RESEARCH ARTICLE

Effect of travel distance and rurality of residence on initial surveillance for hepatocellular carcinoma in VA primary care patient with cirrhosis

Yolanda Rodriguez Villalvazo MD, MPH^{1,2,3} | Jennifer S. McDanel PhD³ |
 Lauren A. Beste MD, MSc^{4,5,6} | Antonio J. Sanchez MD⁷ |
 Mary Vaughan-Sarrazin PhD^{1,3} | David A. Katz MD, MSc^{1,2,3}

¹Center for Access and Delivery Research & Evaluation (CADRE), Iowa City VA Healthcare System, Iowa City, Iowa

²Iowa City VA Healthcare System, Iowa City, Iowa

³Department of Internal Medicine, University of Iowa Hospitals and Clinics, Iowa City, Iowa

⁴General Medicine Service and Health Services Research and Development, Seattle, Washington

⁵VA Puget Sound Health Care System, Seattle, Washington

⁶Department of Medicine, University of Washington School of Medicine, Seattle, Washington

⁷Department of Gastroenterology and Hepatology, University of Iowa Hospitals and Clinics, Iowa City, Iowa

Correspondence

Yolanda Rodriguez Villalvazo, MD, MPH, Comprehensive Access and Delivery Research & Evaluation (CADRE) Center, Iowa City VA Healthcare System, 601 HWY 6 West, Mailcode 111, Building 1, Iowa City, Iowa 52242.

Email: Yolanda.RodriguezVillalvazo@va.gov

Abstract

Objective: To determine the relationship between travel distance and surveillance for hepatocellular carcinoma among veterans with cirrhosis.

Data Sources: Veterans Health Administration (VHA) inpatient and outpatient administrative data were linked to geocoded enrollee files. CMS-VHA merged data were used to assess receipt of Medicare-financed non-VA imaging.

Study Design: A retrospective cohort of US veterans diagnosed with cirrhosis between 2009 and 2015 was examined. First available abdominal imaging following the diagnosis of cirrhosis was analyzed separately as a function of travel distance to the nearest VA medical center (VAMC) and to the patient's assigned VA primary care provider. Veterans with dual use of Medicare and VA services were also examined for receipt of imaging outside of the VA.

Principal Findings: Veterans who resided more than 30 miles from the nearest VAMC were less likely to receive any imaging for HCC surveillance. Among dual users, increased travel distance between the patient's residence and nearest VAMC was associated with an increased likelihood of receiving any abdominal imaging at *non-VA* facilities.

Conclusion: Increased travel distance to the nearest VA medical center reduces the likelihood of receiving imaging for HCC surveillance in cirrhotic veterans. Future efforts should focus on reducing geographic barriers to HCC surveillance.

KEYWORDS

cirrhosis, hepatocellular carcinoma, rural health, screening, Veterans

1 | INTRODUCTION

Hepatocellular carcinoma (HCC), a known complication of cirrhosis of the liver and non-cirrhotic hepatitis B infection, is the second leading cause of cancer-related mortality worldwide^{1,2} and is the fastest rising cancer-related cause of death in the United States.³ Since the

1970s, the age-adjusted incidence of HCC in the United States has tripled from 1.6 per 100 000 to 4.9 per 100 000,⁴ while mortality has increased 43 percent from 2000 to 2016.⁵ HCC is potentially curable if detected at an early stage, but 5-year survival is only 28 percent in localized stages I-IIIB versus 7 percent for regional stages IIIC-IVA and 2 percent in distant stage IVB disease.⁶

In 2005, the American Association for the Study of Liver Disease (AASLD) recommended HCC surveillance with ultrasonography and alpha-fetoprotein (α FP) every 6-12 months for patients with cirrhosis of various etiologies and selected hepatitis B carriers.⁷ Veterans Affairs (VA) 2009 recommendations for management and treatment of cirrhosis reflect these recommendations.⁸ Current AASLD guidelines recommend HCC surveillance imaging plus alpha fetoprotein testing of all adults with cirrhosis every 6 months and suggest not performing surveillance in patients with Child's class C (unless they are on a waiting list for liver transplantation).⁹

Despite these recommendations, it has been estimated that only 45 percent of US veterans with cirrhosis receive any form of HCC surveillance, including limited surveillance with α FP alone.¹⁰ Within the Veterans Health Administration (VHA), guideline-concordant surveillance is performed in less than 20 percent of patients, similar to the proportion of the entire US cirrhosis population who receive appropriate HCC surveillance.¹¹ Previous studies have attributed the gaps in HCC surveillance to health care providers' under-recognition of cirrhosis and lack of knowledge of HCC guidelines,^{12,13} as well as patient-related factors such as lack of health care engagement,¹⁴ nonadherence,¹⁵ and racial and socioeconomic disparities.^{16,17} Geographic factors, such as travel distance to a VA health care facility and rurality, have also been implicated^{18,19} and may be particularly important given that only 55 percent of veterans live within 40 miles of a VA medical center.²⁰ Various definitions of geographic access have been used; however, the association between travel distance, rurality, and HCC surveillance is poorly understood, particularly in dual users of Medicare and VA services.

