Increasing Hepatitis C Screening in a Large Integrated Health System: Science and Policy in Concert

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ABSTRACT

OBJECTIVES: To evaluate whether the updated 2013 US Preventive Services Task Force (USPSTF) hepatitis C virus (HCV) screening recommendations, related Affordable Care Act provisions, and the impending availability of efficacious therapies were associated with increased screening in an integrated health system.

STUDY DESIGN: We analyzed 665,339 records of adult patients visiting Kaiser Permanente Mid-Atlantic States clinics from 2003 to 2014.

METHODS: We used Cox proportional hazards to estimate time to HCV screening and confirmation after June 1, 2013, compared with prior.

RESULTS: HCV screening steadily increased over time, but it jumped 29% (P <.01) from 2013 to 2014 versus 4% (P <.01) from 2012 to 2013. The adjusted hazard ratio for HCV screening since June 2013 was 2.40 (95% CI, 2.34-2.47) times higher than it was pre-intervention among the birth cohort (those born 1945-1965) and 2.00 (95% CI, 1.96-2.04) times higher in those born in other years, representing a 1.20-fold (95% CI, 1.17-1.24) greater increase in the screening rate among the birth cohort. We also identified variability in those thought to be at higher risk of HCV infection.

CONCLUSIONS: HCV screening has been increasing in our healthcare system, more so since June 2013 and among the birth cohort. The availability of efficacious therapies and coverage policies coincident with the USPSTF recommendations may have facilitated access to screening and treatment in ways that were absent at the time of the 2012 CDC recommendations. Health systems must also be poised to make resources available to clinicians and patients in order to incentivize screening. Future research should inform a better understanding of incentives and barriers to screening and linkage to care from all stakeholder perspectives.

Am J Manag Care. 2018;24(5):e134-e140

Between 45% and 85% of the approximately 4 million people in the United States with hepatitis C virus (HCV) infection are unaware of their infection and may infect others and experience disease progression.[1-3] Furthermore, incomplete patient follow-up impedes the provision of appropriate care. In a large cohort study of patients with chronic hepatitis B and/or C, 38% of HCV antibody–positive patients had no follow-up HCV RNA testing documented in the electronic health record (EHR).[4] Larger care gaps exist for patients coinfected with HIV and HCV[5] and for persons of color.[6] Enabling patients to reach each step of the HCV cascade of care (including screening, confirmation, medical management, treatment, and cure) affords them the full benefit of appropriate treatment.[7,8]

In response to growing evidence of a "silent epidemic," the CDC updated its guidelines in 2012 to recommend universal HCV screening of all persons born from 1945 to 1965, the "birth cohort" with the highest burden of disease.[9] The 2012 recommendations also recommended confirmatory RNA testing for all patients with positive HCV antibody results. However, the US Preventive Services Task Force (USPSTF) did not update its ranking of birth cohort screening to a B grade until June 2013.[10,11] The USPSTF update initiated coverage requirements without additional expense to the insured under the Affordable Care Act (ACA).[12] The ACA also eliminated exclusions for pre-existing conditions, prohibited insurers from rescinding coverage, and put an end to lifetime and annual coverage limits, further reducing barriers to diagnosis and linkage to care. Lastly, the 2013 USPSTF recommendations were released just months before the rollout of the first highly efficacious direct-acting antivirals (DAAs) to hit the US market: simeprevir (November) and sofosbuvir (December).[13] We previously analyzed trends in HCV screening from 2004 to 2012 and found a steady increase in HCV screening over time prior to the 2013 interventions.[14] Two other descriptive studies using commercial laboratory and insurance databases to examine changes in HCV screening over time found increases.[15,16] However, these studies were ecological and did not formally test differences in screening rates before and after seminal events

that were intended to increase screening and treatment of HCV.

The objective of this study was to describe whether HCV screening and confirmatory testing, particularly among the birth cohort, were elevated after June 1, 2013, compared with prior. June 1, 2013, marks the contemporaneous introduction of the USPSTF recommendations, ACA protections, and DAAs in the United States. We describe trends for 1) antibody screening and 2) confirmatory RNA and genotype testing. This study will be the first to describe outcomes associated with these collective initiatives to increase screening.

