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Patient Preferences for Hepatocellular Carcinoma Surveillance Parameters

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Abstract

BACKGROUND AND AIMS: Professional societies recommend abdominal ultrasound (US) with or without alpha fetoprotein (AFP) for hepatocellular cancer (HCC) surveillance; however, there are several emerging surveillance modalities, including abbreviated MRI and blood-based biomarker panels. Most studies have focused on provider perspectives for surveillance logistics, but few have assessed patient preferences. We aimed to measure preferences among patients with cirrhosis regarding HCC surveillance modalities.

METHODS: We conducted a choice-based conjoint survey to patients with cirrhosis at four institutions. Participants were provided 15 scenarios in which they were asked to choose surveillance modalities based on five test attributes: benefits, i.e. sensitivity for early HCC (range: 35–95%), physical harm, i.e. false positives requiring additional testing (range: 10–40%), financial harm, i.e. out-of-pocket costs (range: \$10–100), test logistics and convenience, i.e. duration of testing (range: 10–60 min). Hierarchical Bayes discrete choice conjoint analysis was used to derive attribute importance, and preference shares were determined by simulation.

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Supplementary Material

Note: To access the supplementary material accompanying this article, visit the online version of *Clinical Gastroenterology and Hepatology* at www.cghjournal.org, and at <https://doi.org/10.1016/j.cgh.2021.02.024>.

RESULTS: In total 91% (182/199) of approached patients consented to participate in the study and 98% (n=179) successfully completed the survey. Surveillance benefits (importance: 51.3%, 95% CI: 49.0–53.4%) were valued more than risk of physical harm (importance: 7.6%, 95% CI 7.0–8.2%), financial harm (importance: 15.2%, 95% CI 14.0–16.3%), convenience (importance: 9.3%, 95% CI 8.5–10.1%) and test logistics (importance: 16.7%, 95% CI 15.4–18.1%). Based on simulations including all possible tests, patients preferred abbreviated MRI (29.0%), MRI (23.3%), or novel blood-based biomarkers (20.9%) to ultrasound alone (3.4%) or with AFP (8.8%).

CONCLUSIONS: Patients with cirrhosis prioritize early HCC detection over potential surveillance-related harms or inconvenience.

Keywords

Harms; HCC; Screening; Sensitivity

Cirrhosis is the primary risk factor for hepatocellular carcinoma (HCC), the fastest growing cause of cancer-related mortality in the United States.^{1,2} HCC surveillance is associated with reduced mortality in patients with cirrhosis by improving early stage detection.^{3–5} Therefore, professional societies recommend HCC surveillance using abdominal ultrasound (US) with or without alpha-fetoprotein (AFP) in at-risk patients, including those with cirrhosis.^{6,7} However, several studies highlight limitations of the current approach including suboptimal sensitivity for early HCC detection and risk of false positives, leading to potential physical, financial, and psychological harms.^{8–10} Fortunately, there are several emerging surveillance modalities including abbreviated magnetic resonance imaging (MRI) as well as blood-based biomarker panels with promising early phase II results.^{11,12}

The choice between HCC surveillance methods can be complex, as it is influenced by several factors, including potential benefits (early-stage detection), risks (eg, financial and physical harm from false positives), and convenience (eg, time commitment and exam logistics). Further, there are trade-offs that must be considered. For example, a high sensitivity for early HCC may carry a higher risk of false positives, or a method with high sensitivity and specificity may result in high out-of-pocket costs for patients. Finally, patient values and preferences vary, which can play a role in their adherence to recommended surveillance strategies; therefore, optimal test choice may differ between patients. As new modalities for surveillance are validated, this decision will grow more complicated, particularly without direct comparative data. The aim of this study was to measure patient preferences for HCC surveillance attributes in an era of emerging surveillance modalities. We prospectively surveyed patients at risk for HCC from 4 centers to directly elicit their preferences for characteristics of HCC surveillance methods.

Materials and Methods

We conducted a prospective discrete choice-based conjoint survey that was approved by the institutional review boards at each of the 4 participating institutions. Informed consent was obtained from all participants. Discrete choice-based conjoint surveys and analysis are commonly used in marketing research to evaluate individual preferences about

complex purchasing decisions. However, in this context, it can also be used to evaluate patient preferences for complex decisions based on test attribute, such as choice of HCC surveillance modalities. Patients choose between a series of hypothetical HCC surveillance methods differing in benefits, risks, and convenience. The patient choices allow derivation of implied attribute preferences and permit competitive preference share simulations comparing individual surveillance methods.

Study Population

We conducted a prospective observational discrete choice conjoint survey at the University of Michigan, University of Chicago, University of Texas Southwestern Medical Center, and Parkland Health and Hospital System from April 2019 to March 2020. The institutions are members of the North American Liver Cancer Consortium and were chosen to support a broad range of sociodemographic characteristics. We included patients seen in outpatient hepatology clinics eligible for HCC surveillance per American Association of Liver Disease guidelines, including cirrhosis of all etiologies and patients with chronic hepatitis B. We included patients with Child-Pugh A and B liver function and patients with Child-Pugh C cirrhosis listed for liver transplantation. We excluded patients with a history of HCC, liver transplantation, non-English-speaking patients, and those with uncontrolled hepatic encephalopathy or cognitive impairment.¹³

Conjoint Survey Development and Administration

Our discrete choice-based conjoint survey (Supplementary Figure 1) (Sawtooth Software, Provo, UT)¹⁴ used partial profile design to provide respondents with 15 paired choice sets with 3 options. The 3 options in each choice were 2 unique hypothetical HCC surveillance methods and an option to choose neither of the 2 surveillance methods. Each hypothetical surveillance method used the same 5 attributes set at varying levels: sensitivity for early HCC detection (range, 35%–90%),^{11,12,15–18} risk of physical harm (ie, false positive results requiring additional tests [range: 10%–40%]),^{11,12,15–18} financial harm (ie, out-of-pocket costs [range: \$5-\$100]), convenience (exam duration [range: 10–30 minutes]),¹² and exam logistics (flat in small enclosed tube that makes loud noises, lay flat in open space, roll in different positions while a technician uses a probe over your liver, single blood draw). Out-of-pocket costs were derived from the Medicare Fee Schedule based on median deductible (Supplementary Table 1).¹⁹ For the novel biomarker panel and abbreviated MRI, early phase validation data were used to estimate all parameters.^{20–22} Participants either selected which of the 2 hypothetical surveillance scenarios with varying levels of the attributes they would prefer, or they indicated that they would choose not to be tested if those were the only 2 options available. The content of the survey was vetted by 5 volunteer patient advocates reviewing the survey for patient-centered language. The content of the survey was vetted by 3 hepatologists with expertise in HCC surveillance to ensure appropriate supporting literature for the conjoint analysis. The survey underwent precognitive testing for content validity and readability by 5 patients with cirrhosis at each site undergoing HCC surveillance.

