ASSESSMENT OF PHYSICIANS' COLORECTAL CANCER SCREENING PRIORITIES USING THE ANALYTIC HIERARCHY PROCESS (AHP)

James G. Dolan, MD *
Department of Community and Preventive Medicine
University of Rochester
Rochester, NY, USA
E-mail: James_Dolan@urmc.rochester.edu

Thomas F. Imperiale, MD
Department of Medicine
Indiana University School of Medicine
Indianapolis, IN, USA
E-mail: timperia@iupui.edu

Jeroan Allison, MD
Department of Medicine
University of Massachusetts Medical School
Worcester, MA, USA
E-mail: Jeroan.Allison@umassmed.edu

Emily Boohaker, MD
Department of Medicine
University of Alabama at Birmingham
Birmingham, AL, USA
E-mail: eboohake@uab.edu

ABSTRACT

Introduction: Current colorectal cancer (CRC) screening guidelines endorse several options and recommend that patients and providers make choices through a shared decision making process. A key component of shared decision-making is determining decision priorities. Our goal was to assess primary care physicians' (PCP) priorities regarding currently recommended CRC screening programs.

Methods: PCPs from two geographically distinct sites completed an Analytic Hierarchy Process (AHP) analysis of ten CRC screening options for a typical, average-risk 50-year-old patient. The model included four major criteria: *Prevent Cancer, Avoid Side Effects*, *Minimize False Positives*, and *Optimal Test Logistics*. The latter criterion had three sub-criteria: screening *frequency*, *preparation*, and the test *procedure*. Linked elements among comparison sets were used to reduce the number of comparisons among the options from 187 to 76. We used hierarchical cluster analysis to identify common sets of priorities for the major decision criteria.

Results: The study sample consists of 27 academic PCPs, 19 men and 8 women, mean age 41 years. All physicians completed comparisons of the major decision criteria; 21 completed the entire analysis. The median consistency ratios for the major criteria comparisons were 0.15 and 0.12 for the entire analysis. Hierarchical cluster analysis of the major criteria priorities revealed three discreet clusters with 10, 7, and

* Corresponding author

10 members. *Prevent Cancer* was the most important criterion in every cluster. Each of the other criteria was the second most important priority in one cluster. Priority differences among clusters for all criteria were statistically significant ($P < 0.001$).

Conclusion: PCPs' decision priorities regarding considerations affecting the choice among currently recommended CRC screening tests can be assessed using the AHP. While preventing cancer appears to be the most important consideration, several other factors play an important role in choosing a screening option.

Keywords: Medical decision making, colorectal cancer screening, linked elements

Introduction

Colorectal cancer (CRC) is the third most common cancer diagnosed in the United States and the second leading cause of cancer mortality. (American Cancer Society) Although there is general agreement that screening average risk patients for colorectal cancer is worthwhile, there is no similar consensus on how screening should be accomplished. Current United States CRC screening guidelines endorse several screening strategies and recommend that a strategy be selected based on an individualized assessment of the respective advantages and disadvantages. (Levin, et al., 2008; U.S. Preventive Services Task Force recommendation statement, 2008)

By presenting multiple options that have different combinations of strengths and weaknesses, current CRC screening guidelines present doctors and patients with a complex decision task. Cognitive science research has shown that people frequently have difficulty making consistently good decisions in situations like this. (Redelmeier & Shafir, 1995; Russo, Carlson, & Meloy, 2006; Ubel, 2002) These findings suggest a better understanding of how clinical decision makers think about the tradeoffs inherent in current CRC screening guidelines will improve the effectiveness of CRC prevention in clinical practice.

Most colorectal cancer screening decisions are made in primary care settings. Although current guidelines recommend that CRC screening decisions be made through a shared decision making process, physician recommendations greatly influence colorectal cancer screening choices for many patients. (Klabunde, et al., 2005; Seeff, et al., 2004) We therefore analyzed priorities assigned by primary care physicians using the Analytic Hierarchy Process (AHP) to the criteria that differentiate currently recommended CRC screening strategies.

Methods

Study Population

The study population consisted of 27 primary care physicians from Indianapolis IN and Rochester, NY who agreed to participate in a study of decision-making regarding colorectal cancer screening in primary care practice.

