CHD knowledge, depression and anxiety knowledge. Robust standard errors were used to account for the clustering of students in medical schools. We used a moderated mediation PROCESS macro<sup>32</sup> in SPSS to test the direct and conditional indirect effects of patient sex on each of eight clinical recommendation (e.g., blood test) through each mediator (medical students' perceived patient CHD risk and certainty) in a total of 16 models. Outcomes included an index for moderated mediation which indicates the size of the association between the indirect effect and the moderator.<sup>33</sup> As in our case, when the moderator is dichotomous, it is the difference between the two conditional indirect effects. A confidence interval that does not contain 0 is evidence of moderated mediation.<sup>33</sup> Bias-corrected bootstrapped 95% confidence intervals were generated using 5,000 bootstrap samples.

### Results

Of the 225 participants, 57% were female and had a mean age of 27 years old (standard deviation (SD) = 2.58). The majority of participants were non-Hispanic White (62%). The mean CHD knowledge score was 5.46 out of 7 (SD = 0.93). The mean score for depression and anxiety knowledge was 11.65 out of 14 (SD = 1.23). See Table 1 for a description of diagnoses, risk judgements, and clinical recommendations for the vignette patients.

**Table 1**

Means and proportions for diagnoses, risk judgements, and clinical recommendations (N = 225)

	% or mean (SD)	% Recommended (N)
Primary cardiac diagnosis	63%	–
Primary diagnosis certainty	57.67 (20.76)	–
Provider's perceived patient CHD risk	2.12 (0.62)	–
Provider's perceived patient CHD risk certainty	2.67 (0.65)	–
Diagnostic tests		
Blood test	5.93 (1.42)	87%
Ultrasound	3.83 (1.94)	44%
Stress test	5.57 (1.56)	82%
Referrals		
Cardiologist	5.28 (1.66)	77%
ED	3.99 (1.96)	44%
Treatment strategies		
Medication	5.81 (1.11)	87%
Nutritional advice	5.65 (1.37)	84%
Exercise advice	5.58 (1.31)	85%

Note: % recommended includes medical students who responded somewhat likely, likely, or extremely likely for each clinical recommendation; ED = emergency department.

### Does the interaction between patient sex and concurrent psychological symptoms influence diagnosis or diagnostic certainty?

There was not a significant main effect of patient sex on diagnosis (adjusted odds ratio (AOR) = 0.77, 95% CI = 0.41, 1.43,  $p = .401$ ), or patient sex on diagnostic certainty (patient sex  $b = -0.68$ , 95% CI =  $-6.27$ , 4.92,  $p = .812$ ). We did not confirm the hypotheses that patient sex and psychological symptoms would interact to influence diagnosis (AOR = 0.85, 95% CI = 0.25, 2.95,  $p = .804$ ) or certainty about diagnosis ( $b = 6.19$ , 95% CI =  $-5.15$ , 17.53,  $p = .283$ ).

### Does the interaction between patient sex and concurrent psychological symptoms influence medical students' perceived CHD risk for the patient and certainty of risk assessment?

We did not hypothesize and did not find main effects of patient sex on medical students' perceived CHD risk for the patient ( $b = -0.001$ , 95% CI =  $-0.17$ , 0.17,  $p = 0.989$ ). However, as hypothesized, there was a significant interaction between patient sex and psychological symptoms predicting medical students' perceived CHD risk for the patient ( $b = -0.48$ , 95% CI =  $-0.83$ ,  $-0.13$ ,  $p = .007$ ; Fig. 2, Panel A). The effect of patient sex varied as a function of symptom condition. If the patients had psychological symptoms, there was a trend for medical students to perceive female patients to be at lower risk for CHD than males ( $b = -0.23$ , 95% CI =  $-0.48$ , 0.03,  $p = .078$ ). For patients without psychological symptoms, medical students actually perceived female patients to be at greater risk for CHD than males ( $b = 0.25$ , 95% CI = 0.02, 0.48,  $p = .035$ ). The effect of psychological symptom condition also varied as a function of patient sex. Medical students perceived female patients to be at lower risk for CHD if they had psychological symptoms than if they did not have psychological symptoms ( $b = -0.35$ , 95% CI =  $-0.58$ ,  $-0.12$ ,  $p = .003$ ), but there was not a significant difference as a function of psychological symptoms when the patient was male ( $b = 0.13$ , 95% CI =  $-0.14$ , 0.39,  $p = .349$ ).

