Stochastic Modeling of Medical Testing Decisions using Patient-Specific Utility Functions

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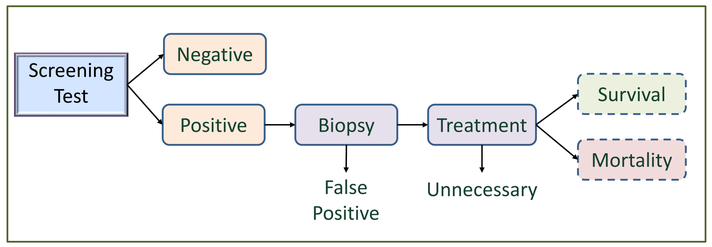
The aim of this research was to model typical cancer screening decisions based on both rewards and risks, in a way that accounts for individual patient preferences.

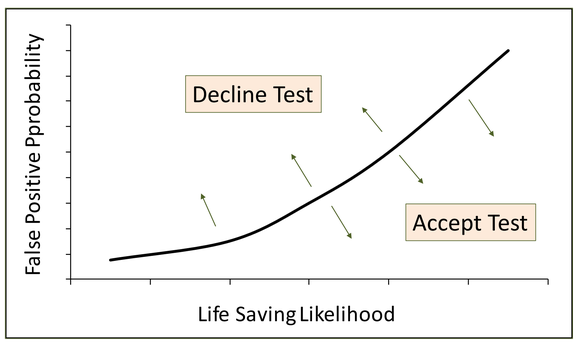
Shared Decision Making

Shared decision making in healthcare is becoming commonplace, where patients are asked to play a role in their medical care. As new technologies are introduced and data analysis methods become more sophisticated, many traditional healthcare recommendations are evolving. In many cases, a patient-centered approach is recommended so that patient-physician discussions dictate courses of action that are personalized. Examples include, mammography, PSA tests, pap smears, colonoscopy, etc.

Typical Cancer Screening Process

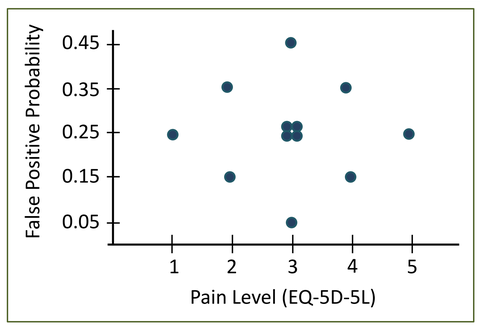


Cancer Screening Decision Frontier



A patient's indifference curve can be determined based on the utility they assign to potential outcomes.

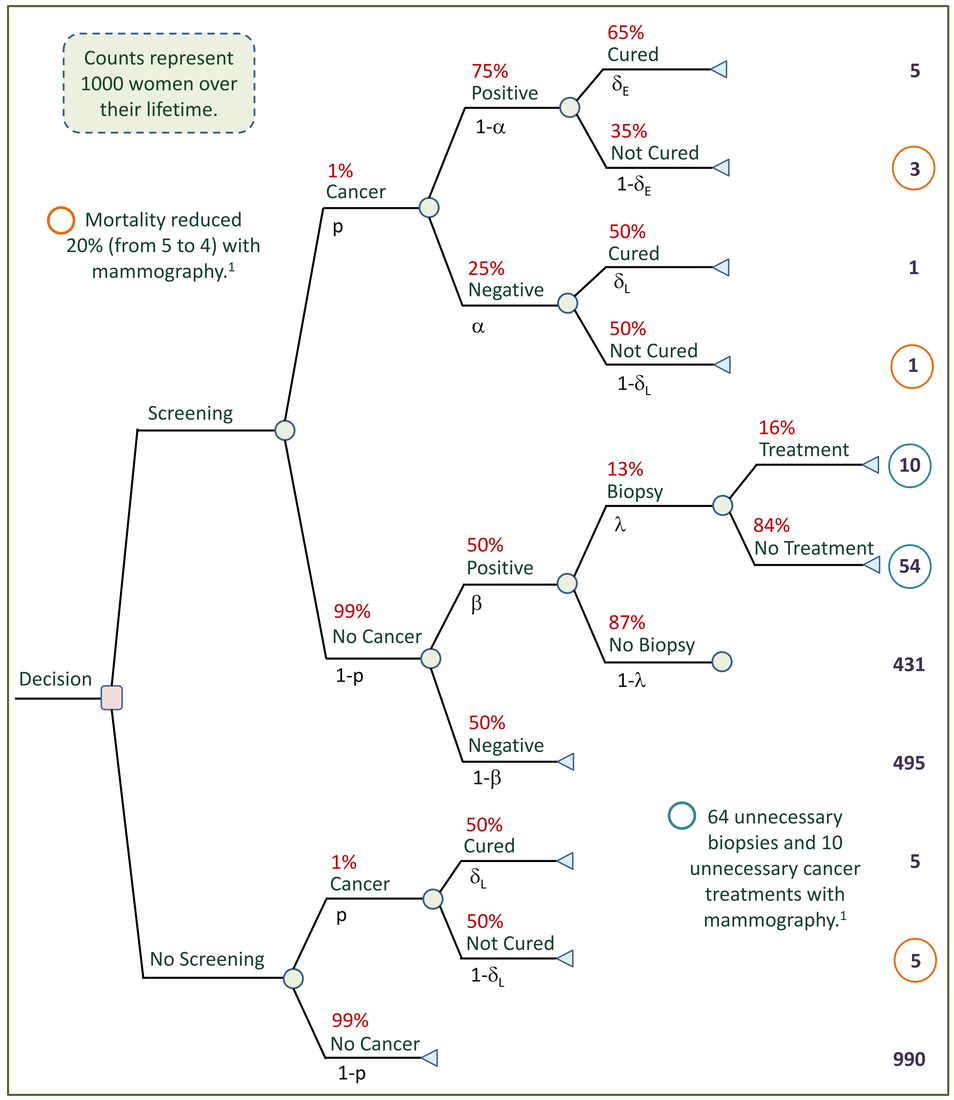
Experimental Design (Central Composite)



