Research Article

Cancer Epidemiology, Biomarkers & Prevention

Hepatitis C Virus Screening Trends: Serial Cross-Sectional Analysis of the National Health Interview Survey Population, 2013–2015

Monica L. Kasting[1,2], Anna R. Giuliano[2,3], Richard R. Reich[4], Richard G. Roetzheim[1,5], David R. Nelson[6], Elizabeth Shenkman[7,8], and Susan T. Vadaparampil[1,2]

Abstract

Background: Rates of hepatitis C virus (HCV) infection are markedly higher for baby boomers compared with other birth cohorts, and they are now recommended for universal one-time screening. This study examines HCV screening rates and predictors for four birth cohorts [born <1945, born 1945–1965 (baby boomers), born 1966–1985, and born >1985] of a nationally representative sample over time.

Methods: We used data from the 2013–2015 National Health Interview Surveys, an annual weighted survey of the U.S. civilian noninstitutionalized population. We assessed HCV screening prevalence stratified birth cohort with bivariate and multivariable logistic regression analyses.

Results: There were 15,100 participants born <1945, 28,725 baby boomers, 28,089 born 1966–1985, and 13,296 born >1985 in the final analytic sample. Screening was 11.5%–12.8% for baby boomers. The second youngest birth cohort was similar to baby boomers (13.7%–14.9%), whereas the older birth cohort was screened less. After excluding participants who typically have higher rates of HCV screening than the general population, we developed a multivariable model of the general population. In the final model for baby boomers the odds of HCV screening increased significantly with each subsequent year (OR=1.20; 95% CI=1.05–1.38 and OR=1.31; 95% CI=1.13–1.52). HCV screening was also significantly associated with age, gender, and race/ethnicity in baby boomers.

Conclusions: While HCV screening is increasing over time, these increases are minimal and there is substantial room for improvement.

Impact: Future research should develop interventions to increase HCV screening with special focus on groups demonstrating significantly lower screening rates, such as Hispanics and females. *Cancer Epidemiol Biomarkers Prev; 27(4); 503–13. ©2018 AACR.*

Introduction

Hepatocellular carcinoma (HCC) is one of the few cancers that have increased in incidence and mortality over the last decade in the United States (1). Death from HCC increased by 56% from 2003 to 2012 (2). The strongest single predictor of HCC in the general population in the United States is chronic hepatitis C virus (HCV) infection, which accounts for approximately half of all HCC incidence (2, 3). Approximately 2.7 to 3.9 million people in the United States are currently chronically HCV infected, according to the Centers for Disease Control and Prevention (CDC; ref. 4). Until 2012, national guidelines recommended risk-based HCV screening for those who ever injected illegal drugs, had selected medical conditions (e.g., persistently abnormal alanine aminotransferase levels), received blood or organ donation before July 1992, had a possible occupational exposure, or were born to an HCV-positive mother. In 2012, in light of new research demonstrating three out of four people with HCV were born between 1945 and 1965 (baby boomers; ref. 5), the CDC augmented their risk-based recommendations to also include a one-time HCV screening for all baby boomers (6). The U.S. Preventive Services Task Force (USPSTF) issued a similar recommendation in 2013 (7).

Risk-based screening alone fails to identify more than 50% of people currently living with a chronic HCV infection, and 75% of those missed would be identified through universal age-based screening for the 1945–1965 birth cohort (8). Cost-effectiveness analyses demonstrate one-time testing in this birth cohort produces an incremental cost-effectiveness ratio observed in other cancer screenings (9, 10). Despite these recommendations and potential benefits, an analysis of the 2013 National Health Interview Survey (NHIS) showed only 12% of individuals born between 1945–1965 reported ever being screened for HCV (11).

Prior to 2014, treatment for HCV infection consisted of interferon and ribavirin which are associated with significant side effects, poor tolerability, and low cure rates (30%–40%; refs. 12, 13), leading to very limited treatment uptake (14). However, in October 2014 the Food and Drug Administration approved new oral and well-tolerated direct-acting antiviral treatments with exceptionally high cure rates (>90%; refs. 15–18). It is unknown whether the national screening guidelines and the availability of

[1]Department of Health Outcomes and Behavior, H. Lee Moffitt Cancer Center, Tampa, Florida. [2]Center for Infection Research in Cancer, H. Lee Moffitt Cancer Center, Tampa, Florida. [3]Department of Cancer Epidemiology, H. Lee Moffitt Cancer Center, Tampa, Florida. [4]Shared Resources, H. Lee Moffitt Cancer Center, Tampa, Florida. [5]Department of Family Medicine, University of South Florida, Tampa, Florida. [6]Department of Medicine, University of Florida, Gainesville, Florida. [7]Department of Health Outcomes and Policy, University of Florida Health, Gainesville, Florida. [8]Cancer Population Sciences, University of Florida Health, Gainesville, Florida.

Corresponding Author: Susan T. Vadaparampil, H. Lee Moffitt Cancer Center, 4115 East Fowler Avenue, MFC-CRISP, Tampa, FL 33617. Phone: 813-745-1997; Fax: 813-745-6525; E-mail: Susan.Vadaparampil@moffitt.org

doi: 10.1158/1055-9965.EPI-17-0855

highly curable and tolerable treatment have influenced the rates of HCV screening, as HCV screening trends have not been assessed across the years following these changes. Without intervention, the United States is unlikely to meet its Healthy People 2020 HCV screening goal of having at least 60% of those infected with HCV aware of their infection (19). To assess whether HCV screening has changed in the overall U.S. population or by risk group (e.g., baby boomer, etc.), we conducted an analysis of NHIS HCV screening data for the period 2013–2015, the years immediately following the changed national recommendations for screening and availability of tolerable curative therapies.

Specifically we (i) report serial cross-sectional HCV screening rates for four birth cohorts of a nationally representative sample from 2013 to 2015 and (ii) evaluate factors associated with HCV screening by birth cohort.

Materials and Methods

Design, setting, and participants

The NHIS is an annual, serial, cross-sectional national survey conducted in-person through a computer-assisted household interview. A nationally representative sample of the civilian noninstitutionalized population in the United States is generated using a stratified, multistage, cluster sample design (20). A detailed survey description and questionnaires can be accessed at http://www.cdc.gov/nchs/nhis/index.htm.

For these analyses, we included the total sample from the 2013, 2014, and 2015 NHIS (the years in which complete data are available). The sample was divided by birth cohort to compare those who are recommended for age-based screening (baby boomers), those born before 1945 (older than the baby boomers), those born 1966–1985 (second youngest group), and those born after 1985 (youngest group) to assess whether screening prevalence is increasing in the baby boomer population compared with other birth cohorts during the same timeframe.

Measures and data analysis

Starting in the year 2013, every adult respondent was asked the question: Have you ever had a blood test for hepatitis C? Response options included: "yes," "no," "refuse," "I don't know," and "not ascertained." A binary variable for the outcome was created such that "no," "refused," "I don't know," and "not ascertained" were compared with "yes" in response to the question. Any participant with missing data regarding the outcome variable was excluded from the study.

Descriptive statistics were generated for the entire sample by survey year and birth cohort and included the following: demographic variables, variables related to factors that would increase the probability of HCV screening, and indicators of participants' use of preventive health services. Variables assessed that are known to be related to an increased probability that the participant had been screened for HCV include: working in healthcare (21), former, regular alcohol consumption (22), lived with someone with hepatitis, or a personal history of liver cancer, hepatitis, any liver condition, or a chronic liver condition (6). Indicators of participants' use of preventive health services included whether a participant had: seen a healthcare provider in last 12 months, health insurance, ever been tested for HIV, a blood pressure or cholesterol check in the last 12 months, and a colon cancer test in last 12 months.

