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Hepatitis C screening trends in a large integrated health system

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Abstract

Background—As new hepatitis C virus (HCV) therapies emerge, only 1–12% of individuals are screened in the U.S. for HCV infection. Presently, HCV screening trends are unknown.

Methods—We utilized the Kaiser Permanente Mid-Atlantic States' (KPMAS) data repository to investigate HCV antibody screening between 1/1/2003 and 12/31/2012. We identified the proportion screened for HCV and 5-year cumulative incidence of screening, the screening positivity rate, the provider types performing HCV screening, patient-level factors associated with being screened, and trends in screening over time.

Results—444,594 patients met the inclusion criteria. Overall, 15.8% of the cohort was ever screened for HCV. Adult primary care and obstetrics and gynecology providers performed 75.9% of all screening. The overall test positivity rate was 3.8%. Screening was more frequent in younger age groups ($p<0.0001$) and those with a documented history of illicit drug use ($p<0.0001$). Patients with missing drug use history (46.7%) were least likely to be screened ($p<0.0001$). While the rate of HCV screening increased in the later years of the study, among those enrolled in KPMAS 2009–2012, only 11.8% were screened by the end of follow-up.

Conclusion—Screening for HCV is increasing, but remains incomplete. Targeting screening to those with a history of injection drug will not likely expand screening, as nearly half of patients have no documented drug use history. Routine screening is likely the most effective approach to expand HCV screening.

Keywords

hepatitis c virus; screening trends; screening rates

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INTRODUCTION

There are approximately 3.2 million people infected with chronic hepatitis C virus (HCV) in the U.S., and HCV leads to approximately 12,000 liver-related deaths in the U.S. each year.^{1,2} As new therapies promise opportunity for HCV cure, the public health agenda has placed emphasis on improving HCV screening and engagement in care.³

The United States Preventive Services Task Force has made a “B” level recommendation that all individuals born between 1945 and 1965 be screened for HCV infection at least once. Similarly, the U.S. Centers for Disease Control and Prevention (CDC) recommends routine, one-time HCV screening for individuals born between 1945 and 1965.⁴ Previous studies assessing HCV screening patterns at private healthcare or managed care organizations report that only 1–12% of eligible adults are ever tested for HCV.^{5–7} Screening practices, however, typically vary by geographic region, and even between individual practices.^{8,9} Further, previous studies have not considered how HCV screening has changed over time in response to increasing awareness of improved HCV treatments; nor have they considered the rate at which individuals are screened, focusing instead on the proportion of individuals ever screened and factors associated with screening.

Understanding the frequency with which people are screened for HCV is critical to evaluating the marginal benefits and costs of future interventions to expand HCV screening. We employed data from Kaiser Permanente Mid-Atlantic States (KPMAS), a large integrated healthcare system that serves a broad array of patients in the Maryland, Virginia and Washington, D.C., to study HCV screening frequency, as well as temporal trends in screening practice.

METHODS

Overview

We used the KPMAS’s data repository to investigate HCV screening among patients enrolled with KPMAS between 1/1/2003 and 12/31/2012. We investigated rates of screening stratified by age and sex, trends in screening over time, the proportion of patients who had ever been screened for HCV, provider type of those ordering HCV antibody test (HCV Ab), patient-level factors associated with ever being screened, and the test positivity rate.

Data source

KPMAS is an integrated healthcare system that serves over 500,000 individuals in Maryland, Virginia, and the District of Columbia. KPMAS includes both public and private insurance programs. Studies in other Kaiser Permanente regions demonstrate the demographics of its enrollees closely match those of the population it serves.^{10,11} We utilized the KPMAS electronic medical record data repository, which includes information on demographics, clinical encounters, and laboratory test results for all patients enrolled in KPMAS.

For patients with a reactive HCV Ab, we also utilized the KPMAS HCV registry to abstract relevant laboratory results. The KPMAS HCV-registry includes 6,892 individuals (as of

12/31/2012) enrolled at KPMAS who have documented HCV infection. Inclusion criteria for the HCV registry include: 1) Positive HCV RNA result or HCV genotype; 2) Two or more prescription refills of anti-HCV medications within 365 days; 3) Positive HCV Ab and 2 or more HCV negative RNA tests after the first positive HCV Ab test; 4) Positive HCV Ab test plus 2 or more outpatient HCV coded visits by a provider; 5) Positive HCV Ab test plus 1 outpatient HCV visit by a provider, or 1 positive HCV Ab test; 6) 2 or more outpatient HCV visits by a provider 7) HCV inpatient discharge diagnosis with 1 or more outpatient visits to a provider, or an HCV inpatient discharge diagnosis.

