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MAJOR ARTICLE

Efficacy of a Primary Care-Based Mobile Application to Increase Hepatitis C Screening Among Asian Americans: A Secondary Analysis of a Randomized Clinical Trial

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Background. Hepatitis C virus (HCV) screening remains suboptimal. We assessed the efficacy of a mobile application and provider alert in enhancing HCV screening among Asian Americans.

Methods. A secondary analysis of a cluster-randomized clinical trial was performed during the birth cohort screening era to assess the efficacy of a Hepatitis App (intervention), a multilingual mobile application delivering interactive video education on viral hepatitis and creating a Provider Alert printout, at primary care clinics within 2 healthcare systems in San Francisco from 2015 to 2017. A comparison group received usual care and a similar intervention on nutrition and physical activity. The outcome was electronic health record (EHR) documentation of HCV screening along with patient-provider communication about testing and test ordering.

Results. Four hundred fifty-two participants (mean age 57 years, 36% male, 80% foreign-born) were randomized by provider clusters to the intervention (n = 270) or comparison groups (n = 182). At 3-month follow up, the intervention group was more likely than the comparison group to be aware of HCV (75% vs 59%, *P* = .006), to discuss HCV testing with their providers (63% vs 13%, *P* < .001), to have HCV testing ordered (39% vs 10%, *P* < .001), and to have EHR-verified HCV testing (30% vs 6%, *P* < .001). Within the intervention group, being born between 1945 and 1965 (odds ratio, 3.15; 95% confidence interval, 1.35–7.32) was associated with increased HCV testing.

Conclusions. The Hepatitis App delivered in primary care settings was effective in increasing HCV screening in a socioeconomically diverse Asian American cohort. This highlights the importance of mobile technology as a patient-centered strategy to address gaps in HCV care.

Keywords. healthcare disparities; language; technology; viral hepatitis.

Chronic hepatitis C virus (HCV) affects over 71 million people worldwide [1] and is associated with liver cirrhosis and hepatocellular carcinoma (HCC) [2]. The US Preventive Services Task Force (USPSTF) [3] and the Centers for Disease Control and Prevention (CDC) [4] previously recommended risk-based HCV screening for patients to promote early detection of HCV infection. These risk factors included current or prior history of intravenous drug use, blood transfusions before 1992, hemodialysis, human immunodeficiency virus infection, birth to HCV-positive mothers, and birth during years 1945–1965 (ie, birth cohort) [5, 6]. However, significant reduction in the rate of acute HCV infection has not yet been achieved in the United States [7]. Thus, recognizing the limitations of risk-based HCV screening, in March and April 2020, the USPSTF and CDC recommended universal HCV screening in all adults, respectively [8, 9].

The availability of highly effective, direct-acting antiviral therapies to treat HCV infection has highlighted the importance and cost-effectiveness of HCV screening, early diagnosis, and treatment [10]. Among Asian Americans, despite traditionally low rates of HCV infection, there is an unmet need to improve access to HCV screening and timely treatment with effective antiviral therapies. Although national survey data suggests a low HCV rate in Asian adults at 0.2% [11], several studies with convenience sampling have found higher HCV prevalence at 5.5%–7.9% in Asian Americans [12], with rates up to 15% among Vietnamese Americans and older adults [13–15]. Furthermore, Asian Americans are more likely to experience delays in HCV diagnosis

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[16], have higher rates of HCV cirrhosis [17], and a greater HCC risk [18] than other racial groups. In addition, less common risk factors including dental care, surgeries outside of the United States, acupuncture, tattoos, and body piercing have been associated with HCV infection in Asian Americans [19–21]. In some studies, HCV-infected Asian Americans had no identifiable risk factors, making universal HCV screening all the more critical [12, 19, 22, 23]. Thus, effective and culturally appropriate strategies to enhance HCV screening among Asian Americans remain timely and critical.

Various interventions such as formal patient education, flipbook, and video sessions have been shown to improve HCV knowledge among individuals at risk of or with HCV infection, but only a limited number of studies have focused on Asian Americans [24–27]. In this study, we performed a secondary analysis of a randomized clinical trial (RCT) to evaluate the effectiveness of a primary care-based multilingual mobile application delivering viral hepatitis video education and a provider alert on receipt of HCV screening, and we assessed whether HCV risk factor status influences receipt of HCV screening among Asian Americans.

METHODS

Study Design

We performed a secondary analysis of a cluster RCT that aimed to evaluate the efficacy of the intervention, a Hepatitis App (https://vimeo.com/180742576), which is an interactive educational mobile application that generates a printout for patients and providers (Provider Alert), compared with usual care and a mobile application on nutrition and physical activity (comparison group), in increasing hepatitis (B and C) screening among Asian Americans in the primary care setting [28]. Details of the intervention and comparison groups are provided in a prior publication [28] and in the Supplemental Methods. In this report, we focus on the secondary outcome of HCV screening, which was determined a priori. We hypothesized a priori that the patients receiving the intervention would have a greater increase in the rates of patient-provider discussion about HCV and in receiving and completing HCV screening at 3 months postintervention than patients in the comparison group.