For all other analyses, the sample was weighted using the standard NHIS-based approach applying the 2010 decennial census to best obtain population estimates. Each participant was assigned a sampling weight equal to the inverse probability of the participant being selected and was adjusted for survey nonresponse. We assessed HCV screening prevalence by year and birth cohort as well as prevalence of the respective reasons for receiving HCV screening, among those screened. There are some groups of people who have higher prevalence of HCV infection or that are more likely to have been screened for HCV as compared with the general population. These special populations include participants with a personal history of liver cancer (23), a personal history of hepatitis (of any type; ref. 24), a chronic liver condition (24), any liver condition (5), lived with someone who had hepatitis (2), reported previous high alcohol use ("former, regular drinker"; ref. 8), or reported that they work in healthcare (4). As our primary goal was to assess HCV screening among the healthy general U.S. population subsequent analyses excluded these special populations. Bivariate logistic regression analyses stratified by birth cohort were conducted to assess factors associated with HCV screening using the data combined across the three years of study. Finally, a multivariable logistic regression model per birth cohort was developed using backward elimination approach with a P value of 0.05 required to stay in the model. Some of the preventive health services we assessed are not recommended for all of the included birth cohorts and analyzing a variable in the model that is not routinely recommended would not necessarily be an indicator of preventive health services use, but rather a reflection of a more serious health issue for that individual. Therefore, based on USPSTF recommendations for screening (25–27), in the youngest two birth cohorts we removed cholesterol check in the last 12 months, and colon cancer test in the last 12 months from the model. In addition, we also removed blood pressure check in the last 12 months from the youngest age group. All statistical analyses were conducted with SAS, version 9.4 and SAS-callable SUDAAN, version 11.0.1 in 2017.

Results

Sample description

Survey data included 88,744 participants from 2013 (n = 29,275), 2014 (n = 31,128), and 2015 (n = 28,341). After excluding 3,534 participants for whom birth year was unknown, the final analyses included 15,100 who were born before 1945 (older), 28,725 baby boomers, 28,089 born 1966–1985 (second youngest), and born after 1985 (youngest) for a total analytic sample size of 85,210. Demographic characteristics varied between birth cohorts. For example, 61.0% of those born after 1985 were non-Hispanic white while this group comprised 73.5% of baby boomers, and 79.9% of those born before 1945. For a full sample description, see Table 1.

HCV screening prevalence

Weighted analyses indicated screening was between 11.5 and 12.8% across the three survey years for baby boomers (Table 2). Screening prevalence in the second youngest birth cohort was similar to that of baby boomers (13.7%–14.9%), whereas the older birth cohort was screened between 3.9 and 4.5%. Among the response options available to select reporting the reason for HCV screening (i.e., their doctor thought they were at risk because they experienced symptoms, they were born between

Table 1. Sociodemographic characteristics of participants in the 2013-2015 National Health Interview Surveys[a]

Population characteristics	Born post-1985[b] (*n* = 13,296) % (95%CI)	Born 1966–1985[b] (*n* = 28,089) % (95%CI)	Born 1945–1965[b] (*n* = 28,725) % (95%CI)	Born pre-1945[b] (*n* = 15,100) % (95%CI)
Demographic characteristics				
Region				
Northeast	14.4 (12.9–16.1)	15.8 (15.0–16.7)	17.8 (17.0–18.5)	19.6 (18.3–21.0)
Midwest	24.8 (22.4–27.4)	23.4 (22.3–24.5)	23.5 (22.7–24.3)	24.1 (22.8–25.5)
South	38.5 (35.9–41.1)	38.1 (36.9–39.2)	38.6 (37.6–39.6)	37.1 (35.6–38.7)
West	22.3 (20.3–24.3)	22.7 (21.8–23.7)	20.1 (19.3–21.0)	19.1 (18.0–20.2)
Age (Mean; 95% CI)	23.6 (23.5–23.8)	38.2 (38.1–38.3)	58.8 (58.7–58.9)	77.6 (77.5–77.8)
Race/Ethnicity				
Non-Hispanic white	61.0 (59.4–62.6)	61.2 (60.3–62.2)	73.5 (72.6–74.4)	79.9 (78.9–80.9)
Non-Hispanic black	14.3 (13.2–15.5)	13.6 (12.9–14.2)	12.5 (11.8–13.1)	9.5 (8.7–10.3)
Non-Hispanic Asian	3.7 (3.3–4.2)	3.9 (3.6–4.3)	2.1 (1.9–2.3)	1.9 (1.6–2.2)
Non-Hispanic Other	3.1 (2.8–3.6)	3.1 (2.8–3.4)	2.3 (1.9–2.3)	1.9 (1.7–2.2)
Hispanic	17.8 (16.7–19.0)	18.2 (17.4–19.0)	9.6 (9.1–10.1)	6.8 (6.3–7.3)
Gender				
Male	50.5 (49.3–51.6)	50.4 (49.6–51.2)	48.6 (47.9–49.3)	40.0 (39.0–40.9)
Female	49.5 (48.4–50.7)	49.6 (48.8–50.4)	51.4 (50.7–52.1)	60.0 (59.1–61.0)
Education				
Less than high school graduate	11.0 (10.2–11.9)	12.0 (11.5–12.6)	12.2 (11.7–12.7)	21.4 (20.4–22.4)
High school graduate or GED	25.4 (24.1–26.8)	21.9 (21.2–22.5)	26.9 (26.2–27.7)	31.7 (30.7–32.8)
Some college/associate's degree	40.7 (38.8–42.7)	28.9 (28.2–29.7)	29.6 (28.9–30.2)	23.6 (22.7–24.5)
Bachelor's degree or higher	22.6 (21.3–24.1)	36.9 (36.0–37.9)	30.9 (30.1–31.7)	22.5 (21.5–23.6)
Marital status				
Married/living with partner	28.1 (26.7–29.6)	60.2 (59.4–61.0)	55.0 (54.2–55.8)	39.6 (38.5–40.7)
Not currently married (includes divorced, separated, and widowed)	2.3 (2.0–2.7)	15.3 (14.8–15.9)	32.5 (31.8–33.2)	55.5 (54.4–56.6)
Never married	69.6 (68.0–71.0)	24.4 (23.7–25.2)	12.5 (11.9–13.1)	4.9 (4.4–5.4)
Income				
<$35,000	52.0 (49.9–54.2)	30.6 (29.7–31.4)	34.2 (33.3–35.1)	53.3 (52.0–54.7)
$35,000–$74,999	28.8 (27.4–30.3)	31.5 (30.7–32.2)	30.5 (29.8–31.3)	30.8 (29.7–31.9)
$75,000–$99,999	8.0 (7.4–8.7)	13.4 (12.8–13.9)	11.7 (11.2–12.2)	6.9 (6.4–7.5)
$100,000+	11.1 (10.2–12.1)	24.6 (23.8–25.4)	23.6 (22.8–24.4)	9.0 (8.4–9.6)
Risk factors				
Alcohol use				
Lifetime abstainer	25.7 (24.5–27.0)	16.1 (15.5–16.6)	16.5 (15.9–17.1)	27.8 (26.8–28.8)
Former	4.7 (4.3–5.1)	9.8 (9.4–10.3)	18.3 (17.7–19.0)	26.0 (25.1–26.9)
Current infrequent/light/unknown frequency	43.2 (42.2–44.3)	48.8 (48.0–49.6)	41.9 (41.1–42.6)	30.8 (29.8–31.8)
Current moderate/heavy	25.0 (23.7–26.4)	23.7 (23.0–24.5)	21.7 (21.1–22.4)	14.1 (13.3–14.9)
Drinking status unknown	1.4 (1.1–1.6)	1.6 (1.4–1.8)	1.6 (1.4–1.8)	1.4 (1.2–1.7)
Health care factors				
Saw/talked to HCP in last 12 months				
No	44.5 (44.3–46.6)	38.5 (37.7–39.3)	24.0 (23.3–24.7)	12.6 (11.8–13.4)
Yes	53.0 (51.9–54.1)	59.9 (59.1–60.7)	74.5 (73.8–75.2)	86.2 (85.4–87.0)
Don't know/Refused/Not ascertained	1.5 (1.2–1.8)	1.6 (1.4–1.8)	1.5 (1.3–1.7)	1.2 (1.0–1.4)
Have health insurance coverage				
No	19.7 (18.7–20.8)	18.7 (18.0–19.3)	10.3 (9.9–10.8)	0.4 (0.3–0.6)
Yes	79.4 (78.2–80.4)	81.0 (80.3–81.7)	89.4 (88.9–89.8)	99.5 (99.3–99.6)
Don't know/Refused/Not ascertained	0.9 (0.7–1.2)	0.3 (0.3–0.4)	0.3 (0.2–0.4)	0.1 (0.1–0.2)
Other health screenings				
Ever been tested for HIV				
No	60.3 (58.9–61.6)	45.9 (45.0–46.7)	65.0 (64.2–65.8)	82.5 (81.7–83.2)
Yes	35.4 (34.0–36.7)	49.3 (48.5–50.1)	29.8 (29.0–30.5)	11.4 (10.8–12.0)
Don't know/Refused/Not ascertained	4.4 (3.9–4.9)	4.8 (4.5–5.2)	5.2 (4.8–5.6)	6.1 (5.6–6.6)
Blood pressure check, last 12 mo				
No	20.6 (19.8–21.5)	16.3 (15.7–16.9)	9.1 (8.7–9.6)	4.0 (3.6–4.4)
Yes	59.6 (58.4–60.8)	63.2 (62.5–63.9)	70.1 (69.5–70.7)	76.7 (75.8–77.5)
Don't know/Refused/Not ascertained	19.7 (18.9–20.6)	20.5 (19.9–21.1)	20.8 (20.2–21.3)	19.4 (18.6–20.2)
Cholesterol checked last 12 mo				
No	46.8 (45.7–47.9)	32.7 (31.9–33.4)	17.6 (17.1–18.2)	8.7 (8.1–9.3)
Yes	30.0 (29.0–30.9)	45.1 (44.4–45.9)	60.7 (60.1–61.4)	70.0 (69.0–71.0)
Don't know/Refused/Not ascertained	23.2 (22.3–24.2)	22.2 (21.6–22.8)	21.7 (21.1–22.2)	21.3 (20.5–22.2)
Had colon cancer test in last 12 months				
No	—	37.1 (36.4–37.8)	76.5 (75.8–77.1)	77.5 (76.7–78.3)
Yes	—	2.6 (2.3–2.8)	20.9 (20.3–21.6)	19.8 (19.1–20.6)
Don't know/Refused/Not ascertained	—	60.4 (59.6–61.1)	2.6 (2.4–2.9)	2.7 (2.4–3.0)

