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SPECIAL TOPIC

Assessing State Variation in Plastic Surgeons' Risk of Hepatitis C Exposure: Revisit in Methodology

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Background: As the national opioid epidemic escalates, rates of the Hepatitis C (HCV) infection have similarly risen. Surgeons exposed intraoperatively secondary to sharp instrument or needle-sticks are affected both socioeconomically and physically. Current treatment strategies involve antiretroviral agents that have not been universally available. This study evaluates the current risk of surgeon exposure to HCV.

Methods: CDC data regarding state-by-state HCV diagnosis reporting were combined with the plastic surgery workforce data from the ASPS. Proxy variables for exposure risk to HCV were generated for each state and compared.

Results: West Virginia plastic surgeons were found to have a significantly elevated risk of exposure (60.0 versus 18.7, P < 0.0001). Their exposure risk is a notable outlier compared with the rest of the country (Risk >3 × IQR + 75th percentile). Similarly, states within the Ohio Valley were found to be at increased risk (34.8 versus 16.0, P = 0.05). States most heavily burdened by the opioid crisis were found to be at an increased risk for HCV exposure (40.8 versus 13.6, P = 0.0003).

Conclusions: Plastic surgeons employed in states within the Ohio Valley were found to be at an increased risk of exposure to HCV. Plastic surgeons operating in states severely impacted by the opioid crisis were found to be at an increased risk of exposure. These findings underscore the importance of reducing the risk in the operating room and the need for better data collection to better understand this association and mitigate the risk to the operating surgeon. *(Plast Reconstr Surg Glob Open 2020;8:e3220; doi: 10.1097/GOX.0000000000003220; Published online 27 October 2020.)*

INTRODUCTION

Risk of plastic surgeons' exposure to hepatitis C has been previously discussed in the plastic surgery literature, albeit in the early 2000s.[1] However, in the 15 years since this topic was last visited in plastic surgery, the escalation of the opioid crisis in the United States has led to important contextual changes.

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Although hepatitis C can be acquired through a plethora of routes, including unsanitary tattoo art, dental procedures, and accidental needle stick, the opioid public health epidemic has directly led to a large increase in the incidence of hepatitis C diagnoses in recent years.[2] While in 2010 fewer than 1000 new cases of acute hepatitis C were reported,[2] numbers from 2016 from the Centers for Disease Control (CDC) identify more than 3000 new acute cases of hepatitis C (Fig. 1). Central Appalachian states (including Kentucky, Tennessee, Virginia, and West Virginia) witnessed a rate increase up to 36.4% between 2006 and 2012.[3]

Exposure to and transmission of the hepatitis C virus is an important occupational hazard for plastic surgeons to consider, given the potential for needle- and sharp instrument-sticks in the operating room when working with patients diagnosed with hepatitis C positive or whose status is unknown but are at a high risk. No studies in the plastic surgery literature have characterized the risk of exposure to hepatitis C among the US plastic surgery workforce.

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The study describes a model that estimates the risk of exposure to hepatitis C among plastic surgeons based upon the geographical region wherein they work. We further review the literature and summarize the current understanding of hepatitis C to promote an awareness of the risk to plastic surgeons.

METHODS

To assess the prevalence of hepatitis C in each state, we analyzed CDC data describing state-by-state HCV diagnostic reporting for the most recent year, 2017.[2] We then queried the American Society of Plastic Surgeons (ASPS) website[4] to gather the number of plastic surgeons practicing in each state. These plastic surgery workforce data were then divided into the total population of each state to determine the number of plastic surgeons per capita. This information was used to calculate a proxy variable to assess HCV exposure risk for each state. Proxy variables were calculated by multiplying the plastic surgery workforce per capita for each state by the rate of hepatitis C for the respective state, and then multiplying by 10. States where data were unavailable or not reported per the CDC was excluded from the analysis. These states are indicated in Table 1.

States with the highest rates of opioid use were determined to be those with the highest rates of drug overdose deaths based on CDC data.[5] Data collected in 2017 identified West Virginia, Ohio, Pennsylvania, the District of Columbia, and Kentucky among the highest (Table 2). States geographically located in the Appalachian region of the United States as defined by the Appalachian Regional Commission in 1965[6] were specifically analyzed due to their high rates of HCV and opioid overdose deaths. This region includes areas in West Virginia, New York, Pennsylvania, Ohio, Maryland, Kentucky, Virginia, North Carolina, Tennessee, South Carolina, Georgia, Alabama, and Mississippi.