The survey software considered the active ratings of the respondents to generate a personalized choice set that maximized analyzability of their respondents. The experiment

had a near-orthogonal design with level balance and minimal attribute level overlap. Details of the administered surveys are provided in Supplementary Table 2.

The survey was administered by trained research assistants at each site. Participant demographics (age, sex, race/ethnicity) and clinical history (liver disease etiology and severity) were extracted from the electronic medical record.

Statistical Design

Hierarchical Bayesian modeling and a Markov chain Monte Carlo algorithm were used to estimate part-worth utilities (and their 95% confidence intervals [CIs]) for each attribute level.^{23–25} A total of 50,000 posterior simulation iterations were used. These part-worth utilities are an interval measure of patient preference for levels within an attribute, somewhat analogous to a beta coefficient from a logistic regression. The model estimates a unique set of part-worth utilities for each patient, which captures each patient's unique weight that they place on the different attributes and levels while deciding on a preferred test. We will provide the individual patient-level part-worth utilities as Supplementary Material; results presentation will focus on average part-worth utilities.

Owing to dummy coding in the design matrix, part-worth utility values are scaled to an arbitrary additive constant within an attribute. For example, in a logistic regression, we can directly compare beta coefficients from different categorical variables because they are all on the same scale. However, here, while we can compare part-worth utilities for levels within an attribute (eg, sensitivity 90% vs sensitivity 80%), we cannot directly compare part-worth utilities across attributes (eg, sensitivity 90% vs cost \$50). Attribute importance is the estimated average relative importance participants placed on that attribute when making HCC surveillance modality selection decisions. For each participant, attribute importance was calculated as the range of their part-worth utilities for that attribute, divided by the sum of the ranges for all attributes multiplied by 100 (ie, $\frac{\text{Specific attribute utility range}}{\sum \text{All attribute utility ranges}} \times 100$). The average attribute importance was reported as a percentage and a 95% CI. All attribute importances sum to 100%.

Demographic data were summarized with descriptive statistics. Patient-specific attribute importances were modeled using linear regression. The covariates used for analysis included age, location, sex, race, ethnicity, education, health insurance, employment status, household income, commute time, patient perception of lifetime cancer risk, patient perception of cancer curability with early stage, and patient perception of the chance of detecting cancer at an early stage with surveillance. The mean attribute importance difference was calculated between each covariate subgroup.

The part-worth utility values for a combination of HCC surveillance method properties were combined to build a multiproduct competitive model using the randomized first choice method to estimate share of preference. Patient-specific share of preference was calculated as the antilog of the total product utility (based on patient-specific part-worth utilities). Results for each product and none (ie, "chose not to be tested") are rescaled to sum to 100%. Simulation results were completed in order to complete a sensitivity analysis of

preference shares for sensitivity of early HCC detection, false positive rate, out-of-pocket expenses, involvement during the exam, and time commitment. A reference test was made assuming 35% HCC detection sensitivity, 40% false positive rate, \$100 out-of-pocket cost, requirement of lying flat in loud tube, and 60-minute test duration. Simulations were performed changing 1 attribute level at a time against the no surveillance option. The outcome was the percentage of patients that would prefer to get HCC surveillance under each test parameter.

Market simulations were performed to compare existing surveillance methods, abbreviated MRI, and novel biomarker panel surveillance methods using the patient-level part-worth utilities derived from our study. The surveillance methods and associated parameters are listed in Supplementary Table 3. Although 7 HCC surveillance methods were formally analyzed in our patient-centered preference share simulations, the simulator derived from our data (Supplementary Material) permits the user to input any combination of attribute levels based on available HCC surveillance methods and to update the analysis as novel surveillance methods become available.

Statistical analysis was performed using SAS software (version 9.4; SAS Institute, Cary, NC). For primary endpoints, $P < .05$ was considered significant. For secondary endpoints (ie, when assessing differences in attribute importance), $P < .01$ was considered significant to account for multiple comparisons.

Results

Patient Characteristics

Of the 199 patients approached to participate, 179 (90.0%) completed the survey (Supplementary Figure 1). Details of the study population are provided in Tables 1 and 2. The most common etiologies of liver disease were nonalcoholic fatty liver disease (26%), chronic hepatitis C (21%), and alcohol-related liver disease (18%). The majority were Child-Pugh class A (76%) with a mean Model for End-Stage Liver Disease score of 11. The cohort was diverse in terms race-ethnicity, educational attainment, and socioeconomic status.

Over one-third (35%) of patients reported being likely or very likely to develop HCC, while 50% reported they were neither likely nor unlikely to develop HCC in their lifetime. Patients appeared to believe HCC surveillance was effective at facilitating early tumor detection and curative treatment. Approximately three-fourths (73%) of patients felt that surveillance was likely or very likely to detect HCC at an early stage, and 61% felt that HCC was likely or very likely to be amenable to curative treatment if detected at an early stage.

Importance of Surveillance Attributes

Respondents' values for each HCC surveillance attribute are included in Figures 1 and 2, with pairwise comparisons provided in Supplementary Table 4. Patients considered sensitivity for early HCC detection to be the most important attribute (Table 3). Attributes are listed as follows in descending order of importance (%): (1) sensitivity for early HCC detection (51.2%; 95% CI, 49.0%–53.4%), (2) test logistics (16.7%; 95% CI, 15.4%–

18.1%), (3) risk of financial harms (15.2%; 95% CI, 14.0%–16.3%), (4) convenience (9.3%; 95% CI, 8.5%–10.1%), and (5) risk of physical harms (7.6%; 95% CI, 7.0%–8.2%).

Attribute importance varied by several factors, including race-ethnicity, socioeconomic status, and educational attainment (Table 3, Supplementary Table 5). Compared with their counterparts, Hispanic patients, patients of high socioeconomic status, and patients with low educational attainment each placed less importance on sensitivity for early HCC detection and more importance on convenience. Hispanic patients also placed increased importance on potential financial harms than non-Hispanics. We did not find significant differences in patient preferences by other characteristics including location, age, sex, health insurance, perception of HCC risk, liver disease etiology, or liver disease severity.