[a]This is table includes both low- and high-risk participants (work in healthcare, former, regular alcohol consumption, lived with someone with hepatitis, or a personal history of: liver cancer, hepatitis, any liver condition, or a chronic liver condition).
[b]All variables listed were significantly different between age groups ($P < 0.0001$).

Table 2. Proportion screened for HCV by age group and year[a]

	Born post-1985			Born 1966–1985			Born 1945–1965			Born pre-1945		
	2013 (%) (95%CI)	2014 (%) (95%CI)	2015 (%) (95%CI)	2013 (%) (95%CI)	2014 (%) (95%CI)	2015 (%) (95%CI)	2013 (%) (95%CI)	2014 (%) (95%CI)	2015 (%) (95%CI)	2013 (%) (95%CI)	2014 (%) (95%CI)	2015 (%) (95%CI)
HCV Screening	9.2 (8.2–10.2)	10.6 (9.5–11.9)	9.8 (8.7–10.9)	13.8 (13.0–14.6)	13.7 (12.9–14.5)	14.9 (14.0–15.8)	11.9 (11.2–12.7)	11.5 (10.8–12.3)	12.8 (12.0–13.7)	3.9 (3.3–4.5)	4.3 (3.7–4.9)	4.5 (3.9–5.2)
Reasons for having HCV screen (of those screened)												
HCP thought at risk due to blood test or symptoms like fatigue, nausea, stomach pain, yellowing of the eyes or skin	9.2 (6.6–12.6)	8.0 (5.8–10.9)	9.3 (6.7–12.6)	10.7 (9.1–12.6)	11.5 (9.6–13.7)	11.9 (10.0–14.2)	16.9 (14.9–19.1)	13.3 (11.4–15.5)	18.6 (16.1–21.3)	12.9 (8.8–18.5)	14.5 (9.8–20.9)	17.4 (12.5–23.8)
Born 1945–1965	—	—	—	—	—	—	17.4 (15.0–20.1)	18.5 (16.3–20.9)	14.4 (12.2–16.9)	-	-	-
HCV exposure to blood on the job, injection drug use, or recipient of transfusion before 1992	12.9 (9.5–17.3)	14.6 (11.4–18.6)	12.9 (10.0–16.5)	20.9 (18.5–23.5)	20.5 (17.8–23.4)	19.1 (16.6–22.0)	23.6 (21.0–26.4)	21.5 (18.9–24.3)	20.4 (17.9–23.2)	15.4 (11.1–21.0)	28.6 (22.2–35.8)	21.6 (15.8–28.8)
Other reason	76.2 (71.2–80.7)	76.0 (71.4–80.1)	76.0 (71.3–80.2)	66.8 (64.1–69.4)	66.2 (63.1–69.1)	66.5 (63.4–69.5)	40.7 (37.7–43.8)	45.2 (41.9–48.6)	45.4 (42.4–48.5)	64.2 (56.9–71.0)	50.3 (42.9–57.7)	54.7 (46.5–62.6)
Don't know/Not Ascertained	1.4 (0.6–3.3)	1.4 (0.7–2.8)	1.2 (0.5–3.2)	0.8 (0.5–1.5)	1.5 (0.9–2.4)	2.0 (1.3–3.2)	1.3 (0.8–2.2)	1.5 (0.9–2.6)	1.3 (0.7–2.3)	3.2 (1.5–6.6)	4.2 (2.0–8.6)	2.4 (0.8–7.3)

[a]This is table includes both low- and high-risk participants (work in healthcare, former, regular alcohol consumption, lived with someone with hepatitis, or a personal history of: liver cancer, hepatitis, any liver condition, or a chronic liver condition).

1945 and 1965, they were at risk due to exposure, other, refused, not ascertained, or don't know) "other" was the most frequently reported response regardless of age or study year. Of the baby boomers screened, less than 20% indicated the reason was their age.

Regression models: factors independently associated with HCV screening

Bivariate and multivariable models of factors associated with HCV screening by birth cohort are presented in Table 3.

