Using Decision Analytic Methods to Assess the Utility of Family History Tools

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Abstract: Family history may be a useful tool for identifying people at increased risk of disease and for developing targeted interventions for individuals at higher-than-average risk. This article addresses the issue of how to examine the utility of a family history tool for public health and preventive medicine. We propose the use of a decision analytic framework for the assessment of a family history tool and outline the major elements of a decision analytic approach, including analytic perspective, costs, outcome measurements, and data needed to assess the value of a family history tool. We describe the use of sensitivity analysis to address uncertainty in parameter values and imperfect information. To illustrate the use of decision analytic methods to assess the value of family history, we present an example analysis based on using family history of colorectal cancer to improve rates of colorectal cancer screening. (Am J Prev Med 2003;24(2):199–207) © 2003 American Journal of Preventive Medicine

Introduction

Family history (FH) of disease is a risk factor for most diseases of public health significance.[1] Although FH information is routinely collected in clinical settings, its systematic use in public health and preventive medicine is largely absent. Other papers in this issue attest to the usefulness of FH information.[2–9] This article addresses the use of decision analysis to quantify the value of FH information. Questions we consider are: (1) Of what use is FH information? and (2) How valuable is it? At a simple level, the answer to the first is that FH can be used to differentiate risk, motivate individuals to seek care or change behavior, and target interventions more effectively. A simple answer to the second question is that the value of FH is the improvement it brings about in desirable health outcomes (taking into account the potential costs associated with obtaining and using FH information). We start by outlining the main components of a decision analytic approach and issues to consider when exploring the value of FH. We then present an illustration based on using FH of colorectal cancer (CRC) to improve rates of CRC screening.

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The Elements of Decision Analysis

Decision analysis is a systematic method for making decisions when outcomes are uncertain. The basic building blocks of a decision analysis are (1) decisions, (2) outcomes, and (3) probabilities. A *decision* is a choice made by a person, group, or organization to select a course of action from among a set of mutually exclusive alternatives. The decision maker compares expected outcomes of available alternatives and chooses the best among them. This choice is represented by a *decision node,* a square, with branches representing the choices in the decision-tree diagram (for example, see Figure 1). Because a decision is chosen and does not occur by chance, no probability is attached to it. For example, after receiving information that a person has FH of a disease, that person may decide (choose) to seek medical advice or choose not to do so. *Outcomes* are the chance events that occur in response to a decision. Outcomes can be intermediate or final. Intermediate outcomes are followed by more decisions or chance events. For example, if a person decides to seek medical care for hypertension, his or her physician may advise behavior modification alone or a combination of behavior modification and drug therapy. From the person's perspective, this is a chance outcome; from a healthcare provider's perspective, it is a decision. An outcome can be intermediate or final depending upon the context of the decision problem. For example, hypertension control may be the final outcome in a decision analysis focusing on hyperten-