TAKEAWAY POINTS

This was an observational study to measure the increase in hepatitis C screening since the implementation of revised national screening guidelines and wide availability of novel direct-acting antivirals (DAAs) starting in June 1, 2013, compared with prior. The availability of effective treatment may have facilitated a greater increase in screening than screening guidelines alone:

- In the year following the revised US Preventive Services Task Force (USPSTF) recommendations and availability of novel DAAs (2013), hepatitis C screening increased by 29%.
- In comparison, hepatitis C screening increased just 4% in the year after the release of updated screening guidelines by the CDC in 2012.
- Overall, we observed a 2-fold increase in hepatitis C screening since June 1, 2013, compared with prior and adjusting for factors that influence screening.
- The screening increase was even greater among those born between 1945 and 1965 (defined as the birth cohort), who were the target of the 2013 USPSTF recommendations.

METHODS

Study Design, Setting, and Participants

We conducted an observational study among patients 18 years and older with at least 8 months of enrollment in the Kaiser Permanente Mid-Atlantic States (KPMAS) health insurance plan and who attended at least 1 clinical visit from January 1, 2003, to February 28, 2015. For the screening analysis, patients were followed from the date of this first clinic visit during the study period through December 31, 2014. Patients testing positive for HCV antibodies were followed through February 28, 2015, for confirmatory RNA or genotype testing. The investigation followed the guidelines of the HHS regarding protection of human subjects. The study protocol was approved and renewed annually by the KPMAS Institutional Review Board.

KPMAS is well positioned to describe changes along the HCV care continuum over time. The average retention of patients in the health system is more than 4 years.[14] Clinical expertise, comprehensive service, and competitive pricing are incentives to seek care within the health system. A robust EHR ensures near-complete capture of all clinical and demographic data, including diagnosis, pharmacy, laboratory, behavioral, and insurance data for patients seeking care in our integrated multispecialty practices and clinics.

Study Variables

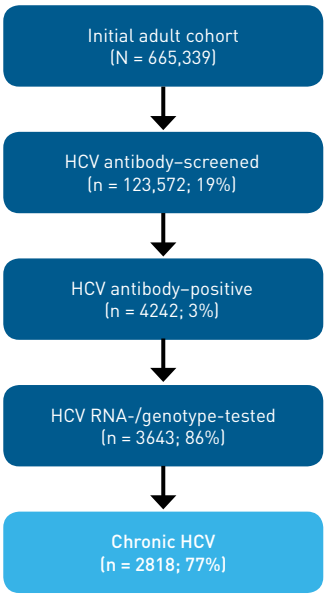
All study data were collected from the KPMAS EHR. Primary outcomes were (1) antibody screening and (2) RNA or genotype (confirmatory) testing. A priori factors of interest included birth cohort status, race, gender, hepatitis B virus (HBV) or HIV coinfection, area median household income (defined by the residential Census block), primary clinic location (DC/suburban Maryland, northern Virginia, or Baltimore/other), provider type at first encounter during the study period (adult medicine, emergency/urgent care, obstetrics/gynecology [OB/GYN], pediatrics, or specialty/other), and prior visit to a gastroenterology or infectious disease (ID) specialist who provided HCV care in our system. HBV and HIV coinfections were identified through the KPMAS HBV and HIV registries, respectively. During regular clinical care, patients are asked about their history of ever using illicit drugs (including marijuana) and men having sex with men (MSM) status, and results are recorded in the EHR. We included these variables in descriptive tables and a sensitivity analysis, but we excluded them from our main analysis because of a high number with missing values (~30% for both variables). We used the Bayesian Improved Surname Geocoding algorithm to impute racial probabilities in those missing reported race/ethnicity.[17]

Statistical Analysis

We estimated the annual screening rate as the number of antibody-tested patients per patients enrolled in KPMAS from January 1 to December 31 of each year. We removed those who had been screened in previous years from subsequent year denominators. Significant differences in screening rates between years were compared using a *z* test for difference in proportions.