At the time of the study, HCV screening was recommended based on risk and birth cohort status [3, 4]. Participating primary care providers (PCPs) were first stratified by healthcare system (academic or safety-net) and provider type (attending physician, resident, or nurse practitioner). The PCPs were then randomized (ie, cluster) to the intervention or comparison arm in a 1:1 ratio within each stratum using a computer-generated random number table (Figure 1) [29]. Eligible and enrolled patients received the intervention assigned to their PCP and were not randomized individually. Investigators who participated in the data analysis and interpretation were blinded to participant and provider assignments. The study was approved by the University of California San Francisco (UCSF) Institutional Review Board and registered at ClinicalTrials.gov (NCT02139722, https://clinicaltrials.gov/ct2/show/NCT02139722).

Participants and Settings

The study was conducted from January 2015 to December 2017, at 5 primary care clinics at UCSF, an academic institution, and the Zuckerberg San Francisco General Hospital, a safety-net hospital. All PCPs at the 5 clinics were invited to participate. Participants (1) self-identified as Asian American, (2) were aged 18 or older, (3) did not have a documented hepatitis B surface antigen (HBsAg) test in the electronic health records (EHRs), (4) spoke English, Cantonese, Mandarin, or Vietnamese, (5) and had an upcoming primary care appointment at one of the sites. Patients whose PCP excluded them for medical reasons or inability to provide consent were ineligible.

Recruitment

Using EHR, research staff generated a list of eligible patients and sent it to each PCP every 6 months to obtain permission to recruit patients and notify the provider that this list of patients had not been tested for hepatitis B virus (HBV). Eligible patients received a letter from the PCP describing the study and the option of notifying the research team if they did not want to be contacted. Research staff then contacted patients with upcoming PCP appointments by telephone or in-person before their visit. Participants received $50 for their participation.

Data Collection

Participant Measures

Participants completed the following: (1) a preintervention survey, (2) a postvisit survey, and (3) a 3-month follow-up survey either by telephone or mail. The preintervention survey asked participants about their HBV and HCV screening status and awareness. The postvisit survey assessed demographics, language preference and fluency, a Single Item Literacy Screener [30, 31] for health literacy, need for medical interpretation, and HCV risk factors. The HCV risk factors were categorized as follows: (1) birth cohort, (2) other HCV risk factors—presence of common and less common risk factors (Supplemental Table 1), and (3) no risk factors. The 3-month follow-up survey assessed HCV knowledge and attitudes towards HCV (Supplemental Table 2). At postvisit and 3-month follow-up surveys, participants were also asked whether they had asked their provider for HCV testing, discussed HCV screening with their provider, and whether their provider recommended screening. Participants may have felt uncomfortable answering some of the survey questions, but they had the choice of skipping questions.

Outcomes

We assessed 2 primary outcomes: (1) patient-provider communication about HCV testing and (2) receipt of HCV screening

