Original Research

Implementation of a Voice Messaging System is Associated With Improved Time-to-Treatment and Overall Survival in Patients With Hepatocellular Carcinoma

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Abstract

Background: The diagnosis and treatment of cancer is a continuum, with multiple steps and interfaces between patients and providers allowing for potential delays in cancer recognition and subsequent treatment. The diagnosis and treatment of hepatocellular carcinoma (HCC) is especially prone to missteps along the continuum, leading to treatment delays due to non–tissue-based diagnosis and multiprovider treatments. The aim of this study was to evaluate outcome measures after implementation of a voice messaging system (VMS) designed to streamline patient referrals to downstream treatment physicians and ultimately reduce delays in HCC treatment, thereby improving outcome measures. **Methods:** A retrospective study of outpatients with HCC was conducted in a safety net hospital between February 2008 and January 2012. In February 2010, VMS notification of HCC to the ordering physician and downstream treating physicians was implemented. Patients were divided into 2 groups: (1) preintervention: diagnosis 2 years before implementation or failure of notification following implementation, and (2) postintervention: diagnosis 2 years after implementation. Demographics, tumor characteristics, treatment, and survival were compared. **Results:** This study included 96 patients diagnosed with HCC: 51 in the preintervention group and 45 in the postintervention group. The main cause of chronic liver disease was HCV infection, and no differences in symptoms, liver dysfunction, tumor characteristics, or treatment were observed between groups. The time from diagnosis to clinic contact (0.5 vs 2.9 months; *P*=.003) and time from detection to treatment (2.2 vs 5.5 months; *P*=.005) was significantly shorter after implementation of the VMS. Barcelona Clinic Liver Cancer stage A status (hazard ratio [HR], 3.1; 95% CI, 2, 6), treatment (HR, 1.9; 95% CI, 1, 4), and VMS (HR, 1.8; 95% CI, 1, 3) were independently associated with overall survival. Patients diagnosed after implementation of the VMS had a median survival of 28.5 versus 15.7 months (*P*=.02). **Conclusions:** Implementation of VMS reduces time to treatment and time to clinic visit. Reduction in time to treatment is associated with improved outcome independent of tumor stage, underlying liver function, and treatment.
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Background

The Institute of Medicine reports on health care in general and cancer care specifically, builds on the argument that health care within the United States is a fragmented and uncoordinated process that fails to deliver optimal care to patients.[1,2] Cancer screening is well accepted in cervical, colorectal, and breast cancer and has led to decreased incidence rates and overall cancer morbidity.[3–5] However, rates of advanced disease at diagnosis and failure in follow-up of abnormal diagnostic tests persist, particularly in racial minorities and other underserved areas.[6–10] A recent review found that 25% to 50% of patients with abnormal findings from cancer screening tests had a lack of appropriate follow-up.[11]

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The transition from hepatocellular carcinoma (HCC) diagnosis to treatment is a complex process involving multiple steps and providers from a multitude of specialties. Unlike many solid organ cancers, HCC is not diagnosed based on tissue biopsy results but rather on characteristic radiographic imaging on dynamic contrasted-enhanced CT or MRI. Most of these diagnostic imaging studies are ordered by primary care physicians, who are at the beginning of the cancer care continuum and must not only discern an abnormal radiographic finding but also refer the patient to the appropriate downstream treating physicians. Because of the complexity and heterogeneity of HCC treatment options, potential delays in timely referrals are commonplace. This is especially true in safety-net health systems where socioeconomic and racial disparities in HCC treatment have led to worse patient outcomes, potentially due to underuse and/or delays in appropriate treatment.[13,14] Our group and others have previously demonstrated that delays in HCC diagnosis and treatment are associated with worse patient outcomes. Delays of as little as 3 months in treatment are associated with significant tumor growth, potentially decreasing the options for curative therapies and thereby impacting survival.[15,16]

As part of a quality improvement initiative at UT Southwestern Medical Center, we have recently initiated an automated electronic messaging system to communicate abnormal imaging results to not only the ordering primary care physician but also the appropriate downstream treating physicians within a multidisciplinary clinic. The purpose of this study was to determine whether the direct messaging of critical imaging results diagnostic for HCC to a specialized multidisciplinary clinic would streamline patient care by reducing time-to-follow up and time-to-treatment, potentially improving patient outcomes.