There was a trend for medical students to be less certain of female patient's CHD risk than male patient's risk ( $b = -0.16$ , 95% CI =  $-0.33$ , 0.01,  $p = .072$ ). As hypothesized, there was a significant interaction between patient sex and psychological symptoms on perceived CHD risk certainty ( $b = -0.45$ , 95% CI =  $-0.81$ ,  $-0.09$ ,  $p = .014$ ; Fig. 2, Panel B). The effect of patient sex varied as a function of symptom condition. When the patient had psychological symptoms, medical students were less certain of the female patient's CHD risk than male

patient's risk ( $b = -0.37$ , 95% CI =  $-0.60, -0.15$ ,  $p = .001$ ). There was no difference by sex when patients did not have psychological symptoms ( $b = 0.08$ , 95% CI =  $-0.19, 0.34$ ,  $p = .557$ ). The effect of psychological symptom condition also varied as a function of patient sex. Medical students were less certain about their risk assessment when the female patient had psychological symptoms than when they did not ( $b = -0.27$ , 95% CI =  $-0.51, -0.03$ ,  $p = .03$ ), but there was no difference by presence of psychological symptoms for males ( $b = 0.18$ , 95% CI =  $-0.08, 0.45$ ,  $p = .178$ ).

*Does the interaction between patient sex and concurrent psychological symptoms influence medical students' recommendations for CHD diagnostic testing, referrals, and treatments?*

There were no main effects of patient sex or psychological symptoms on clinical recommendations. Our interaction hypotheses were supported for two clinical recommendations. There was a significant interaction between patient sex and psychological symptoms on medical students' recommendation for exercise as a treatment strategy ( $b = -0.74$ , 95% CI =  $-1.47, -0.01$ ,  $p = .048$ ; Fig. 3, Panel A). For patients with psychological symptoms, medical students were less likely to recommend exercise for female patients compared to males ( $b = -0.62$ , 95% CI =  $-1.15, -0.10$ ,  $p = .02$ ), but there was no difference by sex for patients without psychological symptoms ( $b = 0.12$ , 95% CI =  $-0.36, 0.60$ ,  $p = .631$ ). There was also a marginally significant interaction between patient sex and psychological symptoms on ED referrals ( $b = -0.98$ , 95% CI =  $-2.07, 0.11$ ,  $p = .077$ ; Fig. 3, Panel B). The effect of patient sex varied as a function of symptom condition. For patients with psychological symptoms, medical students were less likely to recommend going to an ED for female patients compared to males ( $b = -0.73$ , 95% CI =  $-1.48, 0.02$ ,  $p = .057$ ), but this was not the case for patients without psychological symptoms ( $b = 0.25$ , 95% CI =  $-0.52, 1.02$ ,  $p = .527$ ). There were no interactions effects on the diagnostic tests, referral to a cardiologist, or medication or nutritional advice.

*Is there moderated mediation effect of patient sex conditioned on psychological symptoms on clinical recommendations through medical students' perceived patient CHD risk and/or certainty?*

Given the interaction effects of patient sex and experience of psychological symptoms on medical students' perceived patient CHD risk and certainty, and the association between medical students' perceived patient CHD risk and risk certainty, and clinical recommendations, we tested for moderated mediation effects of patient sex on clinical recommendations through CHD risk and risk certainty. As

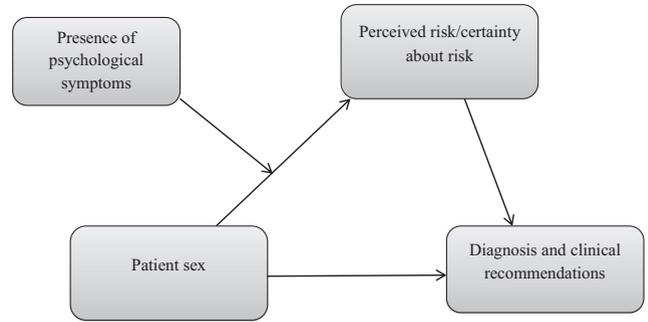


Fig. 1. Conceptual model of moderated mediation of patient sex on clinical recommendations through perceived patient CHD risk/certainty about risk.

shown in Fig. 1, we hypothesized that the patient sex would indirectly influence clinical recommendations through perceived patient CHD risk and certainty, but only for those with concurrent psychological symptoms. The direct and conditional indirect effects, and index of moderated mediation of patient sex on clinical recommendations through medical students' perceived patient CHD risk are provided in Table 2. Consistent with our hypotheses, there was evidence of a moderated mediation effect of patient sex on stress test recommendations and cardiologist referrals through medical students' perceived patient CHD risk, conditioned on patients' having psychological symptoms. There was also evidence of a moderated mediation effect of patient sex on treatment recommendations for medication, nutrition and exercise advice through medical students' perceived patient CHD risk conditioned on patients' having psychological symptoms.