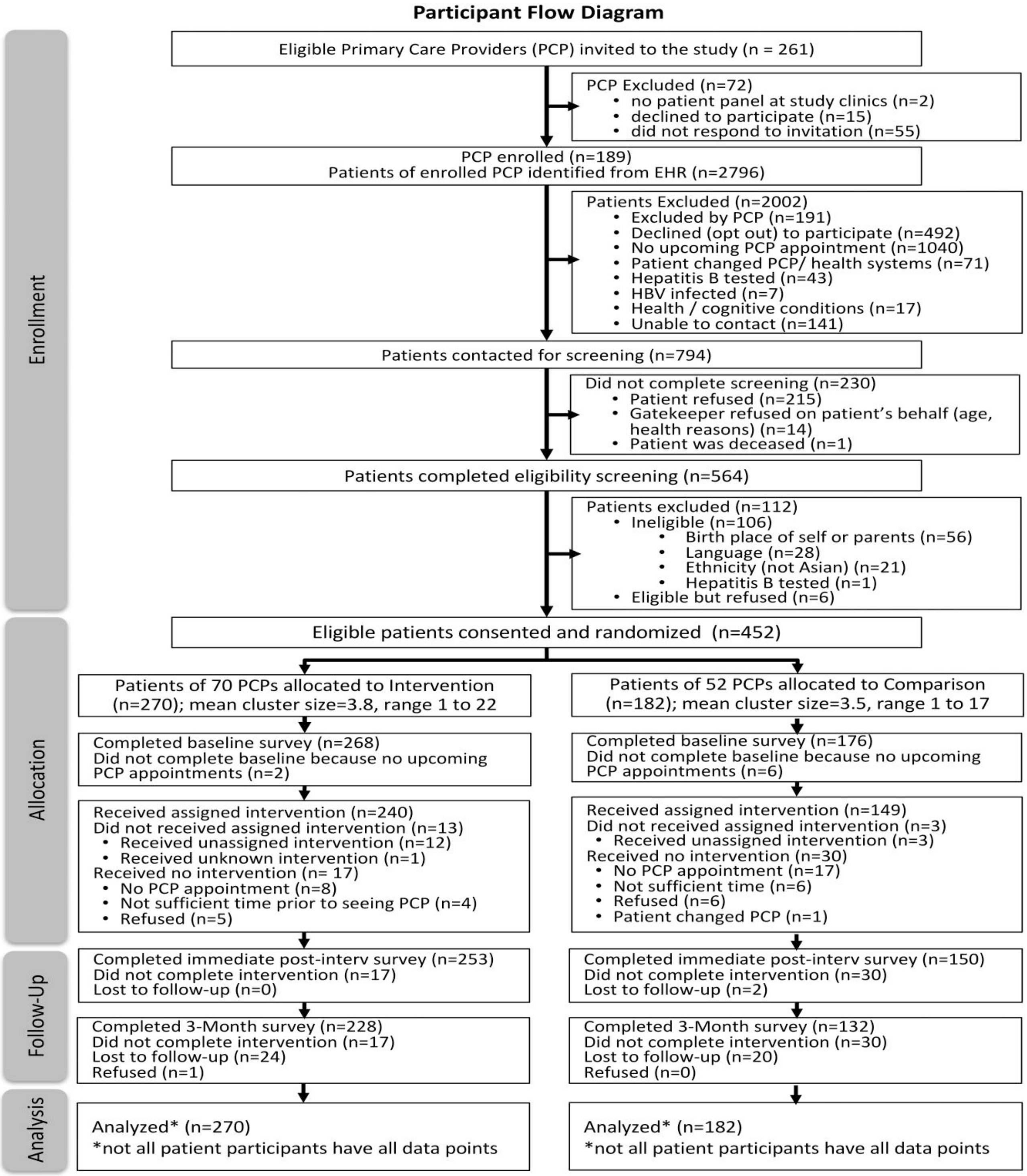

Figure 1. CONSORT flow diagram. * Not all participants have all data points; ** born within the birth cohort or with hepatitis C virus (HCV) risk factor. HBV, hepatitis B virus; PCP, primary care provider.

(EHR documentation of HCV antibody test within 3 months). We also assessed HCV awareness, defined as answering "yes" to "have you ever heard of HCV?", as a secondary outcome.

Sample Size Calculation

The a priori sample size estimation was determined based on HBV testing as the primary outcome of the overall RCT, in which HCV testing was embedded. We performed sample size calculations to test our primary hypothesis at $\alpha = 0.05$ significance level (2-sided) and 80% power, for the primary outcome of getting an HBsAg test within 3 months postintervention. Based on a pilot study [32], we assumed an intraclass correlation of 0.14. With 450 participants, we would be able to detect a 20% difference between intervention and comparison groups.

Statistical Analysis

Participant characteristics were summarized by intervention and HCV risk factor status. We analyzed patients as randomized using the intent-to-treat approach. To account for missing data, we assigned missing values into its own category for each variable. This allowed us to minimize the loss of information and reduce the data variance by placing all missing data into 1 category, as opposed to imputing missing data into many different categories. We computed descriptive statistics, including examination of the means, medians, proportions, and measures of variability, of participant characteristics and HCV awareness, patient-provider communication about HCV testing, and receipt of HCV screening. We used generalized linear mixed models over all time periods (preintervention or 3 months after intervention) to compare changes over time and from pre- to postintervention between the groups. Before creating the models, we performed a collinearity analysis for the potential variables in the models using the methods of Belsley et al [33], with a Condition Index score >30 indicating collinearity. Predictors in the multivariable models included those considered important a priori and those with a $P < .05$ on univariable analysis. Binary outcomes were analyzed using logistic regression models with a logit link. We reported odds ratios (ORs) with 95% confidence intervals (CIs) for binary outcomes and model coefficients for continuous outcomes. The multivariable models evaluating the intervention effect on HCV test ordering and receipt among those eligible for testing (ie, birth cohort, risk factors) were adjusted for age, sex, clinic site, birthplace, duration of US residence, education, employment, spoken language, English fluency, self-reported health, and health literacy.