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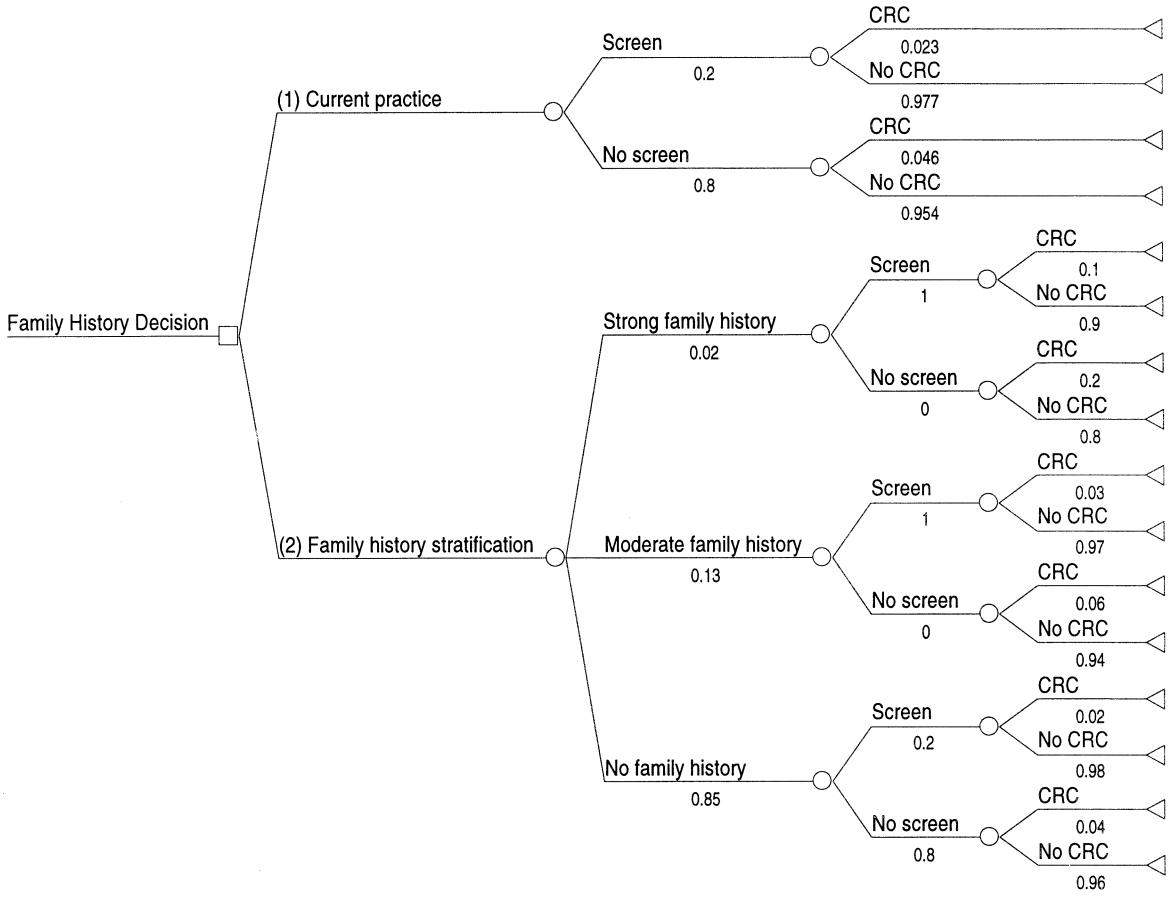

Figure 1. A basic decision tree depicting the alternative courses of action of (1) continuing with the current practice with no explicit use of family history (the top "branch" emanating from the square decision node) versus (2) use of a colorectal cancer (CRC) family history tool for risk stratification and improved screening (the bottom "branch" emanating from the square decision node). Chance events, represented by branches emanating from circular chance nodes, are assumed to occur with the probabilities shown under the respective branches. This illustration assumes that the use of family history motivates 100% of individuals with strong and moderate family histories to get screened.

sion as the health condition of interest, but it may be an intermediate outcome in a decision analysis focusing on myocardial infarction. In this essay, we define an *outcome as an event resulting from chance*. This is represented by a chance node in a decision tree, a circle, with branches representing different outcomes that occur by chance, one and only one of which occurs. Each chance outcome has a probability by which it can occur written below the branch in a decision-tree diagram. The sum of probabilities for all outcomes that can occur at a chance node is one. The building blocks of decision analysis—decisions, outcomes, and probabilities—can be used to represent and examine complex decision problems.