In separate models, we used Kaplan-Meier curves, log-rank tests, and multivariable Cox proportional hazards with robust standard errors[18] to assess time to antibody testing among all patients and time to confirmatory testing among those who tested HCV antibody–positive. We followed patients in calendar time from the first office visit (for screening analysis) and from positive antibody test (for the confirmatory testing analysis) until the time of event, disenrollment from the health plan, death, or the administrative end of study, whichever occurred first. Covariates were assessed prior to the event and up to 1 month after first visit for the screening analysis and up to 14 days after the antibody test for the confirmatory testing analysis. We categorized time before and after June 1, 2013 (the earliest date of the USPSTF recommendations/ACA protections and DAA release). We created an interaction term between birth cohort status and pre- and postintervention time to directly compare changes in screening and confirmatory testing before and after the intervention by birth cohort status. For time to screening, we also stratified the analysis by clinic location

FIGURE 1. Study Cohort[a]



HCV indicates hepatitis C virus.
[a]Percentages refer to the proportion based on the prior cell.

to describe practice differences across locations. As a sensitivity analysis, we include MSM and illicit drug use, along with all other variables, in a complete-case analysis.

Data compilation, annual time series, and graphs were conducted in SAS 9.2 (SAS Institute; Cary, North Carolina). The stcox function in Stata 13 (StataCorp; College Station, Texas) was used for proportional hazards modeling. Figures were created in Stata 13 and Microsoft Excel and Word (Microsoft; Redmond, Washington).

RESULTS

We observed 665,339 patients over time for an average of 33 months. **Figure 1** describes the flow of patients through the study. The cohort was diverse; 37% of patients were Black and 57% were female. On average, patients resided in areas where median household income was approximately $84,000/year (**Table 1**).

HCV Antibody Screening

Screening rates increased from 23.6 per 1000 person-years in 2004 to 70.8 in 2014 (**Figure 2**). The screening rate increased by 29% ($P < .01$) from 2013 to 2014 (after June 2013 interventions). In comparison, the screening rate increased by 4% ($P < .01$) from 2012 to 2013 (after the CDC recommendations). In total, 18.6% of all adult patients (17% of the birth cohort) were ever screened for HCV. The youngest patients were screened at the highest rate, followed by the birth cohort; those born before 1945 had the lowest rate of screening (**Figure 3**). However, the increase since the 2013 interventions was 1.2 (95% CI, 1.17-1.24) times greater in the birth cohort compared with those not in the birth cohort (**Table 2**). The adjusted hazard ratio (aHR) for HCV screening comparing after the intervention with prior was 2.40 (95% CI, 2.34-2.47) among the birth cohort and 2.00 (95% CI, 1.96-2.04) among those not in the birth cohort. These trends were consistent across all locations (**eAppendix A** [eAppendices available at **ajmc.com**]). Among all patients enrolled in the health plan as of December 31, 2014, 23.8% (70,016/294,034) had been antibody-screened, including 22% (29,175/131,612) of the birth cohort.

Other significant predictors of screening included first encounter with a primary care provider (ie, internal medicine, OB/GYN, or family practice), which is consistent with our clinical practice model, and non-White race. The adjusted hazards of screening (Table 2) were notably elevated among those with HBV (aHR, 4.42; 95% CI, 3.99-4.90) and HIV (aHR, 6.84; 95% CI, 6.47-7.23). Males had lower hazards than women (aHR 0.96; 95% CI, 0.94-0.97), as did those with higher compared with lower income (aHR, 0.97; 95% CI, 0.96-0.97). We observed some practice variation, with those whose first encounter was in OB/GYN having slightly increased hazards of screening compared with family practice or internal medicine (aHR, 1.24; 95% CI, 1.21-1.26) and those seen in Virginia clinics having slightly lower screening hazards compared with DC/suburban Maryland (aHR, 0.96; 95% CI, 0.94-0.97).

Results from the complete-case analysis that included MSM and illicit drug use in the model were robust and showed a greater hazard for screening in MSM compared with non-MSM (aHR, 1.99; 95% CI, 1.87-2.12) and in patients who inject drugs (aHR, 7.19; 95% CI, 3.17-16.35) compared with those not using drugs (**eAppendix B**).

Confirmatory HCV RNA or Genotype Testing

A total of 4242 patients tested positive for HCV antibodies, of whom 3643 (86%) underwent subsequent confirmatory testing and 2818 tested positive (2.3% of the 123,572 patients screened). Median time from antibody test to RNA/genotype test was less than 1 month and did not vary by birth cohort, sex, race, income, provider type, or HIV or HBV status. The rate of confirmatory testing was more than 50% higher after 2013 compared with before, and the increase in confirmatory testing did not differ by birth cohort status. Patients whose primary clinic location was in Baltimore (aHR, 1.27; 95% CI, 1.15-1.40) or Virginia (aHR, 1.25; 95% CI, 1.12-1.39) also had greater hazards of confirmatory testing compared with those seen in DC/suburban Maryland, as did those with a prior gastroenterology/ID visit compared with no prior visit (aHR, 1.39; 95% CI, 1.27-1.53) (Table 2).