Univariate analyses were performed to assess associations between states with high levels of opioid use and HCV exposure risk, as well as associations between Appalachian states and HCV exposure risk. Fisher's exact tests and unpaired t tests were performed where indicated, using STATA statistical software (STATACorp LLC, College Station, Tex.). P values were considered to be significant at $P \leq 0.05$.

RESULTS

Among the 50 states, the calculated total risk of exposure for plastic surgeons is 18.7. States with the highest risk using the pseudovariable include Delaware, Massachusetts, Ohio, Kentucky, Tennessee, and West Virginia (Fig. 2). For these calculations, the Ohio Valley includes West Virginia, Kentucky, Pennsylvania, Ohio, and Indiana.

West Virginia plastic surgeons were found to have a significantly elevated risk of exposure (60.0 versus 18.7, $P < 0.0001$). This risk is a notable outlier compared with the rest of the country (Risk > 3 × IQR + 75th percentile). States within the Ohio Valley were also found to be at increased risk (34.8 versus 16.0, P = 0.05). States most heavily burdened by the opioid crisis, as shown by the number of overdose deaths in Table 2, were also found to be at an increased risk for HCV exposure when compared with the nation as a whole (40.8 versus 13.6, P = 0.0003) (Table 2).

DISCUSSION

Hepatitis C affects the liver and may lead to both acute and chronic hepatitis. The infection may range in severity from a mild illness, lasting only weeks, to a

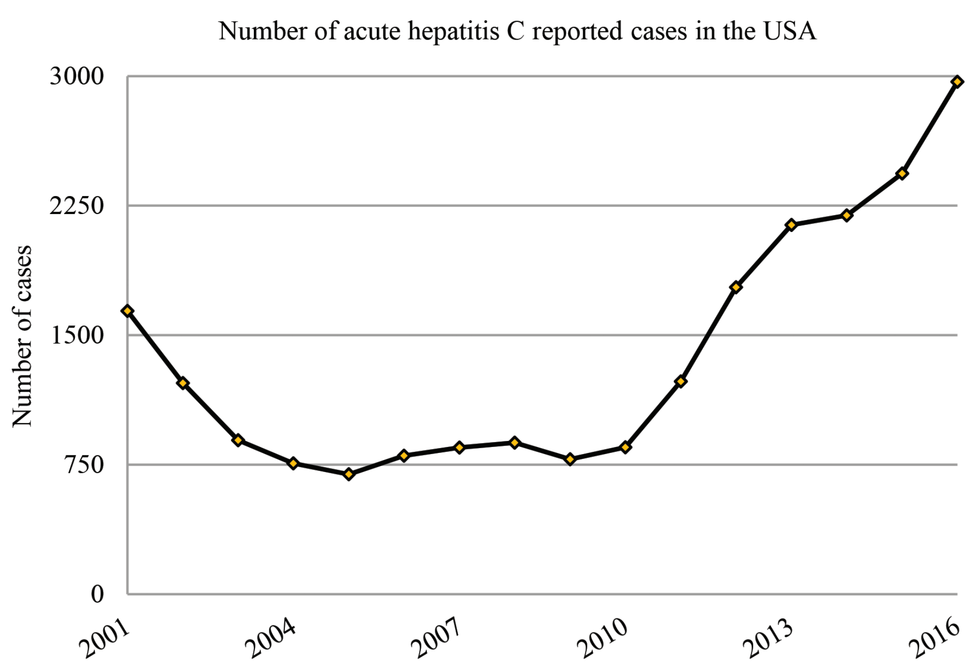

Fig. 1. Number of acute cases reported in the United States from 2001 to 2016.