Perspective Matters

The value of an FH tool can be assessed from the perspectives of different stakeholders and may differ between an individual, family, healthcare provider, public health policymaker, and society. For public health decisions, a societal perspective is recommended.[10,11] Although framing a decision analysis using the societal perspective is standard practice, examining the decision problem from other perspectives may provide important information. For example, even if an intervention such as the use of a particular FH tool is recommended on the basis of a societal perspective, the question of whether such an intervention will be acceptable to stakeholders other than public health decision makers is not necessarily answered by a societal analysis. Looking at the decision problem from the perspective of all major stakeholders may help to identify implementation problems that a public health decision maker or a preventive medicine practitioner may face. Examining the decision problem from perspectives other than the societal perspective should be conducted as a subanalysis of the societal analysis. Such a subanalysis is often useful before the societal analysis because its results are often valuable sources of information for the societal analysis. For instance, an analysis of an FH tool from the perspective of a healthcare provider yields information needed for a societal per-

Table 1. Outcome and cost measures that may be included in an assessment of family history tools

Outcomes	Costs
Behavior or behavioral risk factors changed	Time cost to patient
Nonbehavioral risk factors changed	Cost of collecting information
Change in risk from change in risk factors	Cost of managing information
Time saved to detection of risk factors (early detection)	Cost of communicating the information to patients, e.g., counseling
Time saved to detection of onset of conditions	Cost of clinically using the information (computer-assisted decision making may be helpful)
Mortality averted	Screening and testing costs for individual (including adverse social, psychological, and health outcomes)
Disease cases averted	Screening and testing costs for the family members for risk factors, if necessary
Life-years saved	Cost of screening program
Quality- and disability-adjusted life years saved (QALYs and DALYs)	Cost of treatment or behavior change
Productivity loss avoided	
Money saved by (1) individual, (2) family members, (3) provider or insurer, (4) public health agencies, and (5) society	

spective analysis; for example, the question of whether and to what extent providers will use the tool should be answered before examining the question about whether it is a valuable intervention from a societal perspective.

The importance of multiple perspectives is highlighted when individual characteristics not only stratify risk but also affect participation and compliance. For example, this will be the case if a public health decision maker wants to design programs to encourage participation and compliance for an intervention, such as blood pressure and cholesterol screening for low-income persons with FH of coronary heart disease. In this case, the public health policymaker would want to vary program structure with individual characteristics because these characteristics will affect the participation and compliance decisions of individuals.

Quality of Information Matters

Both the quality and quantity of information collected through an FH tool are important for decision making. A tradeoff exists between keeping an FH tool simple and collecting all relevant information.[1] More information may add disproportionately more noise. Some individuals are more informed about their families, and some diseases are discussed more openly than others. FH information may be inaccurate or incomplete.[12,13] Even though a simple decision analysis (such as our illustration below) may assume 100% accuracy of FH information, in a realistic decision scenario the quality of FH information will be an important consideration. Sensitivity analysis on the probability that the information is accurate can be useful in shedding light on how important the quality of the information is to a particular decision. Although sensitivity analysis is usually performed after a decision analysis is conducted, it can also be informative during the design of FH tools (e.g., by illustrating the potential sensitivity of results to varying levels of detail in FH information). Techniques for sensitivity analysis are discussed in more detail below, and other papers in this issue deal explicitly with internal and external validity of FH information.

Measures of Outcomes and Cost

To assess the value of FH information, we need to measure its impact on desirable outcomes (positive health effects) and undesirable outcomes (costs, negative health effects). Effectiveness of FH information can be measured in different ways (Table 1), depending on the possible intervention points and outcomes of interest.[14]

The costs associated with using FH information depend on how the information is obtained and the intervention that results from its use. There are a number of nuances for the assessment of costs that are detailed in the literature.[15,16] In general, the costs in the decision to use an FH tool may include those shown in Table 1.