DISCUSSION

In the year following the release of the 2013 USPSTF HCV screening recommendations highlighting the need for birth cohort screening,

associated protections under the ACA, and DAA availability, the adjusted hazard of HCV screening among the birth cohort more than doubled compared with prior years. This increase was 20% higher than the increase observed in patients outside of the birth cohort and demonstrates the influence of guidelines on changes in practice. In addition, the overall screening rate increased by 29% in the year after the interventions, compared with 4% in the year after the 2012 CDC recommendation. The distinction between the CDC and USPSTF recommendations is that, although both provided guidance, the USPSTF recommendations were supported by policy and science that facilitated access to screening and treatment in ways that were absent during the announcement of the CDC recommendations. First, the USPSTF B grading for HCV screening triggered a policy under the ACA to provide screening without additional cost to all those covered under private or public plans.[11] Cost has been cited as a barrier to screening for other chronic conditions, such as HIV and breast cancer.[19,20] We observed an increase in the per population screening rate that may be associated with removing barriers posed by the cost of screening.

The availability of DAAs shortly after USPSTF announced its recommendation was another timely screening incentive. The goals of screening are to (1) stop transmission of HCV and (2) identify disease in early stages so that it may be treated more effectively and lead to better outcomes than would occur if it were treated at a later stage. Limited therapeutic options prior to 2013 made these goals elusive and may have deterred screening.[21,22]

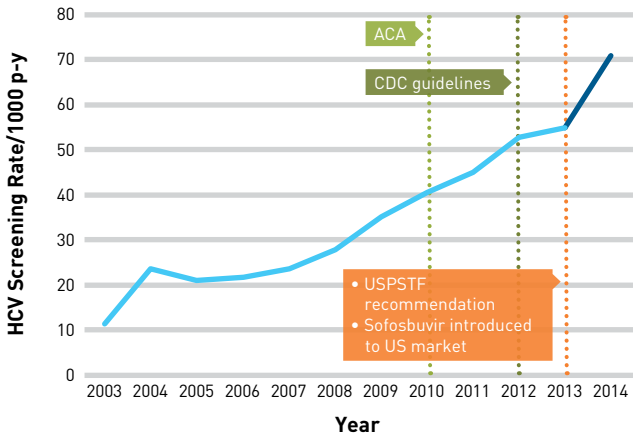
Although the age group with the greatest increase in HCV screening was the birth cohort, traditional risk factors for HCV remain important predictors of screening. Patients with HIV and HBV infection, which are often associated with HCV, had 4 to 7 times higher rates of screening than those without these infections. In our complete-case analysis, we show that screening was almost 2-fold higher in MSM and more than 7-fold higher in patients who inject drugs compared with those who denied using drugs. These data suggest a bias toward screening in

TABLE 1. Characteristics of Patients 18 Years and Older, KPMAS, 2003-2014[a]