Patients who received HCV screening before the study were excluded from the HCV screening outcome analysis. We then evaluated the relationship between HCV risk factor status and receipt of HCV testing postintervention using generalized linear models adjusted for age, sex, clinic site, HCV knowledge, and attitudes towards HCV. Hepatitis C virus knowledge and attitude scores were quantified as described in Supplemental Methods and Supplemental Table 2. Data analysis was performed using SAS v9.4. A significance level of .05 was used for all statistical tests.

RESULTS

Participants

Participants had a mean age of 57 years and included 36% male, 61% college educated, 80% foreign-born, 34% limited English fluency, and 13% with a family history of hepatitis or liver cancer (Table 1). Participant characteristics were similar between the intervention (n = 270) and comparison (n = 182) groups (Table 1). Overall, only 53% had heard of HCV before the study (56% in the intervention vs 50% in the comparison group).

Half of the participants (n = 226) were in the birth cohort, 29% (n = 133) had other HCV risk factors, and 21% (n = 93) had no HCV risk factors. In the intervention group, 50%, 31%, and 19% compared to 49%, 27%, and 24% in the comparison group, were born in the birth cohort, had other HCV risk factors, and no HCV risk factors, respectively. Participants without HCV risk factors (38%) were less likely to have heard of HCV than those in the birth cohort (57%) or other HCV risk factor groups (58%) ($P = .003$) (Supplemental Table 3). Distribution of HCV risk factors was not statistically different by intervention status (Supplemental Table 4). Participant characteristics by HCV risk factor status are described in Supplemental Table 3.

Hepatitis C Virus (HCV) Awareness, Patient-Provider Communication About HCV Testing, and Receipt of Screening After Intervention

Immediately postvisit, the intervention participants were more likely than comparison participants to discuss HCV with their providers (63% vs 13%) and to ask their provider for HCV testing (52% vs 6.6%) (Table 2). At 3 months postintervention, more participants in the intervention group than comparison group reported HCV awareness (63% vs 43%). Participants in the intervention group also had significantly higher mean HCV knowledge (4.2 vs 3.2, $P < .001$) and attitude scores (5.3 vs 4.1, $P < .001$) than the comparison group.

Among participants eligible for HCV testing (n = 245), intervention participants were more likely than comparison participants to receive an order for HCV antibody testing (39% vs 10%, $P < .001$) and complete the HCV antibody test (30% vs 6.0%, $P < .001$) based on EHR-documentation (Table 2). In multivariable analysis, participants in the intervention group were more likely than the comparison group to receive an order for HCV testing (OR, 8.8; 95% CI, 3.12–24.8; $P < .001$) and to have an HCV test (OR, 10.5; 95% CI, 2.97–36.8; $P < .001$) (Table 3).

Among the 270 intervention participants, the highest increase in testing was seen in the birth cohort (42%), followed by other (30%) and no (19%) HCV risk factor groups ($P = .01$). On univariable analysis, the only factor associated with postintervention HCV testing was birth cohort status (vs no risk factor) (OR, 3.17; 95% CI, 1.38–7.27; $P = .006$). Having other HCV risk factors (vs no risk factor) was also associated with higher odds of HCV testing, but this was not statistically significant (OR, 1.83; 95% CI, .76–4.42; $P = .18$). In multivariable analysis, when controlling for age, sex, clinic site, HCV knowledge, and attitudes towards HCV, birth cohort status (OR, 3.15;

Table 1. Baseline Characteristics for All Participants and by Intervention Status

