

ORIGINAL ARTICLE

Patient-Centered Insights and Biases Regarding Cardiologists Via Online Review Platform Analysis

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BACKGROUND: Online cardiologist reviews, such as those on the Yelp website, are a frequently used method for patients to find a cardiologist. It remains unknown how bias may influence such reviews. Our objectives for this study were to (1) determine which cardiologist- or practice-related factors influence the overall rating of cardiologists and patient satisfaction and (2) discover any associations between sex and race with the overall rating of cardiologists or with cardiologist- or practice-related factors.

METHODS AND RESULTS: Cardiologist Yelp reviews from practices in the United States from 2007 to 2020 were analyzed. A total of 563 reviews were coded for positive and negative themes. Binary logistic regression was used to determine whether certain factors increased the likelihood of high ratings. Chi-squared tests were used to determine associations between sex and race with certain factors and overall cardiologist ratings. Cardiologists were more likely to receive higher ratings when reviewers noted the characteristics of competency/knowledge base and thoroughness, positive interactions with staff, and when the cardiologist's name was mentioned in the review. Negative interactions with staff were associated with lower ratings. Female cardiologists received lower ratings and more negative mentions of cardiologist–patient communication than expected. White and Black cardiologists received lower ratings than expected compared with other racial groups.

CONCLUSIONS: Patient-perceived cardiologist competency, thoroughness, and positive staff interactions were associated with positive reviews in online assessments. Sex and racial differences were also found. Further research must be done to confirm these findings and to understand the association of online reviews with clinical care and patient outcomes.

Key Words: cardiologist reviews ■ cardiology ■ race ■ sex

Online reviews are an important and frequently used source for patients to find a cardiologist.^{1,2} The ability for patients to be able to choose their cardiologist by viewing online reviews is especially important in cardiology. Cardiovascular disease is very common in the United States, with an overall prevalence of 49.2%,³ suggesting that a large number of people are in need of finding a cardiologist. Even when a referral to a specific cardiologist is provided by a primary care cardiologist, within the United States, patients will often first need to assess if the cardiologist is within their health care network. Beyond those limitations, patients have a choice in whom they see, and their choices may be increasingly influenced by

online reviews. Racial and sex disparities exist regarding cardiovascular disease, and research has shown that sex and racial concordance improve health care outcomes.^{3–6} Thus, evaluating potential bias in reviews is especially important, as it may influence a patient's choice of cardiologist, which could directly impact the care the patient receives.

Multiple websites exist for patients to leave reviews of cardiologists, including but not limited to Healthgrades, Vitals, Zocdoc, Angie's List, and Yelp.⁷ Analysis of online reviews to discover factors influencing patient satisfaction in various medical fields has yielded important insights that can be used to improve patient care and satisfaction.^{7–11} Studies have also

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CLINICAL PERSPECTIVE

What Is New?

- Online Yelp reviews of cardiologists were analyzed to determine which cardiologist- or practice-related factors influence cardiologist rating.
- High cardiologist ratings were associated with positive staff interactions, as well as cardiologist competency and thoroughness.
- Female cardiologists and White and Black cardiologists received a lower frequency of 4- and 5-star ratings.

What Are the Clinical Implications?

- There are tangible actions that cardiologists can take to improve online ratings and overall patient satisfaction, including encouraging positive staff interactions with patients and showing competency and thoroughness in all patient encounters.
- Patient biases against cardiologists may lead to lower online ratings than potentially deserved. These ratings could harm the cardiologist-patient relationship of current patients by leading them to expect suboptimal care. The ratings may also influence prospective patients' decision making while choosing a cardiologist.
- It is important for future research to confirm these biases and develop ways to reduce any confirmed biases.

shown a high correlation of similarity between results from patient surveys that were done using standard methods and online reviews, suggesting that analysis of online reviews is a valid way to assess patient satisfaction.^{12,13} To our knowledge, this is the first study to discover factors influencing patient satisfaction via analysis of cardiologist Yelp reviews. Conclusions drawn from evaluating reviews could help also inform cardiologists of changes they can make to their clinical practice, style of communication, or to issues within the practice itself to influence and improve patient satisfaction. Our objectives for this study were to (1) to determine which patient- and cardiologist-related factors influence patient satisfaction and online Yelp review ratings of cardiologists and (2) to discover if there are any associations between race and sex with cardiologist- and practice-related factors as well as the overall cardiologist rating.

