

Pilot of Decision Support to Individualize Colorectal Cancer Screening Recommendations

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Colorectal cancer (CRC) is the third most common cancer and the second leading cause of cancer deaths in the United States.¹ CRC has a long preclinical phase from the development of adenomatous polyps to symptomatic cancer.² Randomized controlled trials of fecal occult blood tests (FOBTs) and sigmoidoscopy and case-control studies of colonoscopy have shown that screening reduces CRC mortality,³⁻⁸ with the interval between screening and mortality benefit thought to be at least 5 to 7 years.⁹

While screening for CRC has considerable benefits, it also has harms. The possible harms of colonoscopy include inconvenience, cardiopulmonary complications from sedation, and complications from the colonoscopy itself.^{9,10} The decision to screen for CRC involves balancing the immediate harms with longer-term benefits; often, advanced age is used as a surrogate for an unfavorable harm-to-benefit profile. The US Preventive Services Task Force (USPSTF) recommends screening beginning at age 50 years and continuing until age 75 years using FOBT, sigmoidoscopy, or colonoscopy, noting that "The lead time between detection and treatment of colorectal neoplasia and a mortality benefit is substantial, and competing causes of mortality make it progressively less likely that this benefit will be realized with advancing age."¹¹

Comorbidity and frailty may be more important than age in determining life expectancy (LE) and the individualized benefit-to-harm profile. Despite the importance of incorporating comorbidity and frailty into screening decisions, guidelines do not specify how to do this.¹¹⁻¹³ In practice, CRC screening is as common among those with severe comorbidities as among healthy persons.¹⁴⁻¹⁶

Most research regarding implementation of CRC screening has focused on increasing use, with minimal evaluation of strategies to reduce overuse and misuse.¹⁷ Overuse may occur because physicians have difficulty estimating LE, few validated

ABSTRACT

Objectives: To test the feasibility of using an electronic medical record (EMR)-based decision support system (DSS) that incorporates morbidity and frailty information to individualize colorectal cancer (CRC) screening recommendations.

Study Design: Our framework used the payoff time, defined as the minimum time until the benefits of screening exceed the harms.

Methods: Subjects were 24 patients eligible for CRC screening and 22 primary care providers (PCPs). Measures included PCP satisfaction with existing reminder systems and with decision support.

Results: The run-in phase, during which the intervention was inactive but its performance was verified, had 14 patients enrolled. The intervention phase, during which payoff time and life expectancy calculations were used to recommend for or against CRC screening, had 10 patients enrolled. Of the 10 patients enrolled in the intervention phase, the DSS recommended in favor of CRC screening for 6 patients. (The PCPs also recommended it for those 6 patients, although 3 refused the screening.) The DSS recommended against CRC screening for 4 patients, while the PCPs recommended against it for 3 of those 4 and ordered the screening for 1 patient. PCPs who had patients enrolled in the intervention phase indicated interest in having payoff time information for all patients eligible for CRC screening. This pilot study was small and was not powered to determine the effect of the intervention on screening behavior.

Conclusions: Colorectal cancer screening involves balancing immediate harms with longer-term benefits; EMR decision support may facilitate personalized benefit/harm assessment. The payoff time framework is feasible for implementation in EMR decision support.

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Take-Away Points

We tested the feasibility of using an electronic medical record-based decision support that incorporates morbidity and frailty information to individualize colorectal cancer screening recommendations.

- Colorectal cancer screening involves balancing immediate harms with longer-term benefits.
- Our framework used the payoff time: the minimum time until the benefits of screening exceed the harms.
- Electronic medical record decision support may facilitate personalized benefit/harm assessment.

accessible tools for doing so, or little time to do so in the context of competing demands. Because screening is offered largely in the context of clinic visits, ill patients with frequent visits may be inappropriately targeted.¹⁵ Quality measures and clinical reminder systems often promote CRC screening regardless of comorbidity. The clinical reminder in the Veterans Administration (VA) electronic medical record (EMR), or Computerized Patient Record System (CPRS), is activated for patients aged 50 to 75 years, regardless of comorbidities. At the time this study was conducted, the VA's External Peer Review Program chart audits excluded only patients with esophagus, liver, or pancreatic cancer; enrollment in hospice; or estimated LE less than 6 months from the CRC screening measure.¹⁸

Individualized CRC screening decisions might be facilitated by incorporating explicit consideration of comorbidity in screening guidelines, the development of tools to estimate LE and incorporate this information in screening decisions, and inclusion of LE and comorbidity in clinical reminder systems. Our objective was to develop a decision support system (DSS) for using comorbidity and frailty information to individualize screening recommendations.

METHODS

Our DSS incorporated the “payoff time” framework: the minimum time until the benefits attributable to a guideline exceed its harms.¹⁹ We estimated the payoff time for CRC screening based on individual characteristics. We then integrated this calculation into an EMR and pilot-tested this DSS.

Applying the Payoff Time to CRC Screening Decisions

We used previously published methods to estimate the mortality payoff for CRC screening.^{19,20} This requires estimating LE for a particular patient, then estimating the payoff time for CRC screening, adjusting that payoff time (based on comorbidities, frailty, and other factors that in-

fluence the balance of benefits and harms), and then comparing the adjusted payoff time to the patient's LE.

Four-year mortality was estimated from a prognostic index developed in a population-based sample of community-dwelling US adults older than 50 years.²¹ The index incorporates both comorbid conditions and measures of frailty, and has good discrimination (C statistic = 0.84, derivation cohort; 0.82, validation cohort).

To adapt the prognostic index's estimates of 4-year mortality to estimates of LE, we used the declining exponential approximation of life expectancy. Payoff time is calculated based on estimated age- and sex-specific CRC incidence and death rates from Surveillance, Epidemiology, and End Results data; the estimated risk reduction for CRC mortality based on data sources used by the USPSTF (assuming benefit from screening begins after 5 years); and estimates of adverse events following colonoscopy.^{19,20} Next, the payoff time is adjusted based on 18 patient characteristics that may affect the risk for CRC death or colonoscopy-induced death, including smoking, use of anticoagulants, American Society of Anesthesiologists class, and family history of CRC. The individual's risk for benefit (based on the risk of CRC death) is divided by the individual's risk for harm (based on the risk of death from colonoscopy-related complications); this yields an individualized risk-to-benefit adjuster. The adjusted payoff time is then compared with the patient's estimated LE to yield a recommendation to pursue or avoid CRC screening.²⁰

Incorporating the Payoff Time Within a Clinical DSS

We adapted the VA clinical reminder system so that CRC screening recommendations were tailored to individual patients' likelihood of benefit.