The direct and conditional indirect effects, and index of moderated mediation of patient sex on clinical recommendations through perceived patient CHD risk certainty are provided in Table 3. Consistent with our hypotheses, there was evidence of moderated mediation effects of patient sex on treatment recommendations for medication, nutrition and exercise advice and recommendation for referral to a cardiologist and an ED through medical students' perceived patient CHD risk certainty that was conditioned on patients' experiences of psychological symptoms. For those with psychological symptoms, being female rather than male was indirectly associated with a lower recommendation to go to an ED, take medication, eat better, and exercise.

**Discussion**

Our hypotheses were supported for CHD risk judgements and some clinical recommendations. We found evidence of a gender bias

**Table 2**  
Direct and conditioned indirect effects, and index of moderated mediation of sex on clinical recommendations mediated through perceived patient CHD risk

Outcome:	Direct Effect		Indirect effects				Index of moderation mediation	
	Effect	95% CI	Without psychological symptoms		With psychological symptoms		Index	95% CI
<b>Diagnostic tests</b>								
Blood test (N = 215)	-0.08	-0.48, 0.31	-0.003	-0.09, 0.06	0.003	-0.07, 0.09	0.01	-0.12, 0.16
Ultrasound (N = 215)	0.03	-0.51, 0.57	0.01	-0.05, 0.14	-0.01	-0.15, 0.06	-0.02	-0.24, 0.12
Stress test (N = 215)	-0.30	-0.71, 0.11	0.09	-0.005, 0.26	-0.09	-0.29, 0.02	-0.18*	-0.46, -0.02
<b>Referrals</b>								
Cardiologist (N = 215)	0.03	-0.39, 0.44	0.17	-0.03, 0.41	-0.17	-0.45, 0.05	-0.34*	-0.75, -0.03
ED (N = 215)	-0.23	-0.76, 0.30	0.06	-0.01, 0.24	-0.06	-0.26, 0.01	-0.13	-0.43, 0.01
<b>Treatment strategies</b>								
Medication (N = 215)	-0.13	-0.43, 0.16	0.07	-0.004, 0.21	-0.07	-0.21, 0.01	-0.13*	-0.36, -0.02
Nutritional advice (N = 211)	0.05	-0.33, 0.42	0.09	-0.01, 0.28	-0.08	-0.27, 0.03	-0.18*	-0.46, -0.01
Exercise advice (N = 211)	-0.23	-0.57, 0.10	0.14	-0.02, 0.36	-0.12	-0.37, 0.05	-0.26*	-0.63, -0.02

Note: CI = confidence intervals; all confidence intervals were boot strapped; ED = emergency department.

\* $p < .05$ .