Youngest group (born after 1985). In the multivariable model, HCV screening did not significantly change over time in this birth cohort. Age was significantly associated with screening and increasing age was associated with an increase in the odds of screening (aOR = 1.04; 95% CI = 1.00–1.07). Likewise, whether or not the participant had ever been screened for HIV was associated with an increased odds of screening (aOR = 5.72; 95% CI = 4.75–6.90). Female gender was associated with a decreased odds of screening (aOR = 0.79; 95% CI = 0.66–0.95).

Second youngest group (born 1966–1985). There was a significant difference in screening over time in the multivariable model for this birth cohort and screening increased significantly from 2013 to 2015 (aOR = 1.20; 95% CI = 1.06–1.35). People residing in the Midwest (aOR = 0.78; 95% CI = 0.66–0.94) and females (aOR = 0.66; 95% CI = 0.60–0.74) had lower odds of HCV screening. Non-Hispanic black participants (aOR = 0.70; 95% CI = 0.62–0.80), non-Hispanic Asian participants (aOR = 0.64; 95% CI = 0.50–0.83), and Hispanic participants (aOR = 0.68; 95% CI = 0.59–0.78) all had lower odds of screening than their non-Hispanic white counterparts. Several indicators of use of preventive health services were positively associated with the odds of HCV screening including having health insurance coverage (aOR = 1.19; 95% CI = 1.03–1.37), having been tested for HIV (aOR = 4.59; 95% CI = 4.06–5.18), and having their blood pressure checked in the last 12 months (aOR = 1.64; 95% CI = 1.38–1.94).

Baby boomers. Among the baby boomer population, the only variables not significantly associated with HCV screening in the multivariable model were insurance status and having blood pressure checked in the last 12 months ($P > 0.05$). In the final model the odds of HCV screening increased significantly from 2013 to 2014 (OR = 1.20; 95% CI = 1.05–1.38) and from 2013 to 2015 (OR = 1.31; 95% CI = 1.13–1.52). Age was significant but in the opposite direction than was observed in the youngest group: increasing age was associated with decreasing odds of HCV screening (aOR = 0.90; 95% CI = 0.85–0.94). Non-Hispanic black participants (aOR = 0.81; 95% CI = 0.69–0.94) and Hispanic participants (aOR = 0.79; 95% CI = 0.66–0.95) were still less likely to have been screened as compared with their non-Hispanic white counterparts, but there was no longer a significant difference for non-Hispanic Asian participants in this birth cohort. As with the other birth cohorts, female gender was associated with decreased odds of screening (aOR = 0.71; 95% CI = 0.63–0.79), and several variables reflecting use of preventive health services were positively associated with screening including seeing a healthcare provider in the last 12 months (aOR = 1.27; 95% CI = 1.11–1.47), ever having been tested for HIV (aOR = 4.17; 95% CI = 3.70–4.70), having their blood pressure checked in the last 12 months (aOR = 1.43; 95% CI = 1.15–1.57), and having a

Table 3. Factors associated with HCV screening by age group for the population at average risk of HCV[a]

	Univariate OR (95% CI)	Multivariable aOR (95% CI)
Born post-1985		
Population characteristics		
Year		
2013 (ref.)	—	—
2014	1.20 (0.98–1.48)	†
2015	1.06 (0.87–1.30)	†
Demographic characteristics		
Region		
Northeast (ref.)	—	—
Midwest	0.97 (0.73–1.27)	†
South	1.09 (0.85–1.40)	†
West	1.06 (0.82–1.37)	†
Age (continuous, 5-year increments)	**1.70 (1.50–1.94)**	**1.04 (1.00–1.07)**
Race/ethnicity		
Non-Hispanic white (ref.)	—	—
Non-Hispanic black	0.93 (0.74–1.16)	†
Non-Hispanic Asian	0.84 (0.54–1.29)	†
Non-Hispanic Other	0.81 (0.56–1.17)	†
Hispanic	**0.75 (0.61–0.92)**	
Gender		
Male (ref.)	—	—
Female	1.04 (0.88–1.23)	**0.79 (0.66–0.95)**
Education		
Less than high school graduate (ref.)	—	—
High school graduate or GED	**1.62 (1.18–2.23)**	**1.58 (1.15–2.17)**
Some college/associate's degree	**1.83 (1.36–2.46)**	**1.78 (1.33–2.38)**
Bachelor's degree or higher	**1.58 (1.15–2.17)**	1.32 (0.94–1.87)
Don't know	2.42 (0.80–7.30)	**3.61 (1.25–10.45)**
Marital status		
Married/living with partner (ref.)	—	—
Not currently married (divorced, separated, and widowed)	**1.66 (1.13–2.45)**	1.45 (0.97–2.17)
Never married	**0.68 (0.57–0.81)**	0.85 (0.70–1.03)
Income		
<$35,000 (ref.)	—	—
$35,000–$74,999	0.93 (0.78–1.12)	†
$75,000–$99,999	0.78 (0.57–1.05)	†
$100,000+	0.75 (0.53–1.05)	†
Risk factors		
Alcohol use		
Lifetime abstainer (ref.)	—	—
Former infrequent/unknown	**3.15 (2.19–4.55)**	**1.94 (1.33–2.84)**
Current infrequent/light/unknown frequency	**2.11 (1.70–2.62)**	**1.50 (1.19–1.89)**
Current moderate/heavy	**2.40 (1.91–3.03)**	**1.65 (1.28–2.14)**
Drinking status unknown	0.55 (0.22–1.43)	0.50 (0.19–1.31)
Health care factors		
Saw/talked to HCP in last 12 months		
No (ref.)	—	—
Yes	**1.33 (1.13–1.57)**	†
Have health insurance coverage		
No (ref.)	—	—
Yes	1.10 (0.93–1.31)	**1.24 (1.03–1.50)**
Don't know/Refused/Not ascertained	**0.17 (0.04–0.67)**	**0.17 (0.04–0.68)**
Other health screenings		
Ever been tested for HIV		
No (ref.)	—	—
Yes	**6.05 (5.06–7.24)**	**5.72 (4.75–6.90)**
Don't know/Refused/Not ascertained	1.27 (0.74–2.17)	1.42 (0.81–2.49)
	Univariate OR (95% CI)	**Multivariable aOR (95% CI)**
Born 1966–1985		
Population characteristics		
Year		
2013 (ref.)	—	—
2014	1.02 (0.91–1.14)	1.03 (0.92–1.16)
2015	**1.15 (1.03–1.28)**	**1.20 (1.06–1.35)**
Demographic characteristics		
Region		
Northeast (ref.)	—	—

(Continued on the following page)

Table 3. Factors associated with HCV screening by age group for the population at average risk of HCV[a] (Cont'd)

