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A Reanalysis of the Stanton *et al.* Pleural Sarcoma Data

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An analysis of the Stanton *et al.* (1981, *J. Natl. Cancer Inst.* 67, 965–975) data reconfirms number of index particles as the primary dimensional predictor of tumor incidence. Fitting separate intercepts and/or slopes to each mineral type results in substantial significant improvement in fit, indicating the importance of mineral type. This contrasts with the "Stanton hypothesis," which states that dimensional properties alone determine carcinogenesis. Log mean aspect ratio is not as good a predictor of tumor incidence as the number of index particles; among those samples that did not have index particles, log mean aspect ratio is not a significant predictor of tumor incidence.

INTRODUCTION

Stanton *et al.* (1981) report the results of 72 experiments wherein fibrous minerals were surgically inserted in the pleurae of rats and the rats were observed for the incidence of pleural sarcoma. Specific methods and materials used by these researchers can be found in their paper and references therein. The key finding of their research was that the ability of mineral particles to cause tumors is mostly a function of the dimensional properties of the particles, rather than physicochemical properties; this is sometimes called the "Stanton hypothesis." The present paper reanalyzes the Stanton *et al.* data and makes two claims. First, in disagreement with the Stanton hypothesis, the Stanton *et al.* data contain evidence that mineral type is an important determinant of carcinogenicity in addition to the important effect of particle dimensions. Second, in agreement with the Stanton *et al.* results, the number of index particles is superior to other dimensional properties of particles (such as log mean aspect ratio) as a predictor of tumor; the other dimensional properties may derive what predictive power they have from their correlation with the number of index particles.

Interest in the Stanton *et al.* data has been reinvigorated recently as OSHA has proposed new rules on occupational exposure to nonasbestiform tremolite, anthophyllite, and actinolite, and the Stanton *et al.* data figure prominently in the OSHA document (OSHA 1990).

BACKGROUND

Our concern here is the statistical analysis of the Stanton *et al.* data and the ways in which it can be improved. For each mineral sample, 30 to 50 (N_i) rats were surgically treated and followed for 2 years. Rats surviving more than 1 year were used to estimate the probability of tumor. Since some rats died due to other causes, a life table method was used to estimate the probability of tumor $\hat{p}_i$, for i from 1 to 72. The technique as described in Stanton *et al.* (1977) is also known as

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