Chapter VII

Application of a GIS-Based Statistical Method to Assess Spatio-Temporal Changes in Breast Cancer Clustering in the Northeastern United States

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This chapter examines spatio-temporal changes in breast cancer clustering in the Northeastern United States to assess the statistical significance of clusters using GIS-based kernel methods. It first describes higher-than-average breast cancer mortality rates in the Northeast and introduces statistical methods for detecting geographic clusters of disease. A GIS-based kernel method based upon the theory of Gaussian random fields is applied to the breast cancer mortality data taken from the National Center for Health Statistics’ Compressed Mortality File. The method makes use of a map of rates, smoothed using a Gaussian kernel. The maximum smoothed value is compared with the statistic’s critical value to identify significant clusters.

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Results from the analyses show changes in spatio-temporal clustering patterns in the Northeast during the period 1968-1998. The results reveal not only the existence of statistically significant breast cancer clusters, but also the changing patterns of those clusters over time. Since environmental risk factors may play an important role in explaining the unknown etiology of breast cancer, analyses of spatio-temporal changes of breast cancer clustering may provide important clues to the study of breast cancer and environment relationships.

INTRODUCTION

Breast cancer is the most commonly occurring cancer among women in the United States. It is estimated that one out of every nine women in the United States will develop breast cancer. To explain the causes of breast cancer, epidemiologic investigations have used known risk factors, including demographic and socioeconomic factors, family history factors, and hormonal and reproductive factors, but many other factors remain unknown. Being age 45 or higher for white women, high socioeconomic status, having never married, urban residence, and residence in the Northeastern United States are all considered to be important risk factors (Kelsey and Horn-Ross, 1993; Madigan et al., 1995).

Previous studies of the geographical patterns of breast cancer have found that mortality from breast cancer is highest in the Northeast (Blot et al., 1977; Sturgeon et al., 1995; Kulldorff et al., 1997). Blot et al. (1977) concluded that the location of residence plays an important role in explaining geographic variations in breast cancer risks, especially for post-menopausal women. Sturgeon et al. (1995) evaluated geographic differences in breast cancer mortality rates to explain excess mortality in the Northeast and Midwest relative to the South. The higher rates in the Northeast are in part explained by the regional distribution of risk factors and related lifestyle differences, including late age at first birth, late menopause, early menarche and mammography history. A recent study using a spatial scan statistic found the New York City-Philadelphia Metropolitan area as the most statistically significant cluster (Kulldorff et al., 1997). The study also identified several subclusters within the Northeast, including Buffalo, the District of Columbia, Boston and eastern Maine, all with higher-than-average mortality rates.

The purpose of this chapter is to investigate spatio-temporal changes in breast cancer clustering in the Northeastern United States, and to assess statistical significance using GIS-based kernel methods. A newly developed GIS-based kernel method based upon the theory of Gaussian random fields (Rogerson, 2001a) is applied to breast cancer mortality data. The method makes use of a map of rates,
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