Data to estimate LE and payoff time were obtained from CPRS and supplemented by patients' self-report. Medical comorbidities, medication use, smoking and alcohol status, body mass index, and demographic information were extracted from CPRS (see [eAppendix](#), available at www.ajmc.com). Data regarding frailty and family history of CRC were obtained by having patients complete a 7-question survey prior to seeing their primary care provider (PCP). Responses were input into CPRS by the research assistant prior to calculation of the payoff time; survey completion and entry generally took about 2 or 3 minutes.

The DSS “turned off” the usual CRC screening reminder when LE was less than the payoff time (see [Figures 1a](#) and [1b](#)), modifying the VA reminder algorithm by: a) basing the

■ **Figure 1a.** The “Recommendation Not to Screen” Reminder

Reminder Resolution: CRC Screen: Recommend NOT to Screen

Based on this patient's clinical characteristics, the risks may outweigh the benefits of colorectal cancer screening. Please refer to COLORECTAL CANCER SCREENING RESEARCH NOTE for additional information. Please discuss with this patient. If shared decision is NO SCREEN, select, "Due to comorbidities and/or frailty colorectal cancer screening is no longer indicated."

☐ Due to comorbidities and/or frailty colorectal cancer screening is no longer indicated.

☐ Patient was given fobt cards (x3) with written instructions at this encounter.

☐ Patient was reminded to return the FOBT cards given at a prior VISIT to complete Colorectal Cancer Screening.

☐ Patient had a prior colonoscopy done. Patient should be encouraged to bring in outside results to this VAMC.

☐ Patient had a prior flexsigmoidoscopy done.

☐ Patient had outside fobt results x3 within 12 months.

☐ Patient refused colorectal cancer screening.

☐ Colorectal cancer screening or F/U is no longer indicated.

☐ Patient is scheduled for a colonoscopy.

☐ GI/Colonoscopy Consult ordered at this encounter.

☐ Reset reminder frequency for F/U colonoscopy.

Clear Clinical Maint Visit Info < Back Next > Finish Cancel

<No encounter information entered>

* Indicates a Required Field

■ **Figure 1b.** The “Recommendation to Screen” Reminder

Reminder Resolution: CRC Screen: Recommend to screen.

Based on this patient's clinical characteristics, this patient may benefit from colorectal cancer screening. Please refer to COLORECTAL CANCER SCREENING RESEARCH NOTE for additional information. Please discuss with this patient.

☐ Due to comorbidities and/or frailty colorectal cancer screening is no longer indicated.

☐ Patient was given fobt cards (x3) with written instructions at this encounter.

☐ Patient was reminded to return the FOBT cards given at a prior VISIT to complete Colorectal Cancer Screening.

☐ Patient had a prior colonoscopy done. Patient should be encouraged to bring in outside results to this VAMC.

☐ Patient had a prior flexsigmoidoscopy done.

☐ Patient had outside fobt results x3 within 12 months.

☐ Patient refused colorectal cancer screening.

☐ Colorectal cancer screening or F/U is no longer indicated.

☐ Patient is scheduled for a colonoscopy.

☐ GI/Colonoscopy Consult ordered at this encounter.

☐ Reset reminder frequency for F/U colonoscopy.

Clear Clinical Maint Visit Info < Back Next > Finish Cancel

<No encounter information entered>

* Indicates a Required Field

■ **Figure 1c.** Electronic Medical Record Note Indicating the Recommendation Not to Screen for Colorectal Cancer

LOCAL TITLE: CRC SCREENING STUDY:RECOMMENDATION NOT SCREEN
 STANDARD TITLE: RESEARCH NOTE
 DATE OF NOTE: JAN 22, 2012@20:20 ENTRY DATE: JAN 23, 2012@14:18:08
 AUTHOR: SCHWARTZ,AMY R EXP COSIGNER:
 URGENCY: STATUS: COMPLETED
 SUBJECT: CLINICAL DECISION SUPPORT

Based on this patient's clinical characteristics, the risks may outweigh the benefits of colorectal cancer screening based on the following:

Benefit from screening is reduced:
 Diabetes increases chances of dying from causes other than colorectal cancer.
 Cancer increases chances of dying from causes other than colorectal cancer.
 Lung Diseases increase chances of dying from causes other than colorectal cancer.
 Congestive heart failure increases chances of dying from causes other than colorectal cancer.
 Frailty increases chances of dying from causes other than colorectal cancer.

Harm from screening is magnified:
 AAS Class 3 ("Severe Systemic Disease") increases risk of complications from colonoscopy.

This recommendation was generated by comparing RICHARD SIBLEY's predicted life expectancy (derived from Lee SJ et al. Development and validation of a prognostic index for 4-year mortality in older adults. JAMA 2006;295: 801-808.) with the estimated 'payoff time' (the time until s/he would benefit from screening).

View detailed summary document at: \\vhaconfpc\CRC_Documents\Summary_S2088.docx

/es/ AMY R SCHWARTZ
 ATTENDING
 Signed: 01/23/2012 16:36

recommendation to screen (or not) on the payoff time, rather than a blanket “screen” recommendation for patients in the aged 50 to 75 years group, and b) adding an option for resolving the reminder by selecting “Due to comorbidities and/or frailty, colorectal cancer screening is no longer indicated.”

A note explaining the rationale for the screening recommendation was also created in CPRS (see **Figure 1c**). An explanatory document with full details of the calculations was available to PCPs, but not made a part of the EMR. The final decision regarding screening remained with the PCP and patient (**Figure 2**). PCPs could screen for CRC using colonoscopy, sigmoidoscopy, or FOBT.