Table 1. Hepatitis C Exposure Risk for Each State

State	Hepatitis C Rate	Plastic Surgeons per Capita	Exposure Risk*
Alabama	0.7	1.1	7.6
Alaska	N	0.8	—
Arizona	U	1.9	—
Arkansas	0	0.6	0
California	0.2	1.9	3.9
Colorado	0.6	1.5	9.1
Connecticut	0.5	2.3	11.4
Delaware	2.6	2.5	64.9
Florida	1.1	2.2	23.9
Georgia	0.9	1.6	14.5
Hawaii	0	1.4	0
Idaho	0.4	1.2	4.8
Illinois	0.2	1.7	3.4
Indiana	2.2	3.4	27.1
Iowa	U	0.7	—
Kansas	0.5	1.5	7.7
Kentucky	2.3	1.4	32.0
Louisiana	0.1	1.4	1.4
Maine	1.9	1.0	19.9
Maryland	0.6	2.3	13.7
Massachusetts	6.2	1.7	103.0
Michigan	1.1	1.5	16.5
Minnesota	0.9	1.4	12.6
Mississippi	U	1.1	—
Missouri	0.4	1.5	6.1
Montana	1.9	0.9	18.1
Nebraska	0.1	1.3	1.3
Nevada	0.5	1.1	5.5
New Hampshire	N	1.3	—
New Jersey	1.4	2.21	31.4
New Mexico	0.9	0.8	6.9
New York	0.9	2.3	20.9
North Carolina	0.8	1.4	11.1
North Dakota	0.1	1.7	1.7
Ohio	1.6	1.5	24.6
Oklahoma	0.8	0.9	7.1
Oregon	0.5	1.3	6.6
Pennsylvania	1.8	1.7	31.2
Rhode Island	U	1.2	—
South Carolina	0.2	1.4	2.8
South Dakota	2.3	1.6	37.0
Tennessee	2.3	1.3	30.8
Texas	0.1	1.6	1.6
Utah	2.5	1.5	38.7
Vermont	0.8	0.8	6.4
Virginia	0.5	1.	9.7
Washington	0.9	1.3	11.3
West Virginia	5.1	1.2	59.0
Wisconsin	1.8	1.1	20.2
Wyoming	U	0.7	–

N indicates HCV is not a reportable by law, statute, or regulation in this state; U denotes the data are unavailable to the CDC.
*Calculated using pseudo-variable.
— Due to lack of data, this state is excluded from the data analysis.

Table 2. States with the Highest Rates of Drug Overdose Deaths in 2017

	Rate of Drug Overdose Deaths*
West Virginia	57.8
Ohio	46.3
Pennsylvania	44.3
District of Columbia	44.0
Kentucky	37.2

*Deaths per 100,000.

serious, lifelong illness.[7] The ability to evade host immune responses, along with the lack of symptoms associated with the acute phase, allow HCV to persist in the infected individual and develop into a chronic state. Approximately 30% of patients with acute hepatitis spontaneously clear the virus within 6 months of infection without any treatment.[7] Disease in the majority of primary HCV-infected patients is asymptomatic; thus, symptoms are not useful as specific indicators of disease. Untreated, an estimated 70% of patients will develop a chronic infection, leading to a risk of liver cirrhosis and hepatocellular carcinoma, in addition to extra-hepatic manifestations like thyroid dysfunction.[8] Morbidity associated with disease escalates over time as the risk of cirrhosis grows to 15%–30% at 20 years post-infection in chronically affected patients. As the risk of cirrhosis increases, so does the risk of developing hepatocellular carcinoma.[7] Further, co-infection of HCV among HIV-positive drug users has been observed to be as high as 90%.[3]

In 2009, the World Health Organization suggested that the prevalence of HCV approximated 2.2%–3.0% worldwide (130–170 million people). This rate is 5 times greater than the prevalence of HIV worldwide.[9] Regions with the highest prevalence are noted in the African and the Eastern Mediterranean regions of the world. Globally, there is an estimated 71 million people afflicted with chronic HCV. In 2016, the mortality rate from hepatitis C approximated 399,000 people largely due to cirrhosis and hepatocellular carcinoma.[7]

In the United States, 3216 cases of acute hepatitis were reported in 2017. A majority of these cases were reported in patients who were white/non-Hispanic and aged 20–29 years. There is a near-equal distribution of reported cases between males and females. The largest numbers of cases were reported in the Health and Human Services "Region 4" of the United States, which includes the states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.[2]

Certain populations have been identified at risk for Hepatitis C. In countries where infection control measures are not practiced, the distribution of disease may range widely within the general population. In developed countries, such as the United States, HCV is most often linked to intravenous drug use. It is the most common means of HCV transmission in the United States.[2] The World Health Organization reports that 23% of new HCV infections and 33% of HCV mortality is attributable to injection drug use.[7] In 2017, 17,253 death certificates in the United States cited HCV as the underlying or contributing cause of death[10] and it is recognized that this may be a falsely low estimate due to lack of diagnosis and/or reporting. From a cohort of patients with known HCV infection who received care at 4 large health care organizations in the United States, only 19% of deceased patients had HCV infection listed on their death certificates; however, more than 70% of these patients had evidence of moderate to severe underlying liver disease, resulting from chronic HCV infection.[10]

