

The Hong Kong University of Science and Technology
Dept of Information Systems, Business Statistics and Operations Management
Dept of Industrial Engineering & Decision Analytics
Joint Seminar Announcement



**Optimizing Initial Screening for Colorectal Cancer
Detection with Adherence Behavior**

by

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Date : **12 November 2021 (Friday)**
Time : **10:30 - 11:45 am**
Zoom ID : **981 9920 2378 (passcode 767205)**



Abstract: Cancer remains one of the leading causes of human death, and early detection is the key to reducing mortality. To detect cancer in the early stages, two-stage screening programs are widely adopted in practice. Individuals receiving positive outcomes in the first-stage (initial) test are recommended to undergo a second-stage test for further diagnosis. The initial test design—i.e., selecting cutoffs to report test outcomes—is crucial for screening effectiveness (i.e., cancer detection) and efficiency (i.e., second-stage capacity costs). However, not all individuals who receive positive outcomes follow up with the second-stage test; evidence shows that adherence behavior is closely associated with the cutoff used in the initial test. This paper studies the initial test design in the context of colorectal cancer (CRC) screening to balance the trade-off between screening effectiveness and efficiency and takes into account individuals' guideline adherence behavior.

We adopt a Bayesian persuasion framework with information avoidance to model the initial test design and individuals' response to screening guidelines. We analytically prove that under certain conditions, an initial test using a single cutoff (i.e., a dichotomous test) is optimal for screening follow-up maximization, and a continuous test (i.e., showing exact readings of the biomarker) is optimal for screening effectiveness maximization. We apply the framework to Singapore's CRC screening guideline design and calibrate the model using various sources of data, including a nationwide survey in Singapore. Our results suggest that compared with the current practice, increasing the cutoff to the level that maximizes expected follow-ups by cancer patients can detect 969 more CRC incidences and prevent 37,820 colonoscopies, which are the second-stage test for CRC screening. Aiming only for high-sensitivity initial tests using lower cutoffs (as in the current practice) can backfire and lead to large numbers of unnecessary colonoscopies and low follow-up rates from cancer patients. We further explore the benefits of using different cutoffs for different subpopulations and use an interpretable clustering technique to construct implementable rules for partitioning the population. We demonstrate that using a lower cutoff for males older than 60 and females older than 70 (high-risk and high-adherence groups) and a higher cutoff for the rest of the screening population (low-risk and low-adherence groups) can further improve screening effectiveness and efficiency.

Bio: Dr Zhichao Zheng is an Associate Professor of Operations Management at the Singapore Management University. His main research interests lie in data analytics and optimization for healthcare operations management and medical decision making. He also applies his research in sharing economics and supply chain risk management, etc. He received his BS (First Class Honors) in Applied Mathematics from the National University of Singapore in 2009, and Ph.D. in Management from the Department of Decision Sciences (renamed to Department of Analytics & Operations) in the National University of Singapore in 2013.

All interested are welcome!
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