Materials and Methods

Voice Messaging System

The voice messaging system (VMS) consists of an electronic notification system (Veriphy V.4.2, Nuance Communications, Inc., Burlington, MA) integrated into a voice recognition dictation system for radiology reports (PowerScribe, V.5.0.862.0, Nuance Communications, Inc.). The ordering clinician's information is autopopulated into the system via interface from the radiology information system (EPIC Radiant; Version, Spring 2009, Verona, WI). Within the application, the radiologist has the option to manually remove or add additional contacts. As of February 1, 2010, imaging findings obtained from CT or MRI consistent with a liver mass concerning for HCC were routed to the ordering physician and physicians of the HCC multidisciplinary clinic (A.C.Y. and A.G.S.) via secure electronic mail. Because ultrasonography findings of a liver mass are not confirmatory for HCC, messages with abnormal sonographic findings were not included in this study. Before initiation of the VMS, the ordering physician was responsible for recognition and follow-up of abnormal imaging findings and placement of the subsequent referral to the appropriate treating provider. After initiation of the system, although the ordering physician was notified of the abnormal imaging findings, the patient was automatically referred to the weekly HCC multidisciplinary clinic without the need for subsequent referral. The Institutional Review Board (IRB) of the UT Southwestern Medical Center approved this study.

Discussed elsewhere in detail, the HCC multidisciplinary clinic is a weekly, dedicated clinic and tumor board meeting consisting of attending physicians, fellows, and residents from surgical oncology, transplant hepatology, interventional radiology, and medical oncology.[17] Subsequent abdominal imaging was completed at the discretion of the ordering and HCC multidisciplinary clinic physicians. However, the date of diagnosis was defined as the date the initial message was sent. A more detailed description of the overall process of the VMS has been described previously.[18]

Study Population

Using a prospectively maintained HCC database at Parkland Memorial Health and Hospital System (PHHS) at UT Southwestern Medical Center, all patients with HCC diagnosed between February 2008 and January 2012 were identified. As the safety-net hospital system for Dallas County, Texas, Parkland serves a large population of patients with cirrhosis and cares for approximately half of the patients with HCC within Dallas County.

HCC diagnosis was based on American Association for the Study of Liver Diseases (AASLD) criteria.[19] We excluded patients who had a liver mass without either characteristic imaging (arterial enhancement with delayed washout) or histologic confirmation. Only patients with axial imaging char-

acteristics for HCC were included; patients with sonographic findings consistent with a liver mass did not trigger the VMS and therefore were not included in the current study. The IRB of the UT Southwestern Medical Center approved this study.

The study population included patients diagnosed with HCC in the 2-year period before (preintervention, February 1, 2008–January 31, 2010) and after (postintervention, February 1, 2010–January 31, 2012) initiation of the VMS. Patients diagnosed with HCC after February 2010 who did not initiate a voice message were included in the preintervention cohort. Imaging studies related to inpatients, patients seen in the emergency department, or patients admitted the day of imaging were excluded.