We hypothesized that both increased travel distance to the nearest VA medical center and to the assigned VA primary care provider (PCP) may reduce the utilization of appropriate HCC surveillance in these patients. Community-based outpatient clinics (CBOCs)

typically have on-site basic laboratory services but are rarely equipped to perform diagnostic imaging (including ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI), which are usually done at VA medical centers). Thus, the aim of this study is to evaluate initial HCC surveillance among veterans with cirrhosis as a function of travel distance between the veteran's residence and the following locations: (a) VA diagnostic imaging services and (b) the outpatient clinic of the patient's assigned VA PCP. We also extend prior research by evaluating the relationship between travel distance and use of non-VA HCC surveillance by dual users. Further information is needed to increase the appropriate use of HCC surveillance in at-risk veterans in the era of the Veterans Choice Act.²¹

2 | MATERIALS AND METHODS

2.1 | Conceptual model

Figure 1 illustrates the relationship of HCC surveillance as a function of geographic access. Our model of access to HCC surveillance is based on the framework of Aday and Anderson, who described the key determinants of potential and actual entry of a given population into the health care delivery system.²² Given recent innovations in communications technology, others have argued that access should be re-conceptualized to include digital connectivity,²³ such as telehealth and teleradiology.

Our conceptual model assumes a well-defined population at risk for HCC, defined by a documented diagnosis of cirrhosis and active use of VA services. In this framework, geographic access is defined by the relationship between the patient's residence (defined by a zip code and rurality), other predisposing patient characteristics (eg, age, sex, race, ethnicity, income, comorbidities, and

FIGURE 1 Conceptual model for HCC Surveillance as a function of geographic access. d_1 —Travel distance between the patient's residence and the outpatient clinic of his/her assigned VA primary care provider (PCP). d_2 —Travel distance between the patient's residence and the medical center. d_3 —Travel distance from the patient's residence to non-VA medical services (ie, non-VA medical provider or imaging center)—this is shown as a dotted line as these distance values are not available in the dataset. The outpatient clinic could be located in a CBOC or within a medical center. Note that $d_1 = d_2$ if the patient's VA outpatient clinic is also located in the nearest VA medical center. Abbreviations: CBOC, community-based outpatient clinic; HCC, hepatocellular carcinoma

severity of liver disease), and characteristics of the health care facility (eg, medical center versus CBOC, laboratory, and imaging capability) that may drive actual utilization of HCC surveillance. In Figure 1, d_1 denotes the travel distance required for the patient to access the health care system, typically through a PCP. While the patient is likely to get laboratory services on-site at the PCP's office, the necessary imaging is generally performed at a VA medical center (in special cases, diagnostic imaging is contracted to an independent non-VA imaging center). For this procedure, the patient needs a separate appointment, often on a different date, and must travel from his/her residence to the VA medical center (d_2). An exception to this travel model occurs when the PCP is located within a VA medical center with imaging capability ($d_1 = d_2$). Alternatively, the patient could be a dual user of VA and non-VA primary care, where HCC surveillance is ordered through a non-VA PCP and performed at a non-VA imaging center (d_3).

In the 1970s, the Veterans Health Administration (VHA) instituted travel reimbursement for eligible veterans to receive health care at VA facilities²⁴; it is estimated that 76.7 percent of veterans are eligible for travel reimbursement. In more recent years, veterans may also receive HCC surveillance at a non-VA imaging center if they reside more than 40 miles from the closest VA imaging facility as a result of the Veterans Choice Act.²¹

2.2 | Design and study population

The Department of Veterans Affairs (VA) health care system includes 154 medical centers and over 900 community-based outpatient clinics (CBOCs). Using national VA data, we assembled a retrospective cohort of veteran patients who were diagnosed with cirrhosis at 18 years of age or older between October 1, 2009, and September 30, 2015 (with follow-up through 2016), and who had at least one inpatient or two outpatient diagnosis codes for cirrhosis. Cirrhosis was defined by *International Classification of Diseases, Ninth and Tenth Revision, Clinical Modification* (ICD-9 CM) codes 571.2, 571.5, and 571.6 and (ICD-10 CM) codes K70.30, K74.0, K74.60, K74.69, K74.3, K74.4, and K74.5. These ICD-9-CM codes for cirrhosis were previously shown to have a positive predictive value (PPV) of 90 percent, a negative predictive value (NPV) of 87 percent, and kappa = 0.70 in a veteran population.²⁵ The start date of the study cohort was four years after the AASLD's HCC surveillance guidelines were released.^{7,8} For the purpose of this analysis, we focused on HCC surveillance in patients with cirrhosis from any etiology and excluded hepatitis B carriers without cirrhosis.