Characteristic	All Participants N = 452 (n, %)	Comparison Group n = 182 (n, %)	Intervention Group n = 270 (n, %)	*P* Value*
Clinic Site				
Safety net	181 (40.0)	73 (40.1)	108 (40.0)	.99
Academic	271 (60.0)	109 (59.9)	162 (60.0)	
Age (mean ± SD)	56.8 ± 16.8	55.8 ± 17.0	57.5 ± 16.8	.45
Age				
18–34	64 (14.2)	27 (14.8)	37 (13.7)	.58
35–49	68 (15.0)	31 (17.0)	37 (13.7)	
50–64	177 (39.2)	68 (37.4)	109 (40.4)	
65 or more	143 (31.6)	56 (30.8)	87 (32.2)	
Sex				
Male	163 (36.0)	55 (30.2)	108 (40.0)	.07
Female	289 (64.0)	127 (69.8)	162 (60.0)	
Marital Status				
Married	213 (47.1)	79 (43.4)	134 (49.6)	.56
Living with partner	23 (5.1)	4 (2.2)	19 (7.0)	
Widowed	38 (8.6)	17 (9.3)	22 (8.2)	
Separated	7 (1.6)	2 (1.1)	5 (1.9)	
Divorced	30 (6.6)	10 (5.5)	20 (7.4)	
Single, never married	94 (20.8)	39 (21.4)	55 (20.4)	
Missing	46 (10.2)	31 (17.0)	15 (5.6)	
Education				
Less than high school	50 (11.1)	14 (7.8)	36 (13.3)	.49
Completed high school	78 (17.3)	29 (16.1)	49 (18.2)	
College or higher	276 (61.1)	107 (58.8)	169 (62.6)	
Others/missing	48 (10.6)	32 (17.6)	16 (5.9)	
Employment				
Employed	167 (37.0)	61 (33.5)	106 (39.3)	.28
Unemployed	31 (6.9)	12 (6.6)	19 (7.0)	
Student	13 (2.9)	5 (2.8)	8 (3.0)	
Homemaker	20 (4.4)	9 (5.0)	11 (4.1)	
Retired	154 (34.1)	57 (31.7)	97 (35.9)	
Other	20 (4.4)	6 (3.3)	14 (5.2)	
Refused	2 (0.4)	2 (1.1)	0 (0.0)	
Missing	45 (10.0)	30 (16.5)	15 (5.6)	
Foreign-Born	79.7	77.5	81.1	.61
Years in the US (mean ± SD)	31.3 ± 16.9	30.2 ± 16.5	32.0 ± 17.1	.45
Years in the US, 20 years or more	316 (74.1)	117 (64.3)	199 (78.4)	.46
Spoken English Fluency				
Fluently	174 (38.5)	70 (38.5)	104 (38.5)	.78
Well	80 (17.7)	31 (17.0)	49 (18.2)	
So-so	70 (15.5)	22 (12.1)	48 (17.8)	
Poorly	59 (13.1)	22 (12.1)	37 (13.7)	
Not at all	23 (5.1)	7 (3.9)	16 (5.9)	
Missing	46 (10.2)	30 (16.5)	16 (5.9)	
Language				
English	311 (68.8)	134 (73.6)	177 (65.6)	.19
Cantonese	88 (19.5)	28 (15.4)	60 (22.2)	
Mandarin	33 (7.3)	16 (8.8)	17 (6.3)	
Vietnamese	20 (4.4)	4 (2.2)	16 (5.9)	
Need a Translator at Doctor's Office				
Yes	105 (23.2)	39 (21.4)	66 (24.4)	.59
No	297 (65.7)	112 (61.5)	185 (68.5)	
Don't know	5 (1.1)	1 (0.6)	4 (1.5)	
Missing	45 (10.0)	30 (16.5)	15 (5.6)	
Need Help to Read Material From Doctor				
Always	46 (10.2)	17 (9.3)	29 (10.7)	.76

Table 1. Continued

Characteristic	All Participants N = 452 (n, %)	Comparison Group n = 182 (n, %)	Intervention Group n = 270 (n, %)	*P* Value*
Often	31 (6.9)	7 (3.9)	24 (8.9)	
Sometimes	57 (12.6)	27 (14.8)	30 (11.1)	
Rarely	30 (6.6)	11 (6.0)	19 (7.0)	
Never	238 (52.7)	88 (48.4)	150 (55.6)	
Missing	50 (10.8)	32 (17.6)	18 (6.7)	
Self-Reported Health				
Excellent	30 (6.6)	6 (3.3)	24 (8.9)	.56
Very good	94 (20.8)	39 (21.4)	55 (20.4)	
Good	134 (29.7)	51 (28.0)	83 (30.7)	
Fair	113 (25.0)	42 (23.1)	71 (26.3)	
Poor	31 (6.9)	12 (6.6)	19 (7.0)	
Missing	50 (11.1)	32 (17.6)	18 (6.7)	
Family has hepatitis or liver cancer	57 (12.6)	21 (11.5)	36 (13.3)	.55
Ever Asked Doctor to Get Hepatitis B or C Test				
Yes	81 (17.9)	31 (17.0)	50 (18.5)	.66
No	334 (73.9)	141 (77.5)	193 (71.5)	
Don't know	37 (8.2)	10 (5.5)	27 (10.0)	
Annual Household Income				
Less than $10 000	65 (14.4)	22 (12.1)	43 (15.9)	.96
$10–20 000	72 (15.9)	30 (16.5)	42 (15.6)	
$20–50 000	69 (15.3)	25 (13.7)	44 (16.3)	
$50,000–$100 000	66 (14.6)	24 (13.2)	42 (15.6)	
More than $100 000	85 (18.8)	33 (18.1)	52 (19.3)	
Don't know	34 (7.5)	12 (6.6)	22 (8.2)	
Missing	61 (13.5)	36 (19.8)	25 (9.3)	

Abbreviations: SD, standard deviation; US, United States.

**P* value considered significant if <.05.

95% CI, 1.35–7.32; $P = .008$) was an independent predictor of receiving an HCV test (Table 4).