Data Collection

A retrospective review of each patient's medical record was performed to obtain patient demographics, clinical history, laboratory data, and imaging results. Clinical history of interest included hepatitis C virus (HCV) and hepatitis B virus (HBV) serostatus, alcohol abuse (defined as intake >60 g/d for men and >40 g/d for women), treatment delivery (as described later), and long-term outcome. Laboratory data included total bilirubin, aspartate aminotransferase (AST), alanine aminotransferase (ALT), albumin, platelet count, international normalized ratio (INR), and alpha fetoprotein (AFP). Tumor characteristics of interest included the number of lesions, maximum tumor diameter, lymph node involvement, portal vein invasion, presence of extrahepatic metastases, and stage of the tumor at diagnosis. The Barcelona Clinic Liver Cancer (BCLC) and TNM staging systems were used for tumor staging.[19]

We abstracted a number of key clinical time points (Figure 1):

- Time of diagnosis was defined as the time a notification message was sent, which was assumed to be simultaneous to and interchangeable with the time of imaging. The imaging test triggering the notification message was characteristic of HCC, and therefore time of diagnosis is actual time of HCC diagnosis seen on the first imaging study. In the preintervention cohort, time of diagnosis was defined as the first dynamic contrasted imaging study characteristic of HCC, whereby if the VMS was previously implemented it would have triggered a notification.
- Time of initial clinic contact, which was defined as the time at which the clinic visit with the patient related to the imaging finding was completed. In the absence of clinic documentation, clinic time was recorded as the time a test was ordered for additional evaluation of the finding.
- Time of treatment, which was defined as the time definitive management of HCC was initiated (ie, date of surgical resection, first chemotherapy administration, or date of locoregional therapy).
- Time of death or last follow-up.

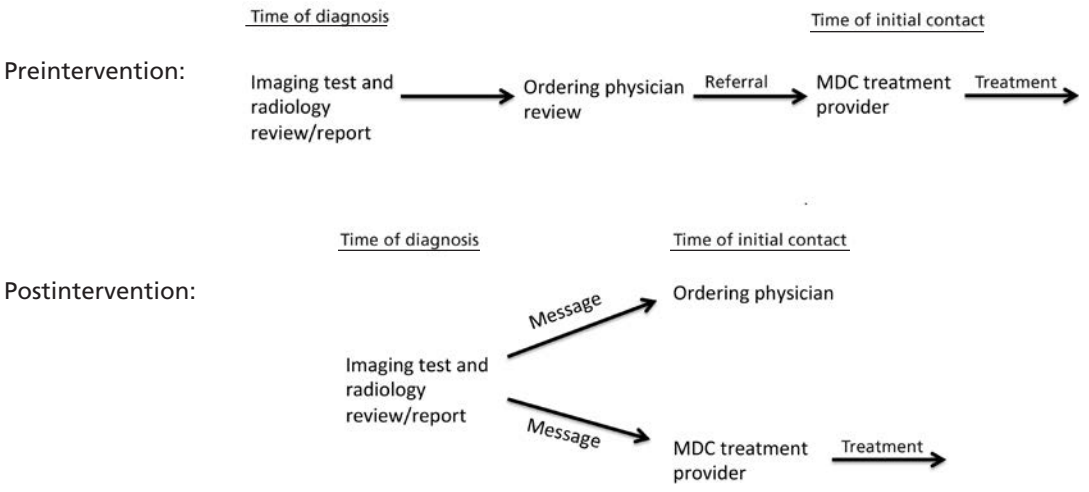

Figure 1. Flow diagram of preintervention and postintervention response to radiologic findings.
Abbreviation: MDC, multidisciplinary clinic.