Each veteran was assigned an index date based on the first documented diagnosis of cirrhosis using the diagnosis codes noted above. A minimum of two inpatient or outpatient visits (at least one during the year prior to diagnosis and at least one during the year after the index date) designated the patient as an active recipient of VA health care services. We excluded patients with a documented diagnosis of hepatocellular carcinoma or metastasis to the liver from another primary cancer prior to or at the time of the diagnosis of cirrhosis. Patients with dementia, disseminated malignancy without

specification of site, and those enrolled in Hospice/Palliative Care were also excluded, as surveillance is generally indicated only for those patients who are treatment candidates if HCC is discovered at a potentially curable stage. Patients who died within one year of the cirrhosis index date and those whose cirrhosis index date was less than 6 months from the end of the study period were also excluded, as we required at least one year of follow-up to assess HCC surveillance. In addition, patients with missing age, gender, zip codes, rurality designation, or pertinent laboratory data (ie, creatinine, INR, total bilirubin) were excluded (Figure 2).

This study was approved by the University of Iowa Institutional Review Board.

2.3 | Data sources

Study data were derived from four data sources. The VA Outpatient Care File (OPC) contains administrative records for all encounters in VA outpatient clinics and inpatient settings. Data elements include the following information: residential zip code, clinic identifier, clinic specialty (eg, primary care, mental health), and principal and secondary diagnoses codes based on the ICD-9 CM, ICD-10 CM, and *Current Procedural Terminology* (CPT) codes. The VA Inpatient Treatment Files (PTF) contains similar information for care provided in inpatient settings. The VHA Fee Basis Program (2009) contains data on non-VA encounters that are paid for by the VA. For the purpose of risk adjustment, we used the VA Managerial Cost Accounting (MCA) laboratory files to identify the most recent values (within 6 months of the cirrhosis index date) of the following laboratory tests: creatinine, INR, and total bilirubin.

Information on Medicare enrollment and services received through Medicare for those veterans who were simultaneously enrolled in VA and CMS (dual users) was obtained from the CMS-VHA Medicare merged data files for years 2009-2015, available through the VA Information Resource Center (VIREC).²⁶ For this study, information about enrollment in Medicare was derived from the Medicare Beneficiary Summary File, the outpatient Carrier Standard Analytical File (SAF) for outpatient physician services (Medicare Part B) and the inpatient Carrier Standard Analytical File for inpatient hospital services (Medicare Part A). Medicare records were merged with VA administrative data using a unique scrambled social security number.

2.4 | Measurements

2.4.1 | Independent variables

The primary independent variables of interest were travel distance and the rurality of the patient's residence. Two types of travel distance were determined using the Department of Veterans Affairs Planning Systems Support Group (PSSG) geocoded enrollee file: (a) the distance between the patient's residence and the nearest VA medical center, and (b) the distance between the patient's residence and his/her assigned VA PCP (Figure 1). These distance variables were divided into

FIGURE 2 Flowchart of analysis sample cohort inclusion and exclusion criteria.

Notes. *Cirrhosis defined by ICD-9 CM Codes 571.2 Alcoholic cirrhosis of the Liver, 571.5 Cirrhosis of the Liver without Alcohol, 571.6 Biliary Cirrhosis (ICD-10 CM codes K70.30 Alcoholic cirrhosis of the Liver, K74.0 Hepatic fibrosis, K74.60 Unspecified cirrhosis of the Liver, K74.69 Other Cirrhosis of the Liver, K74.3 Primary Biliary Cirrhosis, K74.4 Secondary Biliary Cirrhosis, K74.5 Biliary Cirrhosis, unspecified).

†Liver cancer defined by ICD-9 CM codes: 155.0 Malignant neoplasm of the liver, primary, 155.1 Malignant neoplasm of intrahepatic bile ducts (ICD-10 CM codes: C22.0 Liver cell carcinoma (including hepatocellular carcinoma and hepatoma), C22.1 Intrahepatic bile duct carcinoma (including cholangiocarcinoma), C22.2 Hepatoblastoma, C22.3 Angiosarcoma (including Kupffer cell sarcoma), C22.4 Other sarcomas of liver, C22.7 Other specified carcinomas of liver, C22.8 Malignant neoplasm of liver, primary, unspecified as to type).

#Metastatic cancer to the liver defined by ICD-9 CM Code 155.2 Malignant neoplasm of liver, not specified as primary or secondary (ICD-10 CM code C22.9 Malignant neoplasm of liver, not specified as primary or secondary) and ICD-9CM Code 199.0 Carcinomatosis NOS disseminated malignant neoplasm, unspecified (ICD 10-CM code C 80.0 Carcinomatosis NOS disseminated malignant neoplasm, unspecified).