Selection of study population

Individuals included were aged ≥ 18 years, enrolled at KPMAS for at least 8 consecutive months at any time between 1/1/2003 and 12/31/2012 and had at least one primary care visit during the enrollment period. We excluded patients with documented HCV status at enrollment in KPMAS, defined as having any one of the following: 1) documented HCV Ab in the KPMAS registry from a prior enrollment period when the patient was not eligible for this study; 2) a detectable serum HCV RNA or HCV genotype that was ordered before or without HCV Ab and within 6 months of the initial provider visit. Primary care visits included visits to any provider listed as a primary care in the KPMAS system.

Measurement

Demographics—Demographics included birthdate, sex, race, income, and location of KPMAS service area. Because fewer than 50% of KPMAS member records include race/ethnicity and income data, we used the “Bayesian Improved Surname and Geocoding algorithm,” (BISG) to impute missing values.¹² The BISG algorithm links an individual’s surname and census block with population data from the US Census Bureau to estimate the probability that the individual belongs to each of six distinct racial/ethnic categories (white non-Hispanic, black non-Hispanic, Asian/Pacific Islands, Hispanic/Latino, American Indians/Alaska Native, and multiracial).¹³ The method has been validated and demonstrated to accurately estimate the racial/ethnic composition of populations, including the membership in other Kaiser Permanente regions.¹⁴ For patients who reported their race/ethnicity in the KPMAS electronic medical record, the individual probability distributions were replaced by “1” for the indicated racial/ethnic category. Because the majority of racial values were imputed, we conducted all multivariable analyses twice, once including and once excluding race/ethnicity.

Similarly, we imputed income by linking geographically coded addresses with public census data. We used the median household income from the patient’s geocoded census tract as patient’s household income. This method has been previously validated using KPMAS data.¹⁵

Drug use history—Drug use history was extracted from the electronic medical record and reflects patient self-report, as well as physician documentation (or lack of documentation). Documented drug use histories included specific history of both injection drug use and non-injection drug use, as well as a documented history of never using drugs. Because many

members had no documented drug use history (missing data) we maintained “missing” as a distinct category in all multivariable analyses.

Laboratory tests—Laboratory test dates and results included HCV Antibody (Ab), HCV RNA quantitative level, HBV surface antigen (Ag) and surface antibody, HIV antibody, and liver transaminase tests.

Statistical Analysis

We used descriptive statistics, chi square analysis, and t-tests to identify: 1) the proportion of individuals who received at least one HCV Ab test during follow-up; 2) the cumulative incidence of obtaining an HCV Ab over five years; 3) patient-level factors associated with ever being screened with HCV Ab; and 4) the HCV positivity rate among those screened. We also conducted multivariable logistic regression to analyze the odds of ever receiving an HCV Ab test as a function of birth year, sex, race, income level, KPMAS service area location, HIV-infection status, hepatitis B virus (HBV) infection status, history of having 2 sequential alkaline aminotransferase (ALT) levels > 60 IU/L, and documented drug-use history.

To investigate the change in screening rates over time, we utilized Cox proportional hazards modeling, in which receipt of an HCV Ab test was the event of interest. We divided calendar time into 3 periods: 2003–2005, 2006–2008, and 2009–2012, and allowed patients to accrue follow-up in a time updated manner such that those who were followed during two or more calendar periods contributed time to multiple periods as appropriate.

All analyses were performed using SAS version 9.2 (SAS Institute Inc., Cary, NC). We obtained approval from KPMAS Institutional Review Board (IRB), which waived the requirement for informed patient consent, as well as from the Boston Medical Center IRB.

RESULTS

From 1/1/2003 to 8/1/2012, 444,594 patients met the inclusion criteria and were included in the analysis (Figure 1). The mean age at enrollment was 43.6 years and the median length of continuous enrollment was 49 months (Interquartile range [IQR] =24 to 108 months). The cohort was 59.7% female, and the imputed racial composition was 36.3% black (non Hispanic), 39.2% white (non Hispanic), 8.9% Hispanic, and 15.6% other (Table 1). The imputed median household income was \$83,331. 52.0% of patients reported never having used illicit drugs, 46.7% had missing drug use history, 0.6% were HIV-infected, and 0.5% were HBV-infected (Table 1).