Screening and History

Due to the asymptomatic nature of new HCV infections, few people are diagnosed following initial exposure. Rather, patients are often diagnosed with a chronic HCV infection following the development of symptoms secondary to liver damage, decades after infection. In

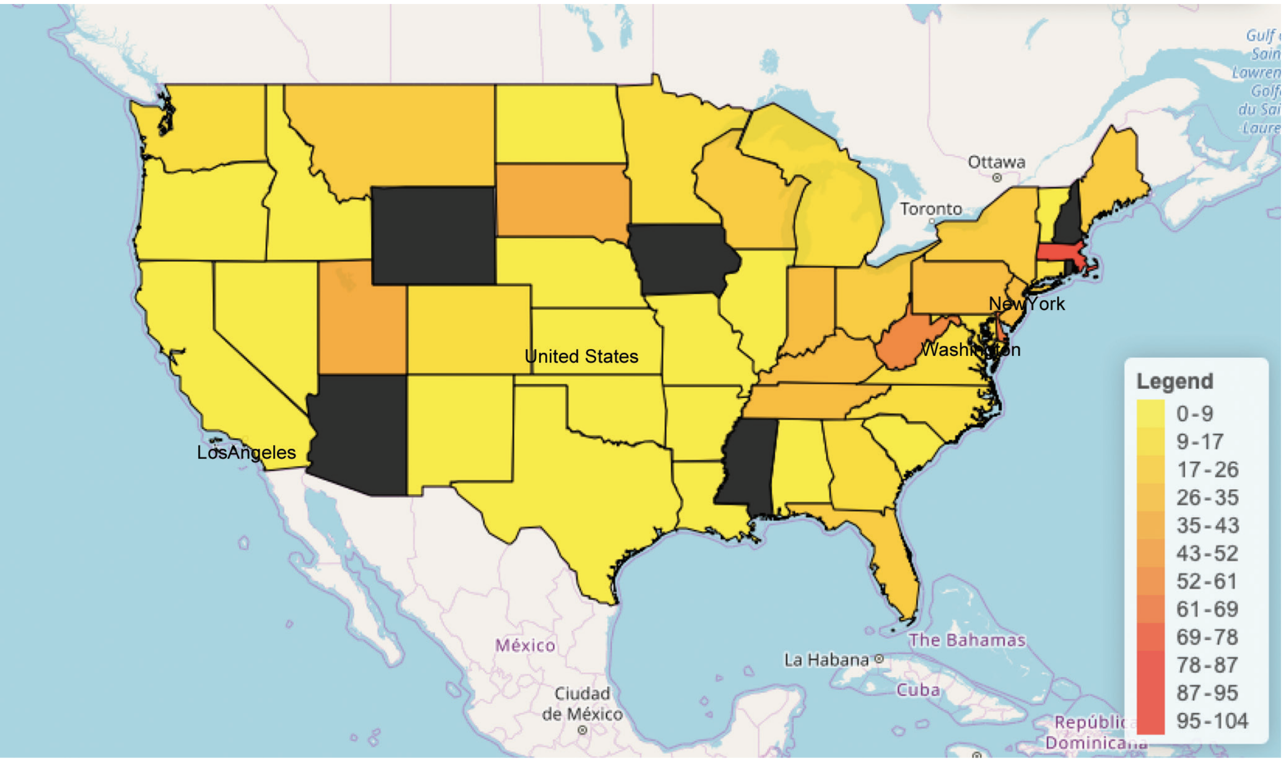

Fig. 2. Heat map of the United States exhibits the risk of exposure among plastic surgeons working in each state, based on the results of our model. Note: black areas in the map represent states not reporting data.

areas with disproportionately high rates of HCV infection, like West Virginia, more extensive, "opt-out" screening programs are being developed to more effectively identify these patients.[3] Diagnosis is made in 2 ways. Patients may be tested for anti-HCV antibodies following exposure to the virus. Panels probe for anti-HCV IgM, which indicates recent infection, and anti-HCV IgG, which indicates either a recent or a past infection. Thirty-percent of those infected will spontaneously clear the infection via a robust immune response without targeted treatment, meaning they will still test positive for antibodies despite being no longer infected. As a result, it is recommended that patients with a positive test for anti-HCV antibodies undergo confirmation testing for the presence of HCV RNA. Following a diagnosis of chronic HCV infection, patients should have an assessment to define the degree of hepatic involvement and define early fibrosis and/or cirrhosis. This may be achieved either through non-invasive measures or liver biopsy.