Preference Share Simulator Model

Figure 3 reports simulation analyses to characterize patient willingness to perform HCC surveillance with varying surveillance attributes. Simulations were compared with a reference modality with 35% sensitivity for early HCC detection, 40% false positive rate, \$100 out-of-pocket expense, 60-minute duration, and requiring one to lay flat in an enclosed tube (ie, a surveillance test with the most undesirable characteristics across attributes). With these attributes, 47.5% of participants preferred to undergo HCC surveillance, with the remaining 52.5% preferring not to undergo HCC surveillance. Figure 3 shows how preference for undergoing surveillance changed when a single attribute was changed at a time. For example, if sensitivity for early HCC detection was increased from 35% to 65%, the proportion of patients preferring HCC surveillance would increase from 47.5% to 76.6%, with the remaining 24.4% continuing to prefer no surveillance.

The proportion of patients preferring to undergo surveillance increased with improved sensitivity for early HCC detection (from 35% to 90%) from 47.5% to 91.4%; lower out-of-pocket costs (from \$100 to \$5) from 47.5% to 65.3%; decreased test duration (from 60 minutes to 10 minutes) from 47.5% to 55.1%; and test logistics (lying flat in an enclosed tube vs single blood draw) from 47.5% to 63.5%. The preference for surveillance did not significantly change with decreasing false positive rate (from 40% to 10%), with the proportion remaining between 44.2% and 47.5% of patients.

Multiproduct competitive market simulations, comparing HCC surveillance tests, were performed to determine which HCC surveillance method would dominate if patients knew the details of the available tests and values that directed surveillance selection (Table 4). In our base scenario with commonly available surveillance methods (AFP alone, US alone, US + AFP, computed tomography scan, and MRI), MRI had a preference share of 52.2%. The dominance of MRI vs other options appeared to be primarily driven by higher sensitivity for early HCC detection.

In simulations adding abbreviated MRI (aMRI), aMRI had the highest preference share: aMRI 35.1% vs 27.4% for full MRI. Preference share was primarily driven by maintaining highest sensitivity for early HCC detection, while decreasing exam duration. After introducing potential novel biomarker panels, market share was split between these 3 options (preference share: aMRI 28%, MRI 23%, biomarker-based surveillance 21%). Blood-based

biomarker surveillance approached similar preference shares as MRI-based surveillance despite lower sensitivity for early HCC detection due to higher convenience and a short time commitment.

Discussion

Patients with cirrhosis undergoing HCC surveillance strongly prioritize early tumor detection over surveillance-related risks and convenience. Among surveillance-related risks and logistics, patients place greater importance on test logistics and potential financial harms over time commitment and physical harms. These relationships are maintained regardless of patient demographics and background. These data are particularly important in light of US's suboptimal sensitivity for early HCC detection, and highlight patients' desire for novel imaging- and blood-based surveillance strategies.

HCC surveillance from the patient's perspective is more nuanced than potential benefits (eg, early cancer detection) or a single type of surveillance harm. This point is important because current literature has exclusively focused on potential benefits and risk of physical harms.^{8,10,26,27} While surveillance benefits were highly valued, the risk of a physical harms was the least important HCC surveillance attribute among patients in our study. There have been limited data on financial or psychological harms of HCC surveillance, despite literature suggesting that these can be common in other cancer surveillance programs as well as lead to lower utilization of HCC surveillance in clinical practice.^{28,29} Overall, a comprehensive assessment of benefits, harms, and patient barriers are important to consider when attempting to align patient values with choice of a surveillance plan.³⁰

Surveillance strategies provide the best value when there is a clear balance between benefits and harms vs patient-centered values. In all of our simulations, patients had lower preference for US alone or US with AFP compared with abbreviated MRI, full MRI, and novel biomarker-based surveillance. Abbreviated MRI was the most preferred method due to its high sensitivity for early HCC detection and high convenience. There are several emerging biomarker panels that are awaiting large-scale validation (eg, GALAD score, methylated DNA marker panels), and our study affirms that patients demonstrate a preference for the convenience of such testing, despite potentially lower early HCC sensitivity than MRI-based modalities. Prior studies indicate direct patient involvement in decisions regarding HCC surveillance improves satisfaction and adherence.³¹ These findings and simulation tools can be used as a way for providers to engage with patients when making decisions to build a personalized surveillance plan and improve surveillance utilization in clinical practice.

In our study, we found patient variation in surveillance attribute weights. For example, patients of Hispanic ethnicity placed less importance on early HCC sensitivity and greater importance on financial harms and test convenience. These data are important given Hispanics' experience a disproportionately high burden of HCC, in terms of not only incidence and mortality, but also decreased surveillance utilization.^{1,32-35} These data reflect how socioeconomic barriers and perceived surveillance inconveniences affect healthcare decision making and this population. These data help understand how perceptions and

inconveniences related to surveillance can contribute to racial-ethnic disparities in early detection and overall survival.

Our work had several limitations. First, no preexisting conjoint instrument existed as a base for our survey instrument; however, we vetted survey content by nonauthor experts with expertise in survey design, hepatologists with expertise in HCC surveillance, and 5 patients with cirrhosis from each center for readability and survey content. Risk of bias in the design of the survey was minimized through use of professional conjoint software to create a near-orthogonal design with level balance and minimal attribute level overlap and administering the survey by a trained patient interviewer at each site. Second, survey studies are inherently limited by response and nonresponse biases; however, our study had an excellent response rate of approximately 90%. Third, our study was conducted in 4 health systems with a diverse patient population but may not be generalized to other types of patient populations followed in community practices of other types of integrated systems such as the Veterans Affairs health system. Future studies in broader patient populations are needed to validate our study findings. Fourth, our subgroup analyses were exploratory and likely underpowered to detect meaningful differences. Fifth, the part-worth utilities, attribute importances, and share of preference are based on number of attributes and attribute levels asked in the survey. Although our results could differ if different attributes or levels were included, we selected attribute levels based on the full range of HCC surveillance techniques at the time of study design. Although we believe we have accounted for all attributes that could affect the choices, future studies may choose wider attribute level ranges for variables such as costs, or include additional attributes. Finally, hypothetical scenarios and implications of factors such as physical harms may not have been fully understood by all patients. These weaknesses are outweighed by study strengths, including its unique and clinically important question, high response rate, and diverse patient population.