Other Considerations

A decision analysis examining an FH tool must explicitly state the *time horizon* for which costs and effects are included in the analysis. For example, if measuring cost savings from avoided future treatment resulting from reduction in disease risk, the time horizon is the remaining lifetime of the individual. In this case, future cost savings should be discounted to present costs because present is preferred over the future. An important consideration is choosing the discount rate. Shadow prices that correct for the failure of the market to reflect social valuation provide the correct theoretical basis for valuation of costs and health effects and for choosing a discount rate.[17–20] In practice, shadow price-based recommendations can be difficult to implement. The Panel on Cost-Effectiveness in Health and Medicine[10] recommends that costs and health effects be discounted at the same annual rate of 3% and sensitivity analysis be done using a range of 0% to 7%. It is also recommended that the costs be in real currency units after adjustment for inflation.[20]

At times, the decision about the potential use of an FH tool can be simple: whether to use the FH tool or not to use it. In such simple cases, decision rules that rank alternatives can be used to select the optimal alternative. However, a decision is often more complex where many FH tools are available and they are not mutually exclusive (i.e., they can be used in combination and collect different degrees of detail about FH). In such a scenario, a decision algorithm can be used to rank FH tools or clusters of FH tools that can be combined or used in sequence.[21,22] In a decision analysis, considerations of returns to scale for implementation of the FH tool can be important. The question is whether the costs of using an FH tool increase proportionally when the tool is implemented in larger populations or healthcare organizations.[22,23] This issue can affect generalizability of results and alter the overall results of a decision analysis if the cost of implementing an FH tool changes at a different rate than the size of the healthcare setting (e.g., hospital or health organization). The Panel on Cost-Effectiveness in Health and Medicine[10] recommends assuming proportional changes unless these effects are likely to be large.[16] Elbasha (Centers for Disease Control and Prevention, unpublished observations, 2001) cites evidence for nonproportional change in cost with change in the scale for healthcare inputs. An implication is that on cost grounds alone, different FH tools or administration methods (e.g., self-administered vs. assisted) may be suitable for different sizes of populations and settings. However, the cost of an FH tool alone, excluding treatment changes, is likely to be relatively low. According to evidence from the Utah Heart Tree Study, the cost of the FH tool was $27 for the identification of a high-risk family.[24,25]

Dealing with Uncertainty: Sensitivity Analysis

Parameter values (probabilities, costs, and health effects) often are not known with certainty or are expected to change over time or between settings. This uncertainty can be dealt with by using sensitivity analysis. Decision analytic methods are particularly useful for examining how the value of an intervention varies with changes in the input factors. Sensitivity analysis can be used to answer questions such as, "Which factors most affect the value of an FH tool?" and "Which factors make a difference in the decision between alternatives?" The sensitivity analysis can be *one-way*, in which only one parameter varies at a time. For example, the effectiveness of an FH tool may depend on the probability of screening, treatment, or control of a health condition in those with a positive FH. Therefore, the decision about the effectiveness of an FH tool is likely to be sensitive to the probability of adoption of healthy behaviors or the probability of compliance with medical decisions. These parameters can be varied one at a time over the range of their likely values to see if the overall results of the decision analysis change. In real-life scenarios, many parameters may change together. The sensitivity to this change can be assessed with *multi-way sensitivity analysis*, in which two or more parameters vary simultaneously. Because keeping track of the analysis becomes difficult if too many parameters are varied together, carefully choosing a few important parameters at a time is advisable.

When outcomes are continuous, statistical *joint confidence intervals* can be used. The probabilistic approaches range from those that rely on parametric assumptions, such as the delta method, to simulation and resampling approaches that ease parametric assumptions, such as the bootstrap method.[26–30] For example, this approach could be used for average time costs for patients using the FH tool, the proportion of those who are screened for a condition after being identified by an FH tool, and the average treatment costs after screening. Because a decision model is a subjective representation of reality and the elements considered important by the modeler, sensitivity of results to the model structure may also be examined.[31] Another type of sensitivity analysis is called *threshold analysis*. This analysis attempts to identify parameter values (one-way) or combinations of parameters values (multi-way) at which the decision between alternatives would change. Similarly, it is often useful to identify best-case and worst-case scenarios and to examine the alternatives under extreme values of the parameters. We also should keep in mind the uncertainty related to generalizability and extrapolation of results of a decision analysis done in one setting to other settings. Transfer of parameter values to other situations must be followed by sensitivity analysis.[29] An important use of sensitivity analysis is to guide better and more detailed data collection on parameters for which there is high sensitivity.[32]