METHODS

Data used in this study can be obtained by contacting the first author in the study, Erica Mark, via email

at ejm5we@virginia.edu. Using the Yelp website, cardiologist reviews between September 11, 2007, and October 1, 2020, from cities within the United States across 4 different regions (East, West, Midwest, South) were analyzed and coded. The cities included Bayside, New York; Brooklyn, New York; New York, New York; Philadelphia, Pennsylvania; South Ozone Park, New York; Beverly Hills, California; Los Angeles, California; San Diego, California; San Francisco, California; Phoenix, Arizona; Chicago, Illinois; Houston, Texas; San Antonio, Texas; and Jacksonville, Florida. These cities were chosen on the basis of diverse geographic distribution and large population size. Reviews from the Yelp website, in particular, were chosen for this study because the website is commonly used¹⁴; the free-response portion lends itself to qualitative analysis; and the reviews are not behind a paywall, increasing accessibility. Additionally, Yelp discourages businesses from soliciting ratings, and its algorithm attempts to find and hide ratings it deems fake.¹⁵ Because of the nature of this research, which used online, public information, this study was exempt from institutional review board approval.

To find reviews, the term *cardiologist* or *cardiology* was typed into the Yelp search along with the name of one of the US cities listed above. A maximum of 150 reviews per city were collected on the basis of whichever cardiologists were shown first on Yelp. A maximum of 30 of the most recent reviews per practice were coded, and the total number of reviews per practice was also recorded. If a practice had <5 reviews, it was excluded from the study. The practice type (academic, nonacademic/private, or other) was also determined by looking at practice websites for any hospital affiliation and recorded as well as the total number of cardiologists at each practice.

Themes were identified and coded until thematic saturation and organized by both cardiologist- and practice-related factors on the basis of previous methods (Tables 1 and 2).¹¹ Positive and negative examples of themes such as “competency” and “thoroughness,” among others, can be seen in Table 2. Up to 4 positive and 4 negative themes were coded for each review. Most reviews rarely exceeded 8 themes (4 positive and 4 negative). However, if a dominant theme was identified, then the data coder could expand the set to include 9 themes. To achieve parsimony, we wanted coded themes to be overtly mentioned in the text of the review, and therefore the empiric theme limit under 8 was to ensure that we did not identify themes that were not well represented in the data. All reviews found using methods described above were used for data collection, as all were found to include at least 1 theme upon review. The frequencies of each theme were then calculated on the basis of how many times that theme was found by the coder divided by the total number of