Proportion of patients screened and factors associated with being screened

Among patients in the analysis, 15.8% were screened for HCV at least once during follow-up (Table 1). Adult primary care (44.2%) and obstetrics and gynecology providers (31.7%) performed the majority of screening. Of those born between 1945 and 1964, 14.4% were ever screened for HCV. 16.4% of women and 15.0% of men were ever screened. Among those with documented histories of illicit injection and non-injection drug use, 67.4% and 31.6% respectively were ever screened for HCV. Of those with documented history of never

using illicit drugs, 19.9% were ever screened, while of those with missing drug use history, 10.9% were screened. Among patients who ever had 2 sequential ALT tests >60IU/L, 63.9% were ever screened. 75.8% of HIV-infected and 70.2% of HBV-infected individuals were ever screened for HCV. In secondary analysis, 20.1% of black patients and 13.4% of non-black patients were screened for HCV infection.

In multivariate logistic regression, more recent birth year was associated with higher odds of being screened for HCV (Table 2). Compared to those born 1945–1954, the adjusted odds ratio of HCV screening for those born 1965–1974, 1975–1984, and 1985–1994 were 1.54, 1.66, and 1.72, respectively. Females were more likely to have ever been screened compared to males (adjusted odds ratio [aOR] = 1.12). Clinical factors associated with being more likely to have been screened for HCV included having a documented history of illicit injection drug use (aOR = 6.55 vs. a documented history of never using drugs), or illicit non-injection drug use (aOR = 1.48), having 2 or more sequential ALT levels >60 IU/L (aOR = 14.35 vs. no sequential ALT >60IU/L), HIV-infection (aOR = 16.35 vs. no HIV infection), and HBV-infection (aOR = 11.16 vs. no HBV infection). Patients who had no documentation of their drug use history were less likely to be screened than those who had a documented history of never having used illicit drugs (aOR = 0.57). Screening did not differ significantly by the location of the service area. When we included imputed race and income in the analysis, black patients were more likely to be screened compared to white patients (aOR = 1.73). Those with annual income ≥\$100,000 were more likely to be screened than those with income <\$57,000 (aOR = 1.13), as were those with income \$57,000–\$78,999 (aOR = 1.09 vs. income <\$57,000).

Cumulative incidence of HCV screening, screening rates and HCV positivity rate

The 60-month cumulative incidence of screening was 11.5% for males and 12.2% for females (11.9% for in total) (Figure 2). The 60-month cumulative incidence of screening was highest among females born 1985–1994 (24.6%) and lowest among females born prior to 1944 (5.5%). At all time points, the cumulative incidence of screening was highest among those born between 1985 and 1994 and it decreased monotonically with older age. The rate of screening was not linear. Nearly half of all screening (43.7%) occurred in members' first 12 months of enrollment, while only 9.5% occurred in year 5.

Among those who had an HCV Ab test, the highest positivity rate among females and males were those born between 1945–1954 (6.3% and 14.3%, respectively). The overall positivity rate among females and males was 2.5% and 6.0%, respectively (3.8% in total) (Table 3).

HCV testing rates over time

In time to event analyses, the rate of HCV screening was constant between 2003 and 2008, but increased significantly between 2009 and 2012 (adjusted hazard ratio [HR] 2009–2012 vs. 2006–2008 = 1.92; 95% CI 1.89–1.96). Among those who were enrolled 2009–2012 and had at least 8 months of consecutive follow-up, 11.8% were ever screened by the end of follow-up.

DISCUSSION

This analysis demonstrates that among patients attending a large U.S. integrated healthcare system, 15.8% had ever been tested for HCV with serum antibody. Testing rates were significantly higher in high-risk groups such as injection drug users, HIV-infected, HBV-infected, and those with sequential ALT levels >60 IU/L (though even in these highest-risk populations, substantial numbers of patients were never screened).

