



# Association Between Sexual Orientation and Lifetime Prevalence of Skin Cancer

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28 February 2020

Sean Singer

Association Between Sexual Orientation and Lifetime Prevalence of Skin Cancer

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## **Abstract**

**Purpose:** Sexual minority men have reported higher rates of both indoor tanning and skin cancer than heterosexual men, and sexual minority women have reported lower or equal rates of both indoor tanning and skin cancer compared with heterosexual women. Bisexual men, in particular, have reported higher rates of indoor tanning bed use than heterosexual men; however, no study has investigated skin cancer prevalence among gay, lesbian, and bisexual individuals as separate groups.

**Methods:** This cross-sectional study analyzed data from the 2014-2018 Behavioral Risk Factor Surveillance System (BRFSS) surveys of a noninstitutionalized population in the United States that included 845 264 adult participants who self-identified as being heterosexual, gay, lesbian, or bisexual.

**Results:** The study included 845 264 participants, including 351 468 heterosexual men (mean age, 47.7; 95% CI, 47.5-47.8), 7516 gay men (mean age, 42.7; 95% CI, 41.9-43.5), 5088 bisexual men (mean age, 39.3; 95% CI, 38.2-40.4), 466 355 heterosexual women (mean age, 49.7; 95% CI, 49.6-49.9), 5392 lesbian women (mean age, 41.9; 95% CI, 40.7-43.2), and 9445 bisexual women (mean age, 32.7; 95% CI, 32.2-33.2). The adjusted odds ratios (AORs) of skin cancer prevalence were significantly higher among both gay (AOR, 1.26; 95% CI, 1.05-1.51;  $P = .01$ ) and bisexual men (AOR, 1.48; 95% CI, 1.02-2.16;  $P = .04$ ) compared with heterosexual men. The AORs of skin cancer were statistically significantly lower among bisexual women (AOR, 0.78; 95% CI, 0.61-0.99;  $P = .04$ ) but not among gay or lesbian women (AOR, 0.97; 95% CI, 0.73-1.27;  $P = .81$ ) compared with the AORs of skin cancer among heterosexual women.

**Conclusion:** In this study, gay and bisexual men had an increased self-reported lifetime prevalence of skin cancer compared with the prevalence among heterosexual men. Patient education and community outreach initiatives focused on reducing skin cancer risk behaviors among gay and bisexual men may help reduce the lifetime development of skin cancer in this population. Continued implementation of the Behavioral Risk Factor Surveillance System's sexual orientation and gender identity module is imperative to improve understanding of the health and well-being of sexual minority populations.

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## **Glossary of Abbreviations**

SGM = sexual and gender minority

BRFSS = Behavioral Risk Factor Surveillance System

CDC = Center for Disease Control

SOGI = Sexual Orientation and Gender Identity

## **Description of Scholarly Project**

During my research year, I worked with my mentor Arash Mostaghimi on a project hoping to evaluate skin cancer prevalence and risk behaviors among sexual and gender minority populations. This idea came about because I have been interested in sexual and gender minority (SGM) health for years, and I wanted to find a way to evaluate specific vulnerabilities this population faces within dermatology. After performing a brief literature review, I discovered there was some evidence that sexual minority men had an increased lifetime risk of skin cancer. In reviewing the literature, I found a gap in the skin cancer literature that focuses on SGM populations. First, all published data combined gay or lesbian and bisexual individuals into one “sexual minority” group, so no study had yet looked at risk among gay or lesbian and bisexual populations as distinct groups.

My role in this study involved study design, data collection, analysis proposal, drafting of the manuscript, and response to journal revisions. My first task was to identify whether or not the Behavioral Risk Factor Surveillance System (BRFSS) survey, a national survey administered by the Center for Disease Control (CDC), would be a good data source for our study. I found that the BRFSS survey implements a Sexual Orientation and Gender Identity (SOGI) module, which provides information on the sexual and gender identities of respondents. In addition, the BRFSS survey asks respondents whether or not they have a lifetime history of skin cancer. Because of these data points, we were able to combine this data to analyze the prevalence of skin cancer in populations stratified by sexual orientation. Data analysis was performed by one of our study collaborators and study co-authors, Dr. Rebecca Hartman.