Table 1. Demographics

Demographics		No. (%)	Mean	Median	SD
Regions	West	246 (43.7)			
	East	101 (17.9)			
	Midwest	25 (4.4)			
	South	191 (33.9)			
Rating	1 star	121 (21.5)			
	2 star	28 (5.0)			
	3 star	12 (2.1)			
	4 star	19 (3.4)			
	5 star	383 (68.0)			
Race	White	312 (55.4)			
	Black	6 (1.1)			
	Other	245 (43.5)			
Sex	Men	387 (68.7)			
	Women	58 (10.3)			
	Unable to determine	118 (21.0)			
Did they respond to reviews?	Yes	64 (11.4)			
	No	499 (88.6)			
Did they mention the name of the provider?	Yes	434 (77.1)			
	No	129 (22.9)			
Practice type	Academic	11 (2.0)			
	Nonacademic	552 (98.1)			
Mention of positive theme	Temperament	151 (17.5)			
	Knowledge base	212 (24.5)			
	Cardiologist–patient communication	39 (4.5)			
	Thoroughness	211 (24.4)			
	Physical examination	9 (1.0)			
	Cost consciousness	4 (0.5)			
	Wait times	38 (4.4)			
	Cleanliness	15 (1.7)			
	Billing and insurance	2 (0.2)			
	Scheduling	16 (1.9)			
	Innovative use of technology	18 (2.1)			
	Interactions with staff	148 (17.1)			
	Parking	2 (0.2)			
Mention of negative theme	Temperament	13 (4.8)			
	Knowledge base	16 (5.9)			
	Cardiologist–patient communication	22 (8.1)			
	Thoroughness	16 (5.9)			
	Physical exam	1 (0.4)			
	Cost consciousness	11 (4.1)			
	Wait times	36 (13.3)			
	Cleanliness	3 (1.1)			
	Billing and insurance	31 (11.4)			
	Scheduling	37 (13.7)			
	Innovative use of technology	3 (1.1)			
	Interactions with staff	80 (29.5)			
	Parking	2 (0.7)			
Number of reviews per practice			21.1	17.0	14.7
Number of cardiologists per practice			3.1	1.0	6.0

Table 2. Themes and Representative Quotes

	Positive theme	Negative theme
Cardiologist-related themes		
Temperament	They were very accessible and humble. Their compassion was present in each visit.	Dr. B seemed irritated throughout the visit and cut me off when I was explaining my symptoms.
Competency/knowledge base	Dr. B was intelligent and intuitive. Dr. B took the time to understand my lifestyle and diet.	My visit here left me questioning if it was a scam or simply incompetence. Dr. B never gets the diagnosis correct
Cardiologist–patient communication	Incredible communication. Drew on a piece of paper what was happening, and I never felt rushed.	Going here is like getting treated by a robot.
Thoroughness	The doctor listened <i>and</i> asked me questions. The explanation was so good that at the end I could not even think of a question to ask.	The doctor ordered a long list of tests that I doubt were necessary and then never followed up about the results.
Physical examination	It was the most thorough exam I ever had.	I am a new patient and was shocked that Dr. B did not perform a physical exam at all.
Cost consciousness	Dr. B is not the type of cardiologist who will target your pocket by ordering unnecessary testing	Overdiagnosed with unnecessary testing and shocked me with unexpected medical bills.
Practice-related themes		
Wait times	This is the best-run office in the city.	Appointments are never on time.
Cleanliness	The office is far from my house but worth every mile. It is so clean and has beautiful, eclectic decorations.	It was the dirtiest office I have ever seen.
Billing and insurance	The staff makes sure I am well informed of my financial responsibilities before performing a test or procedure.	The doctor would not see me unless I changed insurance.
Scheduling	There was always someone available. It was easy to get an appointment.	The system here has flaws. I have not been able to make an appointment and never get a call back. You are more likely to have a heart attack than get an appointment. And when you do, they overbook and cancel without explanation.
Innovative use of technology	The office was state of the art.	The technology was outdated and led to misdiagnoses.
Interactions with staff	The staff was professional, kind, and personable.	The people in the office were abrasive and rude, even over the phone. I thought Dr. B was great at first, but you are only as good as your staff.
Parking	Plenty of street parking.	There was no handicapped parking.

themes coded. A total of 563 reviews were analyzed by 1 coder.

For each review, the rating (1–5 stars, with 1 being the worst), the sex of the cardiologist, and the race of the cardiologist were collected. The sex of the cardiologist was determined in many cases on the basis of text written on the practice website or photos, and the race was determined on the basis of photos. If the race of the cardiologist was unclear, an image of the cardiologist was analyzed via the Face Secret Pro application (2020 Zift Software LLC), which provides a percentage breakdown of racial appearance of the cardiologist. If a racial category was over 50%, it was recorded as the race of the cardiologist.¹⁶ If the race or sex was not able to be obtained for a given cardiologist, it was recorded as other. The sex or race determination was consistently done by author P.K. and verified by the team when unclear. A potential limitation of these methods includes potentially misclassifying a cardiologist's race or sex because of these data not being generated from self-report by the cardiologist.