Pilot-Testing the Clinical DSS

This study was approved by the Institutional Review Board at the VA Connecticut Healthcare System (VACHS). PCPs and patients consented to participate.

Primary Care Providers

We enrolled staff PCPs at VACHS in West Haven, Connecticut. PCP focus groups indicated a desire for information regarding LE to guide screening decisions; that the intervention be integrated into CPRS and not interrupt clinical work flow; and that patient-specific information regarding the details of the payoff-time calculation be available.

We surveyed PCPs regarding the existing CRC clinical reminder before the study, and at the conclusion of the study surveyed those PCPs whose patients were enrolled in the intervention phase.

Patients

We enrolled a convenience sample of patients from primary care clinics at VACHS in West Haven, CT; patients had clinic appointments that coincided with research assistant availability. Inclusion criteria were being aged 50 to 75 years, being “due” for CRC screening, and having at least 2 comorbid conditions from the mortality index: diabetes, cancer, chronic lung disease, congestive heart failure, or current tobacco use. Exclusion criteria were first visit to the primary care clinic, on panel of a medical resident, and impairment precluding informed consent. Patients undergoing surveillance for adenomatous polyps were not included.

Run-in Phase

The payoff time and clinical reminder intervention was inactive during the run-in phase of the study, during which the decision support parameters were validated, and active during the subsequent intervention phase. Validation involved confirming that all data were accu-

rately extracted from CPRS and the patient survey, and that the decision support algorithm was able to accurately generate LE and payoff time data.

RESULTS

Primary Care Providers

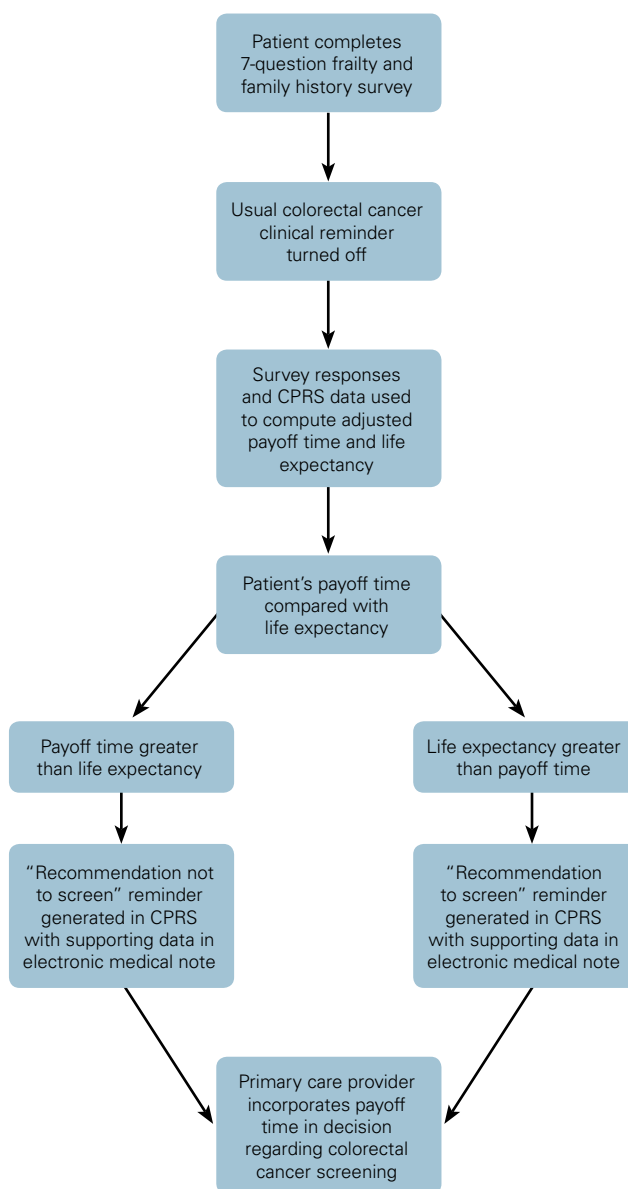
Of 28 PCPs invited to complete our pre-intervention survey, 22 did so. The mean age was 45.5 years (SD = 8.4) with 17 females (77%) and an average of 13.9 years (SD = 7.7) in practice; 20 of 22 were physicians. All indicated that they consider comorbidities in deciding whether to recommend CRC screening. Nonparticipating PCPs mostly had minimal clinical duties or were planning to leave employment in the clinic soon.

PCPs indicated moderate satisfaction (54.5%) with clinical reminders and high ratings of effectiveness (72.7%); 77.3% indicated “The colorectal cancer clinical reminder helps me to screen patients for colorectal cancer.” However, 91% agreed or strongly agreed that “The colorectal cancer clinical reminder sometimes prompts me to screen patients for colorectal cancer who are too sick or frail to benefit from screening.” While 81.8% agreed or strongly agreed that “I feel comfortable determining which patients are appropriate for colorectal cancer screening,” only 31.8% indicated that they “feel confident estimating patient life expectancy to determine appropriateness for colorectal cancer screening.” Most (91%) indicated, “I would like the colorectal cancer clinical reminder to allow me to exclude patients with limited life expectancy” (Table 1).

PCPs showed engagement with the intervention. The note containing the rationale for the screening recommendation was always signed by the PCP. PCPs often commented on the rationale for screening or not screening in their notes, or selected “due to comorbidities and/or frailty, colorectal cancer screening is no longer indicated” in the tailored CRC screening clinical reminder.

Six of the 22 PCPs had subjects enrolled in the intervention phase of the study. These PCPs were surveyed regarding their experience with the intervention. Five of the 6 PCPs reported that the intervention did not interfere with work flow and 4 agreed that the intervention provided “useful information about whether patients would benefit from colorectal cancer screening.” All stated, “I would like to have more information about which patients would benefit from colorectal cancer screening, of the type provided by the CRC payoff time study,” and 5 agreed that “The VA should apply the CRC payoff time study algorithm to all patients potentially eligible for colorectal cancer screening” (Table 2). PCPs largely

■ **Figure 2.** Details of the PayoffTime Clinical Reminder Intervention



CPRS indicates Computerized Patient Record System.

used the clinical decision support tool to formulate their screening recommendation, which they then presented to the patient; patients were largely unaware of the detailed calculations regarding payoff time and LE. No patients reported discomfort or confusion regarding the recommendations, either to their PCPs or the research team.