Table 1. Differences in Patient Characteristics by Messaging Intervention

Variables		Preintervention n=51	Postintervention n=45	*P* Value
Sex				.27
	Male	45 (88%)	36 (80%)	
	Female	6 (12%)	9 (20%)	
Age at diagnosis, y (mean)		55.7 +/– 6.7	58.1 +/– 8.3	.10
Race/Ethnicity				.53
	White	17 (33%)	9 (20%)	
	Black	17 (33%)	17 (38%)	
	Hispanic	12 (24%)	13 (29%)	
	Asian	5 (10%)	6 (13%)	
Insurance status				.48
	Medicare	13 (26%)	6 (13%)	
	Medicaid	9 (18%)	13 (29%)	
	Uninsured	26 (51%)	22 (49%)	
	Private	3 (6%)	4 (10%)	
Cause of chronic liver disease				.22
	Hepatitis C	38 (76%)	29 (64%)	
	Hepatitis B	5 (10%)	4 (9%)	
	Alcohol	6 (12%)	6 (13%)	
	Other/Unknown	2 (4%)	6 (13%)	
Symptomatic at diagnosis		29 (57%)	19 (42%)	.15
Serum total bilirubin, mg/dL (mean)		1.5 +/– 1.6	1.1 +/– 1.4	.49
Serum albumin, g/dL (mean)		3.6 +/– 0.46	3.3 +/– 0.6	.19
Serum platelets, k/mcL (mean)		132 +/– 70.1	152 +/– 114	.37
Serum AST, U/L (mean)		123 +/– 67.4	107 +/– 76.0	.32
Serum ALT, U/L (mean)		72.4 +/– 0.7	84.1 +/– 95.6	.40
MELD (mean)		10.2 +/– 3.1	9.9 +/– 3.8	.69
Child-Pugh class				.73
	A	30 (59%)	30 (67%)	
	B	17 (33%)	12 (27%)	
	C	4 (8%)	3 (7%)	

Abbreviations: ALT, alanine aminotransferase; AST, aspartate aminotransferase; MELD, Model for End-Stage Liver Disease.

Statistical Analysis

We evaluated differences between the preintervention and postintervention groups using the Student *t* test for continuous data and the chi-square statistic for categorical data. We calculated time from diagnosis to clinic contact and time from diagnosis to treatment. We reviewed any interval imaging (CT or MRI) between diagnosis and initial treatment to evaluate for change in tumor size and TNM stage compared with initial imaging. We compared survival between the preintervention and postintervention groups using the Kaplan-Meier estimate and evaluated for statistical significance using the log-rank and Wilcoxon tests. The time of imaging was denoted "time zero." We evaluated for an association between the intervention and survival using a proportional hazards model. All variables significant in the univariate analysis (log rank $P<.05$) were placed in the multivariate model. Statistical significance was defined as *P* value less than .05. Statistical analysis was performed using the Stata software package (Version 13, Stata Statistical Software; College Station, TX).

Results

Patient and Tumor Characteristics

A total of 96 outpatients at PHHS diagnosed with HCC through imaging between February 2008 and January 2012 were identified (Table 1). A total of 51 patients were identified after initiation of the VMS, with 45 patients having voice messages sent (postintervention group, 88% messaging rate), and 6 patients were diagnosed in the postintervention period without appropriate messaging via the VMS (preintervention). The 6 failed messages all occurred in the first 2 months of the VMS rollout. Following re-education of the radiology providers, no further failed messages occurred during the study period. All 6 patients had demographic and tumor characteris-

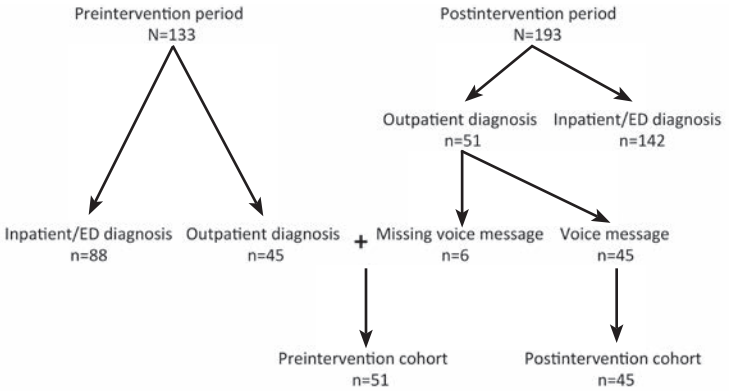

Figure 2. Flow diagram of 328 patients diagnosed with hepatocellular carcinoma between February 1, 2008, and January 31, 2012. Abbreviation: ED, emergency department.

tics similar to those of the preintervention cohort, with similar survival outcomes. All voice messages sent to the ordering physician and the physicians from the HCC multidisciplinary clinic were listened to and closed within 48 hours of notification. A total of 45 patients were diagnosed before initiation of the VMS (preintervention). An additional 31 patients had voice messages conveying abnormal liver imaging on cross-sectional imaging, but findings were not consistent with HCC (Figure 2). These patients were triaged to the appropriate specialty clinic for follow-up and not included in the study cohort.

