Development of a Predictive Risk Model to Identify Patients Unlikely to Complete a Colonoscopy Following an Abnormal Fecal Test in Community Clinics

Amanda Petrik, MS
Erin Keast, MPH
Eric Johnson, PhD
David H. Smith, RPh, PhD
Gloria Coronado, PhD

INTRODUCTION

The Strategies and Opportunities to STOP Colon Cancer in Priority Populations (STOP CRC) project increased CRC screening among patients in Federally Qualified Health Centers (FQHCs) through a direct mailed fecal testing program (FIT).[1] However, a follow-up colonoscopy is recommended for patients with an abnormal fecal test, and rates of completion of the follow-up colonoscopy remain low, especially among patients in the community clinic setting.[2-4] We aimed to develop a prediction model using patient-level data available in the EHR to identify patients who are more and less likely to undergo colonoscopy following an abnormal FIT test.

REFERENCES:

1. Gupta S, Halm EA, Rockey DC, Hammons M, Koch M, Carter E, et al. Comparative effectiveness of fecal immunochemical test outreach, colonoscopy outreach, and usual care for boosting colorectal cancer screening among the underserved: A randomized clinical trial. JAMA Intern Med. 2013;173(18):1725-32.
2. Oluloro A, Petrik AF, Turner A, Kapka T, Rivelli J, Carney PA, et al. Timeliness of Colonoscopy After Abnormal Fecal Test Results in a Safety Net Practice. J Community Health. 2016;41(4):864-70.
3. Martin J, Halm EA, Tiro JA, Merchant Z, Balasubramanian BA, McCallister K, et al. Reasons for Lack of Diagnostic Colonoscopy After Positive Result on Fecal Immunochemical Test in a Safety-Net Health System. Am J Med. 2017;130(1):93.e1-.e7.
4. Issaka RB, Singh MH, Oshima SM, Laleau VJ, Rachocki CD, Chen EH, et al. Inadequate Utilization of Diagnostic Colonoscopy Following Abnormal FIT Results in an Integrated Safety-Net System. Am J Gastroenterol. 2017;112(2):375-82.

FUNDING SOURCE: The research in this publication was supported by the National Cancer Institute of the National Institutes of Health under Award Number UH3CA188640. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. The study sponsor had no role in study design; collection, analysis, and interpretation of data; writing the report; or the decision to submit the report for publication.

This research project is approved by the Kaiser Permanente Northwest IRB (KPNW IRB, Protocol #4364), and is registered at ClinicalTrials.gov (NCT01742065).

60199 CHR 11/17

METHODS

We developed a risk prediction model using data from patients with abnormal fecal tests at STOP CRC clinics.

PARTICIPANTS

- Retrospective cohort of STOP CRC patients in Oregon and California.
- Patients were 50-75 years of age.
- Patients returned an abnormal FIT result from February 4, 2014 through February 28, 2016 (n=1723).

MEASURES

- The outcome measure was whether a patient received a colonoscopy within 6 months of receiving their abnormal FIT test result.
- Predictor characteristics were those that predicted completion of CRC screening or colonoscopy in previous studies, but were limited to those that would be available in the EHR in these community clinic settings.

ANALYSES

- We used Cox proportional hazards models. We fit a full model and used a step-down process to simplify the model by removing characteristics so that the final model retained at least 90% of the variation explained of the full model.
- We assigned points to each level of each variable using R code from Harrell that assigns one point to the smallest increment. The scale of points is arbitrary.
- The model accurately predicts the patients who are least likely to receive a follow-up colonoscopy (lowest two quintiles, 17.8% and 25.4% respectively). Patients with the highest predicted risk of non-adherence (bottom quintile) had and estimated 18% chance of obtaining a colonoscopy; whereas patients with the lowest predicted risk of non-adherence (top quintile) had a greater than 55% chance of obtaining a follow-up colonoscopy.

TABLE 1. Significant characteristics at baseline for all patients and patients with a colonoscopy; hazard ratios and risk score points for the final prediction model