■ Table 1. Primary Care Providers' Baseline Attitudes Regarding the Usual Colorectal Cancer Reminder and Colorectal Cancer Screening Decisions (n = 22)

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|-------------------|------------|-----------|------------|----------------|
| I am overall satisfied with clinical reminders | 0 | 6 (27.3%) | 4 (18.2%) | 12 (54.5%) | 0 |
| Overall, I find clinical reminders to be effective | 0 | 1 (4.5%) | 5 (22.7%) | 16 (72.7%) | 0 |
| Overall, clinical reminders are more useful in principle than practice | 0 | 12 (54.5%) | 5 (22.7%) | 5 (22.7%) | 0 |
| The colorectal cancer clinical reminder helps me to screen patients for colorectal cancer | 1 (4.5%) | 3 (13.6%) | 1 (4.5%) | 17 (77.3%) | 0 |
| The colorectal cancer clinical reminder sometimes prompts me to screen patients for colorectal cancer who are too sick or frail to benefit from screening | 0 | 1 (4.5%) | 1 (4.5%) | 12 (54.5%) | 8 (36.4%) |
| I feel comfortable determining which patients are appropriate for colorectal cancer screening | 0 | 2 (9.1%) | 2 (9.1%) | 16 (72.7%) | 2 (9.1%) |
| I feel confident estimating patient life expectancy to determine appropriateness for colorectal cancer screening | 2 (9.1%) | 7 (31.8%) | 6 (27.3%) | 6 (27.3%) | 1 (4.5%) |
| I would like the colorectal cancer clinical reminder to allow me to exclude patients with limited life expectancy | 1 (4.5%) | 0 | 1 (4.5%) | 13 (59.1%) | 7 (31.8%) |

Patients

Fourteen subjects enrolled in the control phase of the study, during which the intervention was inactive. Ten subjects, all men, were successfully enrolled in the intervention phase of the study; they were aged 52 to 72 years. Subjects had to have at least 2 of the 5 comorbidities (ie, diabetes, cancer, congestive heart failure, chronic lung disease, and smoking) used in the calculation of LE, and some did have more than 2. Subjects reported difficulty with, on average, 1.9 of the 4 frailty items (ie, difficulty with bathing/showering, managing money, walking, and pushing/pulling large objects).

For 6 intervention subjects, the clinical DSS recommended CRC screening; 3 had screening ordered and 3 refused to be screened. For 4 intervention subjects, the clinical DSS recommended not to screen ("The risks may outweigh the benefits of colorectal cancer screening"); the PCP ordered screening for 1 of these patients and did not request screening for 3 of these patients.

DISCUSSION

We pilot-tested the feasibility of using the payoff time framework to individualize CRC screening recommendations in a clinical DSS. We integrated calculation of the payoff time for individual patients in CPRS and adapted

the VA clinical reminder system to tailor CRC recommendations to individual patients' likelihood of benefit.

PCPs showed engagement with the intervention and indicated that they would want the payoff time information to be available when making decisions regarding CRC screening in the future.

Existing clinical reminder systems promote CRC screening regardless of comorbidity, and do not provide an effective means to "opt out" of screening. There has been little evaluation of strategies to reduce overuse of CRC screening; our study adds to this emerging literature on personalization of decision support.²²

Limitations

The limitations of this pilot study include its small size and the fact that it was not designed to determine the effect of the payoff time intervention on screening behavior; this effect would be important to characterize in future studies. PCPs at an academic VA facility may not be representative of PCPs in the general community, and may be more likely to accept computerized decision support. In addition, use of the payoff time should increase confidence regarding the benefit (or lack thereof) of screening; however, estimates of payoff time and life expectancy are indeed estimates and are therefore imprecise when applied to individual patients. If a particular patient has a

■ **Table 2.** Primary Care Providers' Attitudes Regarding the Clinical Decision Support Payoff Time Intervention (n = 6)

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|--|-------------------|-----------|-----------|-----------|----------------|
| The CRC payoff time study interfered with my work flow | 1 (16.7%) | 4 (66.7%) | 0 | 1 (16.7%) | 0 |
| The CRC payoff study was time-consuming | 1 (16.7%) | 4 (66.7%) | 1 (16.7%) | 0 | 0 |
| The CRC payoff time study provided me with useful information about whether patients would benefit from colorectal cancer screening | 0 | 0 | 2 (33.3%) | 3 (50%) | 1 (16.7%) |
| I ignored the information provided by the CRC payoff time study | 1 (16.7%) | 5 (83.3%) | 0 | 0 | 0 |
| In general, I would like to have more information about which patients would benefit from colorectal cancer screening, of the type provided by the CRC payoff time study | 0 | 0 | 0 | 6 (100%) | 0 |
| The VA should apply the CRC payoff time study algorithm to all patients potentially eligible for colorectal cancer screening | 0 | 0 | 1 (16.7%) | 4 (66.7%) | 1 (16.7%) |
| CRC indicates colorectal cancer; VA, Veterans Administration. | | | | | |

strong preference to receive screening even though it decreases his life expectancy, it could be considered in the context of shared decision making.

CONCLUSIONS

The payoff time framework can be used as part of a DSS to inform screening decisions. Future studies should evaluate the DSS in a larger sample with sufficient power to detect whether it influences screening decisions and decision quality.

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eAppendix

Clinical Decision Support Colorectal Cancer Screening Technical Details

The Clinical Decision Support project for Colorectal Cancer (CRC) Screening was designed to integrate smoothly with the existing clinical work flow. The added functionality was provided by a companion server that communicated with VISTA and ran the code used to process the survey and clinical data algorithm. This companion server was a Dell 2650 32-bit machine running Windows Sever 2003. The database was managed by SQL Server 2005.