DISCUSSION

To our knowledge, this is the first study of an interactive and in-language mobile HCV video education intervention with a printed Provider Alert to enhance HCV screening among Asian Americans in the primary care setting. Our primary care-based intervention was effective in improving patient-provider discussion about HCV among all participants and receiving an order for and completing an HCV screening test among those who did not have one. Although this study was conducted before the recommendation for universal HCV screening, the finding in the intervention group that birth cohort status was independently associated with HCV screening ($P = .008$) but other risk factors were not ($P = .18$) indicates that this intervention may be applicable in the universal HCV screening era, but this would need further investigation.

Few studies to date have addressed ways to improve HCV screening rates among Asian Americans, but none have focused on patient-centered approaches within the primary care setting. Ma et al [34] evaluated the use of an in-person educational workshop among Vietnamese participants in a community setting involving 7 Vietnamese community-based organizations, and they found that 83% of participants received HCV screening within 6 months. However, this workshop required a collaborative approach with multiple organizations and did not occur in the clinical setting. Other studies have found that the use of EHR Best Practice Alerts (BPA) can be effective in increasing HCV screening among the birth cohort across different racial/ethnic groups receiving primary care. Yeboah-Korang [35] et al found that commercially insured Asian patients were more likely to experience increased HCV screening rates after implementation of a BPA, but the overall screening rate in the birth cohort was low at 11%. Finally, Konerman et al [36] found that the use of a birth cohort BPA with patient educational materials also increased screening rates within the 1-year, post-BPA period across all racial/ethnic groups. However, this single-center study did not specifically focus on Asian Americans. Although no head-to-head comparisons can be made with other reported interventions to date, in our study that included both insured and under-/uninsured populations, the use of an in-language mobile education intervention along with provider alerts resulted in high rates (>40%) of HCV screening in the Asian American birth cohort,

Table 2. Study Outcomes Postintervention by Intervention Status, Intent-to-Treat

Study Outcome	All Participants N = 452 (n, %)	Comparison Group n = 182 (n, %)	Intervention Group n = 270 (n, %)	*P* Value*
Patient-Provider Communication About HCV Testing (Postvisit)				
Discussed Hepatitis C With Healthcare Provider				
Yes	192 (42.5)	23 (12.6)	169 (62.6)	<.001
No/don't know	211 (46.7)	127 (69.8)	84 (31.1)	
Did not respond/missing[†]	49 (10.8)	32 (17.6)	17 (6.3)	
Asked Healthcare Provider for Hepatitis C Test				
Yes	151 (33.4)	12 (6.6)	139 (51.5)	<.001
No	247 (54.6)	136 (74.7)	111 (41.1)	
Don't know	5 (1.1)	2 (1.1)	3 (1.1)	
Did not respond/missing[†]	49 (10.8)	32 (17.6)	17 (6.3)	
Healthcare Provider Recommended Hepatitis C Test				
Yes	120 (26.6)	18 (9.9)	102 (37.8)	<.001
No	268 (59.3)	128 (70.3)	140 (51.9)	
Don't know	15 (3.3)	4 (2.2)	11 (4.1)	
Did not respond/missing[†]	49 (10.8)	32 (17.6)	17 (6.3)	
Patient-Provider Communication About HCV Testing (at 3 Months)[a]				
Discussed Hepatitis C With Healthcare Provider				
Yes	109 (24.1)	12 (6.6)	97 (35.9)	<.001
No/don't know	251 (55.5)	120 (65.9)	131 (48.5)	
Did not respond/missing[†]	92 (20.4)	50 (27.5)	42 (15.6)	
Asked Healthcare Provider for Hepatitis C Test				
Yes	89 (19.7)	11 (6.0)	78 (28.9)	<.001
No	255 (56.4)	113 (62.1)	142 (52.6)	
Don't know	15 (3.3)	7 (3.9)	8 (3.0)	
Did not respond/missing[†]	93 (20.6)	51 (28.0)	42 (15.6)	
Healthcare Provider Recommended Hepatitis C Test				
Yes	59 (13.1)	11 (6.0)	48 (17.8)	<.001
No	265 (58.6)	107 (70.4)	158 (58.5)	
Don't know	35 (7.7)	13 (7.1)	22 (8.2)	
Did not respond/missing[†]	93 (20.6)	51 (28.0)	42 (15.6)	
HCV Awareness (at 3 Months)				
Have You Heard of HCV?				
Yes	249 (55.1)	78 (42.9)	171 (63.3)	<.001
No	84 (18.6)	42 (23.1)	42 (15.6)	
Don't know	27 (6.0)	12 (6.6)	15 (5.6)	
Did not respond/missing[†]	92 (20.4)	50 (27.5)	42 (15.6)	
HCV Knowledge and Attitude Scores[b] (at 3 Months)				
HCV knowledge (mean ± SD)	3.7 ± 2.7	3.2 ± 2.7	4.2 ± 2.7	<.001
HCV attitudes (mean ± SD)	4.8 ± 3.0	4.1 ± 3.2	5.3 ± 2.8	<.001
HCV Screening Among Participants Eligible for HCV Testing[c] (at 3 Months)				
Hepatitis C Antibody Test Ordered[d]				
Yes	66 (26.9)	10 (10.0)	56 (38.6)	<.001
No	179 (73.1)	90 (90.0)	89 (61.4)	
Hepatitis C Antibody Test Done[d]				
Yes	50 (20.4)	6 (6.0)	44 (30.3)	<.001
No	195 (79.6)	94 (94.0)	101 (69.7)	