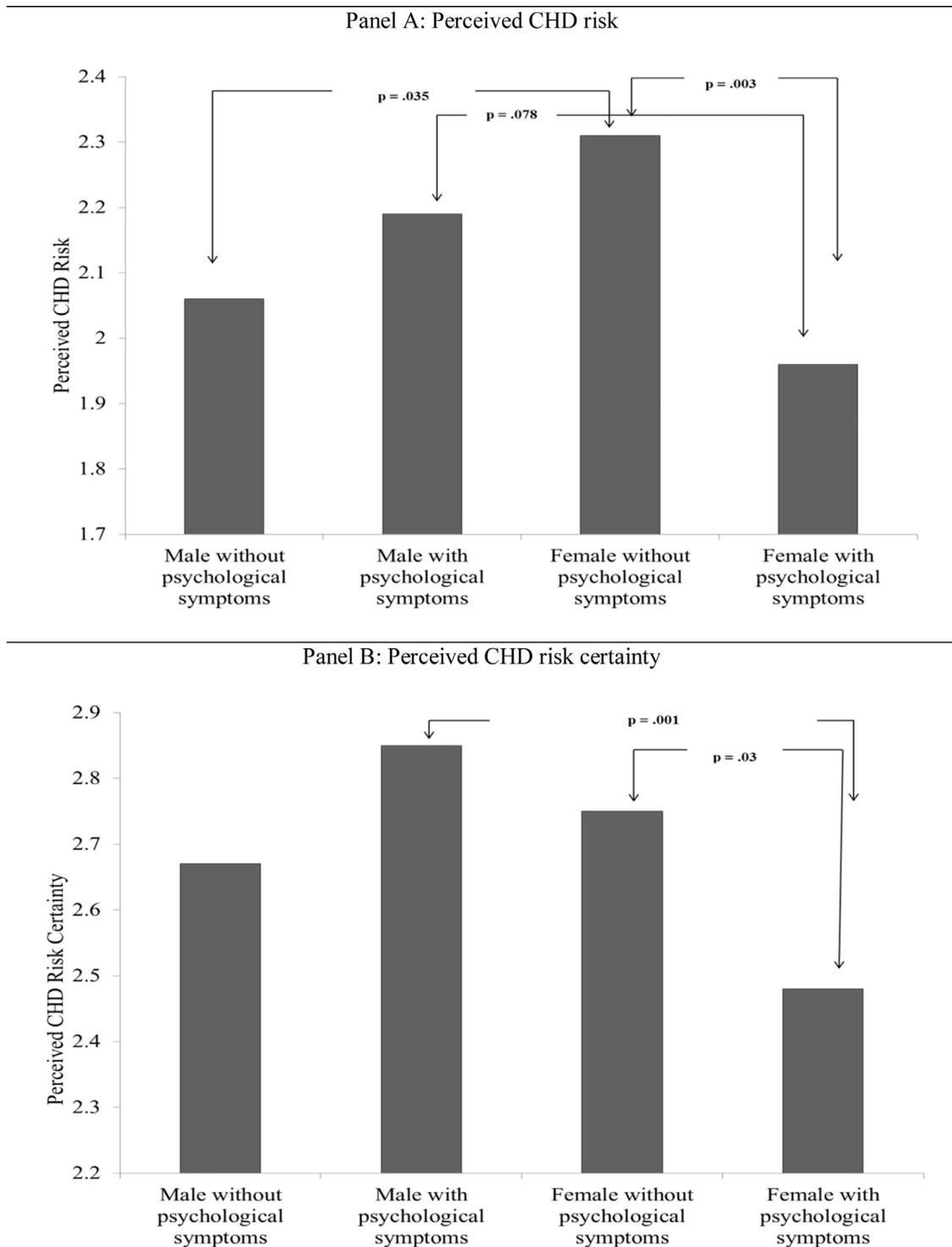
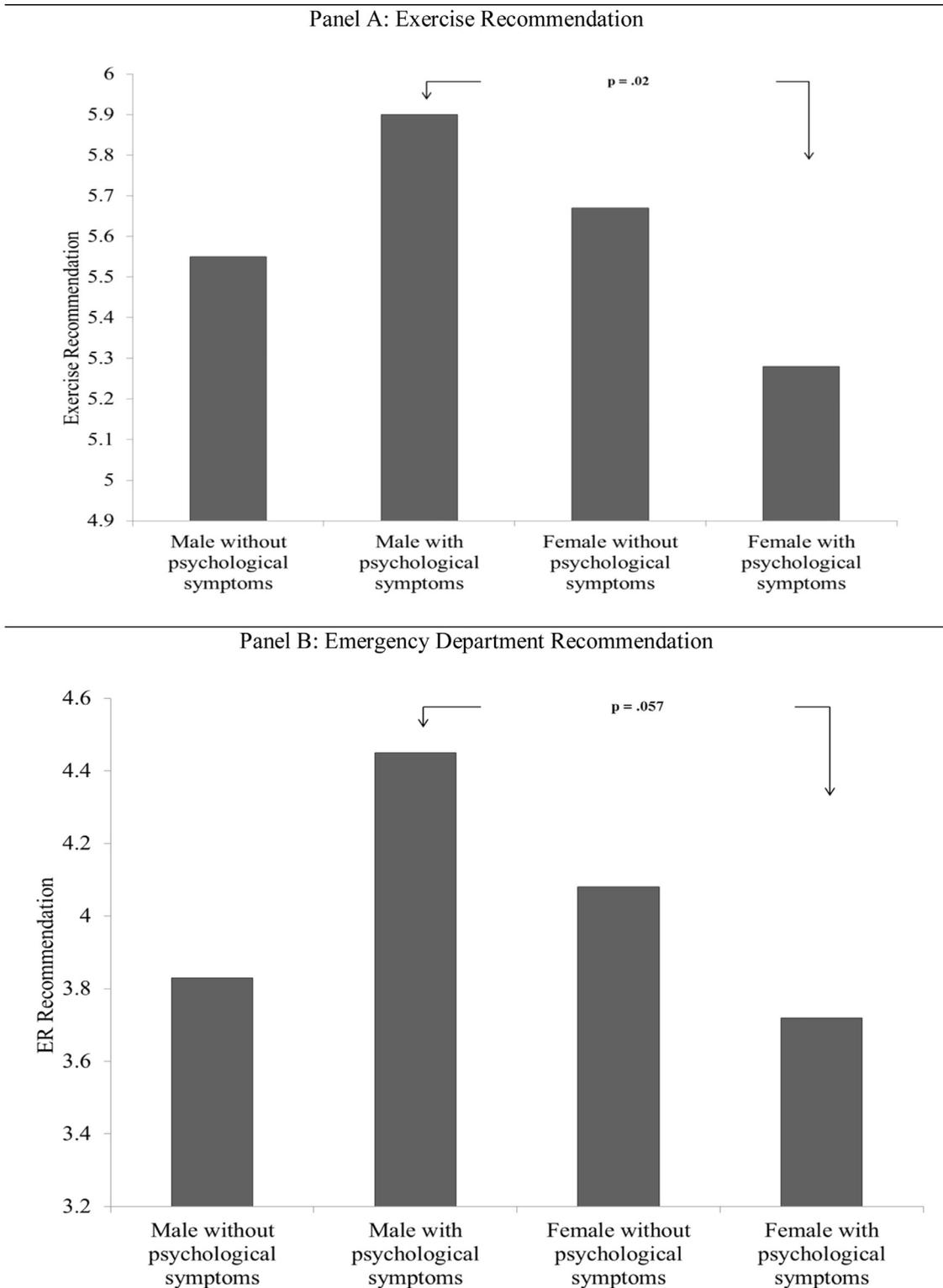