All statistical analysis was done using R version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria) and SPSS 26.0 software (IBM Corporation, Armonk,

NY). To analyze the likelihood of a high Yelp rating given positive and negative themes (included separately) on the basis of cardiologist- or practice-related factors, binary logistic regression was used. This regression was run as a single model controlling for all variables included in Table 3. To make the Yelp ratings binary, the low ratings (1 and 2) were combined, the high ratings (4 and 5) were combined, and ratings of 3 were excluded (n=12, 2.1% of total ratings were excluded). To determine if race or sex affected either the frequency of high or low ratings or of certain themes than would be expected by chance, chi-squared tests were performed. The *P* values for chi-squared tests were adjusted for multiple testing via the Holm method to guard against instances of false-positive significance. *P* values for the single logistic regression model were also adjusted for multiple testing via the Holm method.

RESULTS

Of a total of 563 Yelp reviews, the majority were from the Western region at 43.7% (n=246) followed by the

Table 3. Binary Logistic Regression of High vs Low Yelp Ratings Shows Multiple Themes Positively or Negatively Influence the Likelihood of Receiving a High Rating

	Odds ratio	95% CI	Holm adjusted P value
Cardiologist-related themes			
Competency/knowledge base (positively mentioned)	46.7	5.8–378.5	0.00448 [†]
Thoroughness (positively mentioned)	95.8	8.5–1086.1	0.00345 [†]
Thoroughness (negatively mentioned)	0.2	0.05–0.9	0.306
Temperament (negatively mentioned)	0.1	0.01–0.7	0.230
Cost-consciousness (negatively mentioned)	0.1	0.01–0.8	0.306
Practice-related themes			
Interactions with staff (positively mentioned)	34.4	4.2–282.2	0.0118*
Interactions with staff (negatively mentioned)	0.3	0.1–0.6	0.0143*
Billing and insurance (positively mentioned)	0.4	0.1–1.3	0.763
Parking (negatively mentioned)	0.7	0.03–15.8	1.00
Race (reference=White)			
Black	1.3	0.6–2.9	1.00
Other	0.1	0.001–12.7	1.00
Misc			
Knew name of provider (yes, reference=no)	4.4	1.9–10.1	0.00559 [†]
Responded to comments (yes, reference=no)	0.4	0.1–1.3	0.763
Practice type (academic, reference=non-academic)	2.9	0.7–11.7	0.763
Model summary			
Constant	0.6		0.763
Model summary–nagelkerke R ² : 0.782			

*P<0.05.

†P<0.01.

Southern region at 33.9% (n=191). A 5-star rating was the most frequent rating making up 68.0% (n=383) of the total ratings, followed by a 1-star rating at 21.5% (n=121). The mean number of reviews per practice was 21.1±14.7 (Table 1).

Most of the cardiologists reviewed were White (55.4%; n=312) and were men (68.7%; n=387). Only 11.4% (n=64) responded to the reviews on Yelp. Mentioning the name of the cardiologist in the review occurred in 77.1% (n=434) of reviews. The most common type of practices reviewed were nonacademic (98.1%; n=552), with only 2.0% (n=11) of practices being academic (Table 1).