An Illustration: Colorectal Cancer

CRC is the second leading cause of cancer mortality in the United States, with over 140,000 cases diagnosed and 56,000 deaths from the disease each year.[33] Average lifetime risks of getting and dying from CRC are about 4.6% and 2.6%, respectively. An FH of CRC is one of the strongest risk factors for the disease.[34] The literature suggests that 5%–20% of people report an FH of CRC and that this FH confers a relative risk of two to five—depending upon the number, age, and relatedness of affected relatives[33–45]—although some studies report relative risks of up to nine.[38,40,43] A moderate FH (defined as CRC diagnosed in one relative after age 50 following the classification scheme of Scheuner et al.[45]) increases lifetime risk of CRC to about 6%, and a strong FH (defined as two or more affected relatives or one in

whom CRC is diagnosed before age 50) may increase lifetime risk to 20% or more.[46]

Fortunately, CRC is one of the most preventable cancers.[47] Evidence from the literature suggests that regular endoscopic screening can reduce CRC incidence by 50% or more.[48,49] However, despite the widespread availability of screening tests, the rate of screening remains well below that recommended by the American Cancer Society[33–50] and the U.S. Preventive Services Task Force,[51] with only 20%–40% of persons aged 50 and older having received a recent endoscopic screening.[52,53] Improving the rate of screening is a fundamental component of the strategy for decreasing CRC morbidity and mortality. Persons with FHs of CRC may constitute an important target for FH education. If it can be shown that individuals are more motivated to improve their health when they know they are at a higher risk for CRC than the general population, then FH may prove to be a valuable tool for promoting CRC screening.

The illustration that follows demonstrates a decision analytic approach for evaluating the utility of an FH tool. To demonstrate the approach, we use a decision analytic framework to explore the value of using FH of CRC as a tool for risk stratification and improved disease prevention. The premise of the example is that application of a CRC FH tool will promote awareness of the increased risk of CRC associated with FH and motivate persons with an FH to get screened for the disease, thereby reducing CRC incidence. Using decision analytic methods, we illustrate how to compare the "value added" of this FH intervention in terms of averted CRC cases with the current practice in which no FH tool is systematically applied. Hence, in this illustration, two alternatives exist: (1) use of an FH tool and (2) current practice without an explicit FH tool. Although we have used reasonable estimates of the parameters required in the decision analysis, this example is a simplistic one designed to demonstrate decision analytic methods, and its results should be considered illustrative only. Furthermore, in this illustration we assume that the FH tool yields perfect information (i.e., that the tool is completely accurate in stratifying people according to their FHs), which is unlikely in real-world implementation of an FH tool.

As an example of how decision analysis can be used to examine the utility of an FH tool, consider the basic decision tree depicted in Figure 1. This decision tree graphically represents the two alternative intervention strategies of (1) continuing with the current practice with no explicit use of FH (the Current Practice branch at the square decision node) versus (2) use of a CRC FH tool for risk stratification and improved screening (the Family History Stratification branch at the square decision node). Outcomes are represented by branches from circular chance nodes and are assumed to occur with the probabilities shown under the respective branches. Assumptions used in this decision analysis example are summarized in Table 2 and described below.

Table 2. Assumptions used to assess utility of a hypothetical family history (FH) tool for colorectal cancer (CRC)

Variable	Value	
	Alternative 1: current practice	**Alternative 2: FH stratification**
Prevalence of CRC FH	Not required[a]	13% (moderate FH) 2% (strong FH)
Proportion of individuals screened	20%	100% (strong FH) 100% (moderate FH) 20% (no FH)
CRC lifetime risk	4.6%	20% (strong FH) 6% (moderate FH) 4% (no FH)
Reduction in risk from screening	50% reduction	50% reduction

[a]The prevalence of FH is not a required parameter in the Current Practice alternative. This does not imply that FH does not exist, but rather that FH does not influence any of the decisions or chance outcomes in the Current Practice alternative.

