ANALYSIS OF SURVIVAL DATA: A COMPARISON OF THREE MAJOR STATISTICAL PACKAGES (SAS, SPSS, BMDP)

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Survival analysis techniques have become standard tools for the statistician in medical research. The application of survival models to data is valid when the endpoint of interest is the "time to the occurrence of a particular event." Survival models may be applied to a variety of fields such as biology, medicine, engineering, and economics. With modern computing technology, the analysis of "time-to-event" data has become inexpensive in terms of time. There are several statistical packages on the market today that can be used to do survival analyses. The most commonly used packages are SAS, SPSS, and BMDP. These three packages are compared based upon their capabilities, accuracy, and user-friendliness as applied to survival analysis. Example data sets are used to demonstrate standard and nonstandard conditions that occur when modelling survival data in each of the packages. Several survival analysis applications are presented to determine the agreement among the three packages. Both the univariate and multivariate survival analysis procedures are presented for each package.

1. INTRODUCTION

The application of survival models to data is valid when the endpoint of interest is the "time to the occurrence of a particular event." Survival models may be applied to a variety of fields such as biology, medicine, engineering, and economics. An example of an application in engineering is to model the time it takes for a ball-bearing to wear. The focus will be on applications in biology and medicine where the event of interest may be time to death or time to a particular event such as relapse of a disease. The standard statistical techniques for data analysis are usually not applicable to survival data. First of all

2. COMPARISON OF THE PACKAGES

There are a number of similarities between SAS(version 6.09), SPSS (version 5.0), and BMDP (version 1990) in terms of computational methods for survival analysis. For the most part, the three packages agree with one another with respect to parameter estimation and calculation of available statistical tests. Table 1 lists the procedures that are found in each of the three statistical packages that perform the major survival analysis techniques: Kaplan-Meier method (Kaplan and Meier, 1958), life table methods (Gehan, 1969), Cox proportional hazards models (Cox, 1972), and the accelerated failure time model (Andersen, Borgan, Gill, Keiding, 1993). The life table method is not considered in this discussion since it is no longer commonly used in medical applications. Each of the packages can handle right censored data easily. The major differences among the packages are summarized in Table 2.

2.1 Kaplan-Meier Estimates and Tests

The Kaplan-Meier estimates of the survival function are available in all three packages along with standard errors of the survival function calculated by Greenwood's formula (Greenwood, 1926). The three packages provide the results of the log-rank (Collett, 1994) and the Wilcoxon tests (Gehan, 1969) for comparing the survival of two or more groups. The Tarone-Ware test (Tarone and Ware, 1977) is available in SPSS and BMDP but not in SAS. The Peto-Prentice (Peto and Peto, 1972) test is available only in BMDP. SPSS has the ability to calculate all pairwise comparisons among the groups by issuing a

linear combination of another covariate. Under the first condition, the estimate of the regression parameter is ± infinity. The second condition leads to a singular matrix that is not invertible and therefore the regression parameters cannot be estimated. The results of how each package handles the nonstandard conditions differs among the packages. Both SPSS and BMDP give warning messages that one of the nonstandard conditions is present. SAS provides results without providing any information that a nonstandard condition is present. For example, when condition 1 is present, SAS provides the results of the estimated regression parameters after 15 iterations. These are not the correct estimates because the parameter estimate for the covariate with the condition present is diverging. This can be seen by using the "/itprint" option, but no warning message is given. BMDP provides references that provide information on how to remedy the nonstandard conditions.

2.6 The Accelerated Failure Time Model

Only SAS and BMDP allow the use of the accelerated failure time model. There is an agreement in the results. SAS allows the use of the generalized gamma distribution. It can be useful is choosing which underlying distribution to use to model the data. One must be careful in interpreting the results of both packages, because the estimates that are provided are for the transformed logarithm of survival time. You will want to transform the estimates back to their original units. This can be done using the delta method.

3. CONCLUSION

SAS, SPSS, and BMDP are all very good packages for analyzing survival analysis applications.

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Table 1: Listing of the procedures by survival analysis topic and statistical package.

Survival Analysis Topic	SAS	BMDP	SPSS