OR Forum

Title: A POMDP Approach to Personalize Mammography Screening Decisions

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Comments of Brian Denton

Breast cancer is the most common cancer among women worldwide. In the U.S. about one in eight women will develop breast cancer during their lifetime. Organizations like the Susan G. Komen foundation (http://ww5.komen.org/) have increased public awareness of the health risk of breast cancer, motivating research into ways to achieve early detection, and reduce the burden of breast cancer.

In the September-October issue of *Operations Research*, Turgay Ayer, Oguzhan Alagoz, and Natasha Stout show how stochastic models can be brought to bear on this important problem. They describe some of the open challenges related to the important topic of prevention of breast cancer, beginning their paper with the following quote from *USA Today*:

"For years, mammograms have been recommended every year or two for women beginning at age 40. The new report from the U.S. Preventive Services Task Force, issued Monday night, now says women this age should simply talk to their doctors about the benefits and risks."

The U.S. Preventive Service Task Force (USPSTF) is a panel of experts charged with making recommendations to prevent diseases such as cancer. So, why would they provide such a nonspecific recommendation? The reason lies in the personalized nature of breast cancer screening. As Ayer et al. point out in their article, breast cancer risk depends on individual risk factors such as a women's family history, breast density, body mass index, alcohol consumption, and other factors. Decisions about how frequently to have mammograms must tradeoff the potential benefits of early detection with the possibility of harm from unnecessary biopsies and treatment. Regarding the harms associated with mammography, the authors write:

"false mammograms are serious and harmful since they lead to unnecessary diagnostic follow-up (e.g. additional imaging and invasive procedures such as biopsy)"

The authors also point out that false positive mammograms are not rare (10.7% per mammogram) and the likelihood increases with increased frequency of mammograms.

The tradeoff between potential benefits and harms from screening has stirred debate in recent years, leading to conflicting guidelines for screening. As evidence of this, Ayer and co-authors cite 11 different guidelines including several U.S. guidelines, and international guidelines from countries including Canada, France, Spain, and Sweden.

The goal of personalized medicine, the topic of this article, is to make optimal medical decisions based on all relevant information available for that patient, including not only genetic and genomic

information but also demographic, physiological, and other clinical factors. The article describes a partially observable Markov decision process (POMDP) for determining the optimal frequency of mammograms based on personalized risk factors. This is a departure from the common "one size fits all" recommendations, such as those of the USPSTF.

Ayer et al. make some important contributions to the emerging area of operations research applications to medical decision making. The authors provide insights into the influence of personalized risk factors on screening strategies that maximize quality adjusted life years (QALYs) (a QALY is a commonly used unit of measure in public health that value of a year of life, adjusted for the presence of disease and other factors, on a scale of 0 to 1). The article by Ayer et al. opens up many opportunities for future research related to disease screening, an area that is likely to evolve significantly in years to come as new risk factors are discovered.

The article by Ayer et al. raises questions about how to implement operations research models in a clinical setting. For example, who is the stakeholder that would use the information obtained from the model? Clearly the individual patient is most directly affected by the decision, but family and friends are also affected. Medical decisions are often made through a shared decision making process involving the patient, their physician, and often others such as family members. Another open question related to this article is exactly how this information would be used to arrive at an "optimal" decision. Some patients would undoubtedly struggle with interpreting the notion of a QALY used by the authors, which is dependent on how patients would rate the impact of a mammogram or biopsy on their quality of life. In fact, the goal of maximizing average QALYs may not accurately represent a patient's personal criteria. For example, some patients are likely to be risk averse, and not simply seeking to maximize average QALYs.

There is likely to be growing attention to decisions related to screening for chronic disease due to the discovery of new screening tests that provide useful, albeit imperfect, information about the presence of a disease such as cancer. For example, the controversial *prostate specific antigen* (PSA) test has stirred similar debate about screening for prostate cancer. Another example is bladder cancer, for which more than half a dozen easy to use (but costly) tests have become available.

The article by Ayer et al. is a step forward for the application of operations research to medical decision making, pointing out the potential benefits of personalizing screening decisions for an important chronic disease, and also motivating future research questions about how to use such models to improve medical decisions.