Our study is subject to a number of limitations, a number of which are outlined in our published manuscript. Most important to recognize is that the SOGI module of the BRFSS is optional and states can opt-in to implementing it, and over the 4 years examined in our study only 36 states have chosen to implement this module. For this reason, our data is not necessarily generalizable to the entire United States, only the states in which this optional module has been implemented. With that said, this is the largest data set to be published on skin cancer prevalence in sexual minority populations.

In terms of a project timeline, I began working on this project in October 2018, and data analysis was finalized by January 2019. Our initial manuscript was submitted in February 2019, and we were in the process of revising our manuscript until November 2019, when the

manuscript was accepted by *JAMA Dermatology*. The manuscript was published online in February 2020.

# Association Between Sexual Orientation and Lifetime Prevalence of Skin Cancer in the United States

Sean Singer, BS; Elizabeth Tkachenko, BS; Rebecca I. Hartman, MD, MPH; Arash Mostaghimi, MD, MPA, MPH

**IMPORTANCE** Sexual minority men have reported higher rates of both indoor tanning and skin cancer than heterosexual men, and sexual minority women have reported lower or equal rates of both indoor tanning and skin cancer compared with heterosexual women. Bisexual men, in particular, have reported higher rates of indoor tanning bed use than heterosexual men; however, no study has investigated skin cancer prevalence among gay, lesbian, and bisexual individuals as separate groups.

**OBJECTIVE** To evaluate the association between sexual orientation and lifetime prevalence of skin cancer.

**DESIGN, SETTING, AND PARTICIPANTS** This cross-sectional study analyzed data from the 2014-2018 Behavioral Risk Factor Surveillance System (BRFSS) surveys of a noninstitutionalized population in the United States that included 845 264 adult participants who self-identified as being heterosexual, gay, lesbian, or bisexual.

**MAIN OUTCOMES AND MEASURES** Self-reported lifetime history of skin cancer.

**RESULTS** The study included 845 264 participants, including 351 468 heterosexual men (mean age, 47.7; 95% CI, 47.5-47.8), 7516 gay men (mean age, 42.7; 95% CI, 41.9-43.5), 5088 bisexual men (mean age, 39.3; 95% CI, 38.2-40.4), 466 355 heterosexual women (mean age, 49.7; 95% CI, 49.6-49.9), 5392 lesbian women (mean age, 41.9; 95% CI, 40.7-43.2), and 9445 bisexual women (mean age, 32.7; 95% CI, 32.2-33.2). The adjusted odds ratios (AORs) of skin cancer prevalence were significantly higher among both gay (AOR, 1.26; 95% CI, 1.05-1.51;  $P = .01$ ) and bisexual men (AOR, 1.48; 95% CI, 1.02-2.16;  $P = .04$ ) compared with heterosexual men. The AORs of skin cancer were statistically significantly lower among bisexual women (AOR, 0.78; 95% CI, 0.61-0.99;  $P = .04$ ) but not among gay or lesbian women (AOR, 0.97; 95% CI, 0.73-1.27;  $P = .81$ ) compared with the AORs of skin cancer among heterosexual women.

**CONCLUSIONS AND RELEVANCE** In this study, gay and bisexual men had an increased self-reported lifetime prevalence of skin cancer compared with the prevalence among heterosexual men. Patient education and community outreach initiatives focused on reducing skin cancer risk behaviors among gay and bisexual men may help reduce the lifetime development of skin cancer in this population. Continued implementation of the Behavioral Risk Factor Surveillance System's sexual orientation and gender identity module is imperative to improve understanding of the health and well-being of sexual minority populations.

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Sexual minority groups include, but are not limited to, individuals who identify as gay, lesbian, or bisexual. Sexual minority men (SMM) have reported higher rates of both indoor tanning and skin cancer compared with the rate among heterosexual men, whereas sexual minority women (SMW) have reported lower or equal rates of both indoor tanning and skin cancer compared with the rate among heterosexual women.<sup>1-3</sup> Bisexual men have reported more frequent use of indoor tanning beds compared with use among heterosexual men<sup>4</sup>; however, no study has investigated skin cancer prevalence among gay, lesbian, and bisexual individuals as separate groups. In this study, we evaluated whether lifetime prevalence of skin cancer differs among gay, lesbian, and bisexual individuals compared with heterosexual individuals.