	Univariate OR (95% CI)	Multivariable aOR (95% CI)
Midwest	**0.79 (0.67–0.94)**	**0.78 (0.66–0.94)**
South	0.97 (0.85–1.12)	1.00 (0.86–1.16)
West	1.07 (0.93–1.24)	1.07 (0.92–1.24)
Age (Continuous, 5-year increments)	0.93 (0.90–0.97)	**0.98 (0.98–0.99)**
Race/Ethnicity		
Non-Hispanic white (ref.)	—	—
Non-Hispanic black	1.00 (0.89–1.13)	**0.70 (0.62–0.80)**
Non-Hispanic Asian	**0.56 (0.43–0.72)**	**0.64 (0.50–0.83)**
Non-Hispanic Other	0.96 (0.76–1.21)	0.95 (0.74–1.22)
Hispanic	**0.68 (0.61–0.76)**	**0.68 (0.59–0.78)**
Gender		
Male (ref.)	—	—
Female	**0.87 (0.79–0.96)**	**0.66 (0.60–0.74)**
Education		
Less than high school graduate (ref.)	—	—
High school graduate or GED	**1.36 (1.14–1.62)**	1.18 (0.97–1.42)
Some college/Associates degree	**1.81 (1.53–2.14)**	**1.39 (1.15–1.69)**
Bachelor's degree or higher	**1.52 (1.29–1.80)**	1.22 (0.99–1.51)
Don't know	0.77 (0.24–2.45)	0.84 (0.27–2.62)
Marital status		
Married/Living with partner (ref.)	—	—
Not currently married (divorced, separated, and widowed)	**1.52 (1.33–1.73)**	**1.40 (1.21–1.61)**
Never married	**1.31 (1.19–1.44)**	**1.20 (1.07–1.34)**
Income		
<$35,000 (ref.)	—	—
$35,000–$74,999	**0.88 (0.79–0.99)**	**0.82 (0.73–0.93)**
$75,000–$99,999	0.97 (0.83–1.13)	0.91 (0.77–1.09)
$100,000+	0.90 (0.78–1.02)	**0.83 (0.70–0.99)**
Risk Factors		
Alcohol use		
Lifetime abstainer (ref.)	—	—
Former infrequent/unknown	**2.05 (1.70–2.49)**	**1.46 (1.19–1.78)**
Current infrequent/light/unknown frequency	**1.67 (1.44–1.94)**	**1.20 (1.03–1.40)**
Current moderate/heavy	**1.65 (1.41–1.94)**	1.07 (0.90–1.26)
Drinking status unknown	**0.40 (0.19–0.84)**	**0.40 (0.19–0.88)**
Health care factors		
Saw/talked to HCP in last 12 months		
No (ref.)	—	—
Yes	**1.41 (1.28–1.55)**	†
Have health insurance coverage		
No (ref.)	—	—
Yes	**1.32 (1.17–1.49)**	**1.19 (1.03–1.37)**
Don't know/Refused/Not ascertained	0.93 (0.38–2.30)	0.70 (0.27–1.78)
Other health screenings		
Ever been tested for HIV		
No (ref.)	—	—
Yes	**4.65 (4.14–5.22)**	**4.59 (4.06–5.18)**
Don't know/Refused/Not ascertained	1.24 (0.88–1.73)	**1.45 (1.01–2.08)**
Blood pressure check, last 12 mo		
No (ref.)	—	—
Yes	**1.97 (1.68–2.31)**	**1.64 (1.38–1.94)**
Don't know/Refused/Not ascertained	**1.43 (1.18–1.73)**	**1.27 (1.03–1.56)**
	Univariate OR (95% CI)	**Multivariable aOR (95% CI)**
Born 1945–1965		
Population characteristics		
Year		
2013 (ref.)	—	—
2014	1.11 (0.97–1.27)	**1.20 (1.05–1.38)**
2015	**1.22 (1.06–1.39)**	**1.31 (1.13–1.52)**
Demographic characteristics		
Region		
Northeast (ref.)	—	—
Midwest	**0.82 (0.67–0.99)**	0.88 (0.72–1.07)
South	**1.22 (1.06–1.41)**	**1.22 (1.05–1.42)**
West	**1.56 (1.30–1.86)**	**1.45 (1.20–1.76)**
Age (Continuous, 5-year increments)	**0.88 (0.84–0.92)**	**0.90 (0.85–0.94)**

(Continued on the following page)

Table 3. Factors associated with HCV screening by age group for the population at average risk of HCV[a] (Cont'd)

	Univariate OR (95% CI)	Multivariable aOR (95% CI)
Race/Ethnicity		
Non-Hispanic white (ref.)	—	—
Non-Hispanic black	1.10 (0.95–1.27)	**0.81 (0.69–0.94)**
Non-Hispanic Asian	0.81 (0.57–1.14)	0.85 (0.60–1.22)
Non-Hispanic Other	1.14 (0.86–1.51)	1.03 (0.76–1.40)
Hispanic	**0.85 (0.72–1.00)**	**0.79 (0.66–0.95)**
Gender		
Male (ref.)	—	—
Female	**0.68 (0.61–0.76)**	**0.71 (0.63–0.79)**
Education		
Less than high school graduate (ref.)	—	—
High school graduate or GED	1.01 (0.83–1.23)	1.05 (0.85–1.29)
Some college/Associates degree	**1.76 (1.48–2.10)**	**1.60 (1.33–1.94)**
Bachelor's degree or higher	**1.67 (1.40–2.00)**	**1.56 (1.28–1.91)**
Don't know	0.57 (0.19–1.72)	0.76 (0.24–2.43)
Marital Status		
Married/Living with partner (ref.)	—	—
Not currently married (divorced, separated, and widowed)	**1.28 (1.14–1.43)**	**1.15 (1.01–1.31)**
Never married	1.09 (0.92–1.29)	0.97 (0.82–1.16)
Income		
<$35,000 (ref.)	—	—
$35,000–$74,999	**0.85 (0.74–0.98)**	**0.84 (0.73–0.97)**
$75,000–$99,999	0.85 (0.71–1.02)	**0.77 (0.63–0.94)**
$100,000+	1.10 (0.96–1.26)	0.89 (0.75–1.06)
Risk factors		
Alcohol use		
Lifetime abstainer (ref.)	—	—
Former infrequent/unknown	**2.11 (1.75–2.54)**	**1.62 (1.33–1.97)**
Current infrequent/light/unknown frequency	**1.73 (1.48–2.02)**	**1.30 (1.10–1.54)**
Current moderate/heavy	**1.80 (1.48–2.18)**	**1.29 (1.06–1.56)**
Drinking status unknown	0.52 (0.26–1.02)	0.89 (0.44–1.79)
Health care factors		
Saw/talked to HCP in last 12 months		
No (ref.)	—	—
Yes	**1.46 (1.29–1.67)**	**1.27 (1.11–1.47)**
Have health insurance coverage		
No (ref.)	—	†
Yes	1.16 (0.99–1.37)	†
Don't know/Refused/Not ascertained	0.85 (0.34–2.14)	†
Other health screenings		
Ever been tested for HIV		
No (ref.)	—	—
Yes	**4.79 (4.27–5.37)**	**4.17 (3.70–4.70)**
Don't know/Refused/Not ascertained	1.04 (0.78–1.39)	**1.80 (1.31–2.47)**
Blood pressure check, last 12 mo		
No (ref.)	—	†
Yes	**1.72 (1.40–2.12)**	†
Don't know/Refused/Not ascertained	**1.35 (1.07–1.71)**	†
Cholesterol checked last 12 mo		
No (ref.)	—	—
Yes	**1.61 (1.40–1.85)**	**1.34 (1.15–1.57)**
Don't know/Refused/Not ascertained	**1.19 (1.00–1.42)**	1.11 (0.92–1.33)
Had colon cancer test in last 12 months		
No (ref.)	—	—
Yes	**1.75 (1.56–1.96)**	**1.43 (1.25–1.62)**
Don't know/Refused/Not ascertained	**0.09 (0.04–0.20)**	**0.26 (0.11–0.61)**
	Univariate OR (95% CI)	**Multivariable aOR (95% CI)**
Born pre-1945		
Population characteristics		
Year		
2013 (ref.)	—	†
2014	1.03 (0.79–1.36)	†
2015	1.11 (0.84–1.46)	†
Demographic characteristics		
Region		
Northeast (ref.)	—	—
Midwest	1.01 (0.67–1.54)	1.03 (0.68–1.56)
South	1.31 (0.90–1.89)	1.19 (0.82–1.73)

(Continued on the following page)