This experimental design generates a second-order empirical model including the interaction effect of pain level and false positive probability.

Forty-eight study participants were interviewed using a color grid decision aid to represent various outcomes. For 12 hypothesized scenarios, they were asked to accept or decline a screening test until a point of indifference was identified. A binary search guaranteed convergence in 6 or less iterations.

Decision Tree Representation (Based on Mammogram Data)[1]



Optimal Decision Derivation

When the key false-positive outcome is defined as an unnecessary biopsy, the optimal decision is based on the expected utility of undergoing screening:

$$E(Utility) = U_1 p(1-\alpha)(\delta_E - \delta_L) - U_2(1-p)\beta\lambda$$

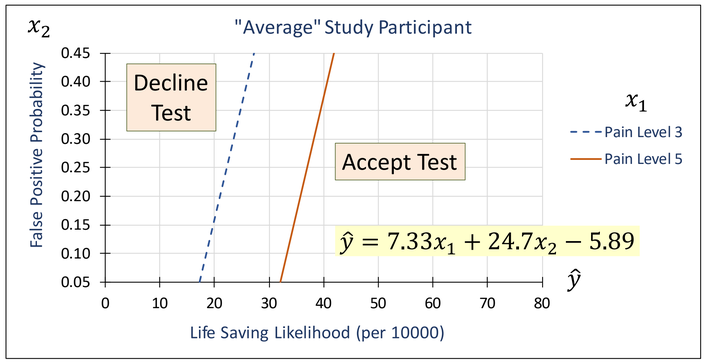
where: U_1 is the utility associated with cancer death and U_2 is the utility associated with an unnecessary biopsy. The cancer screening test would be accepted when:

$$\frac{U_1}{U_2} > \frac{(1-p)\beta\lambda}{p(1-\alpha)(\delta_E - \delta_L)}$$

The empirical model derives the breakeven life saving likelihood (the denominator of the indifference equation).

Experimental Results

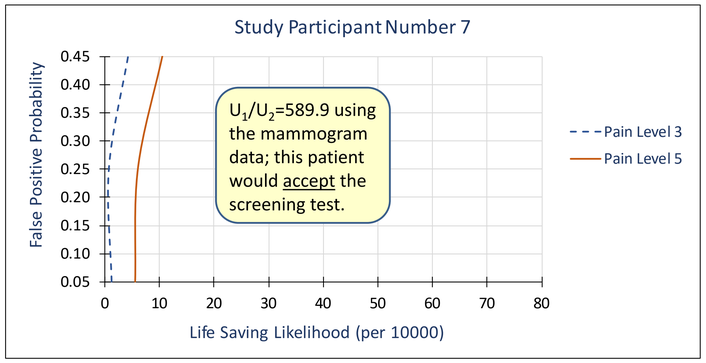
Linear effects of pain level and false positive probability were the only significant effects (i.e., no significant second order or interaction effects). Test subjects differed significantly based on their personal health preferences.

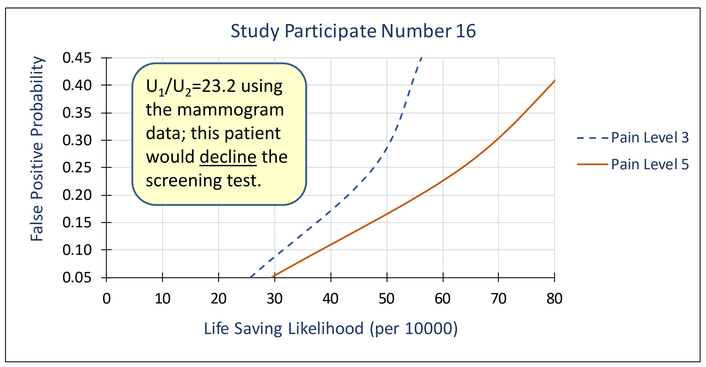


Using the mammogram data, a patient would accept the screening test regimen when the ratio of $U_1/U_2 > 57.2$. The "average" patient would decline the test because this ratio is 36.4. However, patients differ significantly.

Individual Patient Analysis

Two examples are presented to illustrate differences by patient & how these differences would be used to make patient-centered decisions.





Reference:

1. Rifkin, E, Lazris, A. Interpreting Health Benefits and Risks: A Practical Guide to Facilitate Doctor-Patient Communication. New York: Springer International Publishing; 2015.

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