A Model for Optimal Mass Screening and the Case of Perfect Test Reliability

ABSTRACT

This paper considers a population (composed, for example, of people, machines, or livestock) subject to a randomly occurring defect or disease. If there exist testing procedures capable of detecting the defect before it would otherwise become known, and if such early detection provides benefit, the periodic administration of such a test procedure to the members of the population, i.e., a mass screening program, may be advisable. An analytical model of a mass screening program is developed and analyzed. In the development of the model, the defect arrival process is Poisson and the ability of the test to recognize a defect is not, in general, assumed perfect.

The model focuses on the time since incidence of a defect as the factor which determines the reliability of a test administration and the value of a detection. The objective is to minimize an arbitrary increasing function of the detection delay which represents the disutility from the occurrence of the defect and its detection. This disutility is also represented as a function of the type of test applied, the probability of success of the test, the testing intervals and the arrival rates of the defects over Q subpopulations. A relatively simple expression is derived for the objective function and a comprehensive mathematical program is presented. The case of perfect test reliability is then considered and, from the class of "cyclic" schedules, the optimum schedules are shown to be equally spaced. For a polynomial disutility function, properties of the optimal schedules are presented. Finally, a method for determining the disutility function from experimental data is suggested.