In both the preintervention and postintervention groups, the main cause of chronic liver disease was HCV infection (Table 1). There were no differences in race/ethnicity, symptoms at presentation, or underlying liver dysfunction as measured by Child-Pugh and Model for End-Stage Liver Disease (MELD) score between the 2 groups. Most patients had preserved liver function, with more than 60% of both groups presenting with Child-Pugh A cirrhosis.

Table 2 demonstrates the similarities in tumor presentation between the groups. Both groups typically presented with solitary tumors with less than 20% distant metastases and a similar proportion of BCLC stratification. Within the preintervention group, 22 (42%) of 51 patients underwent repeat contrast-enhanced axial imaging before initiation of treatment compared with 5 (11%) of 45 patients in the postintervention group. Within the preintervention group, patients had a mean increase of 2.6 cm in maximum diameter, leading to 23% of patients being upstaged by TNM classification. Screening ultrasound by AASLD guidelines at the time of the study was performed in a similar fashion between the groups and was greater than 70% in both.

Previous imaging demonstrating a liver mass performed less than 3 months from the characteristic dynamic contrasted axial imaging findings was seen in 68% and 78% of the preintervention and postintervention cohorts, respectively. In both groups abdominal ultrasonographic findings of a liver mass was the most common imaging finding. Ten of the 17 patients in the preintervention group and 5 of the 10 patients in the postintervention group had no previous radiologic imaging demonstrating a liver mass but had an elevated AFP level leading to the subsequent dynamic contrasted axial imaging with characteristic features of HCC.

Treatment

Forty-one (80%) of 51 patients in the preintervention cohort and 37 (82%) of 45 patients in the postintervention cohort received treatment following HCC diagnosis (P=.82). Transarterial chemoembolization (TACE) was the most common treatment modality in both groups (51% and 56%, respectively; P=.71). Rate of curative treatments, consisting of surgical resection, ablation, or liver transplantation, was similar in both groups (30% vs 39%, respectively; P=.15). Seven patients in each group underwent surgical resection, with 5 of the 7 patients in the preintervention cohort having microvascular invasion in the resected specimen compared to only 1 of the 7 in the postintervention cohort. There was no difference in median number of TACE treatments or response rates after TACE in either group.

After stratification by BCLC A classification—patients most likely to receive curative therapy—

Table 2. Differences in Tumor Characteristics by Messaging Intervention

Variables		Preintervention n=51	Postintervention n=45	*P* Value
Number of tumors				.38
	Solitary	30 (59%)	30 (67%)	
	Multiple	21 (41%)	15 (33%)	
Tumor size, cm (mean)		3.3 (1.2–11.3)	3.6 (1.0–18.2)	.75
Distant metastases present		10 (20%)	6 (13%)	.41
BCLC class				.46
	A	22 (43%)	25 (56%)	
	B	8 (16%)	5 (11%)	
	C	16 (31%)	9 (20%)	
	D	5 (10%)	6 (13%)	
TNM staging				.75
	I	21 (46%)	26 (59%)	
	II	7 (9%)	4 (9%)	
	III	14 (26%)	9 (20%)	
	IV	9 (20%)	5 (11%)	
Screening ultrasound in year before HCC diagnosis				.77
	Completed	36 (71%)	33 (73%)	
	Not performed	15 (29%)	12 (26%)	
AFP at diagnosis, ng/mL (median)		96 (1–101,977)	27 (2–228,400)	.31
Time from diagnosis to clinic, mo (median)		2.9 (0.16–38)	0.5 (0.1–3.5)	.003
Time from diagnosis to treatment, mo (median)		5.5 (1.1–38.6)	2.2 (0.1–14.0)	.005