The study intervention

The study intervention consisted of a description of the study, a brief review of current (2006) colorectal cancer screening guidelines, collection of demographic and background information, and a multi-criteria analysis of the decision regarding the choice of a colorectal cancer screening strategy for a typical healthy, average risk 50 year old patient using the Analytic Hierarchy Process (AHP). (Saaty, 1980, 2001a; Saaty, 1990) The majority of physicians completed the study intervention at a large group meeting at each study site at the start of the study. Physicians who were unable to attend were subsequently interviewed individually.

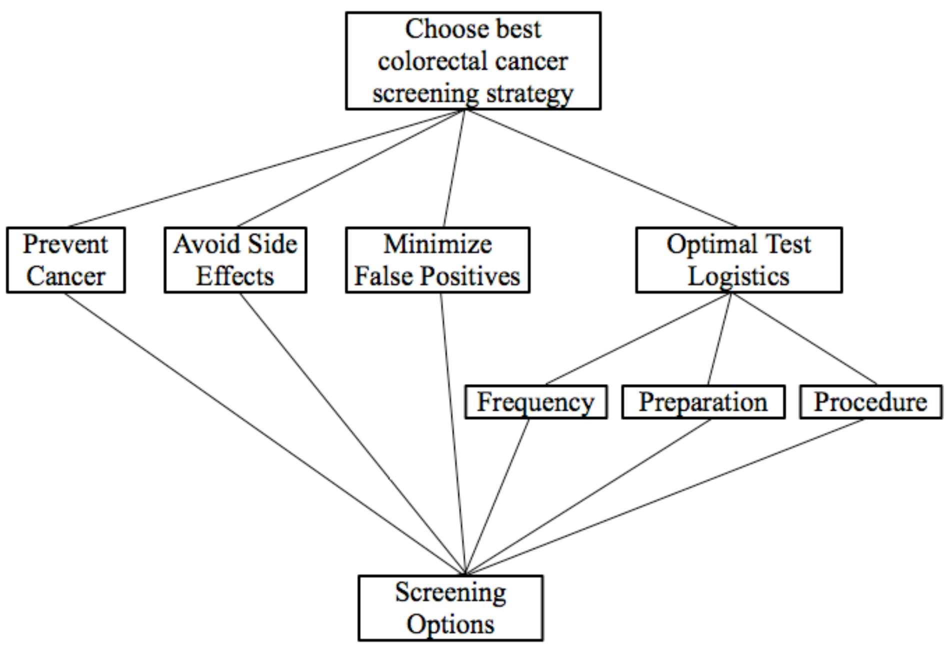
2006 screening guidelines

At the time of the study, screening guidelines for average risk patients included six options: annual guaiac-based fecal occult blood tests, annual immunochemical fecal occult blood tests, flexible sigmoidoscopy every five years, combined annual fecal occult blood tests and flexible sigmoidoscopy every five years, double-contrast barium enema every five years, and colonoscopy every ten years. For all non-colonoscopy options, a follow up colonoscopy was recommended if the initial test was positive. (Pignone, Rich, Teutsch, Berg, & Lohr, 2002; S. Winawer, et al., 2003)

Multi-criteria analysis using the Analytic Hierarchy Process

The decision model used for the study is shown in Figure 1. The goal was to choose the "best" colorectal cancer screening program for a typical, average risk 50 year old patient. There were four major criteria: *Prevent Cancer,* effectiveness in preventing cancer morbidity and mortality; *Avoid Side Effects,* minimize the risk of serious screening-related side effects defined as intestinal perforation or bleeding severe enough to require hospitalization; *Minimize False Positives*, minimize the chance of a false positive screening test; and *Optimal Test Logistics,* the combined importance of three procedure-related characteristics that were included in the model as sub-criteria: *Frequency,* the frequency of screening; *Preparation*, the preparation required for screening; and *Procedure*, the nature of the screening procedure itself.