‡Hospice and Palliative Care defined by ICD-9CM code V66.0 and V66.7 Palliative Care Encounter (and ICD 10-CM code Z51.5 Palliative Care).

**Dementia defined by ICD-9 CM Codes: 290.x Senile dementia with delusional features (with paranoid features), 290.x Senile dementia with depressive features, 290.x Senile dementia with delirium (with acute confusional state), 290.41 Vascular dementia with delirium, 290.42 Vascular dementia with delusions, 291.1, 291.2 Alcohol-induced persisting dementia (Alcoholic dementia, Alcoholism associated with dementia), 294.20, 294.21 Dementia without or with behavioral disturbance (ICD-10 CM codes: F03.- Senile dementia with delusional features (with paranoid features), F03.- Senile dementia with depressive features, F03.- (F05.90) Senile dementia with delirium (with acute confusional state), F01.51 Vascular dementia with delirium, F01.51 Vascular dementia with delusions, F10.96 Alcohol-induced persisting dementia (Alcoholic dementia, Alcoholism associated with dementia), F10.27 Alcohol-induced dementia with alcoholic dependence, F03.90 Dementia without or with behavioral disturbance (without behavioral disturbance) and F03.91 Dementia without or with behavioral disturbance (with behavioral disturbance). [Color figure can be viewed at wileyonlinelibrary.com]

four categories: less than 10 miles, 10 miles to less than 30 miles, 30 miles to less than 60 miles, and more than 60 miles.²⁷

The PSSG geocoded enrollee file also contains a geographic variable (obtained in collaboration with the US Census Bureau) that classifies the rurality of each enrollee's residence using the following prespecified categories, which are based on total population and

commuting flow patterns: urban (>50 000 population), large rural towns (10 000-49 999 population), small rural towns (2500 and 9999 residents), and isolated rural area (<2500 population).^{28,29} This file is used by PSSG and the VA Office of Enrollment and Forecasting to spatially analyze and forecast the use of health services in each regional Veterans Integrated Services Network (VISN).

2.4.2 | Outcome variables

Our main outcome variable was the occurrence of initial HCC surveillance following the cirrhosis index date as identified in the VA inpatient or outpatient encounter data. Acceptable surveillance was defined as having one of the following imaging procedures using *Current Procedural Codes*, with or without α FP (CPT code 82105) testing, within 12 months of the index date: (a) complete abdominal US (CPT code 76700), (b) abdominal CT with and without contrast (CPT code 74170), and (c) abdominal MRI with and without contrast (CPT code 74183). Among those who received US imaging, we determined the proportion of patients who had a limited abdominal ultrasound (CPT 76705), which is defined as a limited study of a single organ or a restricted area of the abdomen. In patients with cirrhosis, limited ultrasound is sometimes used to assess the presence of ascites and may not necessarily include adequate views of the liver for HCC surveillance. Current AASLD guidelines do not specify whether complete or limited US should be used to assess for HCC.⁹ In this study, both complete and limited US studies were included as dependent variables in this analysis.

Acceptable HCC surveillance imaging was broadened to include CT and MRI with and without contrast to assess the use of diagnostic imaging by ordering providers who may or may not be familiar with current guidelines. Alpha-fetoprotein alone in the absence of an abdominal US, CT, or MRI within 12 months of the index date was considered inconsistent with VA recommendations for HCC surveillance.⁸ Despite the fact that AASLD guidelines recommend HCC surveillance every six months, we defined surveillance within 12 months of the index date as a minimum benchmark in order to account for scheduling constraints, transportation barriers, and yearly health maintenance follow-up.

2.4.3 | Covariates

We assessed the following potential patient-related factors related to surveillance: demographics, non-hepatic comorbidities (using the Gagne comorbidity score),³⁰ severity of liver disease (using the Model for End-Stage Liver Disease (MELD) score), and prior use of VA ambulatory care; clinical variables were evaluated at the index date. Ethnicity or race was missing for approximately 7.2 percent of patients; these patients were combined into a separate unknown race category. No patients had missing age, gender, or income information. We did not include the specific etiology of cirrhosis in our models, as the primary aim of this analysis was to evaluate HCC surveillance in patients with documented cirrhosis, irrespective of etiology. If no laboratory studies were available at the cirrhosis index date, then the first complete set of laboratories within 6 months before or after the cirrhosis index date was used. Use of outpatient VA ambulatory care was measured by the number of VA outpatient visits within one year prior to the index date.

2.5 | Statistical analysis

In bivariable analyses, the relationship between travel distance and HCC surveillance was assessed using the chi-square test (or Fisher's exact test) for categorical variables and Student's *t* test (or Wilcoxon rank sum test) for continuous variables.