There were 865 counts of positive themes and 271 counts of negative themes recorded from all the Yelp reviews. Themes that were cardiologist related include temperament, knowledge base, cardiologist–patient communication, thoroughness, physical examination, and cost consciousness.¹¹ Themes that were practice related include wait times, cleanliness, billing and insurance, scheduling, innovative use of technology, interactions with staff, and parking.¹¹

The most mentioned positive themes in the reviews included knowledge base (24.5%; n=212), thoroughness (24.4%; n=211), temperament (17.5%; n=151), and

interactions with staff (17.1%; n=148). Other positive and negative themes at lower frequencies were also recorded and shown in Table 1. Positive interactions with staff were associated with a higher Yelp rating (P=0.0118). If the patient knew the name of the cardiologist and wrote it in the Yelp review, this was also associated with a higher Yelp review rating (P=0.00559). Both competency/knowledge base (P=0.00448) and thoroughness (P=0.00345) were cardiologist-related factors that were associated with a higher Yelp review rating when mentioned positively (Table 3). Positive reviews relating to thoroughness included comments describing the cardiologist as being thorough, taking time to explain things, and going above and beyond with their care. Positive themes of knowledge base were highlighted by patients' comments on the cardiologist being knowledgeable, intelligent, and having expertise. *Compassionate, kind, and professional* were adjectives used by reviewers to positively describe the temperament of the cardiologist. Other quotes from patients expressing positive themes are in Table 2.

The most mentioned negative themes included interactions with staff (29.5%; n=80), scheduling (13.7%; n=37), wait times (13.3%; n=36), and billing and insurance (11.4%; n=31) (Table 1). Negative interactions with

staff were less likely to be associated with a higher Yelp rating ($P=0.0143$) (Table 3). Poor reviews on Yelp were frequently accompanied by negative comments about staff, including expressions that the staff was rude or the office was poorly managed or disorganized. Patients also shared that it was hard to schedule appointments because their phone calls were not answered by the office. More quotes from patients expressing negative themes can be found in Table 2.

Sex was found to be significantly associated with Yelp ratings ($P=0.0036$) (Table 4). Male cardiologists received high ratings at a frequency greater than expected by chance, whereas female cardiologists received high ratings at a frequency lower than expected by chance (Figure). Male cardiologists also received low ratings at a frequency lower than expected by chance and female cardiologists received low ratings at a frequency greater than expected by chance (Figure). The cardiologist-related factor of negative cardiologist–patient communication was also significantly associated with sex ($P=0.00025$) (Table 4). Negative mention of cardiologist–patient communication was observed at a frequency greater than expected by chance in female cardiologists and was observed at a frequency lower than expected by chance in male cardiologists (Figure).

The race of a cardiologist was also found to be significantly associated with Yelp ratings ($P=0.0091$) (Table 4). White and Black cardiologists received high ratings at a frequency lower than expected by chance, whereas cardiologists categorized as having a race of “other” received high ratings at a frequency greater than expected by chance (Figure). Likewise, White and Black cardiologists received low ratings at a frequency greater than expected by chance, and cardiologists who were categorized as having a race of “other” received low ratings at a frequency lower than expected by chance (Figure). Additionally, none of the positive themes tested, including temperament, competency/knowledge base, thoroughness, and interactions with staff, were associated with race (Table 4).

DISCUSSION

Cardiologist-related factors, practice-related factors, cardiologist sex, and cardiologist race were found to influence the cardiologist’s resulting Yelp review rating, which most likely reflects overall patient satisfaction. This is the first time these factors have been examined in cardiology practices. Learning about factors influencing cardiologist Yelp review ratings is important because these factors could potentially impact patient selection of a cardiologist, which in turn could impact care received by the patient.

Cardiologists noted for their competency/knowledge base and thoroughness (physician-related

factors) were found to have higher ratings. The themes of competency/knowledge base and thoroughness, which have also been identified in reviews of dermatology practices,¹¹ were 2 of the most frequent positive themes recorded in the reviews of cardiologists. The importance of these qualities to patients affected their ratings of cardiologists and significantly influenced their reviews positively if the cardiologist expressed either of these 2 traits on the basis of the patient’s assessment.