Screening rates within KPMAS are higher than those reported elsewhere. Roblin et al. report that in Georgia, HCV serum antibody testing was performed in 4.3% of the population analyzed, with a 5.15% positivity rate.⁵ Similarly, Spradling et al. report that across 4 managed care organizations in the U.S. (not including KPMAS), 12.7% of adults were tested for HCV, with a positivity rate of 5.5%. In that study, characteristics independently associated with being tested for HCV were being in the 30–59 age group and being black or American Indian/Native Alaskan.⁶

In our study, screening rates were lower than anticipated in those born 1945–1965, the birth cohort with the highest reported prevalence of HCV infection nationally, and the cohort with the highest positivity rate among those screened in this analysis.¹⁶ The high prevalence of HCV in this group, which likely reflects both an unsafe blood supply throughout much of this cohort's lifetime, as well as a high prevalence of at least one-time injection drug use,¹⁷ motivated the recent CDC recommendation for routine HCV screening among those born 1945–1965 without further risk stratification.¹⁸ It is important to note that CDC released its guidelines only at the end of this study's follow-up period. Further, the U.S. Preventive Services Task Force did not recommend birth cohort-based screening during the time period of this study.¹⁹ As a result, providers in this study likely followed guidelines for HCV screening based on HCV risk behaviors, not age.

This analysis thus demonstrates the potential deficiencies of risk-targeted HCV screening. This cohort had generally low screening rates, and 46.7% of patients had no documentation of screening for drug-use behaviors in their medical record, despite the existence of a dedicated field for drug use history in the electronic medical record. Patients without documented drug use history had the lowest HCV screening rates—even lower than those who had a documented history of never using illicit drugs. The findings suggest that few providers discuss drug use with their patients, and that unless providers actively consider drug use when taking medical histories, they are unlikely to subsequently offer HCV testing.

The analysis also suggests the potential strengths of non-targeted HCV screening. Within KPMAS, screening rates were highest among young women. Given that gynecologists accounted for approximately 1/3 of all HCV Ab tests ordered, the finding likely reflects the local practice of more routine screening for HCV as part of sexually transmitted disease or gynecologic care.²⁰ The test positivity rate among women born 1985–1994 was 0.3%, corresponding to a number needed to screen to find one case of HCV infection of 333 people. While the value of screening this lower risk population is best estimated through formal decision analysis, the unexpectedly high rate of screening among young women is

proof of concept that routine, rather than risk-targeted, HCV screening within an integrated healthcare network does expand the proportion of people who know their HCV status.

Finally, this analysis shows that even without changes in guidelines or dedicated resources, HCV screening in the U.S. is expanding. Patients engaged with KPMAS in the later periods of the study were significantly more likely than those at the beginning to be tested for HCV. Overall, however, testing rates remained low among study subjects. Therefore, this finding should not create a false impression that secular trends will likely expand HCV screening to the extent necessary to achieve HCV screening rates recommended by CDC.

There are several limitations to this analysis. First, because categorical racial data are incomplete in the KPMAS electronic medical record for the time period studied. We imputed missing values, however, using a valid method, and also report results without including imputed data.¹⁴ Additionally, we lacked complete data to assess drug use histories.^{17,21,22} We maintained a “missing” value for drug use history, however, and found that the missing data were themselves informative. Similarly, income-level data is based on geocoding and not based on individual patient reporting. Lastly, the dataset included only laboratory results and visits within the KPMAS system. Some patients may have had HCV screening prior to enrollment in KPMAS, or at an outside site. KPMAS is generally a closed network, however, and most members receive care within the network, minimizing the risk of unobserved events.

In conclusion, this study demonstrates that in a large, U.S. integrated healthcare system, screening for HCV infection is incomplete, and largely targeted at patients with known risk factors for HCV, such as HIV or HBV infection, or those with elevated liver transaminase levels. Other risk factors, such as history of drug use, are infrequently documented, and those without documentation of drug use history are less likely to be screened. Further, screening is incomplete in the age groups that have the highest prevalence of HCV-infection in the general U.S. population. While HCV screening rates have increased over time, few patients are currently ever screened. As more effective HCV therapies become available, interventions are needed to expand HCV screening in the U.S.