The link to VISTA was done using the RPC Broker API and with CacheSQL and ODBC for direct database reading. The RPC Broker functions allow for an external program to create and write a VISTA progress note. The CacheSQL interface permits the running of SQL queries to extract vital sign data and health factors (patient survey entries) as well as other patient data necessary for this project.

LIFE EXPECTANCY ALGORITHM

Age (read from Vista)

```
If age < 10
  then AGEPoint = 0;
else if 60 <= age <= 64
  then AGEPoint = 1;
else if 65 <= age <= 69
  then AGEPoint = 2;
else if 70 <= age <= 74
  then AGEPoint = 3;
else if 75 <= age <= 79
  then AGEPoint = 4;
else if 80 <= age <= 84
  then AGEPoint = 5;
else group = 7;
```

Sex (read from Vista)

```
If sex = male,
  then SEXPoint= 2;
else SEXPoint =0;
```

BMI (computed from Vista height and weight values)

```
Height and weight (EMR)
Compute BMI= 703 x (weight in pounds/height in inches2)
If BMI < 25
  then BMIPoint = 1;
else BMIPoint = 0;
```

Diabetes (EMR- ICD 9 code- 250.x or 357.2)

```
If Diabetes = Yes
    then DIABPoint = 1;
else DIABPoint = 0;
```

Cancer (EMR- ICD9 codes- ([ICD9] <>N'V10.83') and
([ICD9] = N'V10') OR ([ICD9] LIKE N'V10.%(%)') OR([ICD9] LIKE N'140.%(%)') OR([ICD9] =
N'141') OR([ICD9] LIKE N'141.%(%)') OR([ICD9] = N'142') OR
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([ICD9] LIKE N'161.%(%)') OR ([ICD9] = N'162') OR ([ICD9] LIKE N'162.%(%)') OR
([ICD9] = N'163') OR ([ICD9] LIKE N'163.%(%)') OR ([ICD9] LIKE N'164.%(%)') OR
([ICD9] = N'165') OR ([ICD9] LIKE N'165.%(%)') OR ([ICD9] LIKE N'170.%(%)') OR
([ICD9] LIKE N'171.%(%)') OR ([ICD9] LIKE N'172.%(%)') OR ([ICD9] LIKE N'174.%(%)') OR
([ICD9] = N'175') OR ([ICD9] = N'175.0') OR ([ICD9] = N'175.9') OR
([ICD9] = N'176.%(%)') OR ([ICD9] = N'179') OR ([ICD9] LIKE N'180.%(%)') OR
([ICD9] = N'181') OR ([ICD9] LIKE N'182.%(%)') OR ([ICD9] LIKE N'183.%(%)') OR
([ICD9] = N'184') OR ([ICD9] LIKE N'184.%(%)') OR ([ICD9] = N'185.') OR
([ICD9] = N'186.0') OR ([ICD9] = N'186.9') OR ([ICD9] LIKE N'187.%(%)') OR
([ICD9] LIKE N'188.%(%)') OR ([ICD9] LIKE N'189.%(%)') OR ([ICD9] LIKE N'190.%(%)') OR
([ICD9] LIKE N'191.%(%)') OR ([ICD9] LIKE N'192.%(%)') OR ([ICD9] = N'193') OR
([ICD9] LIKE N'194.%(%)') OR ([ICD9] LIKE N'195.%(%)') OR ([ICD9] LIKE N'196.%(%)') OR
([ICD9] = N'199.0') OR ([ICD9] = N'199.1') OR ([ICD9] LIKE N'200.%(%)') OR
([ICD9] LIKE N'201.%(%)') OR ([ICD9] LIKE N'202.3%(%)') OR ([ICD9] LIKE N'202.5%(%)') OR
([ICD9] LIKE N'202.6%(%)') OR ([ICD9] LIKE N'203.%(%)') OR ([ICD9] LIKE N'204.%(%)') OR
([ICD9] LIKE N'205.%(%)') OR ([ICD9] LIKE N'206.%(%)') OR ([ICD9] LIKE N'207.%(%)') OR
([ICD9] LIKE N'208.%(%)'))

```
If Cancer = Yes
    then CANCPoint = 2;
else CANCPoint = 0;
```

Chronic Lung Disease (EMR- ICD9 codes- ([ICD9] LIKE N'277.%(%)') OR

([ICD9] = N'416.0') OR ([ICD9] = N'416.1') OR ([ICD9] = N'416.8') OR
([ICD9] = N'416.9') OR ([ICD9] LIKE N'490.%') OR ([ICD9] LIKE N'491.%') OR
([ICD9] LIKE N'492.%') OR ([ICD9] = N'493.92') OR ([ICD9] = N'493.91') OR
([ICD9] = N'493.90') OR ([ICD9] = N'493.20') OR ([ICD9] = N'493.21') OR
([ICD9] = N'493.22') OR ([ICD9] = N'493.10') OR ([ICD9] = N'493.11') OR
([ICD9] = N'493.12') OR ([ICD9] = N'493.00') OR ([ICD9] = N'493.01') OR
([ICD9] = N'493.02') OR ([ICD9] LIKE N'494.%') OR ([ICD9] LIKE N'495.%') OR
([ICD9] LIKE N'496.%') OR ([ICD9] LIKE N'500.%') OR ([ICD9] LIKE N'501.%') OR
([ICD9] LIKE N'502.%') OR ([ICD9] LIKE N'503.%') OR ([ICD9] LIKE N'504.%') OR
([ICD9] LIKE N'505.%') OR ([ICD9] = N'506.4') OR ([ICD9] LIKE N'515.%') OR
([ICD9] LIKE N'516.%')

If Chronic Lung Disease = Yes
Then CLDPoint = 2;
Else CLDPoint = 0;

Congestive Heart Failure (EMR- ICD9 codes- ([ICD9] = N'402.01') OR
([ICD9] = N'402.11') OR ([ICD9] = N'402.91') OR ([ICD9] = N'404.01') OR
([ICD9] = N'404.03') OR ([ICD9] = N'404.11') OR ([ICD9] = N'404.13') OR
([ICD9] = N'404.91') OR ([ICD9] = N'404.93') OR ([ICD9] LIKE N'428.%')

If Congestive Heart Failure = Yes
then CHFPoint = 2;
else CHFPoint = 0;

Cigarette smoking

Cigarette smoking was determined using the patients recorded Health Factors from VISTA. Patients were considered 'Smokers' if they had an instance of Health Factor 2 'Current Smoker' and no subsequent Health Factor indicating that the patient was a nonsmoker or had quit smoking(Health Factors 3, 4, 5, 689090,650075,689111). These data were derived from VISTA, going back to December of 2007.