Early diagnosis and detection can prevent transmission of the virus, and the WHO recommends that populations at high risk for infection be tested. These groups include intravenous drug users, prison residents, and recipients of infected blood products or invasive procedures in healthcare facilities with inadequate infection control practices. Healthcare professionals (including surgeons) are not included in this group.[7] As there exists no effective vaccine, primary prevention focuses on reducing the risk of exposure to the virus in high-risk populations, including persons who work in the healthcare setting. These measures include safe and appropriate handling of healthcare injectables, appropriate disposal of sharps and wastes, and hand hygiene (including surgical hand preparation procedures and hand washing).[7] Several HCV vaccine candidates are in development that target HCV antigens. Due to viral variability and adaptability challenges in vaccine development yet persist.[11]

Risk of Transmission

As a blood-borne virus, hepatitis C is most commonly transmitted by exposure to quantities of blood or bodily fluids that contain blood. The most common modes of transmission include injection drug use, donated blood, blood products, or organs, needle-stick injuries in the healthcare setting, and vertical transmission during childbirth.[2] Infrequent ways of HCV transmission include sexual encounters, shared personal items like razors or toothbrushes with infected individuals, or unsanitary tattooing.[2]

Since 2013, steady increases in the numbers of acute hepatitis C cases have been reported.[2] This trend is influenced by both an increase in injection drug use in the United States related to the opioid crisis, as well as improved surveillance and reporting.[2] As the prevalence of this disease has continued to increase, healthcare workers, and in particular surgeons, must be cognizant of the risk of transmission of blood-borne illnesses. The risk of HIV transmission to practicing surgeons has historically received the most publicity in the press and in surgical literature, but the risk of transmission is low in comparison with that of hepatitis B and C. While hepatitis B does carry a higher risk of transmission, the widespread use of the hepatitis B vaccine diminishes the risk of infection and allows for immunity. As a result, hepatitis C is the most sinister risk to practicing surgeons. Indeed, the risk of transmission from person infected with HCV to a surgeon following exposure has been reported from 2% to 10%, much greater than the rate for HIV, which currently approximates 0.3%.[12]

As the current study demonstrates, one would anticipate that the density of disease within a given population and the number of those at risk for exposure would notably affect this risk of transmission. Within the United States, surgeons practicing in states within the Ohio Valley that were identified to be most burdened by the opioid crisis were found to be at an increased risk for HCV exposure (40.8 versus 13.6, $P = 0.0003$). Within this group, West Virginia plastic surgeons were at a significantly elevated risk of exposure (60.0 versus 18.7, $P < 0.0001$) in part due to fewer practicing surgeons. Awareness of these state and regional differences are important for those practicing surgeons to incentivize efforts in developing strategies for prevention.

Treatment

While no vaccine to prevent Hepatitis C exists yet, oral treatments are now available that effectively cure most patients. The cost for treatment with these new agents is noteworthy.[13] Until recently, accessibility to treatment was restricted by both treating physician and often insurance carriers, some of whom would not cover the therapy courses. This out-of-pocket expense is often prohibitive to those who could not afford it.