	Total (N = 665,339)	Birth Cohort (born 1945-1965) (n = 260,822)	Other Ages (n = 404,517)
Age at enrollment, years, mean (SD)	42.2 (15.2)	49.5 (6.5)	37.5 (17.1)
Median area household income,[b] $, mean (SD)	83,980 (37,376)	86,366 (38,528)	82,559 (36,599)
Race,[c] %			
Non-Hispanic Black	37.0	35.7	38.9
American Indian/Alaskan Native	0.2	0.2	0.2
Asian/Pacific Islander	9.5	9.9	8.9
Hispanic	10.2	11.0	8.8
Mixed race	1.5	1.6	1.4
Non-Hispanic White	41.6	41.4	41.8
Sex, n (%)			
Female	378,480 (56.9)	143,450 (55.0)	235,030 (58.1)
Male	286,859 (43.1)	117,372 (45.0)	169,487 (41.9)
HBV+, n (%)	1710 (0.3)	664 (0.3)	1046 (0.3)
HIV+, n (%)	3464 (0.5)	1755 (0.7)	1709 (0.4)
MSM, n (%)	3983 (0.6)	1488 (0.6)	2495 (0.6)
Non-MSM	464,377 (69.8)	180,636 (69.3)	283,741 (70.1)
Unknown MSM status	196,979 (29.6)	78,698 (30.2)	118,281 (29.2)
History of drug use, n (%)			
Never	436,906 (65.7)	171,462 (65.7)	265,444 (65.6)
Yes, not intravenous	2701 (0.4)	718 (0.3)	1983 (0.5)
Yes, intravenous	8 (<0.01)	4 (<0.01)	4 (<0.01)
Unknown	225,724 (33.9)	88,638 (34.0)	137,086 (33.9)
First visit provider, n (%)			
Other/specialty	84,371 (12.7)	38,976 (14.9)	45,395 (11.2)
Adult medicine/family practice	451,494 (67.9)	183,816 (70.5)	267,678 (66.2)
OB/GYN	77,893 (11.7)	18,902 (7.3)	58,991 (14.6)
ED/urgent care	49,152 (7.4)	19,020 (7.3)	30,132 (7.5)
Pediatrics	2429 (0.4)	108 (0.04)	2321 (0.6)
Gastroenterology/ID visit up to 30 days after first visit, n (%)			
No	625,777 (94.1)	242,020 (92.8)	383,757 (94.9)
Yes	39,562 (6.0)	18,802 (7.2)	20,760 (5.1)
Clinic location, n (%)			
DC/suburban Maryland	299,599 (45.0)	116,858 (44.8)	182,741 (45.2)
Baltimore	105,517 (15.9)	42,101 (16.1)	63,416 (15.0)
Virginia	260,223 (39.1)	101,863 (39.1)	158,360 (39.1)

ED indicates emergency department; HBV, hepatitis B virus; KPMAS, Kaiser Permanente Mid-Atlantic States; ID, infectious disease; MSM, men who have sex with men; OB/GYN, obstetrics/gynecology.
[a]All characteristics assessed up to 30 days after first visit.
[b]Source: US Census Bureau, American Community Survey.
[c]Nonreported race imputed using Bayesian Improved Geocoding Surname Algorithm.

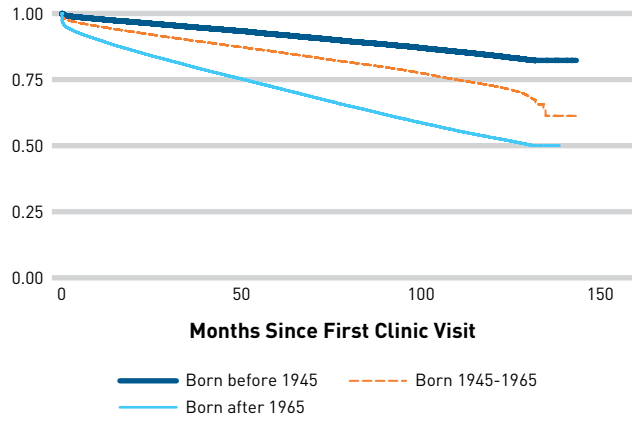
FIGURE 2. HCV Antibody Screening Rate[a] Over Time, KPMAS, 2003-2014



ACA indicates Affordable Care Act; HCV, hepatitis C virus; KPMAS, Kaiser Permanente Mid-Atlantic States; p-y, person-years; USPSTF, US Preventive Services Task Force.

[a]Denominator calculated as the number of enrollees in a KPMAS health insurance plan in a given year among those who had at least 1 visit from 2003-2014 and excluding those who were HCV antibody–tested in prior years.

FIGURE 3. Time to HCV Antibody Test by Birth Year



HCV indicates hepatitis C virus.

patients thought to have transmission risk factors. Yet, 30% of the total sample were missing information on MSM and drug use status. Screening based on risk factors will continue to be incomplete if patient–provider discussions regarding risk factors are not routinely done.[23-25] We also note lower screening rates among patients from higher-income neighborhoods. Increasing HCV screening rates in lower-income neighborhoods is responsive to a known gap in delivering high-quality care for HCV.[1,26] However, if the opioid and heroin epidemic continues to expand beyond poor urban and rural areas into higher-income neighborhoods and affects the epidemiology of viral hepatitis and HIV, excluding patients from HCV screening based on income will leave us vulnerable to underdiagnosing the infection.[27] Variability in screening across geographic areas illustrates the need for further education and outreach. All patients at risk of HCV infection should be screened in order to meet the national and international goal of eliminating viral hepatitis by 2030.[28,29]