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REFERENCES

1. Wise M, Bialek S, Finelli L, Bell BP, Sorvillo F. Changing trends in hepatitis C-related mortality in the United States, 1995–2004. *Hepatology* (Baltimore Md.). 2008 Apr; 47(4):1128–1135.
2. Centers for Disease Control and Prevention. [Accessed May 15, 2013] Disease Burden from Viral Hepatitis A, B, and C in the United States. Available at: <http://www.cdc.gov/hepatitis/HCV/StatisticsHCV.htm>.
3. Holmberg SD, Spradling PR, Moorman AC, Denniston MM. Hepatitis C in the United States. *The New England journal of medicine*. 2013 May 16; 368(20):1859–1861. [PubMed: 23675657]

4. Smith BD, Morgan RL, Beckett GA, et al. Recommendations for the identification of chronic hepatitis C virus infection among persons born during 1945–1965. *MMWR. Morbidity and mortality weekly report*. 2012 Aug 17; 61(RR-4):1–32.
5. Roblin DW, Smith BD, Weinbaum CM, Sabin ME. HCV screening practices and prevalence in an MCO, 2000–2007. *The American journal of managed care*. 2011; 17(8):548–555. [PubMed: 21851142]
6. Spradling PR, Rupp L, Moorman AC, et al. Hepatitis B and C virus infection among 1.2 million persons with access to care: factors associated with testing and infection prevalence. *Clinical infectious diseases : an official publication of the Infectious Diseases Society of America*. 2012 Oct; 55(8):1047–1055. [PubMed: 22875876]
7. Shatin D, Schech SD, Patel K, McHutchison JG. Population-based hepatitis C surveillance and treatment in a national managed care organization. *The American journal of managed care*. 2004 Apr; 10(4):250–256. [PubMed: 15124501]
8. Johnson A, Heitgerd J, Koenig L, et al. Vital signs: HIV testing and diagnosis among adults—United States, 2001–2009. *MMWR. Morbidity and mortality weekly report*. 2010 Dec 3; 59(47):1550–1555. [PubMed: 21124295]
9. Bernstein KT, Begier E, Burke R, Karpati A, Hogben M. HIV screening among U.S. physicians 1999–2000. *AIDS patient care and STDs*. 2008 Aug; 22(8):649–656. [PubMed: 18627282]
10. Krieger N. Overcoming the absence of socioeconomic data in medical records: validation and application of a census-based methodology. *Am J Public Health*. 1992 May; 82(5):703–710. [PubMed: 1566949]
11. Gordon NP. How Does the Adult Kaiser Permanente Membership in Northern California Compare with the Larger Community? Available at: [http://www.dor.kaiser.org/external/uploadedFiles/content/research/mhs/_2011_Revised_Site/Documents/Special_Reports/comparison_kaiser_vs_nonKaiser_adults_kpnc\(1\).pdf](http://www.dor.kaiser.org/external/uploadedFiles/content/research/mhs/_2011_Revised_Site/Documents/Special_Reports/comparison_kaiser_vs_nonKaiser_adults_kpnc(1).pdf).
12. Elliott MN, Fremont A, Morrison PA, Pantoja P, Lurie N. A new method for estimating race/ethnicity and associated disparities where administrative records lack self-reported race/ethnicity. *Health services research*. 2008 Oct; 43(5 Pt 1):1722–1736. [PubMed: 18479410]
13. United States Census Bureau. [Accessed August 30, 2013] Population estimates. Available at: <http://www.census.gov/popest/data/>.
14. Derose SF, Contreras R, Coleman KJ, Koebeck C, Jacobsen SJ. Race and ethnicity data quality and imputation using U.S. Census data in an integrated health system: the Kaiser Permanente Southern California experience. *Medical care research and review : MCRR*. 2013 Jun; 70(3):330–345. [PubMed: 23169896]
15. Knight L, Scott L. Introduction to the GEMS Datamart: Kaiser Permanente. 2010:33.
16. Chak E, Talal AH, Sherman KE, Schiff ER, Saab S. Hepatitis C virus infection in USA: an estimate of true prevalence. *Liver international : official journal of the International Association for the Study of the Liver*. 2011 Sep; 31(8):1090–1101. [PubMed: 21745274]
17. Armstrong GL, Wasley A, Simard EP, McQuillan GM, Kuhnert WL, Alter MJ. The prevalence of hepatitis C virus infection in the United States, 1999 through 2002. *Annals of internal medicine*. 2006 May 16; 144(10):705–714. [PubMed: 16702586]
18. Smith BD, Morgan RL, Beckett GA, et al. Recommendations for the identification of chronic hepatitis C virus infection among persons born during 1945–1965. *MMWR*. 2012 Aug 17; 61(RR-4):1–32.
19. United States Preventive Services Task Force. Screening for Hepatitis C Virus Infection in Adults. 2013 Available at: <http://www.uspreventiveservicestaskforce.org/uspstf/uspshcpch.tm>.
20. Horberg, MA. Personal communication with Linan, BP. BP, L., editor. 2013. 2013.
21. Edlin BR, Carden MR. Injection Drug Users: The Overlooked Core of the Hepatitis C Epidemic. *Clinical Infectious Disease*. 2006; 42(5):673–676.
22. Shepard CW, Finelli L, Alter MJ. Global epidemiology of hepatitis C virus infection. *The Lancet infectious diseases*. 2005 Sep; 5(9):558–567. [PubMed: 16122679]