In conclusion, patient with cirrhosis undergoing HCC surveillance prioritize early HCC detection over surveillance-related risks and convenience. Although these relationships were generally maintained across patient subgroups, patients of Hispanic ethnicity placed greater importance on financial harms and convenience than their counterparts when determining preferred surveillance strategies. These data, and the corresponding simulator, are valuable for understanding patient preferences for a personalized HCC surveillance plan.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Conflicts of Interest

These authors disclose the following: Amit G. Singal has served on advisory boards and as a consultant for Wako Diagnostics, Roche, Exact Sciences, Glycotest, and Bayer. Matthew Davenport has received unrelated royalties

from Wolters Kluwer. Jonathan Troost owns stocks in Procter & Gamble and General Electric. Elliot Tapper has served as a consultant for Novartis, Axcella, Kaleido, Mallinckrodt, and Allergan; and on advisory boards for Mallinckrodt, Novo Nordisk, Takeda, and Rebiotix. Anjana Pillai has served on the Speakers Bureau for Simply Speaking Hepatitis and on the medical advisory board for Exelixis, Eisai, and Genentech. Neehar D. Parikh has served as a consultant for Bristol Myers Squibb, Exact Sciences, Eli Lilly, Freenome has served on advisory boards of Genentech, Eisai, Bayer, Exelixis, Wako/Fujifilm and has received research funding from Bayer, Target Pharmsolutions, Exact Sciences, and Glycotest.

Abbreviations used in this paper:

AFP	alpha fetoprotein
aMRI	abbreviated magnetic resonance imaging
CI	confidence interval
HCC	hepatocellular carcinoma
MRI	magnetic resonance imaging
US	ultrasound

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What You Need to Know

Background

Hepatocellular carcinoma surveillance is recommended for improvement in the early detection of hepatocellular carcinoma (HCC). The preference of patients when considering surveillance modalities has not been studied.

Findings

Our prospective multicenter study shows that patients with cirrhosis eligible for HCC surveillance prefer surveillance sensitivity for early detection over other test attributes. Preferred strategies include magnetic resonance imaging and biomarker-based approaches.

Implications for patient care

With several available HCC surveillance methods, including ultrasound, magnetic resonance imaging, computed tomography, and several emerging imaging and blood based biomarkers, understanding what aspects of tests patients value may influence choice of surveillance methodology.

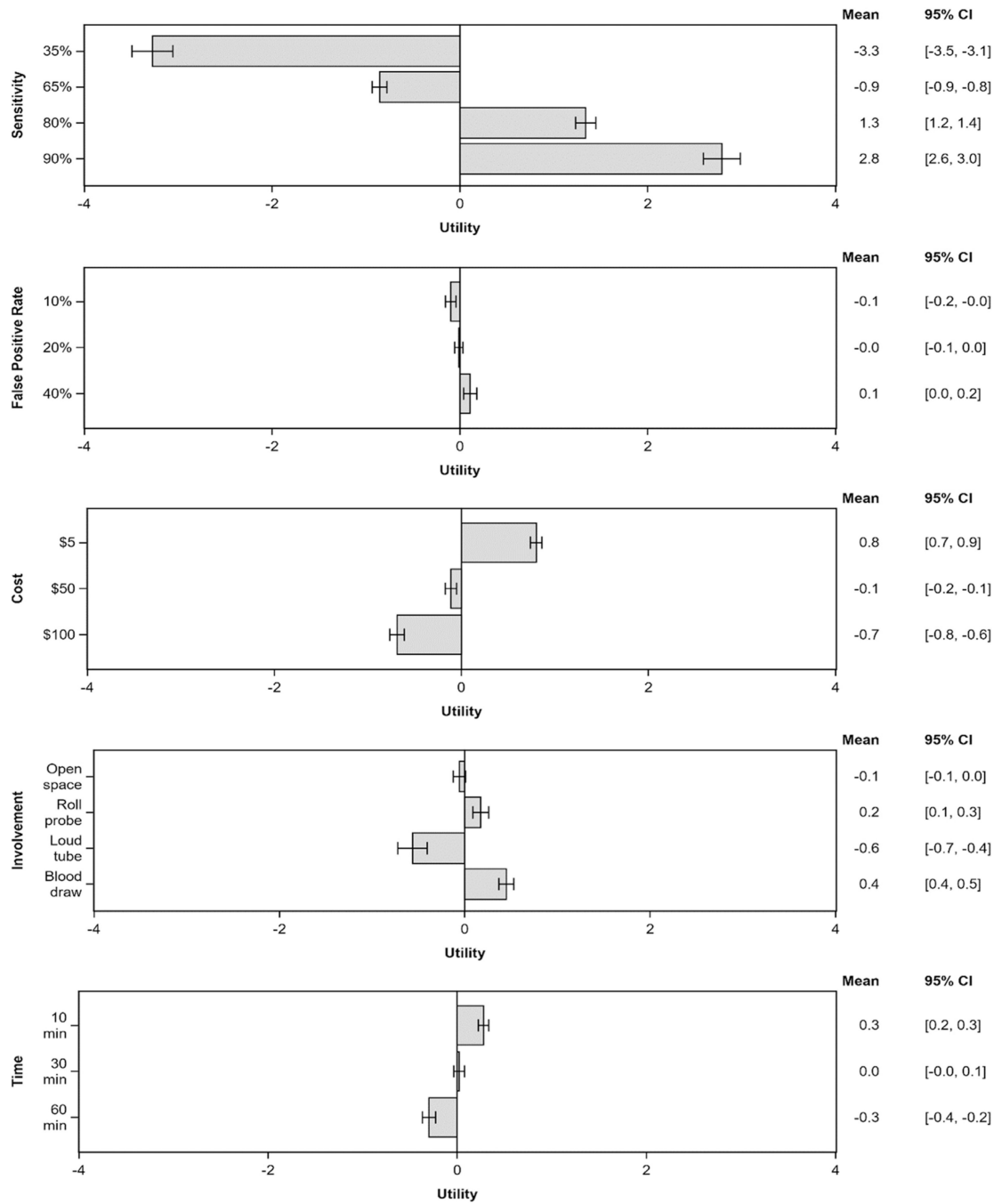


Figure 1. Tornado plots of average part-worth utilities and 95% CIs for all attribute levels.