Table 3. Factors associated with HCV screening by age group for the population at average risk of HCV[a] (Cont'd)

	Univariate OR (95% CI)	Multivariable aOR (95% CI)
West	**2.28 (1.59–3.27)**	**2.00 (1.39–2.88)**
Age (Continuous, 5-year increments)	**0.93 (0.91–0.95)**	**0.85 (0.76–0.95)**
Race/Ethnicity		
Non-Hispanic white (ref.)	—	†
Non-Hispanic black	**1.44 (1.08–1.91)**	†
Non-Hispanic Asian	**2.06 (1.22–3.49)**	†
Non-Hispanic Other	1.79 (0.94–3.42)	†
Hispanic	1.03 (0.71–1.48)	†
Gender		
Male (ref.)	—	—
Female	**0.58 (0.47–0.72)**	**0.71 (0.57–0.89)**
Education		
Less than high school graduate (ref.)	—	†
High school graduate or GED	0.93 (0.67–1.29)	†
Some college/Associates degree	**1.39 (1.04–1.86)**	†
Bachelor's degree or higher	**1.59 (1.16–2.17)**	†
Don't know	0.53 (0.15–1.93)	†
Marital status		
Married/Living with partner (ref.)	—	†
Not currently married (divorced, separated, and widowed)	**0.76 (0.60–0.95)**	†
Never married	0.79 (0.46–1.37)	†
Income		
<$35,000 (ref.)	—	†
$35,000–$74,999	1.28 (0.99–1.64)	†
$75,000–$99,999	**1.56 (1.04–2.33)**	†
$100,000+	**1.96 (1.40–2.75)**	†
Risk factors		
Alcohol use		
Lifetime abstainer (ref.)	—	†
Former infrequent/unknown	**1.57 (1.14–2.15)**	†
Current infrequent/light/unknown frequency	**1.41 (1.04–1.92)**	†
Current moderate/heavy	1.28 (0.87–1.87)	†
Drinking status unknown	0.16 (0.02–1.12)	†
Health care factors		
Saw/talked to HCP in last 12 months		
No (ref.)	—	†
Yes	0.89 (0.64–1.22)	†
Have health insurance coverage		
No (ref.)	—	†
Yes	0.50 (0.18–1.37)	†
Don't know/Refused/Not ascertained	—	†
Other health screenings		
Ever been tested for HIV		
No (ref.)	—	—
Yes	**6.53 (5.19–8.21)**	**5.37 (4.19–6.89)**
Don't know/Refused/Not ascertained	1.28 (0.81–2.03)	**1.64 (1.04–2.58)**
Blood pressure check, last 12 mo		
No (ref.)	—	†
Yes	1.36 (0.69–2.69)	†
Don't know/Refused/Not ascertained	1.06 (0.53–2.14)	†
Cholesterol checked last 12 mo		
No (ref.)	—	†
Yes	1.42 (0.88–2.27)	†
Don't know/Refused/Not ascertained	1.05 (0.64–1.74)	†
Had colon cancer test in last 12 months		
No (ref.)	—	—
Yes	**1.91 (1.51–2.43)**	**1.56 (1.21–2.00)**
Don't know/Refused/Not ascertained	0.37 (0.10–1.31)	0.35 (0.09–1.26)

[a]All variables listed were initially included in the multivariable model, and a significance of 0.05 was required to remain in the model.
†Designates a variable that was eliminated from the multivariable model.

colon cancer test in the last 12 months (aOR = 1.43; 95% CI = 1.25–1.62).

Older group (born before 1945). Few variables were associated with HCV screening among the older birth cohort population in the multivariable model. Geographic location was significant for this birth cohort and people living in the West having higher odds of HCV screening (aOR = 2.00; 95% CI = 1.39–2.88). Age was significant in the same direction as the baby boomers and increasing age was associated with decreasing odds in screening (aOR = 0.85; 95% CI = 0.76–0.95). As with all other birth cohorts, female gender was associated with lower odds of screening (aOR = 0.71;

95% CI = 0.57–0.89). Some indicators of use of preventive health services were positively associated with the odds of screening including ever having been tested for HIV (aOR = 5.37; 95% CI = 4.19–6.89) and having had a colon cancer test in the last 12 months (aOR = 1.56; 95% CI = 1.21–2.00).

Discussion

As of 2013, both the CDC and USPSTF recommend one-time HCV screening for all baby boomers (6, 7). This study provides population estimates of screening rates over three consecutive years for the baby boomer population since the implementation of the new recommendations. In addition, we examined the populations that are older and younger than the baby boomers to compare screening predictors and examine differences between populations for whom there are risk-based versus universal screening recommendations. Our large, nationally representative sample demonstrated screening has increased slightly in the baby boomer population (1.3% from 2014 to 2015), but the proportion screened for HCV (12.8%) falls well below the national recommendation for universal screening in this birth cohort. While the proportion of baby boomers screened appeared to decrease from 2013 to 2014 and then increase from 2014 to 2015, this apparent decrease was attenuated in the multivariable model controlling for other factors. The HCV screening pattern among baby boomers demonstrated by these data are consistent with recent research and indicates the need to dramatically improve rates of screening (28). The relatively low HCV screening prevalence suggests the existence of barriers to screening at multiple levels. For example, recent research demonstrates barriers at the provider-level include low communication skills (29), and low awareness of HCV prevalence and screening recommendations (30). Barriers at the patient level include lack of knowledge and awareness of HCV infection (31), confusion regarding transmission (30), and lack of insurance to pay for screening (32). Practice-level barriers include lack of routine and automated reminders for screening, inadequate funding for HCV prevention and control (31), and inadequate insurance reimbursement (33).

HCV screening prevalence differed by race and ethnicity for the second youngest and baby boomer populations. Specifically, non-Hispanic blacks and Hispanics had lower odds of screening in both of these birth cohorts. It is important to note that this was not significant for baby boomers in the bivariate analysis and the trend was only apparent in the multivariable model, suggesting Hispanics and non-Hispanic blacks were screened more due to other factors that were controlled for in the multivariable model. This is particularly worrisome given findings from a recent study indicating non-Hispanic blacks are more likely to have a current infection than non-Hispanic whites (34) and HCV-infected Hispanics have higher rates of advanced fibrosis and cirrhosis than HCV-infected non-Hispanic whites (35). One of the variables with the strongest association with HCV screening was also HIV testing, which could be a marker of a physician's concern about a patient's intravenous drug use. This may indicate that either providers still screen based on risk factors as opposed to birth cohort (baby boomers), or patients engaging in high risk behaviors specifically sought out HCV screening. The new screening guidelines are meant to augment, not replace risk-based guidelines, but if they are not properly implemented, half of those chronically infected with HCV may fail to be identified (8).

Interestingly, having been screened for colon cancer was positively associated with HCV screening for the two birth cohorts for which it was examined. While it is common for preventive care screening tests and pro-health behaviors to cluster (36), in this study, it was only colon cancer screening, not other tests such as blood pressure or cholesterol screening that was reliably associated with HCV screening regardless of age. It is possible this finding may be due to the fact that colon cancer screening (via colonoscopy) is typically performed by a gastroenterologist, the same provider who treats HCV infections, and these providers may be more aware of HCV screening recommendations. However, it is typically the primary care provider, not a specialist, who orders HCV screening. Therefore, the stronger association between colon cancer screening and HCV screening was an unexpected finding that requires replication in other studies.