Figure 1.

A flow chart of the construction of the analysis cohort from the Kaiser Permanente Mid-Atlantic States Region Electronic Medical Record.

Figure 2.

Cumulative incidence of receiving an HCV antibody test following enrollment in the Kaiser Permanente Mid-Atlantic States integrated healthcare plan. Results are presented for men (A) and women (B) and are stratified by year of birth.

Table 1

Demographic characteristics of patients in KPMAS

Characteristic	Ever Screened N=70,438 (15.8%) N (%)	Never Screened N=374,156 (84.2%) N (%)	Total N= 444,594 N (% of total N)	P-value
Birth year				<0.0001
1985–1994	6,677 (22.9)	22,516 (77.1)	29,193 (6.6)	
1975–1984	15,412 (19.3)	64,607 (80.7)	80,019 (18.0)	
1965–1974	16,172 (18.6)	71,005 (81.5)	87,177 (19.6)	
1955–1964	15,026 (15.5)	81,734 (84.5)	96,760 (21.8)	
1945–1954	10,580 (13.0)	70,637 (87.0)	81,217 (18.3)	
Born before 1944	6,571 (9.4)	63,657 (90.6)	70,228 (15.8)	
Gender				<0.0001
Male	26,821 (15.0)	152,246 (85.0)	179,067 (40.3)	
Female	43,617 (16.4)	221,910 (83.6)	265,527 (59.7)	
Two ALT >60U/L	8,919 (63.9)	5,032 (36.1)	13,951 (3.1)	<0.0001
Co-infection				
HIV	2,124 (75.8)	680 (24.3)	2,804 (0.6)	<0.0001
HBV	1,474 (70.2)	627 (29.8)	2,101 (0.5)	<0.0001
Documented drug use				<0.0001
None	45,935 (19.9)	185,181 (80.1)	231,116 (52.0)	
Non-IDU	1,784 (31.6)	3,850 (68.4)	5,634 (1.3)	
IDU	31 (67.4)	15 (32.6)	46 (0.01)	
Unknown	22,688 (10.9)	185,110 (89.1)	207,798 (46.7)	
KPMAS Service Area (Sub-region)				<0.0001
Baltimore	9,159 (14.8)	52,545 (85.2)	61,704 (13.9)	
DC/South Maryland	36,912 (17.7)	171,836 (82.3)	208,748 (47.0)	
Northern Virginia	24,277 (14.0)	148,685 (86.0)	172,962 (38.9)	
Missing	90 (7.6)	1,090 (92.4)	1,180 (2.6)	
Race ¹				<0.0001
Black (non-Hispanic)	32,418 (20.1)	128,891 (79.9)	161,309 (36.3)	
Latino/Hispanic	6,445 (16.3)	33,048 (83.7)	39,493 (8.9)	
Asian/Pacific Islander	6,553 (16.7)	32,662 (83.3)	39,215 (8.8)	
American Indian/Alaska Native	165 (16.8)	815 (83.2)	980 (0.2)	
Multiracial	1,130 (15.8)	6,033 (84.2)	7,163 (1.6)	
Unknown	1,734 (7.9)	20,220 (92.1)	21,954 (4.9)	
White (non-Hispanic)	21,973 (12.6)	152,416 (87.4)	174,389 (39.2)	
Mean household income (IQR) ^{1,2}	78,745 (52,481–99,613)	84,270 (57,803–105,466)	83,331 (56,883–104,172)	<0.0001

IQR= interquartile range; ALT= alkaline amino transferase; HIV= human immunodeficiency virus; HBV= hepatitis B virus; IDU= injection drug user Note: Household income was conducted by t-test; all other analyses were conducted using χ^2 .