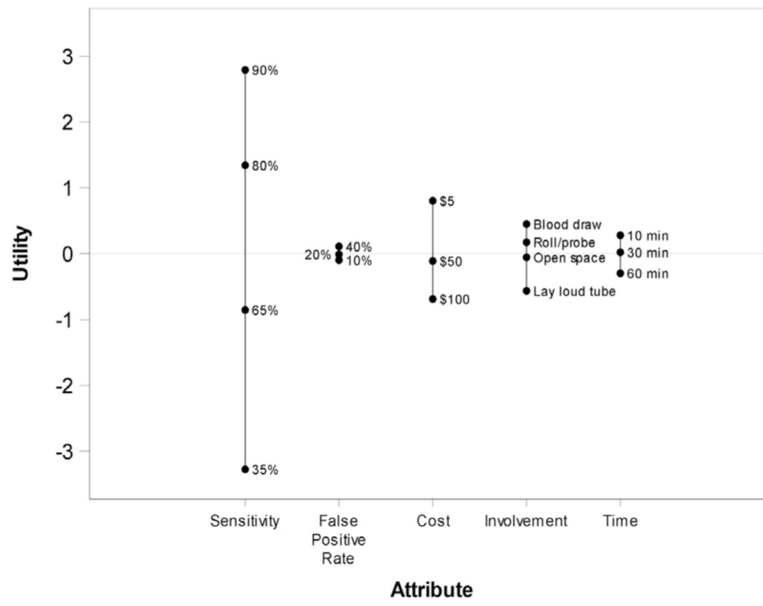


Figure 2. Thermometer plot of range of part-worth utilities for each attribute. A wider range indicates higher importance. Each attribute is centered at 0.

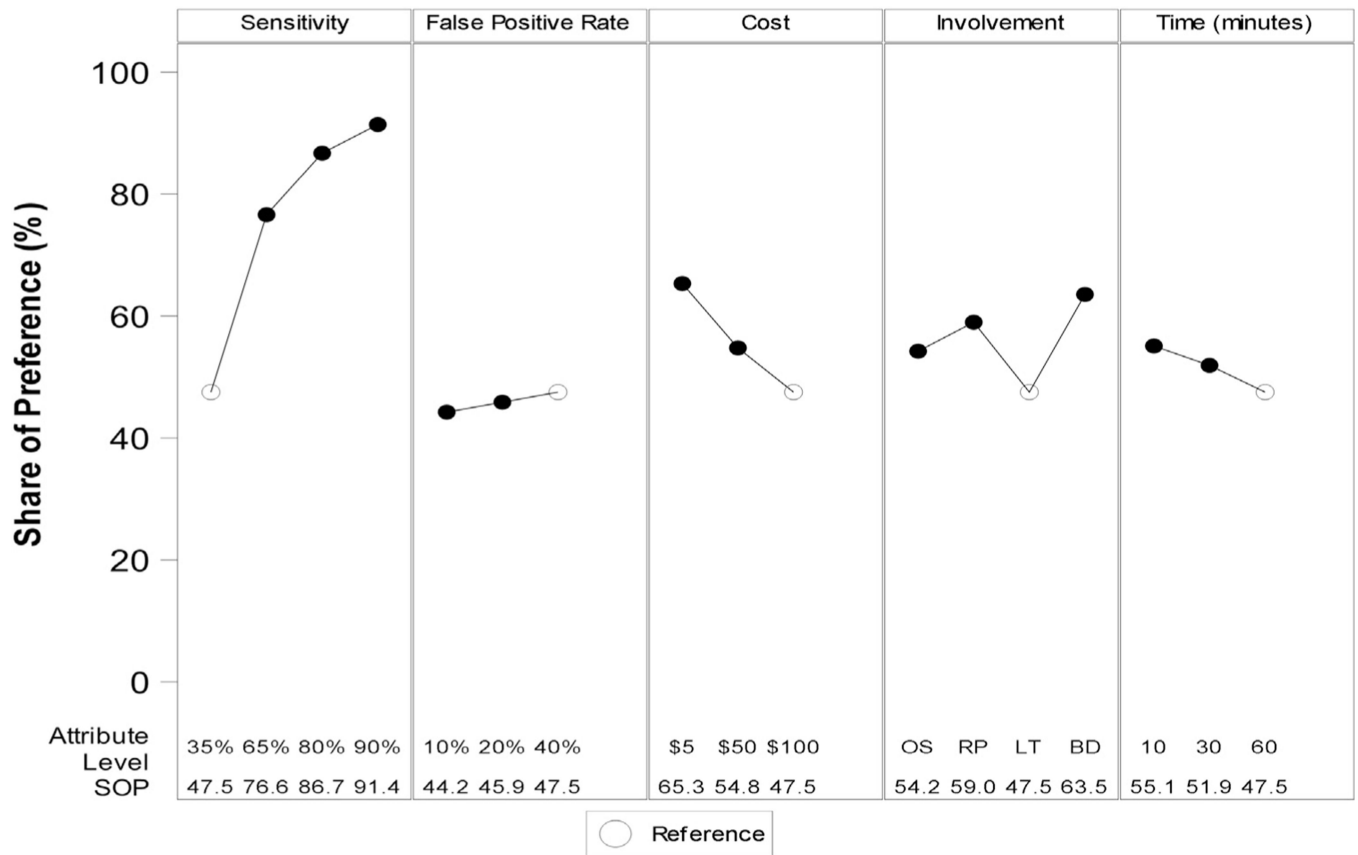


Figure 3. Sensitivity analysis of share of preference based on simulations. BD, a single blood draw; LT, lay flat in a small enclosed tube that makes loud noises; OS, lay flat in an open space; RP, roll in different positions while a technician uses a probe; SOP, share of preference.

Table 1.