Fig. 2. Interaction between patient sex and psychological symptoms on perceived CHD risk and perceived CHD risk certainty.

in medical students' judgments about CHD risk in patients with concurrent psychological symptoms. Medical students perceived female patients with depression and anxiety symptoms to be at lower risk for CHD and were more uncertain of their risk compared to male patients with the same symptoms. The same gender bias was found for recommendations for exercise and referrals to an ED. Our moderated mediation hypotheses were also supported. For patients with

psychological symptoms, being female rather than male was indirectly associated with lower likelihood of receiving clinical recommendations, including referral to a cardiologist, ED and treatment recommendations for medication, nutrition, and exercise through either perceived patient CHD risk or certainty about risk.

While many vignette and observational studies have demonstrated that clinicians are less likely to refer women with CHD for



**Fig. 3.** Interaction between patient sex and psychological symptoms on emergency department recommendation and exercise recommendation.

treatment than their male counterparts,<sup>8–13,16–18</sup> only one other study has tested the hypothesis that gender bias in CHD clinical decision making emerges when providers perceive that patients are under stress, depressed or anxious.<sup>12</sup> Chiamonte and Friend<sup>12</sup> found that medical students and residents diagnosed female vignette

patients with CHD and referred them to cardiologists less often than males, but only when the patient was described as experiencing life stressors and anxiety. Our study expanded on this work by testing the interactive effects of patient sex and psychological symptoms (i.e. symptoms of depression and anxiety) without mention of life stres-

**Table 3**  
Direct and conditioned indirect effects, and index of moderated mediation of sex on treatment recommendations, mediated through perceived patient CHD risk certainty

Outcome:	Direct effect		Indirect effects				Index of moderated mediation	
	Effect	95% CI	Without psychological symptoms		With psychological symptoms		Index	95% CI
			Effect	95% CI	Effect	95% CI		
<b>Diagnostic tests</b>								
Blood test (N = 214)	−0.07	−0.47, 0.32	0.01	−0.02, 0.13	−0.04	−0.20, 0.07	−0.05	−0.27, 0.09
Ultrasound (N = 214)	0.08	−0.46, 0.63	0.03	−0.03, 0.22	−0.10	−0.33, 0.04	−0.13	−0.46, 0.04
Stress test (N = 214)	−0.29	−0.71, 0.13	0.02	−0.02, 0.15	−0.07	−0.23, 0.04	−0.09	−0.31, 0.04
<b>Referrals</b>								
Cardiologist (N = 214)	0.06	−0.39, 0.50	0.04	−0.03, 0.22	−0.12	−0.33, 0.001	−0.16*	−0.46, −0.002
ED (N = 214)	−0.16	−0.70, 0.37	0.05	−0.04, 0.24	−0.14*	−0.41, −0.01	−0.19*	−0.55, −0.01
<b>Treatment strategies</b>								
Medication (N = 214)	−0.10	−0.39, 0.20	0.04	−0.04, 0.17	−0.13*	−0.28, −0.04	−0.17*	−0.38, −0.04
Nutritional advice (N = 210)	0.08	−0.30, 0.46	0.05	−0.03, 0.21	−0.12*	−0.29, −0.02	−0.17*	−0.43, −0.02
Exercise advice (N = 210)	−0.20	−0.56, 0.16	0.05	−0.03, 0.22	−0.11*	−0.29, −0.02	−0.16*	−0.43, −0.02

Note: CI = confidence intervals; all confidence intervals were bootstrapped; ED = emergency department.