Current Practice

Under the Current Practice alternative, 20% of all individuals get screened. Those who undergo screening reduce their risk by 50%, from 4.6% to 2.3%. Of those who do not get screened, the risk of developing CRC is approximated by the population-wide average of 4.6%.

Family History Stratification

Under the Family History Stratification alternative, individuals are stratified according to their FHs of CRC. We assume that 15% of individuals have FHs of CRC, including 13% who possess moderate FHs and 2% who possess strong FHs. Of those without FH, risk of CRC is 4% (i.e., slightly lower than the population average). Individuals with moderate or strong FHs incur CRC risks of 6% or 20%, respectively. Screening is assumed to reduce risk by 50% regardless of degree of FH.

Under the Family History Stratification alternative, the rate of screening among persons with moderate or strong FHs increases relative to the Current Practice alternative, based on the assumption that individuals are more likely to get screened if they perceive they have a higher risk for CRC than the average population. In this simplistic example, we assume that the rate of screening for those with FHs increases to 100%, representing the best-case scenario of complete adherence to screening guidelines among those with FHs.

Consequences

As described earlier under Measures of Outcomes and Cost, decision analytic methods can be used to compare alternative strategies with a variety of metrics. To illus-

Table 3. Results of the illustrative decision analysis

Alternative strategies[a]	Total expected cases per 100,000	Cases averted compared with no screening	Cases averted compared with current practice
No screening[b]	4580	N/A	N/A
Current practice	4122	458	N/A
Family history (FH) stratification, assuming 100% of persons with strong FH are screened[cd]	3962	618	160
FH stratification, assuming 100% of persons with strong and moderate FHs are screened[e]	3650	930	472
100% population-wide screening[b]	2290	2290	1832

N/A, = not applicable.
[a]Each strategy is evaluated in terms of colorectal cancer (CRC) cases averted per 100,000 individuals.
[b]The alternative strategies of No Screening and 100% Population-wide Screening are included because they are intuitive benchmarks against which to compare the FH Stratification and Current Practice alternatives.
[c]Two cases are presented for the FH Stratification alternative: (1) 100% of individuals with strong FH are screened and (2) 100% of individuals with any FH (strong and moderate) are screened.
[d]Assuming 20% screening among those with moderate or no FH.
[e]Assuming 20% screening among those with no FH.

trate decision analytic methods in this example, the Family History Stratification alternative is evaluated in terms of disease incidence. Strictly speaking, each of the alternatives is associated with an expected lifetime risk of CRC. This risk is obtained by taking a weighted average of the lifetime CRC risk associated with each potential consequence of that alternative. For ease of presentation, the expected lifetime CRC risk is converted to CRC cases per 100,000 individuals.

Illustrative Results

Table 3 and Figure 2 present results of the illustrative decision analysis, in which risk stratification using FH is compared to the current practice of no explicit use of FH. The alternative strategies are evaluated in terms of total expected CRC cases and number of cases averted per 100,000 individuals. Because strategies of No Screening and 100% Population-wide Screening are intuitive benchmarks against which to compare the Family History Stratification and Current Practice alternatives, results for these two additional strategies are also presented. We caution that these results are illustrative in nature and intended merely to illustrate the *type* of quantitative information that decision analytic methods can provide in an assessment of an FH tool.