Participant Characteristics

Characteristic	Respondents (n = 179)
Age, y	64 (54–69)
Location	
University of Michigan	54 (30)
University of Texas Southwestern Medical Center	44 (25)
Parkland	26 (14)
University of Chicago	55 (31)
Sex	
Female	80 (45)
Male	99 (55)
Race	
White	107 (60)
Hispanic or Latino	29 (16)
Black or African American	30 (17)
Asian/Pacific Islander	10(6)
Other	3(2)
Ethnicity	
Non-Hispanic	146 (82)
Hispanic	33 (18)
Education	
Less than high school	24 (13)
High school graduate	50 (28)
Trade/technical/vocational training	11 (6)
Associate degree	17(9)
College graduate	44 (25)
More than college	25 (14)
Prefer not to answer	8(4)
Health insurance	
None	6 (3)
Self-insured	2 (1)
Employer based plan	46 (26)
Medicaid	25 (14)
Medicare	91 (51)
Other	9 (5)
Employment status	
Full time employed	42 (23)
Part-time employed	9(5)
Disability	35 (20)
Unemployed	15(8)
Retired	74 (41)

Characteristic	Respondents (n = 179)
Prefer not to answer	4(2)
Household income	
<\$25,000	19(11)
\$25,000-\$49,999	23 (13)
\$50,000-\$99,999	27(17)
>\$100,000-\$149,999	17(9)
Prefer not to answer	93 (52)
Commute time to hospital from home	
0–10 min	12(7)
11–30 min	55 (31)
31–60 min	69 (39)
61–120 min	27 (15)
>120 min	15(8)
Prefer not to answer	1 (1)

NOTE. Values are median (interquartile range) or n (%).

Table 2.

Participant Liver Disease and Cancer Risk Perception characteristics

Characteristic	Distribution
Etiology of liver disease	
Chronic hepatitis B	14 (8)
Chronic hepatitis C	37 (21)
Alcoholic liver disease	33 (18)
Nonalcoholic steatohepatitis	47 (26)
Cryptogenic cirrhosis	7 (4)
Other (includes cardiac)	41 (25)
Child-Pugh class	
A	136 (76)
B	29 (16)
C	12 (7)
Missing	2 (1)
MELD score	
1–10	118 (66)
11–20	42 (24)
21–30	15 (8)
Missing	3 (2)
Patient perception of lifetime cancer risk	
Very likely	15 (8)
Likely	48 (27)
Neutral	89 (50)
Unlikely	20 (11)
Very unlikely	7 (4)
Patient perception of cancer curability with early stage	
Very likely	26 (15)
Likely	82 (46)
Neutral	49 (27)
Unlikely	13 (7)
Very unlikely	9 (5)
Patient perception of the chance of detecting cancer at an early stage with surveillance	
All of the time	21 (12)
Most of the time	109 (61)
Some of the time	39 (22)
Rarely	10 (6)

NOTE. Values are n (%).

MELD, Model for End-Stage Liver Disease.

Table 3. Average Attribute Importance and Univariable Linear Regression Results Testing Differences in Mean Attribute Importance by Participant Characteristics

Parameter	Sensitivity for Early HCC		Risk of Physical Harms		Risk of Financial Harms		Test Logistics		Convenience	
	Mean (95% CI)	<i>P</i>	False Positive Rate	<i>P</i>	Cost	<i>P</i>	Involvement	<i>P</i>	Time	<i>P</i>
Comparisons: Mean importance differences (99% CI)										
Parameter	51.2 (49.0 to 53.4)		7.6 (7.0 to 8.2)		15.2 (14.0,16.3)		16.7 (15.4 to 18.1)		9.3 (8.5 to 10.1)	
Age	<i>P</i> = .39		<i>P</i> = .76		<i>P</i> = .23		<i>P</i> = .98		<i>P</i> = .39	
Age: per 10 y	-0.7 (-2.9 to 1.5)		-0.1 (-0.7 to 0.6)		0.6 (-0.6 to 1.7)		-0.0 (-1.4 to 1.4)		0.3 (-0.5 to 1.1)	
Location	<i>P</i> = .38		<i>P</i> = .32		<i>P</i> = .43		<i>P</i> = .22		<i>P</i> = .14	
Chicago vs UT Southwestern/Parkland	-3.2 (-10.1 to 3.7)		0.4 (-1.5 to 2.3)		1.3 (-2.4 to 4.9)		-0.3 (-4.5 to 4.0)		1.8 (-0.7 to 4.3)	
Michigan vs UT Southwestern/Parkland	-3.1 (-10.0 to 3.8)		1.1 (-0.8 to 3.1)		-0.7 (-4.4 to 3.0)		2.5 (-1.8 to 6.8)		0.1 (-2.4 to 2.7)	
Sex	<i>P</i> = .35		<i>P</i> = .94		<i>P</i> = .44		<i>P</i> = .63		<i>P</i> = .52	
Female vs Male	2.1 (-3.7 to 7.8)		0.0 (-1.6 to 1.7)		-0.9 (-4.0 to 2.1)		-0.7 (-4.2 to 2.9)		-0.5 (-2.6 to 1.6)	
Race	<i>P</i> = .14		<i>P</i> = .17		<i>P</i> = .31		<i>P</i> = .99		<i>P</i> = .14	
Black vs White	-5.0 (-12.9 to 2.8)		1.9 (-0.3 to 4.1)		1.8 (-2.4 to 6.0)		0.0 (-4.9 to 5.0)		1.4 (-1.5 to 4.2)	
Hispanic vs White	-5.6 (-13.6 to 2.3)		0.0 (-2.2 to 2.2)		2.7 (-1.6 to 6.9)		0.7 (-4.3 to 5.7)		2.2 (-0.7 to 5.2)	
Other vs White	1.0 (-10.1 to 12.2)		0.5 (-2.7 to 3.6)		-0.7 (-6.7 to 5.3)		0.2 (-6.8 to 7.2)		-0.9 (-5.0 to 3.2)	
Ethnicity	<i>P</i> = .01 ^a		<i>P</i> = .46		<i>P</i> = .04		<i>P</i> = .19		<i>P</i> = .01 ^a	
Hispanic vs non-Hispanic	-7.5 (-14.8 to -0.3) ^b		-0.6 (-2.7 to 1.5)		3.2 (-0.7 to 7.0)		2.3 (-2.2 to 6.9)		2.6 (-0.0 to 5.3)	
Education	<i>P</i> = .05		<i>P</i> = .18		<i>P</i> = .54		<i>P</i> = .76		<i>P</i> = .002 ^a	
High school vs college	-4.6 (-10.4 to 1.3)		0.9 (-0.8 to 2.5)		0.7 (-2.4 to 3.9)		0.4 (-3.2 to 4.0)		2.5 (0.4 to 4.7) ^b	
Health insurance	<i>P</i> = .07		<i>P</i> = .87		<i>P</i> = .06		<i>P</i> = .70		<i>P</i> = .06	
Medicaid vs employer	-8.7 (-18.1 to 0.6)		-0.6 (-3.3 to 2.1)		4.0 (-1.0 to 8.9)		2.5 (-3.4 to 8.4)		2.9 (-0.5 to 6.3)	
Medicare vs employer	-5.3 (-12.1 to 1.6)		-0.8 (-2.8 to 1.1)		3.4 (-0.2 to 7.0)		0.6 (-3.7 to 4.9)		2.1 (-0.4 to 4.6)	
None vs employer	-8.7 (-25.0 to 7.7)		-0.4 (-5.1 to 4.3)		6.6 (-2.2 to 15.3)		3.7 (-6.6 to 14.0)		-1.2 (-7.2 to 4.8)	
Other vs employer	-10.0 (-22.7 to 2.6)		-0.4 (-4.0 to 3.3)		4.7 (-2.1 to 11.4)		2.5 (-5.5 to 10.4)		3.3 (-1.4 to 7.9)	
Employment status	<i>P</i> = .47		<i>P</i> = .60		<i>P</i> = .56		<i>P</i> = .66		<i>P</i> = .76	
Disability vs full time	-3.8 (-12.5 to 5.0)		-1.1 (-3.5 to 1.4)		2.8 (-1.9 to 7.5)		0.7 (-4.7 to 6.2)		1.3 (-1.9 to 4.6)	
Part-time vs full time	3.4 (-10.6 to 17.5)		-1.6 (-5.6 to 2.3)		0.1 (-7.4 to 7.6)		-3.7 (-12.4 to 5.0)		1.8 (-3.4 to 7.0)	
Prefer not to answer vs full time	-0.3 (-20.4 to 19.7)		-3.4 (-9.0 to 2.3)		3.1 (-7.5 to 13.8)		1.9 (-10.6 to 14.3)		-1.3 (-8.7 to 6.0)	