\*  $p < 0.05$ .

sors. It appears that women with comorbid psychological issues, not just those experiencing stress, may be vulnerable to receiving disparate care for CHD. Another difference between our study and that by Chiaramonte and Friend is that we described patients with atypical CHD symptoms, instead of typical CHD symptoms. This extends the generalizability of the conditioned gender bias effect to the many women who experience atypical symptoms. Gender bias was not likely due to simple activation of the stereotype that CHD patients are men given that we did not find main effects of patient sex on any of the clinical decision making outcomes. Rather, gender bias was conditioned on the presence of psychological symptoms. Participants may have used information about the patient's symptoms differently for males and females.<sup>12</sup> For male patients, psychological symptoms may not have reduced the salience of the CHD symptoms, or were interpreted as symptoms of, or a risk factor for CHD. In contrast, for female patients, the psychological symptoms may have been more salient and CHD symptoms may have been discounted or misinterpreted as additional psychological symptoms.

We did not find evidence of gender bias in diagnoses. Perhaps medical students erred on the side of making a conservative diagnosis given that a cardiac diagnosis would have serious consequences if ignored. This could be more common in vignette studies than actual clinical decision making because participants do not have to be concerned about the costs of over-diagnosis in fictional patients. They may also have consciously attempted to correct for gender bias when making a diagnosis. In contrast, gender bias may influence risk perceptions because these judgments are fairly inconsequential compared to diagnoses and therefore there is little incentive to correct bias. Furthermore, it has been over a decade since Chiaramonte and Friend's<sup>12</sup> results. Since then, gender bias in CHD clinical decision-making has been more widely studied and awareness has increased, which may have mitigated some of the bias in diagnosis.<sup>34</sup>

#### Limitations and future directions

Our study had some limitations. Participants were medical students making clinical decisions about fictional patients and although they were advanced in their medical training, our findings may not generalize to real-world clinical-decision making among physicians who have more clinical experience. While clinical vignette experiments are standard practices for examining clinical decision-making,<sup>35,36</sup> they may not capture the nuanced context of real world clinical decision making. Future research is necessary to examine if the conditioned effects of patient sex on clinical decision-making remains among physicians with more clinical experience. Generalizability of the study findings were limited by a low response rate;

however, we were able to recruit from 13 medical schools, whereas many studies of bias in clinical decision making have only recruited from a single institution. Our study did not include non-physician trainees or practitioners such as nurses, nurse practitioners or physician assistants who may also be making decisions about whether patients should be further evaluated for CHD. A study with emergency room nurses suggests they too make different decisions for patients with cardiac symptoms based on patient sex.<sup>15</sup> Finally, we combined depression and anxiety symptoms in our vignettes because there is substantial overlap between symptoms of depression and anxiety and there is a high degree of comorbidity between the two.<sup>23,37</sup> While patients may often present with a mixture of the two symptoms, it may be beneficial to examine if depression and anxiety symptoms influence clinical decision-making differently.

#### Implications for practice and/or policy

Training focused on diagnosing CHD in women may mitigate gender bias in CHD diagnosis. Broader curricular innovations have been associated with reductions in gender and racial bias in clinical decision-making by medical students including fostering diversity among students and faculty, valuing equitable care and demonstrating this with community engagement, responding to incidents indicating bias and building in opportunities for reflective small group discussion.<sup>38</sup> Increased awareness and monitoring of conscious and unconscious bias<sup>39,40</sup> and use of stereotypes is also important for providers, including nurses making triage decisions about patients who may be at risk for a myocardial infarction.<sup>41</sup> Counter-stereotyping may help reduce gender bias.<sup>42</sup> Encouraging primary care providers to use risk assessment calculators, such as the Framingham risk calculator<sup>27</sup> or atherosclerotic cardiovascular disease (ASCVD) risk estimator,<sup>43</sup> may help them accurately assess patients' CHD risk and mitigate biases.