Two scenarios were evaluated for the Family History Stratification alternative: (1) screening increases to 100% among persons with strong FHs, and (2) screening increases to 100% among persons with any FH (including strong and moderate). In this example, the use of FH to stratify risk and increase screening to 100% among those with strong FHs leads to an additional 160 cases averted per 100,000 compared with the current practice (i.e., population-wide screening rate of 20%). The use of FH to increase screening to100% among persons with any FH results in an additional 472

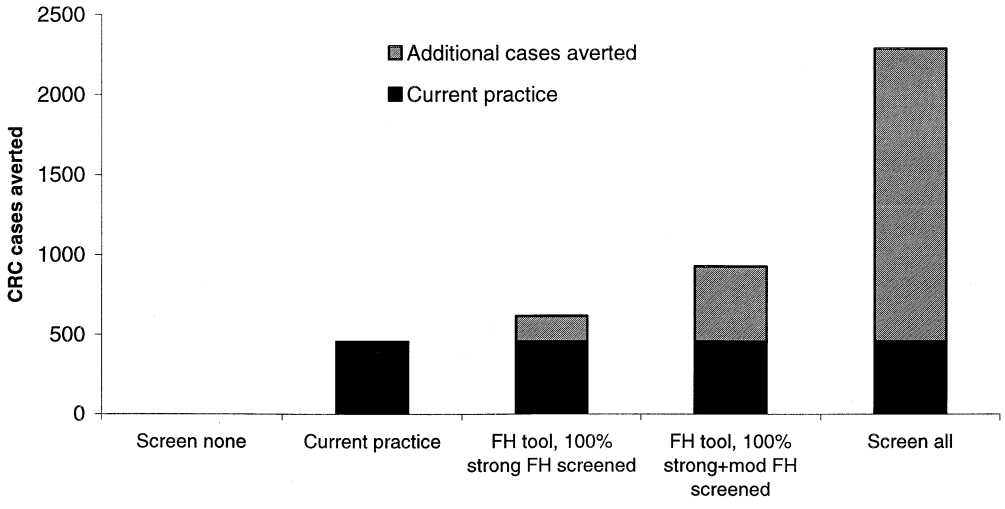

Figure 2. Results of the illustrative decision analysis. The "value added" of using family history (FH) is presented in terms of the additional colorectal cancer (CRC) cases averted per 100,000 individuals using an FH tool to increase screening among persons with FH compared with CRC cases averted using current practice (in which 20% of people are screened without regard to FH)