Multivariable models were created using Cox proportional hazards regression with mixed effects to examine the association between travel distance (or alternatively, rurality category) and initial HCC surveillance, accounting for clustering of events within the same facility.³¹ Patients entered the study period starting on the cirrhosis index date and were censored for HCC diagnosis or death. All models were adjusted for age, gender, race/ethnicity, extrahepatic comorbidities (Gagne score), and severity of liver disease (MELD score). The proportional hazards assumption was evaluated in each model by assessing the interaction between receipt of HCC surveillance and the log of time to first HCC surveillance.³² Because our goal was to evaluate the relationship between travel distance (or patient rurality) and HCC surveillance rather than to create a parsimonious prediction model, all necessary covariates were included in the regression models regardless of their statistical significance.

In our main analysis, we included all veterans with cirrhosis; however, some patients with advanced liver disease may not necessarily be good candidates for surveillance on account of limited life expectancy and few therapeutic options.^{7,9} In a sensitivity analysis, we excluded all patients with decompensated cirrhosis, as defined by the following ICD-9 CM code and ICD-10 CM code complications: esophageal varices (456.0, 456.1, 456.2, 456.20, 456.21; I8501, I8500, I8511, I8510), peritonitis (567.2, 567.23; K650, K652), and hepatic coma or encephalopathy (572.2; K7290, K7291),³⁰ in order to assess performance of HCC surveillance in "ideal" candidates.

Hazard ratios (HR) and 95% confidence intervals (CI) were calculated. Kaplan-Meier survival methods were used to evaluate time to surveillance as a function of distance categories or rurality categories. Missing data for laboratory values needed to calculate the MELD score were derived using multiple imputation methods³³; we did not impute laboratory values when more than two laboratory studies were missing. One, two, and three laboratory values needed to calculate the MELD score were missing in 12.8 percent, 1.1 percent, and 3.7 percent of patients, respectively.

2.5.1 | Subgroup analysis

To quantify the extent of non-VA HCC surveillance in this study cohort, we examined the CMS-VHA merged data containing Medicare claims of all veterans simultaneously enrolled in VA and CMS, as previously described. Patients were excluded from this analysis if they were not enrolled in Parts A and B at the start of the year of cirrhosis diagnosis, but were included if they were enrolled in a Medicare HMO at any time prior to the year of cirrhosis diagnosis. Outpatient

TABLE 1 Characteristics of veterans with cirrhosis stratified by distance to nearest VA medical center in miles (N = 61 770)

	<10 (N = 11 749)	≥10 to <30 (N = 17 443)	≥30 to <60 (N = 14 735)	≥60 (N = 17 843)	Total (N = 61 770)
Age, mean ^a (SD)	60.6 (8.3)	61.1 (8.7)	60.9 (8.6)	60.8 (8.6)	60.9 (8.6)
Gender ^a (% male)	96.9	96.4	96.7	96.6	96.7
Race/Ethnicity ^b (%)					
White	58.2	66.3	72.0	71.4	67.6
Hispanic	8.6	8.9	6.2	6.7	7.6
Black	16.3	16.2	17.1	17.0	16.6
Other ^c	1.3	1.2	0.8	1.0	1.1
Missing	15.6	7.5	4.0	4.0	7.2
Income ^a (mean, SD)	21,659 (42,031)	26,403 (47,564)	27,725 (53,506)	26,525 (52,173)	25,578 (48,818)
Comorbidity score ^d (mean, SD)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)	1 (0-2)
MELD Score ^{e,f} (median, IQR)	10.8 (7.5-12.6)	11.0 (7.5-12.7)	10.8 (7.5-12.7)	10.8 (7.5-12.7)	10.9 (7.5-12.7)

Abbreviations: IQR, interquartile range; MELD, Model for End-Stage Liver Disease; SD, standard deviation.

^aNo patients had missing age, gender, or income information.

^b4447 patients of total population had missing race information; these were placed in a separate "missing" category.

^cOther category includes patients who identified as Asian, Pacific Islander, or Native American.

^dComorbidity score—disease severity related to non-hepatic comorbidities was assessed using the Gagne comorbidity score.²⁸

^eMultiple imputation was applied to 8082 patients with missing INR, 616 patients with missing creatinine, and 870 patients with missing total bilirubin. Patients missing all three laboratory values were excluded.

^fMELD score = $3.78 \times \ln [\text{serum bilirubin (mg/dL)}] + 11.2 \times \ln [\text{INR}] + 9.57 \times \ln [\text{serum creatinine (mg/dL)}] + 6.43 \times \text{etiology (0: cholestatic or alcoholic, 1: otherwise)}$.