#### Conclusions

Our study demonstrates gender bias in medical students' perceived patient CHD risk and risk appraisal certainty for patients with psychological symptoms, with students perceiving women experiencing psychological symptoms to be at relatively lower risk. This gender bias in CHD risk perception may indirectly influence clinical recommendations. Future research should examine whether this conditional gender bias emerges in real-life medical encounters and among practicing physicians and other providers.

## Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.hrtlung.2018.11.005.

## References

- Benjamin EJ, Blaha MJ, Chiuve SE, et al. Heart disease and stroke statistics-2017 update: a report from the American Heart Association. *Circulation*. 2017;135(10):e146–e603.
- Buchholz EM, Butala NM, Rathore SS, Dreyer RP, Lansky AJ, Krumholz HM. Sex differences in long-term mortality after myocardial infarction: a systematic review. *Circulation*. 2014;130(9):757–767.
- Shehab A, Al-Dabbagh B, AlHabib KF, et al. Gender disparities in the presentation, management and outcomes of acute coronary syndrome patients: data from the 2nd Gulf Registry of Acute Coronary Events (Gulf RACE-2). *Plos One*. 2013;8(2):e55508.
- Westerman S, Wenger Nanette K. Women and heart disease, the underrecognized burden: sex differences, biases, and unmet clinical and research challenges. *Clin Sci*. 2016;130(8):551–563.
- Nguyen HL, Gore JM, Saczynski JS, et al. Age and sex differences and 20-year trends (1986–2005) in prehospital delay in patients hospitalized with acute myocardial infarction. *Circ Cardiovasc Qual Outcomes*. 2010;3(6):590–598.
- Nguyen HL, Saczynski JS, Gore JM, Goldberg RJ. Age and sex differences in duration of prehospital delay in patients with acute myocardial infarction: a systematic review. *Circ Cardiovasc Qual Outcomes*. 2010;3(1):82–92.
- Jneid H, Fonarow GC, Cannon CP, et al. Sex differences in medical care and early death after acute myocardial infarction. *Circulation*. 2008;118(25):2803–2810.
- Arber S, McKinlay J, Adams A, Marceau L, Link C, O'Donnell A. Patient characteristics and inequalities in doctors' diagnostic and management strategies relating to CHD: a video-simulation experiment. *Soc Sci Med*. 2006;62(1):103–115.
- Lutfey KE, Link CL, Grant RW, Marceau LD, McKinlay JB. Is certainty more important than diagnosis for understanding race and gender disparities? An experiment using coronary heart disease and depression case vignettes. *Health Policy*. 2009;89(3):279–287.
- Lutfey KE, Link CL, Marceau LD, et al. Diagnostic certainty as a source of medical practice variation in coronary heart disease: results from a cross-national experiment of clinical decision making. *Med Decis Mak*. 2009;29(5):606–618.
- Martin R, Gordon EE, Lounsbury P. Gender disparities in the attribution of cardiac-related symptoms: contribution of common sense models of illness. *Health Psychol*. 1998;17(4):346–357.
- Chiaromonte GR, Friend R. Medical students' and residents' gender bias in the diagnosis, treatment, and interpretation of coronary heart disease symptoms. *Health Psychol*. 2006;25(3):255–266.
- Maserejian Link, Lutfey Marceau, McKinlay. Disparities in physicians' interpretations of heart disease symptoms by patient gender: results of a video vignette factorial experiment. *J Women's Health*. 2009;18(10):1661–1667.
- Mosca L, Linfante AH, Benjamin EJ, et al. National study of physician awareness and adherence to cardiovascular disease prevention guidelines. *Circulation*. 2005;111(4):499–510.
- Arslanian-Engoren C. Gender and age differences in nurses' triage decisions using vignette patients. *Nurs Res*. 2001;50(1):61–66.
- Colella TJF, Gravely S, Marzolini S, et al. Sex bias in referral of women to outpatient cardiac rehabilitation? A meta-analysis. *Eur J Prev Cardiol*. 2014;22(4):423–441.
- Worrall-Carter L, McEvedy S, Wilson A, Rahman MA. Gender differences in presentation, coronary intervention, and outcomes of 28,985 acute coronary syndrome patients in Victoria, Australia. *Women's Health Issues*. 2016;26(1):14–20.
- Redfors B, Angeras O, Ramunddal T, et al. Trends in gender differences in cardiac care and outcome after acute myocardial infarction in Western Sweden: a report from the Swedish Web System for Enhancement of Evidence-Based Care in Heart Disease Evaluated According to Recommended Therapies (SWEDEHEART). *J Am Heart Assoc*. 2015;4(7). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4608084/>.