Surgical Risk, Implication of Infection, and Prevention Protocols

Aside from his or her physical health, the disease has financial implications for an affected surgeon as well. United States Public Health Service guidelines do not address how providers infected with HCV should continue practice. In the United Kingdom, guidelines for HCV-infected providers with circulating HCV RNA advise the avoidance of "exposure-prone" procedures to protect patients. The Society for Healthcare Epidemiology of America released guidelines and recommendations for practicing physicians infected with HCV, HBV, or HIV in 2010. These guidelines recommend that HCV-infected providers not be prohibited from participating in patient-care activities based on infection alone; however, surgeons with a viral burden greater than or equal to 10^4 GE/mL should be restricted from performing Category III (high risk for patient exposure) procedures. Category III procedures include all "extensive plastic surgery procedures," and also include "extensive cosmetic procedures."[14] Afflicted providers are recommended to be tested twice yearly and maintain a viral load less than 10^4 GE/mL. Physicians adherent to the guidelines are not compelled to disclose their infection status to their patients, though they may elect to do so. Disclosure may significantly alter a surgeon's practice. In 2005, a study found that 89% of patients surveyed acknowledged that they would want to know if their surgeon was infected with a blood-borne illness; 82% believed that providers with HBV or HCV should be required to disclose their infection; and only 38% of these patients believed that these providers should be able to provide patient care of any kind.[15] Obviously, the impact of HCV infection would notably alter the practice of most operating surgeons. With these insights in mind, prevention and treatment become important to all, particularly those at a high risk for exposure.

Protocols for prevention and post-exposure treatment in the perioperative environment are scarce. Common practices like double-gloving do partially reduce the risk of skin puncture, which is the leading cause of transmission intraoperatively. Risk may be further mitigated by establishing handling and exchange protocols for sharp items among surgical staff, as the risk is highest inside the surgical field. Unfortunately, no consensus exists with reference to protocols for healthcare workers following exposure.[16]

CONCLUSIONS

Our study demonstrates that plastic surgeons in the Appalachian region are at an increased risk of exposure to HCV. The prevalence of the opioid crisis in these states has contributed to the exposure risk. These findings underscore the importance of risk-reduction protocols in the operating room by all and the need for better data collection to better mitigate the risk to the operating surgeon.

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REFERENCES

1. Yoho RA, Cruz LL, Mazaheri R, et al. Hepatitis C: a review. *Plast Reconstr Surg.* 2003;112:597–605.
2. Surveillance for Viral Hepatitis–United States, 2017. Available at https://www.cdc.gov/hepatitis/statistics/2017surveillance/index.htm#ref10. Accessed Dec 1, 2019.
3. Burrell CN, Sharon MJ, Davis SM, et al. Implementation of a collaborative HIV and hepatitis C screening program in Appalachian urgent care settings. *West J Emerg Med.* 2018;19:1057–1064.
4. Plastic Surgeon Match. Available at https://find.plasticsurgery.org. Accessed Dec 4, 2019.
5. Drug Overdose Deaths. Available at https://www.cdc.gov/drugoverdose/data/statedeaths.html. Accessed Dec 5, 2019.
6. Abramson R, Haskell J. *Encyclopedia of Appalachia.* TN: University of Tennessee Press Knoxville; 2006.
7. Hepatitis C. Available at https://www.who.int/news-room/fact-sheets/detail/hepatitis-c. Accessed Dec 5, 2019.
8. Hammerstad SS, Blackard JT, Lombardi A, et al. Hepatitis C virus infection of human thyrocytes: metabolic, hormonal, and immunological implications. *J Clin Endocrinol Metab.* 2020;105:241.
9. Sherman M, Shafran S, Burak K, et al. Management of chronic hepatitis C: consensus guidelines. *Can J Gastroenterol.* 2007;21 (Suppl C):25C–34C.
10. Hepatitis C Questions and Answers for Health Professionals. Available at https://www.cdc.gov/hepatitis/hcv/hcvfaq.htm. Accessed Dec 4, 2019.

11. Di Lorenzo C, Angus AG, Patel AH. Hepatitis C virus evasion mechanisms from neutralizing antibodies. *Viruses*. 2011;3:2280–2300.
12. Wallis GC, Kim WY, Chaudhary BR, et al. Perceptions of orthopaedic surgeons regarding hepatitis C viral transmission: a questionnaire survey. *Ann R Coll Surg Engl*. 2007;89:276–280.
13. Nall R. How much does hepatitis C treatment cost? Available at https://www.medicalnewstoday.com/articles/323767. Accessed Dec 7, 2019.
14. Reitsma AM, Closen ML, Cunningham M, et al. Infected physicians and invasive procedures: safe practice management. *Clin Infect Dis*. 2005;40:1665–1672.
15. Tuboku-Metzger J, Chiarello L, Sinkowitz-Cochran RL, et al. Public attitudes and opinions toward physicians and dentists infected with bloodborne viruses: results of a national survey. *Am J Infect Control*. 2005;33:299–303.
16. Fisher WD. Hepatitis C and the surgeon. *Can J Surg*. 2013;56:80–81.