Medical center distance (miles)	Any image	Any image + α FP	α FP alone
<10 (reference)	1.00	1.00	1.00
≥10 to <30	1.04 (1.00-1.09) ^b	1.05 (0.99-1.10)	1.04 (0.99-1.08)
≥30 to <60	0.92 (0.88-0.97) ^c	0.95 (0.89-1.02)	1.00 (0.95-1.05)
≥60	0.83 (0.79-0.88) ^d	0.86 (0.80-0.92) ^d	0.94 (0.89-1.00) ^b
Primary care provider distance (miles)	Any image	Any image + α FP	α FP alone
<10 (reference)	1.00	1.00	1.00
≥10 to <30	0.99 (0.96-1.03)	1.00 (0.96-1.05)	1.02 (0.99-1.06)
≥30 to <60	0.94 (0.89-0.98) ^b	0.96 (0.90-1.03)	1.00 (0.95-1.06)
≥60	0.94 (0.84-1.04)	0.93 (0.83-1.04)	0.95 (0.86-1.06)

Note: Hazard ratios and 95% confidence intervals are shown.

Abbreviations: α FP, alpha-fetoprotein; HCC, hepatocellular carcinoma.

^aCox proportional hazards models were adjusted for age, sex, race, ethnicity, income, non-liver comorbidity score (Gagne Score), and liver disease severity using MELD score.

^b $P \leq .05$.

^c $P \leq .001$.

^d $P \leq .0001$.

TABLE 2 Relationship between travel distance and HCC surveillance within 12 mo after cirrhosis index date (N = 61 770)^a

imaging studies (abdominal US, CT, MRI) and α FP were identified using the CPT procedure codes described above. We evaluated the association between travel distance to the VA medical center (and alternatively, rurality category) and receipt of HCC surveillance at non-VA facilities. Because zip code information in CMS claims was

limited to the ordering provider, we were unable to determine the distance from the veteran's residence to the nearest non-VA imaging center.

All statistical analysis was performed using SAS version 9.4 (SAS Institute Inc, Cary, NC).

TABLE 3 Relationship between distance to nearest VA medical center and non-VA HCC surveillance in dual use subgroup within 12 mo after cirrhosis index date (N = 13 884)^a

Distance (miles)	Any image (N = 13 773)	Any image + α FP (N = 13 773)	α FP alone (N = 13 773)
<10 (reference)	1.00	1.00	1.00
≥ 10 to <30	1.20 (0.97-1.48)	1.13 (0.84-1.51)	1.29 (1.00-1.67) ^c
≥ 30 to <60	1.58 (1.29-1.95) ^b	1.30 (0.95-1.76)	1.54 (1.17-2.02) ^c
≥ 60	2.07 (1.69-2.52) ^b	1.86 (1.38-2.50) ^b	2.08 (1.60-2.72) ^b

Note: Hazard ratios and 95% confidence intervals are shown.

Abbreviations: α FP, alpha-fetoprotein; HCC, hepatocellular carcinoma.

^aCox proportional hazard models were adjusted for age, sex, race, ethnicity, income, non-liver comorbidity score (Gagne Score) and liver disease severity using MELD score.

^b $P < .001$.

^c $P \leq .05$.

3 | RESULTS

Figure 2 shows the derivation of the analysis sample, which was comprised of 61,770 patients. The mean age was 60.9 years (SD 8.6), 96.7 percent were male, and 67.6 percent were white. The mean MELD score was 10.9 (SD 7.5-12.7) (Table 1). In bivariate analysis, 56.6 percent of the analysis sample received surveillance imaging for HCC at least once during the 12 months after the index date (at either a VA or non-VA facility). The most common type of imaging modality used was abdominal US (45.8 percent, complete in 17.9 percent), followed by abdominal CT and MRI (Table S1). Approximately 59.4 percent of those patients who lived less than 10 miles from the nearest VA medical center received imaging for HCC surveillance, compared to 52.3 percent of those who lived more than 60 miles away ($P < .0001$). Veterans who received α FP alone as HCC surveillance accounted for 14.2 percent of the total analysis sample, whereas 39.8 percent received both imaging and α FP.

In multivariable analyses, increased travel distance between the veteran's residence and the nearest VA medical center was associated with a lower use of HCC surveillance. Specifically, veterans who resided more than 60 miles from the nearest VA medical center were significantly less likely to receive any imaging (HR 0.83; 95% CI = 0.79-0.88; $P \leq .0001$), both imaging and α FP (HR 0.86; 95% CI = 0.80-0.92; $P \leq .0001$) and α FP test alone (HR 0.94; 95% CI = 0.89-1.00; $P \leq .05$), compared to those who lived less than 10 miles away (Table 2, Figure S1). Veterans who resided 30 to less than 60 miles were also less likely to receive HCC imaging (HR 0.92; 95% CI = 0.88-0.97; $P \leq .001$). When veterans with decompensated liver disease were excluded ($n = 3904$) from the analysis sample, veterans residing 60 miles or more remained less likely to receive any HCC imaging, any imaging and α FP, or α FP alone (Table S2). There was no consistent association between travel distance to the VA PCP and receipt of any imaging, any imaging and α FP or α FP alone (Table 2, bottom).

With regard to rurality of the veteran's residence, those residing in a large rural town, small rural town, or isolated were less likely to receive HCC surveillance with imaging, imaging and α FP, or α FP alone, compared to those residing in urban areas (Table S3, Figure S2).