Abbreviations: HCV, hepatitis C virus; SD, standard deviation.

[a]A greater proportion of participants who completed the 3-month survey (vs those who did not) had lived in the United States for 20+ years, had high school or a higher level of education, had English fluency, had very good/excellent self-reported health, and had an annual household income ≤$50 000. All other baseline characteristics were similar between the 2 groups.

[b]Maximum score of 7 for knowledge and 8 for attitudes (Supplemental Table 2).

[c]Participants with HCV risk factors or born during birth cohort.

[d]Number and percentage of participants based on subgroup of total participants (N = 245), comparison group (n = 100), intervention group (n = 145).

[†]Data missing or survey not completed.

**P* value statistically significant if < .05.

Table 3. Multivariable Models for Intervention Effect on Order and Receipt of HCV Testing in Eligible participants

	Hepatitis C Test Ordered n = 179			Hepatitis C Test Receipt n = 179		
Characteristic	Odds Ratio	95% Confidence Interval	*P* Value*	Odds Ratio	95% Confidence Interval	*P* Value*
Intervention effect	8.80	3.12–24.80	<.001	10.45	2.97–36.8	<.001
Clinic Site						
Academic	…	…	.10	…	…	.18
Safety net	0.36	0.11–1.22		0.40	.10–1.56	
Age	1.002	.95–1.06	.94	0.99	.93–1.05	.62
Sex						
Female	…	…	.89	…	…	.58
Male	1.06	.45–2.48		1.30	.50–3.35	
Birthplace						
US	…	…	.29	…	…	.62
Foreign-born	1.93	.56–6.65		0.70	.17–2.88	
Duration of US residence						
<20 years	…	…	.41	…	…	.55
20 years or more	1.57	.54–4.63		1.44	.43–4.87	
Education						
Less than high school	…	…	.39	…	…	.22
Completed high school	1.08	.28–4.25		1.48	.33–6.71	
College or higher	0.31	.05–1.98		.28	.04–1.98	
Other/missing	<0.001	<.001		.001	<.001	
Unemployed	…	…	.89	…	…	.54
Employed	0.94	.38–2.32		.73	.26–2.04	
Spoken English Fluency						
Less than well	…	…	.24	…	…	.34
Well or fluently	2.37	.56–9.99		.73	.45–10.16	
Language						
English	…	…	.73	…	…	.51
Cantonese	1.58	.08–3.97		0.63	.09–4.64	
Mandarin	0.82	.20–3.34		.48	.10–2.30	
Vietnamese	0.32	.03–2.97		.13	.01–2.26	
Need Help to Read Material From Doctor						
Never	…	…	.74	…	…	.93
Always, often, sometimes, or rarely	0.80	.20–3.22		1.08	.23–5.16	
Self-reported health						
Less than very good	…	…	.80	…	…	.54
Very good or excellent	1.14	.41–3.14		.69	.20–2.32	
Annual household income						
Less than $10 000	…	…	.37	…	…	.15
$10–$50 000	1.95	.48–7.87		5.04	.84–30.3	
$50 000 or more	0.84	.16–4.54		1.95	.25–15.25	
Unknown/missing	2.36	.47–11.98		6.23	.82–47.24	

Abbreviations: HCV, hepatitis C virus; US, United States.

**P* value statistically significant if <.05.

and it has the advantage of implementation within the clinical setting.

Furthermore, the use of mobile technology has already shown promise among Asian Americans for other health indications, including tobacco cessation among Korean and Vietnamese men [37] and cervical cancer screening among Korean women [38]. With respect to HCV care, only 2 prior studies have evaluated the use of mobile technology [39, 40], but its focus was limited to people who inject drugs and did not include any Asian Americans. Talal et al [40] found that HCV knowledge retention was higher in patients who received education through a video format compared with a printed brochure format. In our study, we found that the combined use of mobile technology with patients and a paper handout for clinicians was an effective way to educate both patients and providers. Participants in our intervention group were 9 times more likely to have received an order for HCV testing and 11 times more likely to complete HCV testing compared