## Methods

### Study Design

This cross-sectional study analyzed data from the 2014-2018 Behavioral Risk Factor Surveillance System (BRFSS) annual questionnaires. The BRFSS is a national system of telephone surveys that collects demographic and health-related data on noninstitutionalized US adults. In 2014, the BRFSS introduced a sexual orientation and gender identity (SOGI) module, which was administered at least once in 37 states from 2014 to 2018.<sup>5</sup> This study was deemed exempt from review by Partners Healthcare institutional review board because it used publicly available data without patient identifiers. All survey respondents agreed to have their data publicly released.

### Study Population, Covariates, and Outcome Variable

The study population was stratified by self-reported sex as male or female. Self-reported sexual orientation was ascertained in the SOGI module. The analysis included respondents who identified as gay (for men), gay or lesbian (for women), bisexual, or heterosexual. The demographic characteristics of the study population are given in **Table 1**.

Covariates examined were sociodemographic and health care access variables in the BRFSS questionnaire that are either basic demographic information or factors associated with skin cancer.<sup>6</sup> These included age, geographic region, race/ethnicity, education level, employment status, insurance status, smoking history, current alcohol consumption, and history of another cancer diagnosis.

History of skin cancer diagnosis was assessed by the following question: "Has a doctor, nurse, or other health professional ever told you had skin cancer?" Respondents who answered "don't know," "not sure," or refused to answer any questions pertaining to sex, sexual orientation, or lifetime skin cancer diagnosis were excluded from the analysis.

### Statistical Analysis

All analyses stratified participants by sex and sexual orientation, and heterosexual respondents of each sex were used as the reference group. Data were weighted according to BRFSS

## Key Points

**Question** What is the association between sexual orientation and lifetime prevalence of skin cancer in the United States?

**Findings** In this cross-sectional study of 845 264 adults, both gay and bisexual men had higher adjusted odds of lifetime prevalence of skin cancer compared with heterosexual men. Bisexual women, but not lesbian women, had lower odds of lifetime prevalence of skin cancer compared with heterosexual women.

**Meaning** Patient education and community outreach programs targeting these populations may be helpful in reducing disparities in lifetime skin cancer prevalence.

recommendations. Analysis of variance tests were used to compare age, and  $\chi^2$  analyses were used to compare demographic characteristics between groups. The significance threshold was  $P < .05$  and testing was 2-sided.

Univariate regression analyses were conducted to investigate associations between sexual orientation (**Table 2**) and other covariates (eTables 1 and 2 in the **Supplement**) and lifetime skin cancer prevalence. The direct method for age standardization was used to calculate age-adjusted lifetime skin cancer prevalence. Multivariate logistic regression analyses were conducted to calculate adjusted odds ratios (AORs) for lifetime skin cancer prevalence. No adjustment was made for multiple comparisons. All analyses were performed using R software, version 3.5.1 (R Core Team).

## Results

The total unweighted study sample of 845 264 individuals included 351 468 heterosexual men (mean age, 47.7 years; 95% CI, 47.5-47.8 years), 7516 gay men (mean age, 42.7 years; 95% CI, 41.9-43.5 years), 5088 bisexual men (mean age, 39.3 years; 95% CI, 38.2-40.4 years), 466 355 heterosexual women (mean age, 49.7 years; 95% CI, 49.6-49.9 years), 5392 lesbian women (mean age, 41.9 years; 95% CI, 40.7-43.2 years), and 9445 bisexual women (mean age, 32.7 years; 95% CI, 32.2-33.2 years) (**Table 1**).

Age-adjusted lifetime prevalence of skin cancer diagnosis was 8.1% (95% CI, 6.8%-9.5%) among gay men, 8.4% (95% CI, 6.3%-11.0%) among bisexual men, and 6.7% (95% CI, 6.5%-6.9%) among heterosexual men (**Table 2**). The adjusted odds ratio (AOR) of skin cancer diagnosis was statistically significantly higher among gay men (AOR, 1.26; 95% CI, 1.05-1.51,  $P = .01$ ) and bisexual men (AOR, 1.48; 95% CI, 1.02-2.16,  $P = .04$ ) than among heterosexual men.