If cigarette smoking = Yes
then CIGPoint = 2;
else CIGPoint = 0;

Difficulty with Bathing or showering (SURVEY)

If bathing or showering = Yes
then BATHPoint = 2;
else BATHPoint = 0;

Difficulty with Managing Money (SURVEY)

If Managing Money = Yes
then MONPoint = 2;
else MONPoint = 0;

Difficulty Walking Several Blocks (SURVEY)

If walking = Yes
Then WALKPoint = 2;
else WALKPoint = 0;

Difficulty Pulling or Pushing large objects (SURVEY)

If pulling or pushing = Yes
then PULLPoint = 1;
else PULLPoint = 0;

4-Year Mortality Index

Score= AGEPoint + SEXPoint + BMIPoint + DIABPoint + CANCPoint + CLDPoint +
CHFPoint + CIGPoint + BATHPoint + MONPoint + WALKPoint + PULLPoint

If Score < 1

then 4YrsMR = 1%;
else if Score = 1
then 4YrsMR = 2%;
else if Score = 2
then 4YrsMR = 2%;
else if Score = 3
then 4YrsMR = 4%;
else if Score = 4
then 4YrsMR = 5%;
else if Score = 5
then 4YrsMR = 7%;
else if Score = 6
then 4YrsMR = 9%;
else if Score = 7
then 4YrsMR = 14%;
else if Score = 8
then 4YrsMR = 20%;
else if Score = 9
then 4YrsMR = 22%;
else if Score = 10
then 4YrsMR = 28%;
else if Score = 11
then 4YrsMR = 44%;
else if Score = 12
then 4YrsMR = 46%;
else if Score = 13
then 4YrsMR = 57%;
else if Score => 14
then 4YrsMR = 66%;

Estimated Life Expectancy

If 4YrsMR <= 28%
then ELE => 10;
If 4YrsMR = 44%
then ELE = 6.9;
If 4YrsMR = 46%
then ELE = 6.5;
If 4YrsMR = 57%
then ELE = 4.7;
If 4YrsMR = 66%
then ELE <= 3.7;

PAYOFF TIME ALGORITHM

Relative Risk of Colorectal Cancer

Smoking- (see cigarette smoking above)

If Smoking = Yes
then RRCSmoke = 1.8;

Obesity- (see BMI above)

Compute: BMI > 30
If Obesity = Yes
Then RRCObesity = 1.5;

Heavy Alcohol- EMR (ICD9 Codes- ([ICD9] LIKE N'291.%') OR
([ICD9] LIKE N'303.%') OR ([ICD9] Like N'305.0%') OR ([ICD9] = N'790.3') OR
([ICD9] = N'980.0') OR ([ICD9] = N'980.8') OR ([ICD9] = N'980.9') OR
([ICD9] = N'E860.0') OR ([ICD9] = N'E860.1') OR ([ICD9] = N'E860.8') OR
([ICD9] = N'E860.9') OR ([ICD9] = N'357.5') OR ([ICD9] = N'425.5') OR
([ICD9] = N'535.3') OR ([ICD9] = N'571.0') OR ([ICD9] = N'571.1') OR
([ICD9] = N'571.2') OR ([ICD9] = N'571.3') OR ([ICD9] = N'V11.3'))
If Heavy Alcohol = Yes
Then RRCAlc = 1.3;

Diabetes- (see above)

If Diabetes = Yes
Then RRCDiab = 1.3;

Aspirin-

If Aspirin = Yes
Then RRCAspirin = 0.8;

NSAID-

If NSAID = Yes
Then RRCNSAID = 0.7;

Aspirin and NSAID use was determined by a query of the VA Prescription file and Non-VA Med file. Coumadin use extracted from Prescription file.

Details: Patient drug use data were extracted from VISTA for all days since 1/1/2008. The study-specific list of drugs was contained in the table SCOTT_DRUGS. This list contained codes for Aspirin and the NSAIDS. A patient was considered using the drugs if their scripts were active over 50% of the time during the prior 2 years.

These data were read using this query:

```
Select PATIENT,DRUG,ISSUE_DATE,days_supply,of_refills from  
VISTA.PRESCRIPTION_52 where issue_date > '2008-01-01'  
WHERE DRUG IN (select ID from SCOTT_DRUGS)
```

The Aspirin codes were defined as those drugs with a VA Classification of CN103.

| | |
|---|-------|
| ASPIRIN 125MG SUPP,RTL | CN103 |
| ASPIRIN 300MG SUPP,RTL | CN103 |
| ASPIRIN 325MG BUFFERED TAB | CN103 |
| ASPIRIN 325MG EC TAB | CN103 |
| ASPIRIN 600MG SUPP,RTL | CN103 |
| ASPIRIN 81MG CHEW TAB | CN103 |
| ASPIRIN 81MG EC TAB | CN103 |
| ASPIRIN CHALLENGE 650MG/180ML SOLN,ORAL | CN103 |
| ZZASPIRIN 325MG EC TAB U/D | CN103 |
| ZZASPIRIN TABS 81-MG | CN103 |

The NSAIDS were in VA Classification MS102. These codes are derived from the VA formulary.