Table 4. Multivariable Analysis[a] Evaluating the Receipt of HCV Testing in the Intervention Group (n = 270)

Predictor	Adjusted Odds Ratio (95% CI)	*P* Value*
Age	1.01 (.99–1.02)	.56
Female (vs male)	.93 (.50–1.73)	.82
Clinic Site	…	
Academic	…	
Safety net	.95 (.51–1.76)	.86
Risk Factor	…	
No risk factor	…	
Birth cohort	3.15 (1.35–7.32)	.008
Other risk factor	1.82 (.73–4.55)	.20
HCV knowledge	1.01 (.87–1.19)	.87
Attitudes towards HCV	1.04 (.89–1.21)	.62

Abbreviations: CI, confidence interval; HCV, hepatitis C virus.

[a]Predictors in the multivariable model included those considered important a priori and those with $P < .05$ on bivariate analysis.

**P* value statistically significant if <.05.

to those in the comparison group. This is especially encouraging because provider-level barriers to HCV testing have included clinical time constraints and difficulty in asking patients about HCV risk factors [41]. Our use of an in-language, mobile platform to deliver HCV education to patients waiting to be seen by their provider, and the engagement of providers using a Provider Alert, minimized barriers to HCV testing by increasing patient-provider discussions about HCV during their visit, highlighting the utility of this simple patient-centered intervention in enhancing HCV testing among Asian Americans.

We also found that intervention participants were significantly more likely than comparison participants to report HCV awareness (63% vs 43%) after receipt of HCV education at 3-month follow-up. Direct comparisons are limited in literature, but prior studies have shown low rates of HCV awareness and knowledge among Asian Americans. One study found that 33% of Southeast Asian patients incorrectly believed HCV transmission occurred through food, water, and poor hygiene [42]. A systematic review of Asian patients with chronic HBV found that patients thought hepatitis A, B, and C were "3 levels" with HCV being the worst of the 3 [43]. In addition, patients' lack of knowledge about HCV has been identified as a barrier to HCV testing [41]. In our study, we did not observe an independent effect of HCV knowledge or attitudes towards HCV on receipt of HCV testing, which suggests that perception of risk (ie, birth cohort status) seems to be more influential on HCV testing than other patient-related measures.

Finally, our intervention was especially effective in increasing HCV testing among Asian American participants in the birth cohort because they had approximately 3 times greater odds of receiving HCV testing than those without any HCV risk factors. This is especially pertinent because in an a prior national cross-sectional study, researchers found that Asians were less likely to receive HCV screening compared with Black Americans, despite guideline recommendations for birth cohort testing [44]. Our Provider Alert may have contributed to the enhanced screening by educating providers on the recommendation of birth cohort testing. Because both the CDC and USPSTF now recommend universal HCV testing in all adults, we believe that implementation of a successful educational intervention like ours, tailored to the new recommendations, will be similarly effective in enhancing HCV screening for all adults. We have already showed that our intervention was effective in increasing patient-provider discussion about HBV and HBV screening, which is universally recommended among Asian Americans, in our parent study [28].

Strengths and Limitations

Our study's strengths include its randomized intervention design, a large sample size, EHR documentation of the HCV screening outcome, and greater generalizability because we were able to conduct the study at 2 different primary care health systems that serve socioeconomically diverse patient populations. However, we acknowledge a few limitations. These include missing data often inherent to survey design, and the possibility of unadjusted factors that may have contributed to the increase in HCV awareness, patient-provider discussion, and testing after the study. However, we did adjust for various participant demographic factors, including language, self-reported health, and health literacy, making this less of a limitation. In addition, because this study was done during the birth cohort screening era, the extent to which the intervention may be effective in the universal HCV screening era is unknown. Furthermore, because our study focused on improving HCV screening, we did not collect data on HCV viral load levels and receipt of treatment. Because the HCV screening outcome was performed as a secondary analysis, the study was not a priori powered for this analysis. Thus, the effect of our intervention on linkage to HCV treatment could not be assessed. Finally, because this study was conducted in the United States, the effectiveness of our intervention in other settings is not known.

CONCLUSIONS

An interactive, in-language, mobile education intervention about viral hepatitis with a printed Provider Alert resulted in greater HCV awareness, patient-provider communication about HCV, and receipt of HCV screening among Asian Americans. As universal HCV screening and the availability of highly effective HCV therapies become more common in primary care, it will be critical to implement successful strategies to more efficiently engage patients to identify and treat HCV infections. The use of innovative mobile application strategies is particularly relevant during times like the coronavirus disease 2019 pandemic when providers face unprecedented opportunities and challenges to delivering healthcare remotely. With the current and anticipated future expansion of telehealth, this patient-centered strategy can easily be adapted to improve HCV testing and address the gaps in HCV care among Asian Americans and other populations.

Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

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