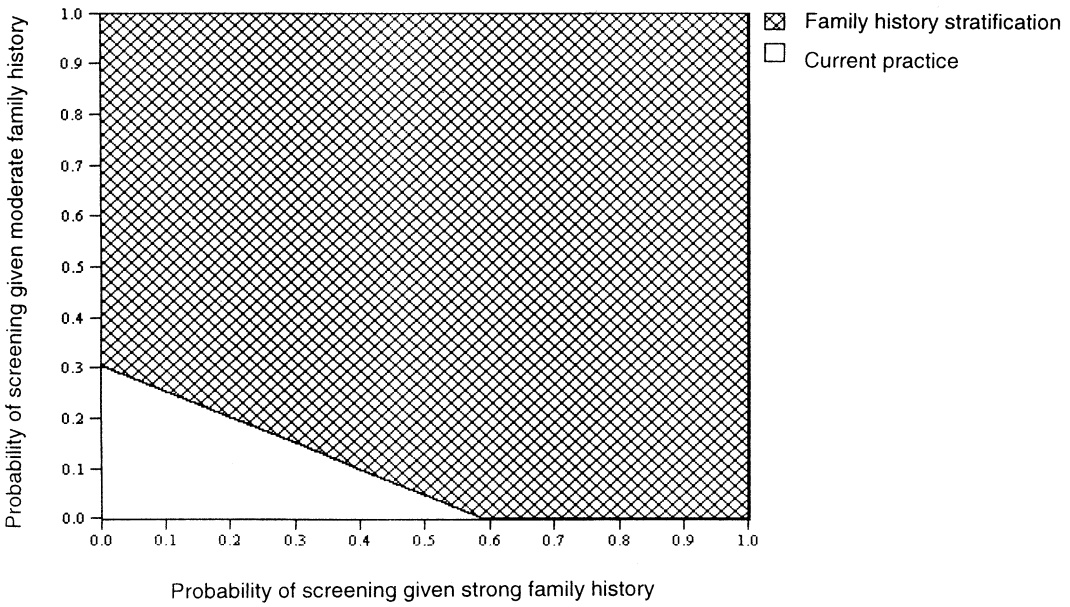

Figure 3. Results from an example sensitivity analysis in which the probability of screening varies from 0 to 1 (analogous to rates of 0 to 100%) among those with strong family histories (along the x-axis) and moderate family histories (along the y-axis). The probability of screening under the Current Practice alternative is held constant at 20%. The upper (cross-hatched) region represents combinations of screening rates for which the Family History Stratification leads to fewer expected CRC cases than the Current Practice. The smaller (white) region at the lower left represents combinations of screening rates for which the Current Practice leads to fewer CRC cases. Although this sensitivity analysis varies only the screening rates among those with family histories, the comparison of the strategies takes into account all cancers, not just cancers among those with family histories.

cases averted per 100,000 compared with the current practice.

An Illustration of Sensitivity Analysis

We assumed that the use of the FH tool resulted in 100% screening among individuals with FHs of CRC. But what happens to the value of the FH tool in the more realistic situation in which the FH tool increases screening but to a lesser extent than 100%? Using sensitivity analysis, we can vary the assumed level of screening among individuals with FHs and examine the value of the FH tool in each case. In practice, computer programs perform these calculations for us. Figure 3 depicts the results of a sensitivity analysis in which we independently varied the rate of screening among persons with strong and moderate FHs. The upper (cross-hatched) region of Figure 3 represents combinations of screening rates that result in the Family History Stratification leading to fewer expected CRC cases than the Current Practice. For screening rates among those with FHs of above 50%, the Family History Stratification is clearly superior to Current Practice. The Family History Stratification remains superior if screening rates are 30% in individuals with strong and moderate FH; in this case, however, the Family History Stratification leads to only an additional 83 cases averted per 100,000, compared with Current Practice. Although these scenarios and data are merely illustrative, they provide insight into the power of sensitivity analysis in exploring the utility of an FH tool.

In this example, Family History Stratification is preferred to Current Practice as long as more than 20% of persons with FH get screened. This makes sense given our baseline assumption that no decrement exists in screening among individuals with no FH. But what would happen if individuals who perceive a negative or null FH become complacent and thus less likely to be screened than if they had not been made aware of their FH? We can use sensitivity analysis to examine the implications of this possibility. For example, assume that persons with strong and moderate FHs have a 50% screening rate. Sensitivity analysis indicates that the Family History Stratification would be preferred as long as the rate of screening in those with negative FHs is greater than 10%. If the rate of screening among persons with negative FHs falls below 10%, the Current Practice would result in fewer expected CRC cases than would the Family History Stratification.

We have illustrated sensitivity analysis for only a few of the many parameters that may influence the utility of an FH tool for CRC. Other parameters for which sensitivity analysis would be recommended in an evaluation of a specific CRC FH tool would include the prevalence of FH, proportion of people who are aware of their FHs, risk of CRC, risk reduction achieved by screening, and prevalence of adverse effects from screening.

Concluding Remarks

In this paper, we have outlined the main elements of decision analytic methods and described how those methods can be used to assess the value of an FH tool. Using a colorectal cancer example, we demonstrated how decision analytic methods might be applied to examine the utility of an FH tool. In addition to illustrating the decision-tree approach, we provided an example of sensitivity analysis, with the intent of demonstrating how such an analysis can be used to quantitatively evaluate the influence of multiple factors on the overall utility of FH tools. While use of decision analytic method requires a planned collection of information and attention to nuances of methodology, we hope readers will consider these methods; we also encourage interested readers to consult comprehensive texts and current literature for discussions of the necessary methods and mechanics.[2,3,46–48] This approach could be applied to any risk factor, not just FH, where cases averted will depend both on prevalence of the risk factor and associated relative risk. By providing an example of the type of information that decision analytic methods can provide, we hope to have provided motivation for and insight into how these methods can be applied for systematically evaluating the use of FH information in public health and preventive medicine.

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