In a subgroup analysis of 13 844 veterans who were dual users of Medicare and VA services, 8.5 percent of patients received any

outpatient imaging for HCC surveillance at a non-VA facility within the first 12 months after the cirrhosis index date (Table S4). Among imaging types, ultrasound was predominantly used across all distance categories in 7.1 percent of patients, with 4.0 percent receiving complete US, whereas MRI (1.4 percent) and CT (1.2 percent) were used at low frequencies across distance categories. In multivariable analysis, veterans who lived at least than 60 miles away were more likely to receive any imaging (HR 2.07, 95% CI = 1.69-2.52; $P \leq .0001$), imaging and α FP (HR 1.86, 95% CI = 1.38-2.50; $P \leq .0001$), and α FP alone (HR 2.08, 95% CI = 1.60-2.72, $P \leq .0001$) at non-VA facilities compared to those who resided less than 10 miles away (Table 3); those who lived 30 to less than 60 miles from the nearest VA medical center were also more likely to receive any imaging and AFP alone at non-VA facilities, compared to those who lived at least 10 miles away from the nearest VAMC. In a trend analysis, α FP alone was more likely to be used for HCC surveillance as distance from a VA medical center increased ($P \leq .0001$). There was no consistent association between rurality of residence and receipt of any HCC imaging or α FP among dual users of VA and Medicare (Table S5).

4 | DISCUSSION

In this national cohort of veterans with cirrhosis, our results demonstrate that 56.6 percent received an abdominal imaging study that could be used to identify HCC during the first 12 months after the diagnosis of cirrhosis, confirming prior studies in the VA population.¹⁰ This percentage is higher than that observed in a systematic review for HCC surveillance in patients with cirrhosis (30 percent), although rates of 60-80 percent have been reported in single-center studies from tertiary care and/or community practices.³⁴

Our results show that patients residing more than 30 miles from the nearest VA medical center were less likely to receive HCC surveillance than patients who lived closer to a VA medical center. These findings confirm those of Goldberg et al,¹⁸ who reported that individuals living more than 35 miles from a primary hospital were less likely to undergo HCC surveillance. We suspect that this is related to the phenomenon of "distance decay" as a result of the increased monetary

and time costs associated with traveling longer distances.^{11,35} In addition, this study shows that distance to a patient's assigned PCP had no consistent correlation with receipt of imaging for HCC surveillance.

Findings for the impact of rurality (isolated, small, and large rural towns) on receipt of HCC surveillance compared to those living in urban areas showed veterans in rural areas were less likely to receive any imaging, any imaging and α FP, or α FP alone. Although the reasons for these findings warrant further investigation, our results are broadly consistent with those of other cancer screening programs, in which utilization of preventive services has been shown to be lower in rural versus urban populations.^{36,37} Our results differ from those of Rongey et al,¹⁹ who showed no significant differences in HCC surveillance between rurality subgroups (highly rural, rural, and urban) among patients with hepatitis C, possibly on account of differences in the definition of rurality.

Among dual users of Medicare and VA services, only 8.5 percent had liver imaging performed outside of the VA. Veterans who lived further from a VA medical center were more likely to receive HCC surveillance at non-VA facilities, which may indicate a "substitution effect."³⁸ Travel distance in this setting would be a proxy for time and money; therefore, by reducing travel distance, one might anticipate an increase in HCC surveillance. The extent to which VA care is substituted for or complemented by non-VA care will determine the demand for HCC surveillance in the VA health care system. Further study is needed to determine whether the Choice Act of 2014^{21,22} has led to improvements in the quality and timeliness of HCC surveillance among veterans who live a long distance from VA facilities.

Despite current guidelines for HCC surveillance,^{7-9,39} why did only a minority of eligible patients receive recommended HCC surveillance imaging? One potential explanation is the dearth of strong evidence for the survival benefits of HCC surveillance in patients with chronic liver disease other than hepatitis B.^{40,41} Despite the known risk of HCC in advanced cirrhosis from many etiologies (0.8 percent-6 percent per year),⁴²⁻⁴⁴ the lack of high-quality evidence from clinical trials in these subgroups may in part explain the relatively low performance of HCC surveillance in the VA. PCPs may not order surveillance for a wide variety of other reasons: (a) poor overall life expectancy and/or decompensated cirrhosis, (b) lack of familiarity with guidelines for HCC surveillance, and (c) competing demands related to a growing list of other recommended preventive care services.^{12,13} PCPs report multiple challenges when providing care for cirrhosis patients, including the complexity of comorbid medical, psychiatric, and substance use disorders; the frequent need for intensive case management; and lack of clarity regarding the division of co-management responsibilities,⁴⁵ with no clear consensus as to who should order HCC surveillance and follow-up on the results.