Age-adjusted lifetime prevalence of skin cancer diagnosis was 5.9% (95% CI, 4.8%-7.3%) among lesbians, 4.7% (95% CI, 3.8%-5.7%) among bisexual women, and 6.6% (95% CI, 6.5%-6.8%) among heterosexual women. The AOR of skin cancer diagnosis was lower among bisexual women (AOR, 0.78; 95% CI, 0.61-0.99;  $P = .04$ ) but not among gay or lesbian women (AOR, 0.97; 95% CI, 0.73-1.27,  $P = .81$ ) compared with that among heterosexual women (**Table 2**).

Table 1. Characteristics of Heterosexual, Gay or Lesbian, and Bisexual Respondents, Stratified by Sex

Characteristic	Men			Women			P Value <sup>a</sup>	P Value <sup>a</sup>
	Heterosexual	Gay	Bisexual	Heterosexual	Lesbian or Gay	Bisexual		
Unweighted, No. <sup>b</sup>	351 468	7516	5088	466 355	5392	9445	NA	NA
Weighted, No.	72 334 280	1 624 508	1 204 967	78 191 198	1 126 745	2 364 343	NA	NA
Age, mean (95% CI), y	47.7 (47.5-47.8)	42.7 (41.9-43.5)	39.3 (38.2-40.4)	49.7 (49.6-49.9)	41.9 (40.7-43.2)	32.7 (32.2-33.2)	NA	<.001
Region, % (95% CI)								
Northeast	16.7 (16.5-16.8)	19.7 (18.3-21.2)	21.6 (19.6-23.5)	17.0 (16.8-17.1)	17.8 (16.0-19.6)	19.6 (18.3-20.9)		
South	39.1 (38.8-39.3)	35.9 (33.4-38.3)	36.5 (33.6-39.4)	40 (39.8-40.2)	38.1 (34.7-41.5)	37.8 (35.7-40.0)		.01
Midwest	21.4 (21.3-21.5)	16.7 (15.4-18.0)	20.4 (18.6-22.2)	21.2 (21.0-21.3)	18.9 (17.0-20.8)	21.3 (19.9-22.8)		
West	22.9 (22.6-23.1)	27.7 (25.1-30.3)	21.6 (18.6-24.6)	21.9 (21.7-22.2)	25.2 (21.4-28.9)	21.2 (19.2-23.3)		
Race/ethnicity, % (95% CI)								
Non-Hispanic White	65.6 (65.2-65.9)	63.9 (61.2-66.6)	60.0 (57.0-63.0)	65.4 (65.0-65.8)	62.3 (58.6-66.0)	62.6 (60.4-64.7)		
Non-Hispanic Black	10.9 (10.7-11.2)	10.3 (8.5-12.1)	11.2 (9.5-12.9)	12.4 (12.2-12.6)	15.3 (12.7-17.8)	13.8 (12.0-15.6)		.02
Hispanic	8.0 (7.7-8.2)	9.3 (7.2-11.3)	10.7 (9.0-12.5)	7.4 (7.2-7.7)	9.2 (6.1-12.3)	9.0 (7.9-10.2)		
Other <sup>c</sup>	15.5 (15.2-15.9)	16.5 (14.4-18.6)	18 (15.1-21.0)	14.8 (14.5-15.1)	13.3 (10.6-15.9)	14.6 (13.0-16.2)		
Education level, % (95% CI)								
High school or less	43.3 (42.9-43.7)	29.6 (27.0-32.2)	42.4 (39.5-45.3)	38.9 (38.6-39.3)	34.8 (31.3-38.2)	40.7 (38.5-42.8)		.02
Some college or more	56.7 (56.3-57.1)	70.4 (67.8-73.0)	57.6 (54.7-60.5)	61.1 (60.7-61.4)	65.2 (61.8-68.7)	59.3 (57.2-61.5)		
Employment status, % (95% CI)								
Unemployed	35.4 (35.0-35.7)	35.4 (33.0-37.9)	42.7 (39.7-45.6)	50.3 (50.0-50.7)	40.5 (36.9-44.0)	43.2 (41.1-45.3)		<.001
Employed	64.6 (64.3-65.0)	64.6 (62.1-67.0)	57.3 (54.4-60.3)	49.7 (49.3-50.0)	59.5 (56.0-63.1)	56.8 (54.7-58.9)		
Insurance status, % (95% CI)								
No	12.4 (12.1-12.6)	11.7 (10.0-13.5)	16.0 (13.7-18.4)	9.6 (9.4-9.8)	11.9 (9.5-14.3)	13.9 (12.4-15.3)		<.001
Yes	87.6 (87.4-87.9)	88.3 (86.5-90.0)	84.0 (81.6-86.3)	90.4 (90.2-90.6)	88.1 (85.7-90.5)	86.1 (84.7-87.6)		
Smoking history, % (95% CI)								
Never smoker	53.1 (52.7-53.4)	52.9 (50.4-55.4)	54.4 (51.5-57.3)	64.2 (63.9-64.5)	50.2 (46.8-53.7)	54.6 (52.5-56.7)		<.001
Former smoker	29.1 (28.8-29.4)	22.2 (20.3-24.1)	22.5 (20.2-24.9)	22.0 (21.7-22.3)	24.6 (21.8-27.4)	18.4 (16.9-20.0)		
Current smoker	17.8 (17.6-18.1)	24.9 (22.6-27.1)	23.1 (20.6-25.5)	13.8 (13.6-14.1)	25.1 (22.1-28.2)	27.0 (25.1-28.8)		
Alcohol use, % (95% CI) <sup>d</sup>								
Nondrinker	40.8 (40.4-41.2)	31.5 (29.2-33.7)	41.2 (38.3-44.2)	52.9 (52.5-53.2)	40.8 (37.4-44.2)	40.0 (37.9-42.1)		<.001
Light drinker	43.3 (42.9-43.6)	50.7 (48.2-53.2)	42.0 (39.1-44.8)	41.8 (41.4-42.1)	47.8 (44.3-51.2)	47.4 (45.3-49.6)		
Moderate or heavy drinker	15.9 (15.7-16.2)	17.8 (16.0-19.6)	16.8 (14.6-19.0)	5.4 (5.2-5.5)	11.5 (9.6-13.4)	12.6 (10.9-14.2)		
Other cancer diagnosis, % (95% CI)								
No	94.3 (94.1-94.4)	94.6 (93.7-95.6)	95.7 (94.5-97.0)	91.4 (91.3-91.6)	92.1 (89.5-94.8)	94.8 (94.0-95.6)		<.001
Yes	5.7 (5.6-5.9)	5.4 (4.4-6.3)	4.3 (3.0-5.5)	8.6 (8.4-8.7)	7.9 (5.2-10.5)	5.2 (4.4-6.0)		