Abbreviations: AFP, alpha fetoprotein; BCLC, Barcelona Clinic Liver Classification; HCC, hepatocellular carcinoma.

both the preintervention and postintervention groups had a similar treatment rate and types of treatments. In the pretreatment cohort, 21 of 22 patients received treatment of any kind, with TACE (n=11) and surgical resection (n=6) the most common treatments given. In the posttreatment group, all 25 patients received treatment, with TACE (n=12) and curative resection (n=6) the most common treatments.

The median time from diagnosis to first clinic contact after imaging was significantly shorter after initiation of the voice messaging intervention (0.5 vs 2.9 months; *P*=.003). Similarly, median time from diagnosis to treatment was significantly shorter after initiation of the voice messaging intervention (2.2 vs 5.5 months; *P*=.005). Time from clinic visit to treatment was similar between the groups.

Clinical Outcomes and Predictors of Survival

Table 3 demonstrates the clinicopathologic variables associated with outcome in the entire cohort after diagnosis of HCC. The estimated 1- and 3-year overall survival for patients diagnosed before and after initiation of the VMS was 67% and 14% versus 77% and 41%, respectively. The median overall survival was 15.7 months in the preintervention group compared with 28.5 months in the postintervention group (*P*=.02) (Figure 3). In an intention-to-treat analysis, if the 6 patients diagnosed with HCC after initiation of the VMS but who did not have appropriate notification to the multidisciplinary clinic providers were included in the postintervention group, median overall survival, time to clinic visit, and time to treatment remained unchanged to the current analysis.

On multivariate analysis, BCLC class A, receipt of treatment, gender, and initiation of the VMS were independently associated with better overall survival (Table 3). Median follow-up time was 14.5 and 15.4 months in the preintervention and postintervention groups, respectively.

Discussion

Cancer care is a continuum ranging from screening and detection of disease to treatment, with multiple accompanying steps where patient information is gathered and transferred among different providers across organizational settings to ultimately provide the best treatment plan.[20] After a diagnostic test, numerous steps must be completed before rendering treatment. These steps include reporting of the results to the ordering physician and patient along with subsequent referral of the patient to the appropriate downstream treating physician. Because of

Table 3. Univariate and Multivariate Analysis in Relation to Overall Death

	Univariate Analysis			Multivariate Analysis		
Variable	Hazard Ratio	95% CI	*P* Value	Hazard Ratio	95% CI	*P* Value
Age (<60 vs ≥60 y)	1.814	1.09–3.018	.026	1.779	1.003–3.155	.049
Sex (female vs male)	0.783	0.388–1.577	.480			
Race/Ethnicity						
White	1.000	1.000–1.000	NA			
Black	0.939	0.515–1.712	.838			
Hispanic	1.346	0.727–2.493	.344			
Asian	1.047	0.478–2.295	.908			
Cause of liver disease						
Hepatitis C	1.000	1.000–1.000	NA	1.000	1.000–1.000	NA
Hepatitis B	0.695	0.220–1.709	.428	1.012	0.390–2.626	.98
Alcohol	2.573	1.293–5.120	.007	1.937	0.945–3.970	.07
Other/Unknown	1.097	0.265–4.546	.899	0.855	0.191–3.826	.83
Symptoms (yes vs no)	2.283	1.418–3.675	.001[a]			
Metastatic disease (yes vs no)	5.923	3.032–11.569	<.001[a]			
BCLC class (A vs B/C/D)	4.216	2.481–7.165	<.001	3.136	1.701–5.781	<.001
Child-Pugh class						
A	1.000	1.000–1.000	NA[a]			
B	1.812	1.073–3.060	.026			
C	2.312	0.893–5.093	.088			
TNM stage						
I	1.000	1.000–1.000	NA[a]			
II	2.450	1.101–5.581	.030			
III	3.654	1.999–6.680	<.001			
IV	10.433	4.764–22.851	<.001			
Treatment (yes vs no)	3.610	1.968–6.622	<.001	1.927	1.002–4.032	.048
Voice messaging system (yes vs no)	1.727	1.070–2.801	.024	1.801	1.016–3.105	.034