| | |
|---------------------------------|-------|
| CELECOXIB 100MG CAP | MS102 |
| CELECOXIB 200MG CAP | MS102 |
| DICLOFENAC EPOLAMINE 1.3% PATCH | MS102 |
| DICLOFENAC NA 50MG EC TAB | MS102 |
| DICLOFENAC NA 75MG EC TAB | MS102 |
| DICLOFENAC POTASSIUM 50MG TAB | MS102 |
| DIFLUNISAL 500MG TAB | MS102 |
| ETODOLAC 300MG CAP | MS102 |
| ETODOLAC 400MG TAB | MS102 |
| ETODOLAC 500MG TAB | MS102 |

| | |
|----------------------------------|-------|
| FLURBIPROFEN 100 MG TAB | MS102 |
| IBUPROFEN 100MG/5ML SUSP | MS102 |
| IBUPROFEN 400MG TAB | MS102 |
| IBUPROFEN 600MG TAB | MS102 |
| IBUPROFEN 800MG TAB | MS102 |
| IBUPROFEN SUSP 100 MG/5 ML, PINT | MS102 |
| INDOMETHACIN 25MG CAP | MS102 |
| INDOMETHACIN 25MG CAP, 20'S | MS102 |
| INDOMETHACIN 50MG CAP | MS102 |
| INDOMETHACIN 75MG SA CAP | MS102 |
| KETOPROFEN 75MG CAP | MS102 |
| MECLOFENAMATE NA 100MG CAP | MS102 |
| MELOXICAM 7.5MG TAB | MS102 |
| MELOXICAM 15MG TAB | MS102 |
| NABUMETONE 500MG TAB | MS102 |
| NABUMETONE 750MG TAB | MS102 |
| NAPROXEN 250MG TAB | MS102 |
| NAPROXEN 250MG TAB, 20'S | MS102 |
| NAPROXEN 375MG TAB | MS102 |
| NAPROXEN 500MG TAB | MS102 |
| NAPROXEN NA 220MG TAB | MS102 |
| OXAPROZIN 600MG TAB | MS102 |
| PHENYLBUTAZONE 100MG TAB | MS102 |
| PIROXICAM 10MG CAP | MS102 |
| PIROXICAM 20MG CAP | MS102 |
| SULINDAC 150MG TAB | MS102 |
| SULINDAC 200MG TAB | MS102 |
| TH-IBUPROFEN 600MG TAB #20 | MS102 |
| TH-IBUPROFEN 800MG TAB #20 | MS102 |
| TH-IBUPROFEN TAB 400MG #20 | MS102 |
| TOLMETIN SODIUM 200MG TAB | MS102 |
| TOLMETIN SODIUM 400MG CAP | MS102 |
| TOLMETIN SODIUM 600MG TAB | MS102 |
| VALDECOXIB 20MG TABLET | MS102 |
| ZZROFECOXIB 12.5MG TAB | MS102 |
| ZZROFECOXIB 25MG TAB | MS102 |
| ZZROFECOXIB 50MG TAB | MS102 |

Hormone replacement therapy-

This variable was assumed to be 1 as there were no female study participants.

If Hormone replacement therapy = Yes

Then RRCHRT = 0.6;

1st Degree relative with CRC, Age Unknown- SURVEY

If 1st degree relative with CRC age Unknown = Yes

Then RRCRelUnk = 2.3;

1st degree relative with CRC, age < 45- SURVEY

If 1st degree relative with CRC, age < 45 = Yes

Then RRRel45 = 3.9;

More than 1 1st degree relative with CRC- SURVEY

If >1 1st degree relative with CRC

Then RRCRelG1 = 4.3;

RRCRC= RRCSMOKE * RRCObesity * RRCAIc * RRCDiab * RRCAspirin * RRCNSAID *
RRCHRT * RRCRelUnk * RRRel45 * RRCRelG1

Relative Risk of colonoscopy Complications

Coumadin- EMR

If coumadin = Yes

Then RRCompCoumadin = 4.0;

Use of Warfarin was derived using this List:

| | |
|-----------------------------------|-------|
| WARFARIN (COUMADIN) NA 5MG TAB | BL110 |
| WARFARIN (COUMADIN) NA 2MG TAB | BL110 |
| WARFARIN (COUMADIN) NA 2.5MG TAB | BL110 |
| WARFARIN (COUMADIN) NA 1MG TAB | BL110 |
| ZZWARFARIN SODIUM 1.25 MG U/D TAB | BL110 |
| ZZWARFARIN 7.5MG TAB U/D | BL110 |
| ZZWARFARIN 1MG TAB U/D | BL110 |
| WARFARIN NA 10MG TAB | BL110 |
| ZZWARFARIN SODIUM 0.5MG U/D TAB | BL110 |
| WARFARIN SODIUM 5MG/VIL | BL110 |
| WARFARIN NA 1.25MG TAB UD | BL110 |
| WARFARIN NA 0.5MG TAB UD | BL110 |
| WARFARIN NA 1MG TAB | BL110 |

| | |
|-----------------------|-------|
| WARFARIN NA 2.5MG TAB | BL110 |
| WARFARIN NA 2MG TAB | BL110 |
| WARFARIN NA 5MG TAB | BL110 |

AASC 1-

If AASC 1 = Yes

Then $RRCompAASC1 = 0.7$;

AASC 3-

If AASC 3= Yes

Then $RRCompAASC3 = 4.3$

American Anesthesiology Society Class 1 (“normal healthy patient”)

- Absence of heavy alcohol (see above)
- Absence of Coumadin (see above)
- Absence of Inflammatory bowel diseases ([ICD9] LIKE N'555.0') OR ([ICD9] LIKE N'555.1') OR ([ICD9] = N'555.2') OR ([ICD9] = N'555.9') OR ([ICD9] = N'556.0') OR ([ICD9] = N'556.1') OR ([ICD9] = N'556.2') OR ([ICD9] = N'556.3') OR ([ICD9] = N'556.4') OR ([ICD9] = N'556.5') OR ([ICD9] = N'556.6') OR ([ICD9] = N'556.8') OR ([ICD9] = N'556.9') OR ([ICD9] = N'V10.05') OR ([ICD9] = N'V10.06')
- Absence of Hodgkin Lymphoma ([ICD9] LIKE N'201.%')
- Absence of Acromegaly ([ICD9] LIKE N'253.0')
- Absence of diabetes or high blood sugar (see above)
- Absence of cancer or a malignant tumor, excluding minor skin cancers (see above)
- Absence of chronic lung disease that limits your usual activities or makes you need oxygen at home (see above)
- Absence of congestive heart failure (see above)
- Absence of cigarettes smoking in the past week (see above)
- Absence of difficulty with bathing or showering (survey)
- Absence of difficulty with managing your money-such as paying your bills and keeping track of expenses (survey)
- Absence of difficulty with walking several blocks (survey)
- Absence of difficulty with pulling or pushing large objects like a living room chair (survey)