VARIABLE	PATIENTS WITH COLONOSCOPY N (%OF ALL)	ALL PATIENTS N (% OF ALL)	POINTS	HAZARD RATIO	(95% CI)
Age				0.97	(0.96 - 0.99)
50-54	200 (40.2%)	498 (31.2%)	50		
55-59	156 (36.7%)	425 (26.6%)	38		
60-64	122 (32.4%)	377 (23.6%)	25		
65-69	62 (30.7%)	202 (12.7%)	13		
70-75	16 (17.0%)	94 (5.9%)	0		
Race				1.49	(1.15 - 1.93)
Non-White	72 (27.1%)	266 (16.7%)	0		
White	484 (36.4%)	1330 (83.3%)	34		
Insurance					
Uninsured	86 (32.5%)	265 (16.6%)	4	ref	
Medicaid	282 (37.7%)	748 (46.9%)	14	1.13	(0.89 - 1.45)
Medicare	136 (31.3%)	435 (27.3%)	4	1.01	(0.76 - 1.34)
Commercial	52 (35.1%)	148 (9.3%)	0	0.96	(0.67 - 1.38)
Census Tract GINI Income Inequality				1.06	(1.00 - 1.12)
0.27 - 0.38	102 (31.0%)	329 (20.6%)	0		
0.38 - 0.41	115 (35.3%)	326 (20.4%)	5		
0.41 - 0.43	122 (37.4%)	326 (20.4%)	10		
0.43 - 0.47	97 (37.9%)	256 (16.0%)	14		
0.47 - 0.82	120 (33.4%)	359 (22.5%)	19		
Long term anticoagulant use				0.52	(0.28 - 0.98)
No	546 (35.3%)	1545 (96.8%)	55		
Yes	10 (19.6%)	51 (3.2%)	0		
Flu shot within 1 year of index date				1.59	(1.28 - 1.98)
No	452 (33.0%)	1368 (85.7%)	0		
Yes	104 (45.6%)	228 (14.3%)	40		
Count of no-show encounters in year prior to index date				0.88	(0.78 - 0.99)
0	394 (34.9%)	1128 (70.7%)	22		
1	99 (39.1%)	253 (15.9%)	11		
2+	63 (29.3%)	215 (13.5%)	0		
Health Center				1.06	(1.00 - 1.12)
HC 2	193 (31.4%)	615 (38.5%)	44	1.68	(1.14 - 2.47)
HC 3	64 (48.1%)	133 (8.3%)	100	3.22	(2.09 - 4.96)
HC 4	44 (42.3%)	104 (6.5%)	81	2.59	(1.63 - 4.12)
HC 5	139 (48.4%)	287 (18.0%)	97	3.09	(2.08 - 4.60)
HC 6	66 (28.5%)	232 (14.5%)	28	1.38	(0.89 - 2.13)
HC 7	19 (27.1%)	70 (4.4%)	32	1.46	(0.82 - 2.59)
HC 8	31 (20.0%)	155 (9.7%)	0	ref	

Not significant characteristics include gender, BMI, language, ethnicity, tobacco use, % of census tract with college degree, percent of census tract households below FPL, census tract median household income, census tract unemployment, census tract population density, census tract low access, ER visits per 1,000, urban/rural, Charlson comorbidity, asthma/COPD, diabetes, severe mental illness, mood disorder, substance/alcohol abuse, blood in stool, hemorrhoid/anal fissure, prior CRC screening, number of outpatient encounters.

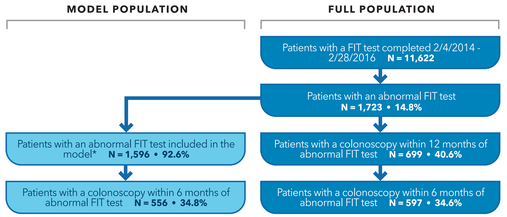
ABBREVIATIONS: CI, Confidence Interval; GINI, Gini Coefficient on Income Inequality

TABLE 2. Performance statistics

C-statistic (95% CI)	0.6598
R2 (95% CI)	13.08 (9.36-17.13)
D (95% CI)	0.794 (0.658-0.931)
Bootstrap-corrected c-statistic	0.6328
Slope Shrinkage	0.0997

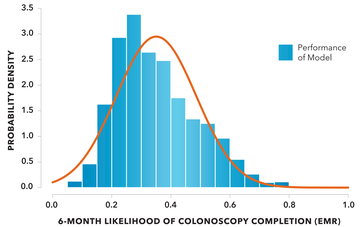
A D-statistic of zero means that the model failed to separate higher and lower risk patients. The R^2 statistic measures the amount of variation explained in the model.

FIGURE 1. Patient Population from STOP CRC



*Patients excluded from clinics too small to contribute and with missing data.
*Patients excluded from clinics too small to contribute and with missing data.

FIGURE 2. Histogram of Predicted Probability



DISCUSSION

- The C-statistic shows adequate separation of patients across risk levels for non-adherence to follow-up colonoscopy, yet the R^2 indicates the discrimination and calibration could be suboptimal because of the calibration (Table 2).
- Focusing efforts for improving screening on the lowest quintiles could provide value to the population most in need of follow-up support. When putting the model into practice, targeting the lowest probability groups could result in the greatest improvements.
- Both patient and system-level barriers were used in the final model, indicating the importance of recognizing multiple levels of barriers to adherence to colonoscopy following an abnormal FIT.
- This is the first model to predict likelihood of follow-up after an abnormal fecal test. Further research is needed to test interventions for patients who have a low and moderate probability of completing follow-up colonoscopy.

Knowing who may be at risk for failing to follow-up on an abnormal FIT test could help providers and clinics identify patients in need of early interventions (including patient navigation) aimed at completing a colonoscopy. Precision delivery of interventions to those most likely to benefit optimizes patient outcomes and organization resources.

KAISER PERMANENTE®
Center for Health Research

CONTACT: Amanda Petrik | 503-335-2483 | Amanda.F.Petrik@kpchr.org