Abbreviation: BCLC, Barcelona Clinic Liver Classification.
[a] Not placed in multivariate model because of concerns of collinearity.

the heterogeneity of treatment options after HCC diagnosis and, frequently, pertinent socioeconomic patient factors, the potential for delay along the continuum of cancer care can be exponential.[15]

As part of a larger, quality improvement initiative to communicate abnormal radiographic findings to the ordering physician through a VMS,[18] findings specifically concerning for HCC have also been communicated to the downstream physicians responsible for HCC treatment. Previous publications have illustrated factors associated with improvement in following up abnormal screening tests, but subsequent tests confirming diagnosis, and interventions aimed at reducing time to treatment, have not been implemented.[13,15] We demonstrated a nearly 14-month improvement in median overall survival in a group of patients for whom downstream treating physicians were notified of imaging findings. This improvement in outcome was independent of tumor characteristics, underlying liver function, or subsequent treatment regimens, all factors with demonstrated impact on HCC outcome. The improved survival appears to be secondary to a reduction in time to clinic visit and corresponding reduction in time to treatment after HCC diagnosis.

In the preintervention cohort of patients with prolonged time to clinic visits who underwent additional contrast-enhanced imaging, a significant growth in tumor size was seen, with nearly one-quarter of patients having an upstaging of TNM classification. Although this did not seem to change the treatment regimens offered to these patients, undoubtedly a change in tumor biology paralleled the increased tumor size. In the small group of patients undergoing surgical resection, microvascular invasion, a surrogate for poor HCC tumor biology and outcome, was more prevalent in the preintervention cohort. However, because of the relative small numbers of patients, it is difficult to prove a causal effect. Our group and others have previously demonstrated that delays in treatment after HCC diagnosis are associated with significantly lower overall survival, and that as little as a 3-month delay can allow for

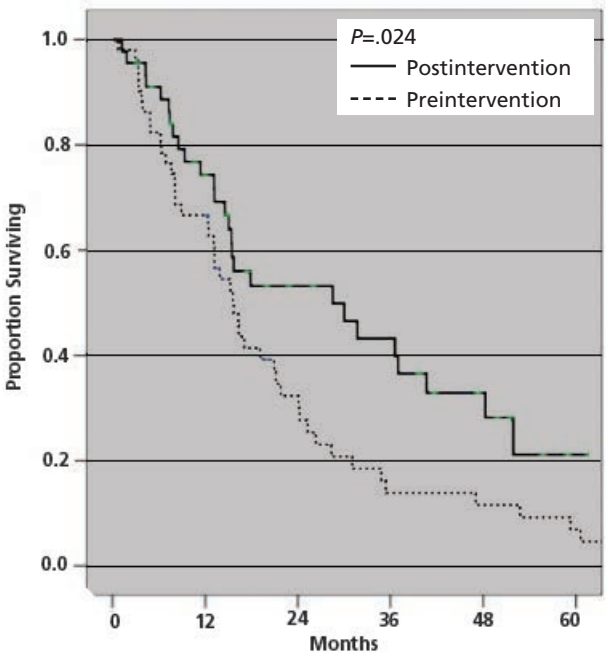

Figure 3. Kaplan-Meier estimated overall survival curves of patients with hepatocellular carcinoma by preintervention and postintervention cohort.

significant tumor growth, impacting options for curative therapies.[15,16,21]

The treatment of HCC during the study period did not change from the earlier to the later cohorts. We chose 2008 as the earliest period because of the approval of sorafenib as the only systemic therapy with proven efficacy in advanced HCC. Available therapies including surgery, locoregional, and systemic therapies have remained unchanged since the initiation of the study. Although a lack of a control group—not part of the messaging system yet receiving similar treatment per stage of diagnosis—in the later 2-year period is a valid limitation of the current study, the relative stability of outcomes after treatment somewhat diminishes those concerns.