Abbreviation: NA, not applicable.  
<sup>a</sup> Analysis of variance used to assess the P value for age.  $\chi^2$  tests used to assess remaining P values.  
<sup>b</sup> Unweighted sample excluded 121 714 (12.2%) individuals with missing data for sexual orientation, sex, and skin cancer. Those with missing data in any covariate were also excluded (32 676 [3.3%]).  
<sup>c</sup> Respondents who self-identified as American Indian or Alaska Native only, non-Hispanic; Asian only.  
<sup>d</sup> Nondrinkers, 0 alcoholic beverages weekly; light drinkers, 1 to 7 alcoholic drinks weekly; moderate or heavy drinkers, more than 7 alcoholic beverages per weekly.  
 non-Hispanic; Native Hawaiian or other Pacific Islander only, non-Hispanic; other race only, non-Hispanic; or multiracial, non-Hispanic.

**Table 2. Age-Adjusted Lifetime Prevalence, Univariate Odds Ratios, and Adjusted Odds Ratios of Skin Cancer, by Sexual Orientation and Sex**

Variable	Age-Adjusted Lifetime Prevalence, % (95% CI) <sup>a</sup>	Univariate OR (95% CI)	P Value	AOR (95% CI) <sup>b</sup>	P Value
<b>Men</b>					
Heterosexual	6.7 (6.5-6.9)	1 [Reference]	NA	1 [Reference]	NA
Gay	8.1 (6.8-9.5)	0.85 (0.72-1.01)	.06	1.26 (1.05-1.51)	.01
Bisexual	8.4 (6.3-11.0)	0.81 (0.59-1.11)	.18	1.48 (1.02-2.16)	.04
<b>Women</b>					
Heterosexual	6.6 (6.5-6.8)	1 [Reference]	NA	1 [Reference]	NA
Lesbian or gay	5.9 (4.8-7.3)	0.66 (0.51-0.84)	<.001	0.97 (0.73-1.27)	.81
Bisexual	4.7 (3.8-5.7)	0.29 (0.23-0.36)	<.001	0.78 (0.61-0.99)	.04

Abbreviations: AOR, adjusted odds ratio; NA, not applicable.

