Department of Managerial Economics and Decision Sciences

Cost Savings from Pooled Testing[1]

Suthipong Treeratana, CEO of Kasemrad Hospital in Bangkok, Thailand, recently failed to win a contract to conduct HIV tests for the Thai government. Dr. Suthipong was surprised when his aggressive bid was unsuccessful and later discovered what led to his rival's triumph.

The winning hospital planned to employ a technique called pooled testing to lower its overall costs. The basic process works like this: combine a number of samples into a larger pool. Since the prevalence of the disease is low, the pool will most likely consist of a group of negative samples. When all the blood sera in the sample are free of the disease, the entire pool will test negative and one single test can diagnose the entire group. If one or more samples are positive then the entire pool will test positive, and each individual's sample will have to be retested to see which sample or samples were driving the result. Individual samples are generally split in half at the beginning of the process so the retesting does not involve additional inconvenience for the patients.

In this case, the winning bidder was testing pools of twenty samples at a time. That meant each pool would require either one test (when each person was negative) or twenty one tests (the initial test plus a retesting of each individual sample.)

The prevalence of HIV among Thai factory workers in 2004 was 1.8%, and so the probability that any particular patient's sample tested negative is .982. In addition, it is reasonable to assume that the results of tests of different individuals' samples are independent. Consider a group of twenty individual blood samples, the probability that all twenty individual samples test negative is given by

$$(.982)^{20} = .6954.$$

Since this is required for the entire pool to test negative, .6954 is also the probability that a bundle made up of all twenty samples would test negative. The probability that the bundle of twenty samples would test positive is therefore 1 – .6954 = .3046.

Now, let the random variable *N* represent the number of tests that are run when following the pooled sample procedure. We have just shown that the distribution of the random variable *N* is as follows:

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[1] This case was prepared for use in class discussion in DECS 433 sections at Kellogg. It is closely based on Saraniti, B. **"Optimal Pooled Testing" Health Care Management Science (2006) 9: 143–149.** A version of this case appears in Sandholm, W & Saraniti, B. **Vital Statistics: Probability and Statistics for Business and Economic Decisions** forthcoming with Addison Wesley. Version of **August 2010**.

n	$P(N = n)$
1	.6954
21	.3046

The expected value of N is equal to .6954 (1) + .3046 (21) = 7.09. This is quite a bit lower than the 20 tests needed to run the standard procedure. Since an individual test costs 100 Thai baht, then the cost per person has been reduced to 709 / 20 = 35.5 baht. That's a 64.5% savings!

1. The question facing Dr. Suthipong is this: is 20 the best number to include in a pool? By adding more samples to a pool, the number of tests per person goes down, but the probability of having to retest a larger group increases. Can he lower his cost per person by optimizing the size of the testing pool?

2. In 2006, the New England Journal of Medicine called for mandatory HIV testing in the United States due to the huge cost savings associated with early detection. If the prevalence of the tested population in the United States is 0.1%, how many samples should be included in the pool to minimize the overall testing costs?