Both positive and negative interactions with staff, which is a practice-related factor, affected Yelp ratings with positive interactions being more likely to be associated with higher Yelp ratings. Interactions with staff were also frequently referenced in patient reviews, in this study as well as in prior studies of other types of medical practices.^{8,11} This demonstrates that patients are highly cognizant of staff behaviors and that their opinions of staff directly affect their rating of the cardiologist themselves and their overall satisfaction. As one patient stated in their review, “You are only as good as your staff.” These results are consistent with a study of 4999 online reviews that found that staff ratings were highly correlated with the overall physician rating.⁷ The ability for cardiologists to receive high ratings is influenced by both cardiologist- and practice-related factors, requiring that cardiology clinical staff consistently perform at a high-quality level.

Another factor found to be associated with higher Yelp review ratings was if a reviewer wrote down the name of the cardiologist in the Yelp review, the cardiologist was more likely to be rated highly (indicating high patient satisfaction). To our knowledge, this finding has not been demonstrated in any other analyses of online reviews. It is possible that if a cardiologist is thorough or estimated by the patient to have a strong knowledge base, both of which were found to be associated with higher ratings, that patients would remember the cardiologist’s name and feel more inclined to write the cardiologist’s name in the review. It is also possible that patients who had a more positive interaction with their cardiologist were more likely to remember the cardiologist’s name and felt inclined to include the cardiologist’s name in their praise. A study done in the field of pediatrics found that parents who knew the name of their child’s physician during an urgent care visit were more likely to be satisfied, supporting this idea.¹⁷ Further research is necessary to determine the cause of this finding.

The association between being a female cardiologist and receiving a negative Yelp review revealed a negative bias of patients toward female cardiologists. Female cardiologists received negative Yelp review ratings at a frequency greater than expected by chance, while male cardiologists received negative Yelp review ratings at a frequency lower than expected by chance (Figure). Some studies across multiple fields (using

Table 4. Chi-Square Analysis Shows an Association Between Sex and Race With Overall Cardiologist Ratings, and Sex with Negative Cardiologist–Patient Communication

	Race		Sex			
	Overall rating chi-squared statistic: 9.4 (P=0.0091)		Overall rating chi-squared statistic: 8.5 (P=0.0036)			
	Positive		Positive		Negative	
	Holm adjusted P value	Chi-squared statistic	Df	Holm adjusted P value	Chi-squared statistic	Df
Cardiologist-related themes						
Temperament	0.732	2.9	2	1.000	0.002	1
Competency/knowledge base	0.732	1.4	2	0.100	6.6	1
Cardiologist-patient communication				1.000	0.3	1
Thoroughness	0.732	3.4	2	1.000	0.3	1
Physical exam				1.000	0.7	1
Practice-related themes						
Wait times				1.000	1.1	1
Cleanliness				1.000	1.7	1
Billing and insurance						
Scheduling				1.000	0.4	1
Innovative use of technology				1.000	0.8	1
Interactions with staff	0.732	2.2	2	1.000	0.05	1