¹Fewer than 50% had documented race in the KPMA medical record. For such patients we imputed racial data using the Bayesian Improved Surname Geocoding Algorithm (see methods section for details). Patients who did not have adequate data for imputation are included in this table as racial category “unknown.”

²US\$; Most recent median household income was derived from U.S. census data (see methods for details).¹³

Table 2

Multivariable logistic regression of the odds of ever being screened for HCV infection

Characteristic	Including imputed race/income		Not including race/income	
	Adjusted Odds Ratio (95% CI)	P-value	Adjusted Odds Ratio (95% CI)	P-value
Birth year		<0.0001		<0.0001
1985–1994	1.72 (1.65, 1.79)		1.72 (1.65–1.79)	
1975–1984	1.66 (1.61, 1.71)		1.62 (1.57, 1.67)	
1965–1974	1.54 (1.49, 1.59)		1.55 (1.51, 1.60)	
1955–1964	1.18 (1.14, 1.22)		1.19 (1.16, 1.23)	
Born before 1944	0.79 (0.76, 0.82)		0.78 (0.75, 0.81)	
1945–1954	Reference		--	
Gender		<0.0001		<0.0001
Female	1.12 (1.10, 1.14)		1.12 (1.10, 1.14)	
Male	Reference		--	
Two ALT>60U/L	14.35 (13.76, 14.96)	<0.0001	13.95 (13.39, 14.53)	<0.0001
Co-infection				
HIV infection	16.35 (14.73, 18.15)	<0.0001	16.91 (15.28, 18.71)	<0.0001
HBV infection	11.16 (9.96, 12.51)	<0.0001	11.25 (10.08, 12.56)	<0.0001
Documented drug use	<0.0001		<0.0001	
Non-IDU	1.48 (1.38, 1.58)		1.52 (1.42, 1.62)	
IDU	6.55 (3.13, 13.70)		6.91 (3.35, 14.26)	
Unknown	0.57 (0.56, 0.58)		0.54 (0.53, 0.55)	
None	Reference		—	
KPMAS Service Area (Sub-region)		0.0596		0.0008
Baltimore	0.88 (0.71, 1.09)		0.92 (0.75, 1.14)	
DC/ South Maryland	1.11 (0.94, 1.31)		1.28 (1.08, 1.50)	
Northern Virginia	Reference		--	
Race ¹		<0.0001		—
Black (non-Hispanic)	1.73 (1.68, 1.78)		--	
Latino/Hispanic	1.07 (1.03, 1.11)		--	
Asian/Pacific Islander	1.23 (1.18, 1.28)		--	
American Indian/Alaska Native	1.60 (1.24, 2.06)		--	
Multiracial	1.21 (1.07, 1.35)		--	
White (non-Hispanic)	Reference		--	
Household income (US\$) ^{1,2}		<0.0001		--
100,000	1.13 (1.10, 1.16)		--	
79,000–99,999	1.11 (1.08, 1.14)		--	
57,000–78,999	1.09 (1.06, 1.12)		--	
<57,000	Reference		--	

ALT= alkaline amino transferase; HIV= human immunodeficiency virus; HBV= hepatitis B virus; IDU= injection drug user

¹Fewer than 50% had documented race in the KPMA medical record. For such patients we imputed racial data using the Bayesian Improved Surname Geocoding Algorithm (see methods section for details). Patients who did not have adequate data for imputation (N= 21,954) were excluded from multivariable analyses.

²US\$; Most recent median household income was derived from U.S. census data (see methods for details). ¹³

Table 3

Positivity rate among those who had HCV serum antibody tests

Birth Year	Female (%)	Male (%)	Total
1985–1994	0.3	0.6	0.4
1975–1984	0.6	0.9	0.7
1965–1974	1.1	1.6	1.3
1955–1964	4.9	9.9	7.0
1945–1954	6.3	14.3	10.0
Before 1944	3.3	4.0	3.6
Total	2.5	6.0	3.8