<sup>a</sup> Age-adjusted prevalence was calculated using direct standardization with heterosexual respondents from the weighted sample, by sex, as the standard population group.

<sup>b</sup> Adjusted for age, geographic region, race/ethnicity, education level, employment status, insurance status, current alcohol consumption, smoking history, and history of another cancer diagnosis.

## Discussion

Gay men and bisexual men were more likely than heterosexual men to have reported a skin cancer diagnosis. Bisexual women were less likely than heterosexual women to have reported a skin cancer diagnosis. Although prior studies showed an increased lifetime prevalence of skin cancer among SMM compared with heterosexual men, that increased prevalence persisted in this study when examining the data on gay and bisexual men separately.

Increased lifetime prevalence of skin cancer among gay and bisexual men likely reflects at least in part the increased indoor UV exposure among both gay and bisexual populations.<sup>4,7</sup> The primary motivators for indoor tanning among SMM have been shown to be concerns about appearance and community pressures,<sup>7,8</sup> and a recent study showed that indoor tanning salons are more likely to be located near neighborhoods with higher concentrations of male-male partnered households.<sup>9</sup> Consistent with US Preventive Services Task Force recommendations for the general population, health care professionals should counsel SMM patients against using indoor tanning beds<sup>10</sup> or to consider sunless tanning, which has proven effective in reducing indoor tanning bed use among women.<sup>11</sup> Patient education and community outreach initiatives centered on the increased rate of skin cancer diagnosis among SMM may reduce skin cancer risk behaviors, as fear of developing skin cancer was identified as a primary motivation for stopping indoor tanning among SMM.<sup>8</sup>

Findings in the present study are also consistent with prior findings that SMW have a decreased prevalence of skin cancer and skin cancer risk behaviors compared with heterosexual women, although in this study prevalence was low among only bisexual women.<sup>1</sup> Although it is possible that this indicates a decreased prevalence of skin cancer or skin cancer risk behaviors among bisexual women, it could also reflect evidence that bisexual women, for cost-related reasons, are less likely to seek medical care.<sup>12</sup>

## Limitations

This study has limitations, and it must be interpreted in the context of the study design. First, BRFSS data are based on self-reported, unvalidated skin cancer diagnoses, which may be inaccurate. Second, BRFSS did not collect information on important potential confounders, including UV exposure, photoprotective behaviors, Fitzpatrick skin type, or HIV and immunosuppression status, which may vary by sexual orientation. Third, because the BRFSS study did not collect information on health care use, the results may be affected by surveillance bias, as same-sex couples are less likely than opposite-sex couples to undergo total body skin examination.<sup>13</sup> In addition, because the BRFSS SOGI module has been implemented in only 37 states, the study population may not be fully generalizable to the entire United States.

The Centers for Disease Control and Prevention (CDC) recently considered stopping implementation of the SOGI module for future BRFSS surveys,<sup>14</sup> which would preclude further data collection on this vulnerable population through the BRFSS. The data in this report and our corresponding article<sup>15</sup> reflect the current sum of national data collected by the CDC on this population, and we strongly advocate for both continued implementation of the BRFSS SOGI module by the CDC and for more states to implement this module annually.

## Conclusions

To our knowledge, this was the largest study to examine lifetime prevalence of skin cancer among sexual minorities and the first to examine gay or lesbian individuals and bisexual individuals separately. Patient education and community outreach initiatives focused on reducing skin cancer risk behaviors among SMM may help reduce lifetime development of skin cancer in this population. Future advocacy efforts should focus on the continued implementation of the BRFSS SOGI module to improve understanding of the health and well-being of sexual minority populations.

### ARTICLE INFORMATION

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**Author Contributions:** Drs Hartman and Mostaghimi are co-senior authors. Mr Singer and Dr Hartman had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.  
*Concept and design:* Singer, Tkachenko, Mostaghimi.

*Acquisition, analysis, or interpretation of data:* All authors.

*Drafting of the manuscript:* Singer.

*Critical revision of the manuscript for important intellectual content:* All authors.

*Statistical analysis:* Singer, Hartman.

*Administrative, technical, or material support:* Tkachenko, Mostaghimi.  
*Supervision:* Mostaghimi.

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