HCC risk is influenced by access to care, social support, and lifestyle. Multiple studies have demonstrated a link between low socioeconomic status and racial or ethnic disparities on HCC incidence, with subsequent delays in treatment and overall inadequate treatment leading to worse outcome measures.[13,21–23] Although it is unclear whether patient- or physician-level factors are responsible for delays in treatment, our study indicates that one possible source of delay is ensuring that patients with newly diagnosed HCC are seen by the appropriate downstream physicians in a timely fashion. With the heterogeneity of treatment options available to the patient with newly diagnosed HCC and the demonstrated benefit of multidisciplinary care,[17] the incorporation of an automated messaging system informing downstream physicians of concerning radiologic imaging findings seems to alleviate some of the initial delays of clinic visit. This VMS is especially germane in a safety-net health system, where frequently primary care providers are the initial entry into the cancer care system and are responsible for the diagnosis and subsequent referral of patients with HCC. Limited resources, patient-level barriers, and primary care physician knowledge of HCC often lead to undesired failures and delays in the HCC care continuum.[24,25] In our system, the ordering physician is informed not only of the original abnormal radiologic findings but also of the subsequent treatment decisions by the multidisciplinary HCC team. Whether the use of a messaging system relaying abnormal findings to a third-party physician would be applicable in a non–safety-net health system is unclear because of concerns about referral patterns and patient preference of treating physician. However, we have recently demonstrated that more than 70% of newly diagnosed cases of HCC in Texas are diagnosed in a safety-net health system (unpublished data). Additionally, similar systems might be useful in other large integrated health systems, such as Veterans Affairs hospitals.

The rollout of the Vocoda VMS occurred as a larger quality improvement initiative in the department of radiology. The impetus for implementing the system was feedback from speciality physicians, treating multiple different tumor types, regarding patients not being triaged in a timely manner. Similar VMS activation is currently occurring for lung and pancreas lesions throughout the institution, and although implementation was discussed with key stakeholders within the primary care physician group, it was not formally addressed with individual providers. Although qualitative analysis regarding feedback from ordering physicians regarding satisfaction with the program was not part of this study, anecdotal evidence from quarterly meetings with their physician group showed overwhelming support of the system. The lack of knowledge regarding appropriate treatment and surveillance of patients with liver masses and/or cirrhosis is well documented by our group and others.[13,15]

In the current study, 31 patients who had messages sent to the multidisciplinary clinic providers did

not have HCC. None of these patients underwent further diagnostic imaging or treatment. Because patients are scheduled into the HCC multidisciplinary clinic within a week of the VMS message, harms to the patient, although plausible, were minimal.

Limitations of the present study include the nonrandomized, uncontrolled, and retrospective nature and accrual of patients from a single-institution, safety-net hospital system, and whether a similar VMS would show similar outcome measures with a different payor mix of patients. Although there was no control group in the later period after initiation of the VMS, the treatments offered both at the study institution and worldwide remained unchanged. It is unlikely that over a 2-year period with the same treating physicians outcomes would have improved to explain the differences between the earlier and later periods. The single-institution nature of the study also provides an element of potential bias due to a singular treatment philosophy, although treatment decisions were made according to BCLC guidelines.

Conclusions

The current study demonstrates that the implementation of a VMS that relays abnormal imaging findings concerning for HCC to downstream treating physicians reduces time to treatment through reduction in time to initial clinic visit. This reduction in overall time to treatment is associated with improved overall outcome, independent of tumor stage, underlying liver function, and treatment modality. Use of the VMS may be applicable to other cancer types in which multimodality therapy is paramount, especially in a safety-net health system with underserved patient populations.

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