Figure 1. Decision Model Presented to Primary Care Physicians to Determine Best Clinical Strategy



Ten screening options were included: the six recommended screening options listed previously and two additional tests that seemed likely to be included in future recommendations: Computer Tomographic

Colonography (CTC) (also known as virtual colonoscopy) and fecal DNA testing. Because the reported sensitivity of non-rehydrated guaiac-based fecal occult blood tests varied widely, two guaiac options were included, with test sensitivities of 20% and 40% respectively. (Imperiale, et al., 2004; Lieberman, et al., 2001) Two combined fecal occult blood test and flexible sigmoidoscopy strategies were also included: one using guaiac-based fecal occult blood tests with 40% sensitivity and one using immunochemical-based fecal occult blood tests.

The PCPs compared the alternatives with respect to *Prevent Cancer*, *Avoid Side Effects*, and *Minimize False Positives* using outcome estimates that assumed regular screening with the same program at the prescribed interval from age 50 through death or age 80. These outcome estimates were obtained using current information about the sensitivity and specificity of screening tests and a modified version of a colorectal cancer simulation program originally developed for the first Multi-Disciplinary colorectal cancer screening guidelines that were published in 1997. (Miller, February 2006; Winawer, et al., 1997) The outcome estimates used for the study, and the other data used to make the comparisons, are summarized in Table 1. All comparisons, except those about the procedure, were done in a blinded fashion.

Table 1. Data used to compare colorectal cancer screening options.

Screening option *	Cancers prevented per 1,000	Serious side effects per 100,000	False positive tests per 1,000	Screening frequency (years)	Test preparation
FOBT 20	11	104	706	1	Diet
FOBT 40	19	104	706	1	Diet
iFOBT	27	91	476	1	None
FlexSig	20	19	0	5	Enema
FOBT & FlexSig	29	114	706	1 & 5	Diet & enema
iFOBT & FlexSig	34	99	486	1 & 5	Diet & enema
fDNA	23	178	1000	3	None
CT scan	30	44	11	3	Full colon prep
DCBE	33	46	10	5	Full colon prep
Colonoscopy	36	326	0	10	Full colon prep

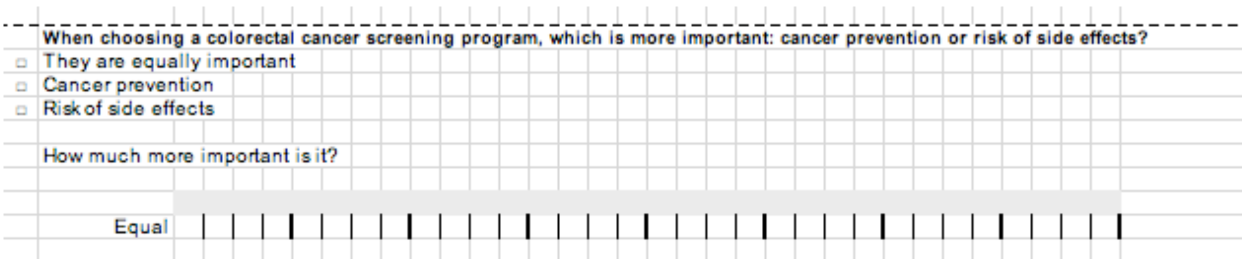
* - Abbreviations: FOBT = fecal occult blood test; iFOBT = immunochemical fecal occult blood test; FlexSig = flexible sigmoidoscopy; fDNA = fecal DNA test; DCBE = double contrast barium enema

To reduce the number of comparisons needed for the analysis, linked elements were used to divide the ten alternatives into two groups of four and one group of three for the comparisons relative to *Prevent Cancer*, *Avoid Side Effects*, *Minimize False Positives*, and *Procedure*. A linked element is a common alternative contained in two comparison subsets that can be used to create a uniformly scaled, complete comparison matrix. (Saaty, 2001b) This procedure reduced the number of required comparisons for each of these criteria from the 45 pairwise comparisons needed to analyze a set of ten alternatives to the 15 needed to compare two sets of four alternatives (6 comparisons each) and one set of three alternatives (3 comparisons).

Comparisons among the five possible screening preparations and the four possible screening frequencies were made as single sets requiring ten and six comparisons, respectively. The total number of comparisons needed to compare the alternatives relative to the criteria was 76: 15 comparisons for each of the four criteria with linked elements plus 16 for the two criteria compared without linked criteria.

The study physicians completed the AHP analysis using a paper form. Preference intensities for both the alternative and criteria comparisons were measured by placing a mark on a horizontal line. Figure 2 illustrates this format.

