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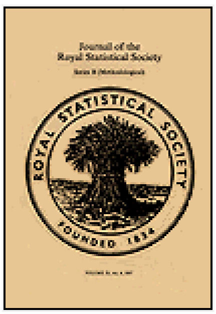

JOURNAL ARTICLE

Regression Models and Life-Tables

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Abstract

The analysis of censored failure times is considered. It is assumed that on each individual are available values of one or more explanatory variables. The hazard function (age-specific failure rate) is taken to be a function of the explanatory variables and unknown regression coefficients multiplied by an arbitrary and unknown function of time. A conditional likelihood is obtained, leading to inferences about the unknown regression coefficients. Some generalizations are outlined.

Journal Information

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Regression Models and Life-Tables

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[Read before the Royal Statistical Society, at a meeting organized by the Research Section, on Wednesday, March 8th, 1972, Mr M. J. R. Healy in the Chair]

Summary

The analysis of censored failure times is considered. It is assumed that on each individual are available values of one or more explanatory variables. The hazard function (age-specific failure rate) is taken to be a function of the explanatory variables and unknown regression coefficients multiplied by an arbitrary and unknown function of time. A conditional likelihood is obtained, leading to inferences about the unknown regression coefficients. Some generalizations are outlined.

Keywords: LIFE TABLE; HAZARD FUNCTION; AGE-SPECIFIC FAILURE RATE; PRODUCT LIMIT ESTIMATE; REGRESSION; CONDITIONAL INFERENCE; ASYMPTOTIC THEORY; CENSORED DATA; TWO-SAMPLE RANK TESTS; MEDICAL APPLICATIONS; RELIABILITY THEORY; ACCELERATED LIFE TESTS.

1. Introduction

Life tables are one of the oldest statistical techniques and are extensively used by medical statisticians and by actuaries. Yet relatively little has been written about their more formal statistical theory. Kaplan and Meier (1958) gave a comprehensive review of earlier work and many new results. Chiang in a series of papers has, in particular, explored the connection with birth–death processes; see, for example, Chiang (1968). The present paper is largely concerned with the extension of the results of Kaplan and Meier to the comparison of life tables and more generally to the incorporation of regression-like arguments into life-table analysis. The arguments are asymptotic but are relevant to situations where the sampling fluctuations are large enough to be of practical importance. In other words, the applications are more likely to be in industrial reliability studies and in medical statistics than in actuarial science. The procedures proposed are, especially for the two-sample problem, closely related to procedures for combining contingency tables; see Mantel and Haenzel (1959), Mantel (1963) and, especially for the application to life tables, Mantel (1966). There is also a strong connection with a paper read recently to the Society by R. and J. Peto (1972).

We consider a population of individuals; for each individual we observe either the time to "failure" or the time to "loss" or censoring. That is, for the censored individuals we know only that the time to failure is greater than the censoring time.

Denote by T a random variable representing failure time; it may be discrete or continuous. Let $\mathscr{F}(t)$ be the survivor function,

$$\mathscr{F}(t) = \mathrm{pr}(T \geqslant t)$$

and let $\lambda(t)$ be the hazard or age-specific failure rate. That is,

$$\lambda(t) = \lim_{\Delta t \to 0+} \frac{\mathrm{pr}(t \leqslant T < t+\Delta t \mid t \leqslant T)}{\Delta t}. \tag{1}$$

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