Parameter	Sensitivity for Early HCC	Risk of Physical Harms	Risk of Financial Harms	Test Logistics	Convenience
Retired vs full time	-1.6 (-9.0 to 5.8)	-1.0 (-3.1 to 1.1)	1.5 (-2.5 to 5.4)	0.4 (-4.2 to 5.0)	0.7 (-2.0 to 3.4)
Unemployed vs full time	-7.4 (-18.9 to 4.1)	-1.0 (-4.2 to 2.2)	3.6 (-2.5 to 9.7)	3.1 (-4.1 to 10.2)	1.8 (-2.5 to 6.0)
Household income	$p = .01^a$	$p = .39$	$p = .07$	$p = .20$	$p = .03^a$
<\$50,000 vs \$50,000	-9.2 (-17.6 to -0.9) ^b	0.8 (-1.5 to 3.1)	3.2 (-1.4 to 7.9)	2.7 (-2.7 to 8.1)	2.5 (-0.4 to 5.5)
Income reported	$p = .84$	$p = .28$	$p = .48$	$p = .97$	$p = .42$
Reported vs Not reported	-0.4 (-6.2 to 5.3)	0.7 (-0.9 to 2.3)	-0.8 (-3.9 to 2.2)	-0.1 (-3.6 to 3.5)	0.7 (-1.4 to 2.8)
Commute time	$p = .28$	$p = .68$	$p = .10$	$p = .29$	$p = .04$
0-10 min vs 31-60 min	1.4 (-10.5 to 13.3)	1.6 (-1.8 to 5.0)	-3.1 (-9.4 to 3.2)	0.4 (-7.0 to 7.8)	-0.3 (-4.6 to 4.0)
11-30 min vs 31-60 min	-2.6 (-9.5 to 4.2)	1.1 (-0.8 to 3.1)	2.1 (-1.5 to 5.7)	-1.2 (-5.4 to 3.1)	0.6 (-1.9 to 3.1)
121-180 min vs 31-60 min	6.4 (-6.0 to 18.7)	-0.2 (-3.7 to 3.3)	-4.2 (-10.7 to 2.4)	2.2 (-5.4 to 9.9)	-4.3 (-8.7 to 0.2)
61-120 min vs 31-60 min	-5.6 (-14.2 to 3.1)	1.2 (-1.2 to 3.7)	2.0 (-2.6 to 6.5)	0.4 (-5.0 to 5.7)	2.0 (-1.1 to 5.1)
>181 min vs 31-60 min	4.5 (-15.1 to 24.0)	0.7 (-4.9 to 6.2)	3.0 (-7.3 to 13.3)	-10.8 (-22.9 to 1.3)	2.6 (-4.4 to 9.7)
Prefer not to answer vs 31-60 min	7.9 (-30.4 to 46.2)	2.0 (-8.9 to 12.9)	4.1 (-16.2 to 24.3)	-7.4 (-31.1 to 16.3)	-6.6 (-20.4 to 7.2)
Patient perception of lifetime cancer risk	$p = .81$	$p = .72$	$p = .68$	$p = .58$	$p = .27$
Very likely vs neutral	0.1 (-10.6 to 10.9)	-0.4 (-3.5 to 2.6)	1.5 (-4.2 to 7.2)	-1.8 (-8.4 to 4.8)	0.6 (-3.3 to 4.5)
Likely vs neutral	0.5 (-6.4 to 7.4)	-0.7 (-2.6 to 1.3)	0.4 (-3.3 to 4.0)	-2.1 (-6.3 to 2.2)	1.9 (-0.6 to 4.4)
Unlikely vs neutral	-0.2 (-9.7 to 9.3)	-0.8 (-3.5 to 1.9)	2.8 (-2.3 to 7.9)	-1.3 (-7.2 to 4.6)	-0.5 (-4.0 to 2.9)
Very unlikely vs neutral	-7.0 (-22.1 to 8.1)	1.3 (-3.0 to 5.5)	1.1 (-6.9 to 9.1)	2.7 (-6.6 to 12.0)	1.9 (-3.6 to 7.4)
Patient Perception of cancer curability with early stage	$p = .93$	$p = .85$	$p = .96$	$p = .71$	$p = .71$
Very likely vs neutral	-1.8 (-11.1 to 7.6)	0.3 (-2.4 to 2.9)	-0.1 (-5.1 to 4.9)	-0.3 (-6.1 to 5.5)	1.9 (-1.5 to 5.3)
Likely vs neutral	-1.5 (-8.4 to 5.5)	0.8 (-1.1 to 2.8)	-0.5 (-4.2 to 3.2)	0.6 (-3.7 to 4.9)	0.5 (-2.0 to 3.1)
Unlikely vs neutral	-1.4 (-13.4 to 10.6)	0.1 (-3.2 to 3.5)	-1.8 (-8.2 to 4.6)	2.3 (-5.1 to 9.8)	0.8 (-3.6 to 5.2)
Very unlikely vs neutral	-4.6 (-18.5 to 9.4)	0.3 (-3.6 to 4.3)	-0.0 (-7.5 to 7.4)	4.0 (-4.6 to 12.6)	0.3 (-4.8 to 5.4)
Patient perception of the chance of detecting cancer at an early stage with surveillance	$p = .96$	$p = .24$	$p = .90$	$p = .82$	$p = .54$
All of the time vs most of the time	-1.8 (-11.0 to 7.4)	1.4 (-1.1 to 4.0)	-0.3 (-5.2 to 4.6)	1.1 (-4.6 to 6.8)	-0.4 (-3.8 to 2.9)
Some of the time vs most of the time	0.7 (-12.0 to 13.4)	1.7 (-1.9 to 5.2)	1.7 (-5.0 to 8.5)	-2.3 (-10.1 to 5.6)	-1.8 (-6.4 to 2.8)
Rarely vs most of the time	-0.0 (-7.2 to 7.1)	1.1 (-0.9 to 3.1)	0.5 (-3.3 to 4.3)	-0.3 (-4.8 to 4.1)	-1.2 (-3.9 to 1.4)
Child-Pugh class	$p = .60$	$p = .95$	$p = .27$	$p = .94$	$p = .97$
B vs A	-0.3 (-8.1 to 7.6)	0.1 (-2.2 to 2.3)	0.7 (-3.5 to 4.9)	-0.3 (-5.2 to 4.5)	-0.2 (-3.1 to 2.7)
C vs A	-4.5 (-16.1 to 7.1)	-0.4 (-3.6 to 2.9)	3.8 (-2.3 to 10.0)	0.8 (-6.4 to 8.0)	0.2 (-4.0 to 4.5)