Our results inform a general increase in HCV screening over time that has been described previously.[14,16] Our study is unique in that we formally estimated and compared screening rates before and after the occurrence of the collective activities of 2013 (ie, the USPSTF guidelines, ACA coverage, and DAA availability) by age group, adjusting for individual-level factors that may confound the relationship between population-level initiatives and screening. This analysis allows us to make inferences on the association between policy measures and screening outcomes across age groups. Specifically, we saw higher screening rates after these coordinated activities compared with before, particularly among the birth cohort, who were a primary target of the updated USPSTF recommendations. Our overall screening rates were similar to those observed in other integrated health systems, which were higher than in the general population and lower than rates in the Veterans Affairs health system.[4,6,30-33]

Although no EHR changes occurred during the course of this study, clinical leadership was engaged to increase provider knowledge about HCV, the need for screening, and the coming availability of efficacious treatment in preparation for a new initiative to increase HCV screening and linkage to care.[34] Cooperative agreements to ensure the availability of competitively priced medication may have further supported screening by providing assurance to clinicians that they would be able to offer therapy to patients with infection. Clinical leadership and the ability to negotiate cooperative agreements are key components of our integrated system that may have contributed to our ability to quickly comply with screening guidelines.

Limitations

We acknowledge some limitations to this study. Although the screening recommendations, ACA protections, and availability of DAAs were universally available to all patients in the study, we were unable to quantify how much each of these played a role in individual clinician or patient decisions to screen. Future research that includes interviews with staff and patients might elucidate a more specific understanding of the individual motivations of patients and providers to promote and accept screening.

Also, we did not study the effects of MSM and substance abuse because they were missing in approximately 30% of the sample. This omission may have biased the results away from the null if MSM or substance abuse were associated with birth cohort status, time, and screening, for example. However, results from a complete-case

analysis that included these variables were robust for all outcomes and showed that patients with a history of MSM and illicit drug use were screened at higher rates compared with those without such a history. Future studies should describe strategies that allow for improved communication between patients and providers on risk factors for transmission and disease progression, as well as educate providers on ways to improve documentation of risk factors.

We did not include data from outside the KPMAS health system (ie, external referrals) in this analysis. As such, some diagnostic and visit data were missing. KPMAS has been working to internalize ID specialties. We will consider including data from external referrals in future analyses.

We recognize that linkage to care is an important follow-up to screening that we did not address. Provider, patient, and health system factors play important roles in linkage to care, which are beyond the scope of the present analysis. We focused this analysis on screening because it is the most proximal effect of the interventions being investigated. We intend to investigate linkage to care in future work.

Finally, a limitation of any health system–based cohort study is limited generalizability to those without insurance, the homeless, and institutionalized populations. Medicaid expansion from 2015 to 2018 under the ACA increased our capture of higher-need patients and enables us to examine the effect of interventions in this population.

TABLE 2. Adjusted HRs of HCV Antibody and Confirmatory Testing, KPMAS, 2003-2014

	Antibody Screening (n = 514,517[a])		Confirmatory Testing (n = 3231[a])	
Characteristic[b]	HR	95% CI	HR	95% CI
Birth cohort	0.66	0.65-0.67	1.18	1.06-1.32
Screening rate after June 2013 vs prior (not in birth cohort)	2.00	1.96-2.04	1.51	1.25-1.82
Screening rate after June 2013 vs prior (in birth cohort)	2.40	2.34-2.47	1.59	1.42-1.77
Difference in screening rate after June 2013 vs before in birth cohort compared with same difference among those not in birth cohort	1.20	1.17-1.24	1.05	0.85-1.30
Male	0.96	0.94-0.97	0.95	0.88-1.03
Race[c] (ref, non-Hispanic White)				
Non-Hispanic Black	1.40	1.37-1.42	0.92	0.82-1.03
Hispanic	1.35	1.32-1.38	0.99	0.76-1.28
Asian/Pacific Islander	1.42	1.39-1.46	1.22	1.03-1.44
American Indian/Alaskan Native	1.08	0.90-1.28	1.61	0.95-2.74
Mixed race	1.57	1.48-1.66	1.28	0.93-1.77
Medicine specialty (ref, other/specialty)				
Family practice/adult medicine	1.28	1.25-1.31	1.17	1.04-1.31
OB/GYN	1.58	1.54-1.62	1.12	0.89-1.40
ED/urgent care	1.23	1.19-1.26	1.12	0.94-1.33
Pediatrics	1.23	1.11-1.37	No events observed	
HBV+	4.42	3.99-4.90	0.81	0.63-1.04
HIV+	6.84	6.47-7.23	1.00	0.86-1.17
Prior visit with gastroenterology/ID	0.87	0.85-0.90	1.39	1.27-1.53
Median area household income[d] (per $10,000 difference)	0.97	0.97-0.97	1.01	1.00-1.02
Clinic location (ref, DC/suburban Maryland)				
Baltimore	0.98	0.96-1.00	1.27	1.15-1.40
Virginia	0.96	0.94-0.97	1.25	1.12-1.39

