11. Steven Nahmias and Charles D.Feinstein, Screening Strategies to Inhibit the Spread of AIDS, Socio-Econ.Plann.Sci. Vol. 24, No. 4, 249- 260, 1990.

The Cost of Screening The General Population

In a schematic representation of a typical screening program an individual to be tested is either infected [I] or not [I']. All individuals are given an enzyme immunoassay blood test. Those testing positively [noted {EIA = +} are given a confirmatory Western blot assay for antibodies to specific HIV proteins. Those testing positively (noted {WB = +} are identified as infected. This test is charcterized by the following parameters:

1. p{I}, the probability that an indivudual is infected.

2. p{EIA= +/I}, the probability that an infected individual will test positively on the EIA. This conditional probability is the sensitivity of the test.

3. p{EIA = -/I'}, the probability that a non-infected individual will test negatively on the EIA. This is the specificity of the test.

4. p{WB= +/I, EIA= +}, the sensitivity of the Western blot conditional on a positive EIA result.

5. p{WB =-/I',EIA= +}, the specificity of the Western blot conditional on a positive result on the EIA.

Given these parameters, it is straightforward to calculate the probabilities of each of the six outcomes in the tree. The top path determines the probability that the screening detects an infected individual. The second and third paths are the events that an infected individual will not be detected. The fourth path yields the probability that an individual will be falsely identified as infected. The fifth and sixth paths represent the correct conclusion about non- infected individuals.

Assume the parameter values listed above and a prevalence rate of HIV positives in the population of 0.000353. If 100,000 individuals were tested, then the prevalence of infection in the tested group would be 35.3 HIV positive and 999,964.7 HIV negative, on average. Of the 35.3 HIV positives, the EIA test would detect an average of (35.3)(0.983)=34.7 cases. Of those cases, the Western blot would detect an average of (34.7)(0.92)-31.9 cases correctly. It follows that the number of false negatives would be, on average, 0.6+2.8=3.4.

The total cost of testing can be computed in the following manner. Suppose that each EIA test costs $6, each Western blot test costs $50, and the counseling cost for each individual is $25. Applying the EIA test to the entire group of 100,000 individuals would thus cost $600,000. Cleary et al. also assumed that counseling is given to each person, so that the total counseling cost for 100,000 tests is $2.5 million. The EIA test would correctly identify 34.7 positive cases and incorrectly label about 200 cases as (false) positives. Hence, the Western blot test would have to be applied to about 235 cases at a cost of $11,750. The total cost is then about $3.11 million under these assumptions and the number of cases of HIV positive detected would be, on average, 31.9. This gives a cost of detection per case of $97,547.02.

Sensitivity Analysis

The cost of detection varies inversely with the prevalence rate; the exact relationship is hyperbolic. For example, when the prevalence rate is one in twenty, the cost per detected case is approx. $750; when the prevalence rate is one in ten, the cost is approx. $400; and when the prevalence rate is one in four, the cost is approx. $200. (These figures assume that counseling is given to all those tested. If one assumes that only those who test positive are given counseling, the costs are slightly lower.) The cost approaches $88 as the prevalence rate approaches one.

A decision model of the question of Screening for HIV Infection

The analysis to this point has been concerned with the cost of an HIV screening program. However, it is surely incomplete to use the cost of detection of an infection as the criterion for implementing a screening program. Until we know the benefit of detecting a case, it is difficult to say that the cost of detection is too large. While identifying those who are infected is indeed the purpose of a screening program, the benefit of such an identification is determined by what happens after an HIV positive indivudual is identified. That is, unless there is a policy in place that exploits the identification of infected persons so as to reduce the spread of the virus, screening for HIV infection has little benefit beyond the value of the information.

Conditions under which screening should be preferred to not screening are therefore dependent upon public policy.

The Benefit of Detecting a Single Case of HIV infection

An approach to measuring the benefit of detecting a case of HIV infection begins with an estimate of the costs to society of a case of AIDS. Those costs can be expressed as the sum of : (1) personal medical care costs, which include hospital services, physican services, nursing services, home care, medication, and counseling; (2) non-personal costs, which include expenditures for research, expenditures for blood screening, testing, and replacement, costs of health education, and other support services; (3) morbidity costs, the value of productivity losses due to illness and disability; and (4) mortality costs, the present value of future earnings lost for those who died prematurely as a result of AIDS.

Assessing the benefit of detecting HIV is difficult since the benefit depends on what kind of indivudial is infected. Indeed, in all cases early detection of infection permits intervention and drug therapy that can delay, if not prevent, the onset of AIDS or other illnesses. If the individual is not in a high risk group, these benefits might constitute the total benefit of detection. However, if the individual is a member of a high-risk group and therefore behaves in ways that tend to spread the infection the major portion of the total benefit of detection is realized only if the infected individual does not infect others. Almost surely, such a realization entails alteration of the behavior of this infected individual.

Therefore, what is important is the subsequent behavior of those who test positive. The subsequent behavior of such individuals can be affected by policy decisions implying that complete analysis of any screening program must entail an analysis of alternative policies.

For example, policies aimed at halting the spread of infection among i.v. drug users vary across at least two dimensions: the scope of testing and the response to a positive test result. The scope of testing could range from voluntary to mandatory testing for all persons arrested for drug-related charges. The response could range from voluntary counseling to sequestering or imprisonment. Included among the alternatives would also be a needle exchange program. Similarly, for prostitutes one can imagine a range of possible policies, from licensing and periodic examination with subsidies for those testing positive who leave the business, to arrest and imprisonment. What is needed is a coherent description of policy alternatives and an approach to model the effects on behavior of each alternative. It is clear that neither of these items is currently available. Screening is currently done in a haphazard manner with little direction from government agencies.