American Anesthesiology Society Class 3 (“severe systemic disease”)

- Presence of 1 of the following - cancer or a malignant tumor, chronic lung disease, congestive heart failure (see definitions above)

$RRCC = RRCompCoumadin * RRCompAASC1 * RRCompAASC3$

HARM to BENEFIT Ratio

$HBR = RRCRC/RRCC$

Adjusted Payoff time (PT)

If male and ages <60

If HBR ≤ 0.05
 Then PT >10
else if $0.06 \leq \text{HBR} \leq 0.1$
 Then PT >10
else if $0.11 \leq \text{HBR} \leq 0.2$
 Then PT >10
else if $0.21 \leq \text{HBR} \leq 0.5$
 Then PT = 7.4
else if $0.51 \leq \text{HBR} \leq 1.0$
 Then PT = 6.2
else if $1.1 \leq \text{HBR} \leq 2.0$
 Then PT = 5.6
else if $2.1 \leq \text{HBR} \leq 4.0$
 Then PT = 5.3
else if $4.1 \leq \text{HBR} \leq 10$
 Then PT = 5.1
else if $10.1 \leq \text{HBR} \leq 20$
 Then PT = 5.0

If male and between the ages of 60-69

If HBR ≤ 0.05
 Then PT >10
else if $0.06 \leq \text{HBR} \leq 0.1$
 Then PT = 9.7
else if $0.11 \leq \text{HBR} \leq 0.2$
 Then PT = 7.3
else if $0.21 \leq \text{HBR} \leq 0.5$
 Then PT = 6.0
else if $0.51 \leq \text{HBR} \leq 1.0$
 Then PT = 5.4
else if $1.1 \leq \text{HBR} \leq 2.0$
 Then PT = 5.3
else if $2.1 \leq \text{HBR} \leq 4.0$
 Then PT = 5.1
else if $4.1 \leq \text{HBR} \leq 10$
 Then PT = 5.0
else if $10.1 \leq \text{HBR} \leq 20$
 Then PT = 5.0

If male and between the ages of 70-79

If HBR ≤ 0.05
 Then PT = 9.8
else if $0.06 \leq \text{HBR} \leq 0.1$
 Then PT = 7.5
else if $0.11 \leq \text{HBR} \leq 0.2$
 Then PT = 6.2
else if $0.21 \leq \text{HBR} \leq 0.5$
 Then PT = 5.5
else if $0.51 \leq \text{HBR} \leq 1.0$
 Then PT = 5.2
else if $1.1 \leq \text{HBR} \leq 2.0$
 Then PT = 5.1
else if $2.1 \leq \text{HBR} \leq 4.0$
 Then PT = 5.0
else if $4.1 \leq \text{HBR} \leq 10$
 Then PT = 5.0
else if $10.1 \leq \text{HBR} \leq 20$
 Then PT = 5.0

If female and age <60

If HBR ≤ 0.05
 Then PT > 10
else if $0.06 \leq \text{HBR} \leq 0.1$
 Then PT > 10
else if $0.11 \leq \text{HBR} \leq 0.2$
 Then PT > 10
else if $0.21 \leq \text{HBR} \leq 0.5$
 Then PT = 8.7
else if $0.51 \leq \text{HBR} \leq 1.0$
 Then PT = 6.8
else if $1.1 \leq \text{HBR} \leq 2.0$
 Then PT = 5.9
else if $2.1 \leq \text{HBR} \leq 4.0$
 Then PT = 5.5
else if $4.1 \leq \text{HBR} \leq 10$
 Then PT = 5.2
else if $10.1 \leq \text{HBR} \leq 20$
 Then PT = 5.1

If female and between the ages of 60-69

If HBR ≤ 0.05
 Then PT > 10
else if $0.06 \leq \text{HBR} \leq 0.1$
 Then PT > 10

else if $0.11 \leq \text{HBR} \leq 0.2$
Then $\text{PT} = 8.7$
else if $0.21 \leq \text{HBR} \leq 0.5$
Then $\text{PT} = 6.5$
else if $0.51 \leq \text{HBR} \leq 1.0$
Then $\text{PT} = 5.7$
else if $1.1 \leq \text{HBR} \leq 2.0$
Then $\text{PT} = 5.4$
else if $2.1 \leq \text{HBR} \leq 4.0$
Then $\text{PT} = 5.2$
else if $4.1 \leq \text{HBR} \leq 10$
Then $\text{PT} = 5.1$
else if $10.1 \leq \text{HBR} \leq 20$
Then $\text{PT} = 5.0$

If female and between the ages of 70-79

If $\text{HBR} \leq 0.05$
Then $\text{PT} > 10$
else if $0.06 \leq \text{HBR} \leq 0.1$
Then $\text{PT} = 8.6$
else if $0.11 \leq \text{HBR} \leq 0.2$
Then $\text{PT} = 6.7$
else if $0.21 \leq \text{HBR} \leq 0.5$
Then $\text{PT} = 5.8$
else if $0.51 \leq \text{HBR} \leq 1.0$
Then $\text{PT} = 5.3$
else if $1.1 \leq \text{HBR} \leq 2.0$
Then $\text{PT} = 5.2$
else if $2.1 \leq \text{HBR} \leq 4.0$
Then $\text{PT} = 5.1$
else if $4.1 \leq \text{HBR} \leq 10$
Then $\text{PT} = 5.0$
else if $10.1 \leq \text{HBR} \leq 20$
Then $\text{PT} = 5.0$