Figure 2. The format used to make the AHP pairwise comparisons.


When choosing a colorectal cancer screening program, which is more important: cancer prevention or risk of side effects?

- ▢ They are equally important
- ▢ Cancer prevention
- ▢ Risk of side effects

How much more important is it?

Equal

All priorities were calculated using the normalized right principal eigenvector procedure. Consistency ratios for each set of comparisons were calculated by first calculating the consistency index using the following formula:

$$CI = (\lambda_{max} - n) / (n-1)$$

where CI equals the consistency index, λ_{max} equals the largest eigenvalue of the comparison matrix, and n is the number of items being compared. We then calculated the consistency index by dividing the consistency index by the random index for the same size matrix. The random index is the mean consistency index for 500 randomly generated matrices. (Saaty, 1980) We calculated the consistency ratios for the overall analysis by multiplying the consistency ratio of each comparison set by the priority assigned to the criterion being addressed. We used this same weighted approach to calculate the consistency ratios for the linked sets of comparisons. We defined comparisons with consistency ratios ≤ 0.10 as consistent and those with consistency ratios between 0.11 and 0.21 as mostly consistent. (Forman & Selly, 2001; Katsumura, Yasunaga, Imamura, Ohe, & Oyama, 2008; Sato, 2004)

All AHP calculations were performed using a programmed *Microsoft Excel* spreadsheet. The results were validated using *Expert Choice 2000*, a commercially available AHP software program. (Expert Choice, Inc., Arlington VA)

Cluster Analysis

Cluster analysis refers to statistical procedures that identify groups of subjects with similar responses to a set of selected variables within a dataset. By helping organize and classify data, cluster analysis can help provide a better understanding of the information within a dataset. A hierarchical cluster analysis starts with each data point in its own cluster and then sequentially groups them together using a one of several standard algorithms.

We performed a hierarchical cluster analysis of the major criteria priorities provided by the study physicians using Ward's method as implemented in *ClustanGraphics*. (Wishart, 2006) Data regarding the priorities assigned to the four major decision criteria – P*revent Cancer, Avoid Side Effects, Minimize False Positives,* and *Optimize Test Logistics* – were first converted to standardized z-scores and then clustered using the increase in the sum of squares of the squared Euclidean distance method.

Data analysis

We summarized the data using standard descriptive procedures and tested the statistical significance of overall priority differences within clusters using analysis of variance. The statistical significance of priority differences between specific clusters was examined using the Bonferroni-Dunn test. All statistical analyses were conducted using Aabel 3. (Aabel 3, Gigawiz Ltd. Co., 2008)

Results

The characteristics of the 27 study physicians are summarized in Table 2.

Table 2. Characteristics of the study population.

Number	27
Age (mean, range)	42.8 (31-68)
Years in practice (mean, standard deviation)	12.5 (10.2)
Gender (n, percent)	
Male	19 (70%)
Female	8 (30%)
Study site (n, percent)	
Rochester	8 (30%)
Indianapolis	19 (70%)

The results of the physicians' AHP analyses are summarized in Table 3. *Prevent Cancer* was the most important major criterion, with a mean priority of 0.524. The mean priorities assigned to the other three major criteria were similar and ranged from 0.144 for *Optimal Test Logistics* to 0.175 for *Avoid Side Effects*. The mean and median consistency ratios for the major criteria comparisons were both 0.15. Fourteen (52%) of the 27 physicians had consistency ratios ≤ 0.10; 6 (22%) had ratios > 0.20.

Procedure was the most important of the subcriteria with a mean priority of 0.497, twice as important as the other two subcriteria, *Frequency* (mean priority 0.256) and *Preparation* (mean priority 0.247). The mean and median consistency ratios for the sub-criteria priority comparisons were 0.16 and 0.05. Twenty-two (81%) of the 27 physicians had consistency ratios ≤ 0.10.

Table 3. The primary care physicians' criteria priorities.