ED indicates emergency department; HBV, hepatitis B virus; HCV, hepatitis C virus; HR, hazard ratio; ID, infectious disease; KPMAS, Kaiser Permanente Mid-Atlantic States; OB/GYN, obstetrics/gynecology; ref, reference.

[a]Analytic cohort number. Cohort reduced by 150,822 for antibody screening analysis and 1011 for confirmatory testing analysis from original number due to missing covariates and to events occurring before the start of follow-up.

[b]All characteristics assessed up to 30 days after first visit (antibody screening) or 14 days after HCV antibody–positive result (confirmatory testing).

[c]Nonreported race imputed using Bayesian Improved Geocoding Surname Algorithm.

[d]Source: US Census Bureau, American Community Survey. HRs interpreted for every $10,000 difference.

CONCLUSIONS

HCV screening has been increasing in our healthcare system, especially among the birth cohort, since June 2013 when the USPSTF updated its HCV screening recommendation (invoking provisions under the ACA) and DAAs became widely available in the United States. The availability of efficacious therapies and access to care and treatment often justifies and facilitates disease screening. Additionally, health systems must be poised to harness such resources and inform clinicians of their availability. By the end of 2014, we screened just 22% of the KPMAS birth cohort. Based on known HCV prevalence (2.3%), there may have been as many as 13,000 undiagnosed HCV cases in the KPMAS population. Health systems need to do much more to improve HCV screening in populations with risk factors for and high burden of HCV. A better understanding of physician and patient motivations and barriers to screening is a natural extension of this work that will improve the implementation of guidelines and maximize available incentives to screen and treat patients with HCV. ■

Acknowledgments

The authors thank Drs Andres Mendez, Cabell Jonas, Dana Sloan, and Bernadette Loftus for their critical review of the manuscript and Michelle Turner, MPH, for her help with manuscript preparation.

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Source of Funding: This work was supported by grants from the National Institutes of Health: R01 DA031059-04, P30 AI042853, and P30 DA040500.

Author Disclosures: The authors report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

Authorship Information: Concept and design (CVR, BL, MH); acquisition of data (HH); analysis and interpretation of data (CVR, KBR, BL, MH); drafting of the manuscript (CVR, BL); critical revision of the manuscript for important intellectual content (KBR, BL, HH, MH); statistical analysis (CVR, KBR); provision of patients or study materials (HH); obtaining funding (BL); administrative, technical, or logistic support (CVR); and supervision (CVR).

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eAppendix A. Adjusted HRs of HCV Antibody Testing by Location