Other indicators of use of preventive health services (e.g., having seen a provider in the last 12 months) were also associated with HCV screening. Approximately 35% of baby boomers had seen a provider in the last 12 months but only 12% had ever been screened for HCV. This demonstrates that, much like other preventive health measures (37, 38), there are missed clinical opportunities both for routine preventive care visits and for HCV screening in this group. The odds of HCV screening did increase for the baby boomer population over the three survey years. These increases, although statistically significant, were relatively small and well below the goal of universal screening in this birth cohort. Interestingly, some variables had associations in the opposite direction for different birth cohorts. For example, not being currently married (i.e. widowed, divorced, or separated) was not retained in the multivariable model for the youngest and oldest birth cohorts but was associated with increased screening for the middle two birth cohorts. It is possible the different pattern between the birth cohorts is because people who are not currently married in the older group are more often widowed and the people not currently married in the younger birth cohort are more likely divorced, indicating a different risk profile. Likewise, age was negatively associated with the odds of being screened for the baby boomer and older group but was positively associated with screening in the youngest group.

This study used data from a large, weighted, nationally representative sample to assess trends in HCV screening in the U.S. population over time. These unique data offer the opportunity to identify important factors associated with HCV screening. Although these are strengths, study findings should be considered in light of certain limitations. First, the survey did not include questions regarding all known HCV risk factors including HIV status, being born to an HCV-infected mother, received a solid organ transplant or blood transfusion before 1992, or a history of injection drug use. Moreover, the NHIS sample excludes certain groups known to have high HCV infection rates including the homeless and incarcerated (39–41). Furthermore, we included people who refused to answer whether they were screened for HCV in the analyses. While it is possible these people were more likely to be positive and did not want to share that information, this group accounted for only 0.1% of the total sample population and is therefore unlikely to affect results. In addition, these data are cross-sectional, longitudinal associations within a cohort cannot be assessed. In particular, we cannot determine whether the reported behaviors included in the "high risk" groups occurred before or after HCV screening.

NHIS data are self-reported and are therefore subject to individual interpretation and recall bias. This is especially relevant given research on other cancer screenings demonstrating people can be unaware of what they are being screened for (42). However, the NHIS does ask participants about several preventive health screenings including HIV and hepatitis B testing, reducing the likelihood a participant may confuse them. In addition, the use of large, nationally representative datasets is a commonly used technique to assess trends across the United States including several preventive health behaviors such as mammography (43), colorectal cancer screening (44, 45), and genetic testing (46). In addition, studies examining the reliability and validity of responses of national surveys found responses were similar between surveys and registry-verified patient data (47, 48), Finally, it is possible some of the statistically significant associations in this population are due to the large sample size. Despite these limitations, this study provides the first analysis of HCV screening trends over these three years for the birth cohort targeted for one-time screening as well as other age and risk groups. While HCV screening is increasing over time, there is substantial room for improvement. Future research should focus on interventions to increase access to primary care, particularly among the baby boomer cohort and HCV recommendation awareness among both providers and patients with a special focus on groups demonstrating significantly lower screening rates, such as Hispanics, non-Hispanic blacks, and females.

Disclosure of Potential Conflicts of Interest

R.R. Reich is a biostatistician at Sarasota Memorial Hospital. D.R. Nelson reports receiving commercial research grants from Gilead, Merck, and AbbVie. No potential conflicts of interest were disclosed by the other authors.

Disclaimer

The content of this manuscript is solely the responsibility of the authors and does not necessarily represent the official views of the Patient Centered Outcomes Research Institute, the National Cancer Institute, or the National Institutes of Health.

Authors' Contributions

Conception and design: M.L. Kasting, A.R. Giuliano, R.R. Reich, R.G. Roetzheim, D.R. Nelson, E. Shenkman, S.T. Vadaparampil

Development of methodology: M.L. Kasting, R.R. Reich, R.G. Roetzheim, D.R. Nelson, S.T. Vadaparampil

Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): M.L. Kasting, S.T. Vadaparampil

Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): M.L. Kasting, A.R. Giuliano, R.R. Reich, D.R. Nelson, S.T. Vadaparampil

Writing, review, and/or revision of the manuscript: M.L. Kasting, A.R. Giuliano, R.R. Reich, R.G. Roetzheim, D.R. Nelson, E. Shenkman, S.T. Vadaparampil

Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): M.L. Kasting

Study supervision: M.L. Kasting, A.R. Giuliano, S.T. Vadaparampil

Acknowledgments

This work was supported, in part, by the Biostatistics Core at the H. Lee Moffitt Cancer Center & Research Institute, an NCI designated Comprehensive Cancer Center (P30-CA076292; PI: Sellers). M. Kasting and A. Giuliano are supported, in part, by the NIH/NCI-funded Center for Infection Research in Cancer (K05-CA181320; PI: A. Giuliano). M. Kasting is also supported by the National Cancer Institute of the NIH (R25-CA090314; PI: Brandon).

Information reported in this publication was supported by the University of Florida Clinical and Translational Science Institute, which is supported in part by the NIH National Center for Advancing Translational Sciences under award number UL1TR001427.

Information reported in this publication was supported in part by the OneFlorida Clinical Data Network, funded by the Patient-Centered Outcomes Research Institute #CDRN-1501-26692.

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked *advertisement* in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

Received September 20, 2017; revised November 20, 2017; accepted January 31, 2018; published first April 3, 2018.

References

1. Ryerson AB, Eheman CR, Altekruse SF, Ward JW, Jemal A, Sherman RL, et al. Annual report to the nation on the status of cancer, 1975-2012, Featuring the increasing incidence of liver cancer. Cancer 2016;122:1312–37.
2. Centers for Disease Control and Prevention. CDC fact sheet: viral hepatitis and liver cancer 2016. Available from: https://www.cdc.gov/nchhstp/newsroom/docs/factsheets/viral-hep-liver-cancer.pdf.
3. Centers for Disease Control and Prevention. Recommendations for prevention and control of hepatitis C virus (HCV) infection and HCV-related chronic disease. MMWR Morb Mortal Wkly Rep 1998;47:1–39.
4. Centers for Disease Control and Prevention. Hepatitis C FAQs for the public 2016. Available from: https://www.cdc.gov/hepatitis/hcv/cfaq.htm.
5. Centers for Disease Control and Prevention. Hepatitis C: Why baby boomers should get tested 2016. Available from: https://www.cdc.gov/knowmorehepatitis/media/pdfs/factsheet-boomers.pdf.
6. Smith BD, Morgan RL, Beckett GA, Falck-Ytter Y, Holtzman D, Teo CG, et al. Recommendations for the identification of chronic hepatitis C virus infection among persons born during 1945-1965. MMWR Morb Mortal Wkly Rep 2012;61:1–32.
7. U.S. Preventive Services Task Force. Final recommendation statement: Hepatitis C screening. 2016. Available from: https://www.uspreventiveservicestaskforce.org/Page/Document/.
8. Ona M, Papafragkakis H, Pan C. Hepatitis C screening in the United States: current models and challenges. Am J Digest Dis 2015;2:29–40.
9. McGarry LJ, Pawar VS, Panchmatia HR, Rubin JL, Davis GL, Younossi ZM, et al. Economic model of a birth cohort screening program for hepatitis C virus. Hepatology 2012;55:1344–1355.
10. Pataky R, Phillips N, Peacock S, Coldman AJ. Cost-effectiveness of population-based mammography screening strategies by age range and frequency. J Cancer Policy 2014;2:97–102.
11. Jemal A, Fedewa SA. Prevalence of hepatitis C virus testing in cohorts born between 1945 and 1965 in the U.S. Am J Prev Med 2015;48:e7–9.
12. Poynard T, Marcellin P, Lee SS, Niederau C, Minuk GS, Ideo G, et al. Randomised trial of interferon alpha2b plus ribavirin for 48 weeks or for 24 weeks versus interferon alpha2b plus placebo for 48 weeks for treatment of chronic infection with hepatitis C virus. International Hepatitis Interventional Therapy Group (IHIT). Lancet 1998;352:1426–1432.
13. McHutchison JG, Gordon SC, Schiff ER, Shiffman ML, Lee WM, Rustgi VK, et al. Interferon alfa-2b alone or in combination with ribavirin as initial treatment for chronic hepatitis C. Hepatitis Interventional Therapy Group. N Engl J Med 1998;339:1485–1492.
14. Raedler LA. Once-a-day Harvoni (Ledipasvir plus Sofosbuvir), a new oral combination for the treament of patients with genotype 1 chronic hepatitis C infection. Am Health Drug Benefits 2015;8:54–58.
15. U.S. Food and Drug Administration. FDA approves first combination pill to treat hepatitis C [press release] 2014. Available from: http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm418365.htm.