Criterion Priority	**Mean priority score (standard deviation)**
Major Criteria	
Prevent Cancer	0.524 (0.088)
Avoid Side Effects	0.175 (0.083)
Minimize False Positives	0.155 (0.143)
Optimize Test Logistics	0.145 (0.083)
Consistency ratio	0.15 (0.11)
Optimal Test Logistics sub-criteria	
Frequency priority	0.256 (0.152)
Preparation priority	0.247 (0.125)
Procedure priority	0.497 (0.166)
Consistency ratio	0.156 (0.3)

Twenty-one physicians successfully completed the full AHP analysis. The primary reason for incomplete analyses was failure to correctly fill out the paper response forms. The AHP-best alternative was colonoscopy every 10 years for 20 (95%) physicians and flexible sigmoidoscopy every 5 years for one (5%). The mean and median consistency ratios for the full analyses were both 0.12. Fifteen (71%) physicians had ratios ≤ 0.10; two (10%) were > 0.20.

The hierarchical cluster analysis of the major criteria priorities resulted in three clusters, containing 10, 7, and 10 physicians each. The details are provided in Table 4; the differences among the clusters are illustrated in Figure 3. *Prevent Cancer* was ranked the most important criterion in all three clusters. Each of the other three major criteria was ranked second most important in one cluster: *Avoid Side Effects* in cluster 3, *Avoid False Positives* in cluster 2, and *Optimize Test Logistics* in cluster 1.The differences in criteria rankings across the clusters were statistically significant for all four criteria. There were no significant among-cluster differences in consistency ratios for either the major criteria comparisons or the overall AHP analyses.

Table 4. Characteristics of the three clusters based on major criteria priorities.

Criterion	Cluster 1 (n=10)	Cluster 2 (n = 7)	Cluster 3 (n = 10)	
	Mean priority (standard deviation)			F ratio
Prevent Cancer	0.562 (0.11)	0.393 (0.16)	0.577 (0.06)	6.5, $p = 0.006$, [2,3]
Avoid Side Effects	0.126 (0.06)	0.133 (0.06)	0.252 (0.05)	13.9, $p < 0.001$, [1,3]
Minimize False Positives	0.078 (0.05)	0.359 (0.14)	0.09 (0.03)	33.7, $p < 0.001$, [2,3]
Optimize Test Logistics	0.233 (0.03)	0.116 (0.06)	0.076 (0.04)	34.1, $p < 0.001$, [1,2]
Consistency ratio, major criteria	0.142 (0.13)	0.166 (0.14)	0.146 (0.07)	0.1, $p > 0.05$
Consistency ratio, overall	0.096 (0.05)	0.17 (0.07)	0.12 (0.03)	2.8, $p = 0.085$

1. Difference between clusters 1 and 2 statistically significant by Bonferroni-Dunn Test, $p < 0.001$.
2. Difference between clusters 1 and 3 statistically significant by Bonferroni-Dunn Test, $p < 0.001$.
3. Difference between clusters 2 and 3 statistically significant by Bonferroni-Dunn Test, $p < 0.001$.

Figure 3. Boxplot of the results of the cluster analysis of the major criteria priorities. The dark gray figures represent cluster 1, the light gray figures cluster 2 and the white figures cluster 3. The boxes show 25th – 75th interquartile range and the whiskers the 95th percentiles. Means are denoted by the diamonds; medians by the horizontal lines..