Parameter	Sensitivity for Early HCC	Risk of Physical Harms	Risk of Financial Harms	Test Logistics	Convenience
MELD score	$p = .80$	$p = .22$	$p = .44$	$p = .69$	$p = .88$
MELD score: per 5 points	-0.3 (-2.8 to 2.3)	-0.3 (-1.1 to 0.4)	0.4 (-1.0 to 1.8)	0.2 (-1.3 to 1.8)	-0.1 (-1.0 to 0.9)

NOTE. Attribute "importance" is the estimated average relative importance participants placed on that attribute when making product selection decisions. For each participant, attribute importance (%) is calculated as the range of their part-worth utilities for that attribute, divided by the sum of the ranges for all attributes multiplied by 100 (ie, $\frac{\text{Attribute utility range}}{\sum \text{Attribute utility ranges}} \times 100$). Reported values in the first row above are the average importances across all 179 participants. CI, confidence interval; HCC, hepatocellular carcinoma; MELD, Model for End-Stage Liver Disease; UT Southwestern, University of Texas Southwestern Medical Center.

^aOverall P value.

^b $P < .01$.

Table 4.

Ranked Simulation Results of Share of Preference

Procedure	Early HCC Sensitivity (%)	Risk of Physical Harm (%)	Out-of-Pocket Costs, (2019 US\$)	Test Logistics	Convenience/Test Duration (min)	Share of Preference (%) (95% CI)
Simulation 1						
MRI	84	10	99.76	LT	37	52.2 (47.0–57.4)
US+AFP	63	16	32.61	RP	35	15.0 (13.0–17.1)
AFP alone	39	24	5.00	BD	10	12.8 (10.4–15.2)
CT scan	63	12	54.71	OS	20	9.3 (8.1–10.5)
None	—	—	—	—	—	5.4 (3.2–7.6)
US alone	45	10	28.47	RP	25	5.3 (4.4–6.2)
Simulation 2						
MRI	84	10	99.76	LT	37	40.0 (35.3–44.7)
Biomarker	68	10	35.95	BD	10	26.9 (24.1–29.8)
US+AFP	63	16	32.61	RP	35	10.6 (8.9–12.2)
AFP alone	39	24	5.00	BD	10	7.8 (6.4–9.3)
CT scan	63	12	54.71	OS	20	6.0 (5.2–6.7)
None	—	—	—	—	—	4.8 (2.7–6.9)
US alone	45	10	28.47	RP	25	3.9 (3.2–4.6)
Simulation 3						
aMRI	84	10	99.76	LT	17	35.1 (32.1–38.0)
MRI	84	10	99.76	LT	37	27.4 (25.0–29.8)
US+AFP	63	16	32.61	RP	35	11.5 (9.5–13.5)
AFP alone	39	24	5.00	BD	10	10.2 (7.9–12.4)
CT scan	63	12	54.71	OS	20	6.9 (5.9–7.9)
None	—	—	—	—	—	4.6 (2.6–6.6)
US alone	45	10	28.47	RP	25	4.3 (3.5–5.2)
Simulation 4						
aMRI	84	10	99.76	LT	17	29.0 (26.3–31.7)
MRI	84	10	99.76	LT	37	23.3 (21.0–25.7)
Biomarker	68	10	35.95	BD	10	20.9 (18.3–23.5)

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Procedure	Early HCC Sensitivity (%)	Risk of Physical Harm (%)	Out-of-Pocket Costs, (2019 US\$)	Test Logistics	Convenience/Test Duration (min)	Share of Preference (%) (95% CI)
US+AFP	63	16	32.61	RP	35	8.8 (7.2–10.5)
AFP alone	39	24	5.00	BD	10	5.5 (4.3–6.8)
CT scan	63	12	54.71	OS	20	4.9 (4.2–5.6)
None	—	—	—	—	—	4.1 (2.3–6.0)
US alone	45	10	28.47	RP	25	3.4 (2.7–4.1)

AFP, alpha-fetoprotein; aMRI, abbreviated magnetic resonance imaging; BD, a single blood draw; CI, confidence interval; CT, computed tomography; MRI, magnetic resonance imaging; LT, lay flat in a small enclosed tube that makes loud noises; OS, lay flat in an open space; RP, roll in different positions while a technician uses a probe; SOP, share of preference; US, ultrasound.