Our study results should be interpreted within the context of several limitations. First, the observational retrospective design of this study precludes assignment of causality between distance and HCC surveillance. Second, potential misclassification of cirrhosis diagnosis based on ICD-9 CM and ICD-10 CM codes, which may vary between VA and non-VA practitioners, may also explain the lower than expected proportion of patients who received HCC surveillance.^{25,26}

Third, we lacked access to travel distance from the patient's residence to non-VA imaging centers or PCPs in the private sector. Fourth, we did not have complete information on laboratory values needed to calculate the MELD score on all study patients; we used multiple imputation techniques to estimate missing values.³³ Fifth, we could not determine precisely whether veterans were co-managed by a PCP and subspecialist (hepatologist or gastroenterologist) and therefore could not determine who ordered HCC surveillance. As receipt of specialty care is highly correlated with travel distance, adjusting for specialty of the ordering physician could have potentially obscured the original intent of this analysis. Sixth, we did not have access to data on the indication for imaging and could not determine whether it was performed specifically for HCC surveillance. In addition, CPT codes for imaging procedures provide a degree of standardization for billing purposes in radiology, but there is some variability in ordering and coding patterns across VA medical centers. Thus, our estimates are likely high, as our aim was to capture any imaging that could have been plausibly used for HCC surveillance, including limited abdominal US. Seventh, the timeframe of our analysis ended in 2015, which partially postdates implementation of the Veterans Choice Act of 2014.²¹ We speculate that the Choice Act may have partially mitigated the effects of travel distance to the nearest VA medical center on HCC surveillance. Eighth, we were unable to obtain all necessary data from VA data sources to operationalize the criteria needed to determine eligibility for travel reimbursement and to determine whether travel reimbursement may have mitigated disparities in receipt of HCC surveillance. This question warrants further investigation. Ninth, because administrative data provided limited information on severity of disease, our analysis may have included some patients with advanced or terminal disease processes, for whom HCC surveillance was not indicated. Lastly, the potential generalizability of our findings is limited by the inclusion of predominantly male veterans who received care in an integrated health care system.

To address distance as a barrier to care, VA has prioritized improving access to specialty care via telemedicine. For example, the Specialty Care Access Network-Extension of Community Healthcare Outcomes (SCAN-ECHO) has applied telemedicine to hepatitis C treatment^{46,47} and cirrhosis co-management by specialist and primary care providers,^{48,49} and has expedited treatment of patients with newly diagnosed hepatocellular carcinoma (using a tumor board teleconference).^{47,50,51} In addition, programs for management of patients with advanced liver disease should include mechanisms for automated ordering, tracking, and follow-up of imaging and laboratory tests to decrease the likelihood of process failures inherent in diagnostic testing.⁵² For example, identification and management systems (such as clinical dashboards) are currently being used within multiple VA sites to help identify and track patients with cirrhosis and to standardize communication between specialists and PCPs through chart review notes in the electronic health record.⁵³ More work also needs to be done in the area of teleradiology, which has the potential to enable timely sharing of imaging data across health care systems.

Other strategies to improve care coordination for cirrhotic patients within VA primary care are the use of collaborative care

agreements and patient registries. The former is particularly important, given that PCPs manage solely up to 80 percent of the cirrhotic population, including many patients with unrecognized cirrhosis and patients with compensated cirrhosis.⁵⁴ Collaborative care agreements (CCAs) can more clearly define the roles of primary care, specialty care, and non-VA clinicians in managing veterans with cirrhosis, facilitate timely referrals to specialty care, and standardize information transfer with clear division of clinical co-management responsibilities using evidence-based protocols.⁵⁵ Registries for managing those at risk for hepatocellular carcinoma, such as those used for lung nodules,⁵⁶ could be implemented to track patients with cirrhosis as they enter the VA health care system through primary care. The use of clinical reminders has also been shown to be effective in increasing HCC surveillance in primary care.⁵⁷

5 | CONCLUSION

Travel distance to the nearest VA medical center is consistently associated with a lower likelihood of receiving HCC surveillance in the veteran population. Future efforts should focus on minimizing patient and facility-related barriers by improving access to HCC surveillance, coordination of care (particularly in tracking HCC surveillance in dual users and veterans eligible for community care services), and collaboration between primary care and specialist clinicians in managing this at-risk population. In this regard, innovative strategies, such as portable, "point-of-care" ultrasonography⁵⁸ and use of telemedicine in primary care, have the potential to increase access to HCC surveillance.

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ORCID

Yolanda Rodriguez Villalvazo <https://orcid.org/0000-0001-7308-1962>

Lauren A. Beste <https://orcid.org/0000-0001-6488-435X>

Antonio J. Sanchez <https://orcid.org/0000-0002-4473-6250>

Mary Vaughan-Sarrazin <https://orcid.org/0000-0001-8717-1061>

David A. Katz <https://orcid.org/0000-0001-5348-6532>

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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