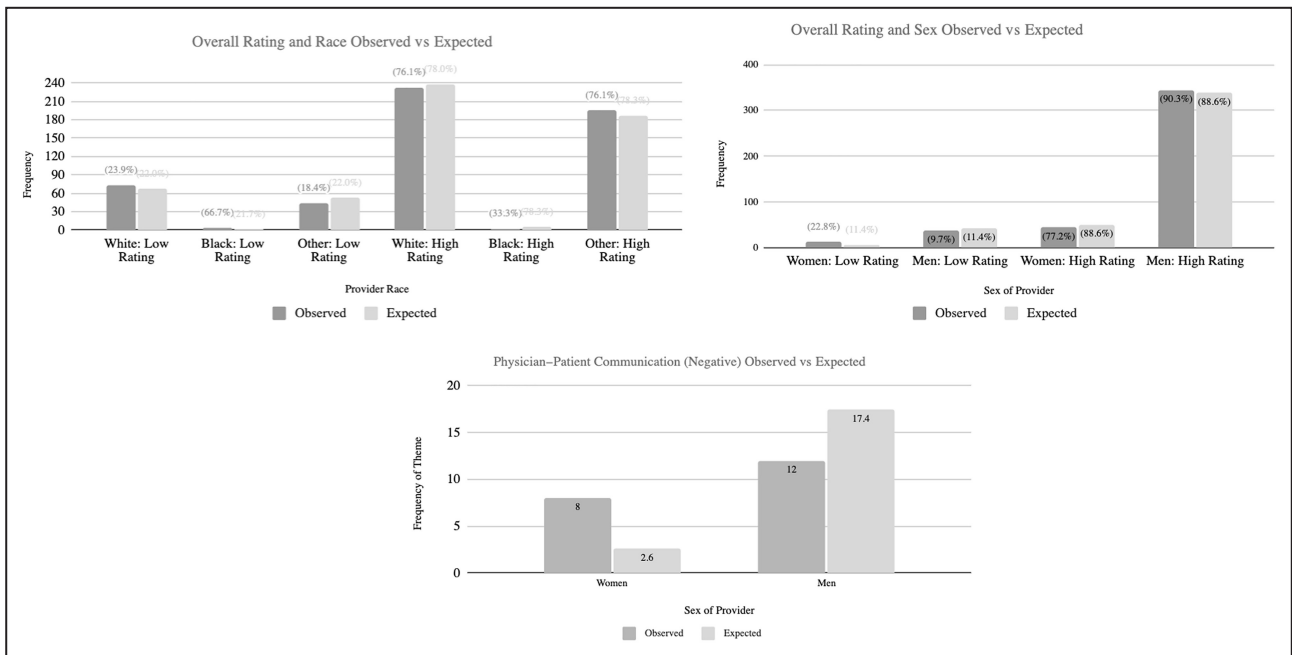


Figure. Observed vs expected (from chi-squared analysis) counts of low or high ratings by cardiologist race and sex.

either online reviews or other physician rating systems) have also found that female physicians receive lower ratings than male physicians,^{10,18,19} while others found no difference in ratings between male and female physicians.^{8,20,21} Female cardiologists are crucial to all fields of medicine, and there is evidence to suggest that female physician sex concordance positively impacts patient care outcomes,^{5,6} but we were not able to assess the sex of those who completed the online reviews. Further work must be done to confirm this bias against female cardiologists, to determine if this bias exists and if there are differing expectations of female physicians. Currently, it is well established that female physicians spend more time with patients,²² and female cardiologists adhere to guidelines more than men.⁵ This should result in more positive evaluations of female cardiologists, despite what is demonstrated in this study.

Female cardiologists in this study received negative comments related to patient-cardiologist communication (a cardiologist-related factor) at a frequency greater than expected by chance. Jefferson et al²³ explored differences in women’s and men’s physician communication styles in a meta-analysis of 33 studies. This analysis demonstrated that female physicians expressed more nonverbal communication, demonstrated less dominance, expressed more empathy, and spent more time with their patients overall.²³ The study also found that female physicians tend to provide more psychosocial information, male physicians tend to provide more biomedical information.²³ Chen et al²⁴ found that “female physicians were more likely to be described

using communal language” than male physicians, and also found that physicians who used more communal language were more likely to receive perfect ratings. If female cardiologists do not conform to sex-based communication expectations, perhaps this could result in lower overall Yelp ratings. Further research could be done to determine whether cardiology patients dislike communication behaviors expressed by female cardiologists, or if their negative views of female cardiologist-patient communication are attributable to biases against the female cardiologists themselves.

