Yanting Hu

Antonio Olivas

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Estimation of Cancer Screening Models Using Deconvolution

Breast Cancer has become one of the most common diseases among women. About one in eight women will have breast cancer in their lifetime while this ratio is still increasing every year. As we all know, cancer is a disease when some parts of our body's cells grow uncontrollably and then spread to other parts of the body. And the whole process of cancer development can be divided into four parts. Usually, the cancer symptoms when the cancerous tumors have grown large enough to push against nearby organs and tissues. However, if people can detect cancer in an early stage instead of detecting cancer when having the symptoms, the treatment is more effective and the chances of a positive outcome are higher. People can't help asking after reading these facts—how to detect the disease early?

The cancer screening program, such as regular breast self-examinations, clinical breast examinations, and mammograms are vital tools for early breast cancer detection. And this research program gives me a clear view of the estimation of breast cancer screening models. In the whole program, I analyzed three unknown parameters—beta, gamma, and lambda to answer how accurate the screening test is, when should women start doing mammogram tests, and how often should they do the mammogram test respectively.

To begin with, beta represents the sensitivity of the screening test, which detects how many percentages of disease is for women with cancer. In general, the result of the test can be classified as a true positive, a true negative, a false positive, and a false negative. We assume no false positive (specificity), which means every positive outcome means cancer. Therefore, we only have three possible outcomes for each test result, and use beta to represent the

probability of true positive in this screening test program. Because we have three possible cases of probabilities if we do not consider false positive, we have a trinomial distribution for each interval test.

Moreover, we define T0 as the lowest possible age of onset, indicating that we may initiate screening tests after T0. Onset refers to the breast cancer beginning to develop, and after a certain period of time, which is a sojourn time, the patient will experience symptoms, known as clinical detection.

Then, we use the random variable U to represent the time interval from birth to onset, and by calculating this variable, we can accurately estimate the optimal time to start doing the screening tests. Then, we assume U follows an exponential distribution and use gamma as rate parameters for this distribution. Similarly, we use Y to represent the duration from onset to the appearance of symptoms(clinical-detected), and through this, we can predict the frequency of screening tests. We also assume Y follows an exponential distribution with an unknown rate parameters lambda.

Based on these information and assumptions, we need to build up probability functions based on this conceptual information and use the sum of all these probability functions to calculate the maximum likelihood estimators, which are beta, gamma, and lambda.

We use the data from research data, which record the number of cases of screen-detected, clinical-detected, and cancer-free from women who attended all screening rounds up to and including the current round. By using the optim function in R, we obtain 0.81 for beta, which represents screening test will detect cancer in 81% of women with cancer. And 0.0031 for gamma, which means 6% of women will have onset of cancer by age 40. This age number can vary if I consider different portions of women who may have cancer out of the total number of population. Finally, we obtain 0.3 for lambda, which means on average, the

sojourn time is 3.33, and therefore, I would suggest women have mammograms no more than two years apart.

In conclusion, although the number of breast cancer cases has been steadily increasing every year, it is imperative to emphasize the importance of regular screenings, heightened awareness of bodily changes, and active participation in treatment. By adopting a proactive stance and working closely with healthcare professionals, individuals can strive for timely interventions, effective management, and improved prognoses in the battle against breast cancer.