- Haukkala A, Konttinen H, Uutela A, Kawachi I, Laatikainen T. Gender differences in the associations between depressive symptoms, cardiovascular diseases, and all-cause mortality. *Ann Epidemiol*. 2009;19(9):623–629.
- Pilote L, Dasgupta K, Guru V, et al. A comprehensive view of sex-specific issues related to cardiovascular disease. *CMAJ*. 2007;176(6):S1–44.
- Grant BF, Hasin DS, Stinson FS, et al. Prevalence, correlates, co-morbidity, and comparative disability of DSM-IV generalized anxiety disorder in the USA: results from the national epidemiologic survey on alcohol and related conditions. *Psychol Med*. 2005;35(12):1747–1759.
- Salk RH, Hyde JS, Abramson LY. Gender differences in depression in representative national samples: meta-analyses of diagnoses and symptoms. *Psychol Bull*. 2017;143(8):783–822.
- Hare DL, Toukhsati SR, Johansson P, Jaarsma T. Depression and cardiovascular disease: a clinical review. *Eur Heart J*. 2014;35(21):1365–1372.
- Coventry LL, Finn J, Bremner AP. Sex differences in symptom presentation in acute myocardial infarction: a systematic review and meta-analysis. *Heart Lung*. 2011;40(6):477–491.
- Maniaci MR, Rogge RD. Caring about carelessness: Participant inattention and its effects on research. *J Res Personal*. 2014;48:61–83.
- Shin JY, Martin R, Suls J. Meta-analytic evaluation of gender differences and symptom measurement strategies in acute coronary syndromes. *Heart Lung*. 2010;39(4):283–295.
- D'Agostino Sr. RB, Vasan RS, Pencina MJ, et al. General cardiovascular risk profile for use in primary care: the Framingham heart study. *Circulation*. 2008;117(6):743–753.
- Mosca L, Jones WK, King KB, Ouyang P, Redberg RF, Hill MN. Awareness, perception, and knowledge of heart disease risk and prevention among women in the United States. American heart association women's heart disease and stroke campaign task force. *Arch Fam Med*. 2000;9(6):506–515.
- Gabriel A, Violato C. The development of a knowledge test of depression and its treatment for patients suffering from non-psychotic depression: a psychometric assessment. *BMC Psychiatry*. 2009;9:56.
- Stata Statistical Software: Release 14* [computer program]. College Station, TX: StataCorp LP 2015.
- IBM Statistics for Windows* [computer program]. Version 24.0. Armonk, NY: IBM Corp; 2016.
- Hayes A. *PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling*. 2012.
- Hayes A. An index and test of linear moderated mediation. *Multivariate Behav Res*. 2015;50(1):1–22.
- McSweeney JC, Rosenfeld AG, Abel WM, et al. Preventing and experiencing ischemic heart disease as a woman: state of the science: a scientific statement from the American heart association. *Circulation*. 2016;133(13):1302–1331.
- Converse L, Barrett K, Rich E, Reschovsky J. Methods of observing variations in physicians' decisions: the opportunities of clinical vignettes. *J Gen Intern Med*. 2015;30(Suppl 3):S586–S594.
- Veloski J, Tai S, Evans AS, Nash DB. Clinical vignette-based surveys: a tool for assessing physician practice variation. *Am J Med Qual*. 2005;20(3):151–157.
- Cassano G, Rossi N, Pini S. Comorbidity of depression and anxiety. In: Kasper S, den Boer JA, Ad Sitsen JM, eds. *Handbook of Depression and Anxiety*. 2 ed. New York, NY: Marcel Dekker, Inc; 2003.
- Williams RL, Vasquez CE, Getrich CM, et al. Racial/Gender biases in student clinical decision-making: a mixed-method study of medical school attributes associated with lower incidence of biases. *J Gen Intern Med*. 2018;Jul 11. <https://doi.org/10.1007/s11606-018-4543-2>. [Epub ahead of print].
- FitzGerald C, Hurst S. Implicit bias in healthcare professionals: a systematic review. *BMC Med Ethics*. 2017;18(1):19.
- White AA, Stubblefield-Tave B. Some advice for physicians and other clinicians treating minorities, women, and other patients at risk of receiving health care disparities. *J Racial and Ethnic Health Disparities*. 2017;4(3):472–479.
- Arslanian-Engoren C. Explicating nurses' cardiac triage decisions. *J Cardiovasc Nurs*. 2009;24(1):50–57.
- Stone J, Moskowitz GB. Non-conscious bias in medical decision making: what can be done to reduce it? *Med Educ*. 2011;45(8):768–776.
- Bandura A. *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice-Hall; 1986.