Our data show that patients had positive experiences with cardiologists of non-White and non-Black races. Surprisingly, patients frequently gave higher ratings at a frequency greater than expected by chance to cardiologists with a race coded as “other,” while White and Black cardiologists received lower ratings at a frequency greater than expected by chance. This is contradictory to studies in other fields in which White physicians received higher ratings than cardiologists of any other race.^{19,20} This positive view of cardiologists coded as “other” was also not associated with several cardiologist- or practice-related factors, and thus cannot be explained by these cardiologists simply having more positive themes in their reviews. Although racial concordance is associated with improved satisfaction and outcomes,^{3,4} we were unable to assess the race of the Yelp reviewers.

The proportion of races and sex of cardiologists reviewed in this study is similar to the proportion of races and sex of cardiologists nationally. Data from 2016 show that 51.2% of US adult cardiologists are White

and 3% are Black, while 55.4% of cardiologists in this study are White and 1.1% are Black.³ However, with such a small representation of Black cardiologists in this study, it is difficult to draw any definitive conclusions about Black cardiologists. Similarly, 12.6% of US adult cardiologists were women and 80.7% were men, while 10.3% of cardiologists in this study were women, 68.7% of cardiologists were men and 21.0% were coded as undetermined on the basis of insufficient data from an online review of provider information.²⁴ Because of the similarities in proportions of race and sex in our study compared with national data, our data are representative of cardiologists nationally.

LIMITATIONS

There are a number of limitations in this analysis. One limitation is the anonymous nature of Yelp reviews, as well as their unverifiability. Fake reviews occur and would be undetected by the coder of the study. Fake reviews may be written to help a business or to reflect poorly on a business. Yelp's proprietary algorithm works toward removing fraudulent reviews,¹⁵ which may reduce this risk. Consistent with other studies, most Yelp reviews were positive (received a 5-star rating), with the next most frequent rating being a 1-star, reflecting a dichotomous distribution of reviews.^{9,18} This may indicate a response bias of patients writing a review who only feel strongly about their cardiologist, which may not capture the perspectives of all patients. Some reviewed practices had >1 cardiologist, while others had only 1 cardiologist. Both types of practices were treated the same in our statistical model. Additionally, some cardiologists had multiple reviews, which may result in data from those cardiologists contributing more to the data set compared with cardiologists with only 1 review.

Other limitations include possible unintentional errors in the data extraction process when determining race, sex, and coding themes. While we attempted objectivity by implementing the Face Secret Pro tool to help determine race, implicit bias does play a role in the process of determining race or sex. Coding themes required the coder to interpret writing from the reviewer, and unintentional misinterpretation could occur. Additionally, many cardiologists in this study were coded to be a race or sex of "other," which limits interpretation, as missing information could have influenced the results if it had been included in the analysis. Additionally, although sex is not binary, it was treated as such, resulting in the potential omission of data about cardiologists who identify as a sex other than man or woman.

The methods used in this study may also lead to data omission because of the desire to focus on the

most recent reviews per each practice and limiting the total number of reviews per city to capture a greater geographic distribution of reviews. We did not analyze regionality as part of our logistic regression model because of potential regional variances not being a focus in this study; however, location could be a potential confounding variable. Our selection had limited data from the Midwest, leading to low generalizability in that region. Additionally, there were limited academic practices analyzed, so the results of this study are much more applicable to private practices, although practice type was controlled for in the binary logistic regression model. Finally, it was not possible to compare hospital- or practice-based evaluations of cardiologists by patients to compare online reviews to internally performed reviews. We were unable to compare the reviews to patient outcomes, patient treatment, or length of time of visit, all of which could influence these online evaluations.

CONCLUSIONS

We have demonstrated that cardiologist-related and practice-related factors, sex, and race of the cardiologist influence patient Yelp online reviews of cardiologists. Further research must be done to analyze the effects of sex and race concordance on patient reviews and satisfaction. This study suggests that patients have higher satisfaction with racially diverse cardiologists, presuming that cardiologists with a race of "other" may represent diversity in race. Additionally, there is a need for further research to assess and address sex bias against female cardiologists.

ARTICLE INFORMATION

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