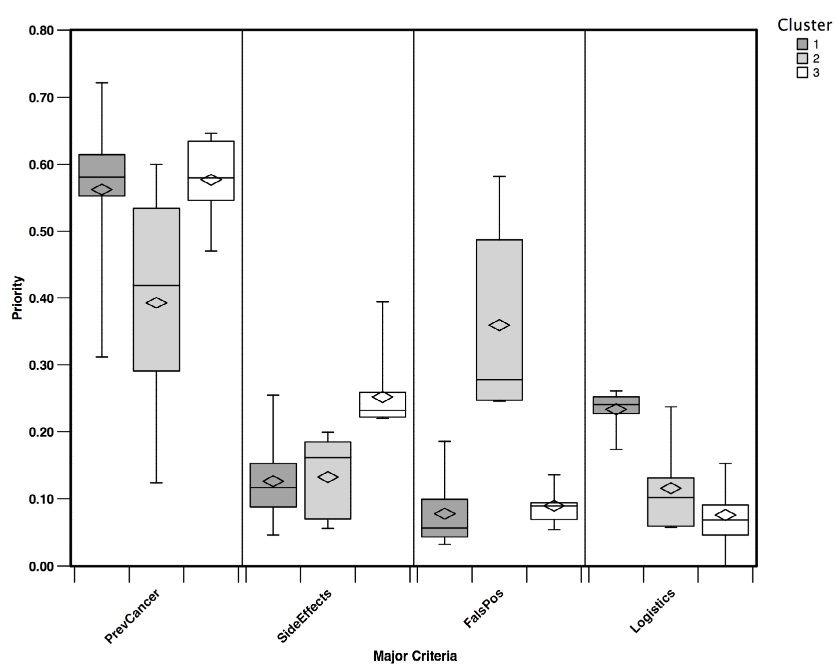


Table 5 summarizes the top five screening alternatives in each cluster. The same five screening options were ranked in each. Colonoscopy every 10 years was the highest ranked screening option in every cluster. The rankings of the other four options differed for each.

Table 5. The top five screening alternatives, by cluster

Cluster 1		Cluster 2		Cluster 3	
Alternative	Score (%)	Alternative	Score	Alternative	Score
Cscope	24.3	Cscope	30.2	Cscope	28.9
DCBE	13.8	FlexSig	19.5	FlexSig	17.5
iFOBT & FlexSig	13.4	DCBE	14.0	DCBE	14.0
CT	11.2	CT	10.8	iFOBT & FlexSig	13.7
FlexSig	10.8	iFOBT & FlexSig	8.9	CT	11.2

Abbreviations: Cscope = colonoscopy every 10 years; DCBE = double contrast barium enema every 5 years; iFOBT & FlexSig = annual immunochemical fecal occult blood tests and flexible sigmoidoscopy every 5 years; CT = CT colonography; FlexSig = flexible sigmoidoscopy every 5 years.

Discussion

In this study, we found that physician subjects learned how to use the AHP to examine colorectal screening decisions and prioritize decision criteria with minimal instruction. Most were also able to perform the necessary pairwise comparisons with acceptable levels of consistency and complete a very complex analysis despite the lack of any feedback during the process. These findings suggest that a clinical decision support system targeted at practicing physicians using the AHP is feasible and could be used to help assess and compare their decision-making priorities. To be successful, however, such systems will need to include provision of ongoing feedback during the analysis to avoid procedural mistakes such as those that occurred in this study.

Although all study physicians considered preventing cancer the most important criterion, as a group they assigned almost half of the overall decision priority to the other criteria. As shown by the differences among the three clusters, there was significant variability in how the study physicians viewed the relative importance of these three considerations. These results suggest that, when given the opportunity, primary care physicians view the choice of colorectal cancer screening strategy as a multi-criteria decision problem and vary in the how they assign decision priorities.

The results of the cluster analysis raise the possibility that primary care physicians prioritize these criteria in predictable patterns. This finding is similar to results of a previous study of patient colorectal cancer screening priorities that also found evidence of similar groups of common priority assessments. (Dolan, 2005) If confirmed, these findings suggest that rapid clinical support systems could be developed based on matching empirically derived sets of common patient and provider decision preferences.

Despite the variations found in decision priorities, colonoscopy every 10 years was the top-ranked screening option in all three clusters and for 20 of the 21 physicians. The clinical significance of this finding is uncertain however, since it is important to consider both physician and patient preferences when making colorectal cancer screening choices. Previous studies have consistently shown differences between doctors and patients in how they assess decision priorities. (Dolan, Bordley, & Miller, 1993; Peralta-Carcelen, Fargason, Coston, & Dolan, 1997) Additional studies comparing patient and physician priorities are needed to address this question.

This study has two main limitations. The first is that the study population consisted of a small, sample of physicians consisting almost entirely of academic general internists. The extent to which the study findings generalize to other primary care providers is unknown. The second is that the stability of the decision priorities over time was not evaluated.

Despite these limitations, we conclude that this study provides evidence that primary care physicians are capable of using the AHP to analyze a complex problem regarding selection of a colorectal cancer screening option and that they consider multiple considerations important when making this decision. Additional research is warranted to confirm these findings and to determine the extent to which patient priorities and preferred screening alternatives agree with those of their primary care physicians.

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