16. U.S. Food and Drug Administration. FDA approves Epclusa for treatment of chronic Hepatitis C virus infection 2016. Available from: http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm508915.htm.
17. Coppola N, Pisaturo M, Zampino R, Macera M, Sagnelli C, Sagnelli E. Hepatitis C virus markers in infection by hepatitis C virus: In the era of directly acting antivirals. World J Gastroenterol 2015;21:10749–10759.
18. Li DK, Chung RT. Impact of hepatitis C virus eradication on hepatocellular carcinogenesis. Cancer 2015;121:2874–2882.
19. U.S. Department of Health Human Services. Healthy People 2020 Topics and Objectives: Immunizations and Infectious Disease. n.d. Available from: https://www.healthypeople.gov/2020/topics-objectives/topic/immunization-and-infectious-diseases/objectives#4696.
20. Centers for Disease Control and Prevention. About the National Health Interview Survey. 2016. Available from: http://www.cdc.gov/nchs/nhis/about_nhis.htm.
21. Henderson DK. Managing occupational risks for hepatitis C transmission in the health care setting. Clin Microbiol Rev 2003;16:546–568.
22. Befrits R, Hedman M, Blomquist L, Allander T, Grillner L, Kinnman N, et al. Chronic hepatitis C in alcoholic patients: prevalence, genotypes, and correlation to liver disease. Scand J Gastroenterol 1995;30:1113–1118.
23. Yu SJ. A concise review of updated guidelines regarding the management of hepatocellular carcinoma around the world: 2010-2016. Clin Mol Hepatol 2016;22:7–17.
24. Joshi SN. Hepatitis C Screening. Ochsner J 2014;14:664–668.
25. U.S. Preventive Services Task Force. Final Recommendation Statement: High Blood Pressure in Adults: screening; 2017. Available from: https://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/high-blood-pressure-in-adults-screening.
26. U.S. Preventive Services Task Force. Final Update Summary: Lipid Disorders in Adults (Cholesterol, Dyslipidemia): screening; 2015. Available from: https://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/lipid-disorders-in-adults-cholesterol-dyslipidemia-screening.
27. U.S. Preventive Services Task Force. Final Update Summary: Colorectal Cancer: screening; 2015. Available from: https://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/colorectal-cancer-screening.
28. Jemal A, Fedewa SA. Recent hepatitis C virus testing patterns among baby boomers. Am J Prev Med 2017;53:e31–33.
29. Zickmund S, Hillis SL, Barnett MJ, Ippolito L, LaBrecque DR. Hepatitis C virus-infected patients report communication problems with physicians. Hepatology 2004;39:999–1007.
30. Dhopesh VP, Taylor KR, Burke WM. Survey of hepatitis B and C in addiction treatment unit. Am J Drug Alcohol Abuse 2000;26:703–707.
31. Mitchell AE, Colvin HM, Palmer Beasley R. Institute of Medicine recommendations for the prevention and control of hepatitis B and C. Hepatology 2010;51:729–733.
32. Ong JP, Collantes R, Pitts A, Martin L, Sheridan M, Younossi ZM. High rates of uninsured among HCV-positive individuals. J Clin Gastroenterol 2005;39:826–830.
33. Reinhardt UE. The disruptive innovation of price transparency in health care. JAMA 2013;310:1927–1928.
34. Liu G, Holmberg SD, Kamili S, Xu F. Racial disparities in the proportion of current, unresolved hepatitis C virus infections in the United States, 2003-2010. Dig Dis Sci 2014;59:1950–1957.
35. Turner BJ, Taylor BS, Hanson J, Liang Y, Veerapaneni P, Villarreal R, et al. High priority for hepatitis C screening in safety net hospitals: Results from a prospective cohort of 4582 hospitalized baby boomers. Hepatology 2015;62:1388–1395.
36. Fortenberry JD, Costa FM, Jessor R, Donovan JE. Contraceptive behavior and adolescent lifestyles: a structural modeling approach. J Res Adolesc 1997;7:307–329.
37. Zapka JG, Lemon SC. Interventions for patients, providers, and health care organizations. Cancer 2004;101:1165–1187.
38. Coughlin SS, Thompson T. Physician recommendation for colorectal cancer screening by race, ethnicity, and health insurance status among men and women in the United States, 2000. Health Promot Pract 2005;6:369–378.
39. Varan AK, Mercer DW, Stein MS, Spaulding AC. Hepatitis C seroprevalence among prison inmates since 2001: still high but declining. Public Health Rep 2014;129:187–195.
40. Nyamathi AM, Christiani A, Windokun F, Jones T, Strehlow A, Shoptaw S. Hepatitis C virus infection, substance use and mental illness among homeless youth: a review. AIDS 2005;19:S34–40.
41. Chak E, Talal AH, Sherman KE, Schiff ER, Saab S. Hepatitis C virus infection in USA: an estimate of true prevalence. Liver Int 2011;31:1090–1101.
42. Kasting ML, Wilson S, Zollinger TW, Dixon BE, Stupiansky NW, Zimet GD. Differences in cervical cancer screening knowledge, practices, and beliefs: an examination of survey responses. Prev Med Rep 2017;5:169–174.
43. Breen N, Gentleman JF, Schiller JS. Update on mammography trends: comparisons of rates in 2000, 2005, and 2008. Cancer 2011;117:2209–2218.
44. Breen N, Wagener DK, Brown ML, Davis WW, Ballard-Barbash R. Progress in cancer screening over a decade: results of cancer screening from the 1987, 1992, and 1998 National Health Interview Surveys. J Natl Cancer Inst 2001;93:1704–1713.
45. Klabunde CN, Cronin KA, Breen N, Waldron WR, Ambs AH, Nadel MR. Trends in colorectal cancer test use among vulnerable populations in the United States. Cancer Epidemiol Biomarkers Prev 2011;20:1611–1621.
46. Mai PL, Vadaparampil ST, Breen N, McNeel TS, Wideroff L, Graubard BI. Awareness of cancer susceptibility genetic testing: the 2000, 2005, and 2010 National Health Interview Surveys. Am J Prev Med 2014;46:440–448.
47. Pierannunzi C, Hu SS, Balluz L. A systematic review of publications assessing reliability and validity of the behavioral risk factor surveillance system (BRFSS), 2004–2011. BMC Med Res Methodol 2013;13:49.
48. Nelson DE, Powell-Griner E, Town M, Kovar MG. A comparison of national estimates from the National Health Interview Survey and the behavioral risk factor surveillance system. Am J Public Health 2003;93:1335–1341.