	DC/Suburban Maryland		Baltimore		Virginia	
Characteristic[a]	**HR**	**95% CI**	**HR**	**95% CI**	**HR**	**95% CI**
Birth cohort	0.65	0.64-0.67	0.67	0.65-0.70	0.67	0.65-0.68
Effect of time after June 2013 (not in birth cohort)	2.23	2.17-2.29	2.22	2.12-2.33	1.62	1.56-1.67
Effect of time after June 2013 (birth cohort)	2.29	2.20-2.38	2.24	2.10-2.39	2.58	2.47-2.69
Difference in effect of time after June 2013 in birth cohort vs not in birth cohort	1.03	0.98-1.07	1.01	0.93-1.09	1.59	1.52-1.68
Male	0.93	0.91-0.95	0.92	0.89-0.95	1.00	0.98-1.02
Race[b] (ref, non-Hispanic white)						
Non-Hispanic black	1.26	1.23-1.29	1.82	1.76-1.89	1.39	1.35-1.44
Hispanic	1.29	1.24-1.34	1.56	1.41-1.73	1.33	1.29-1.38
Asian/Pacific Islander	1.30	1.25-1.36	1.40	1.29-1.52	1.47	1.43-1.52
American Indian/Alaskan Native	1.17	0.91-1.51	0.85	0.54-1.34	1.03	0.76-1.39
Mixed race	1.60	1.48-1.73	1.87	1.55-2.26	1.32	1.19-1.46
Medical specialty (ref, other/specialty)						
Family practice/adult medicine	1.33	1.29-1.37	1.19	1.11-1.27	1.22	1.18-1.26
OB/GYN	1.73	1.67-1.80	1.45	1.34-1.57	1.39	1.32-1.45
ED/urgent care	1.27	1.22-1.32	1.11	1.01-1.23	1.18	1.13-1.24
Pediatrics	1.34	1.16-1.53	1.08	0.85-1.38	1.14	0.94-1.39
HBV+	4.74	4.11-5.48	5.20	4.23-6.41	4.28	3.68-4.97
HIV+	7.54	7.06-8.06	5.96	5.29-6.71	4.83	4.10-5.69
Prior visit with GI/ID	0.79	0.76-0.83	1.42	1.27-1.59	0.95	0.91-1.00
Median area household income[c] (per $10,000 difference)	0.97	0.96-0.97	0.95	0.94-0.96	0.97	0.97-0.98

ED indicates emergency department; GI/ID, gastroenterology/infectious disease; HBV, hepatitis B virus; HCV, hepatitis C virus; HR, hazard ratio; OB/GYN, obstetrics/gynecology; ref, reference.

[a]All characteristics assessed up to 30 days after first visit.

[b]Nonreported race imputed using Bayesian Improved Geocoding Algorithm.

[c]Source: US Census Bureau, American Community Survey. HRs interpreted for every $10,000 difference.

eAppendix B. Complete Case Analysis of Adjusted HRs of HCV Antibody Testing, including Men Who Have Sex With Men and Illicit Drug Use

	Antibody Screening	
Characteristic[a]	**HR**	**95% CI**
Birth cohort	0.55	0.54-0.56
Effect of time after June 2013 (not in birth cohort)	1.93	1.88-1.98
Difference in effect of time after June 2013 in birth cohort vs not in birth cohort	1.35	1.29-1.40
Male	0.84	0.82-0.86
Race[b] (ref, non-Hispanic white)		
Non-Hispanic black	1.42	1.38-1.45
Hispanic	1.26	1.22-1.30
Asian/Pacific Islander	1.35	1.31-1.40
American Indian/Alaskan Native	1.27	1.02-1.58
Mixed race	1.59	1.48-1.71
Medical specialty (ref, other/specialty)		
Family practice/adult medicine	1.24	1.21-1.28
OB/GYN	1.32	1.27-1.36
ED/urgent care	1.21	1.16-1.26
Pediatrics	1.23	1.08-1.40
HBV+	3.99	3.45-4.60
HIV+	4.36	4.00-4.75
Prior visit with GI/ID	0.91	0.87-0.95
Median area household income[c] (per $10,000 difference)	0.96	0.96-0.96
Clinic location (ref, DC/suburban Maryland)		
Baltimore	0.98	0.96-1.00
Virginia	0.95	0.93-0.97
Men who have sex with men	1.99	1.87-2.12
History of illicit drug use (ref, never used)		
Yes, nonintravenous	2.12	1.97-2.27
Yes, intravenous	7.20	3.17-16.35
Unknown	0.98	0.96-1.01

ED indicates emergency department; GI/ID, gastroenterology/infectious disease; HBV, hepatitis B virus; HCV, hepatitis C virus; HR, hazard ratio; OB/GYN, obstetrics/gynecology; ref, reference.

[a]All characteristics assessed up to 30 days after first visit.

[b]Nonreported race imputed using Bayesian Improved Geocoding Algorithm.

[c]Source: US Census Bureau, American Community Survey. HRs interpreted for every $10,000 difference.