Chapter 8
Introduction to Analysis
Using Time Components

INTRODUCTION

The introduction of a time component requires the use of statistical methods that can utilize dependent data. The assumption of independence that is required for regression models is no longer applicable. In this section, we will work with time series analysis.

Time series analysis requires that data are collected at discrete, fixed time intervals. Observational and insurance data contain time stamps as to the date of service. These time stamps are transactional in nature and do not occur at fixed time intervals. Therefore, the first step in such an analysis is to convert the transactional time points into fixed time intervals. We need to decide upon the interval: every minute, hour, day, week, month, year. The specific interval will depend upon the analysis to be performed. Once that is completed, the standard time series analysis methods can be used. As an example, we use the MEPS dataset for medications. We use the date of January 1 as time zero.

BACKGROUND

Use of Time Series Models in Medical Research

While the use of time series is occasional, there have been some applications. One recent study used time series models to determine if an intervention was successful in reducing the number of patients with co-prescriptions for the drug, Warfarin. (Feldstein,
et al., 2006) Time series are also used to investigate time trends with respect to one patient. (Kirk & Jahoda, 2009) They have been mostly used to examine general trends in public health and patient treatments. (Johansson, Bockerman, & Uutela, 2009; Warm, et al., 2009)

Another important use of time series analysis is in the investigation of services and the scheduling of personnel. (Coory, Kelly, & Tippett, 2009) The use of anomaly techniques as part of a time series analysis can demonstrate how emergency department utilization can be investigated to find epidemics and bioterrorism problems. A recent study examined the causes of increased time spent in the emergency department. (Rathlev, et al., 2007) Access to care was also examined in relationship to emergency department utilization. (Fuente, Pino, Blanco, & Alvarez, 2007) Some very interesting applications in regards to time series have been to investigate the relation of geography and region to health care utilization and disparities. (A. M. Wilson, Wake, Kelly, & Saloway, 2005)

However, because of the lack of use, there are some questions as to whether time series models are appropriate to investigate patient outcomes, or the best way to use time series models to study patient outcomes. (Harbarth & Samore, 2008; Meier, Weiner, & Guttman, 2007) Because the use of time series is so relatively infrequent, there are many papers that discuss the modeling, and how to apply the models to public health data. (Zeger, Irizarry, & Peng, 2006)

Just recently, we have the rather sudden emergence of the swine flu (H1N1 flu) that originated in Mexico. Almost immediately, there were attempts to predict the spread of the disease and to estimate the number of cases, although most of the initial papers in the medical literature discussed anecdotal cases, and methods of treatment. (Belmont, et al., 2009; Centers for Disease & Prevention, 2009a, 2009c; Enserink & Enserink, 2009; O’Dowd, Charatan, O’Dowd, & Charatan, 2009; Van Hoeven, et al., 2009) These attempts involve time series methods, although such methods are slow to make their way into the medical literature, staying more on the internet. (Anonymous-H1N1, 2009) There were, however, almost immediately, papers in the literature that speculated on the future of the swine flu without any attempt at modeling. (Anonymous, 2009; J. Cohen, Enserink, Cohen, & Enserink, 2009; Enserink & Enserink, 2009; Silversides & Silversides, 2009) There was some use of cluster analysis to examine the source of the infection. (Solovyov, Palacios, Briese, Lipkin, & Rabadan, 2009) Ultimately, these attempts to examine future progress of swine flu remained speculative without relying upon statistical models. (Centers for Disease & Prevention, 2009b; Dunham, et al., 2009; Gallaher & Gallaher, 2009; Gooskens, et al., 2009; Health Protection, Health Protection, National Public Health Service for, & teams, 2009; Mossad & Mossad, 2009)

**Time Series Models**

We give a very brief introduction to time series here. If you are interested in more detailed information concerning time series analysis, we suggest the book by Brockwell (2009). A time series model takes into consideration the following characteristics of the data:

- **Autocorrelation.** A positive deviation from the mean is likely to stay positive; a negative deviation is likely to stay negative.
- **Trend.** A positive or negative trend requires a first or second difference.
- **Seasonality.** The data have a seasonal trend. This trend could be based on a 12-month period, or some other period.
- **Transformation.** To maintain the assumption of normality, a transformation is sometimes required.

The models assume that the data are collected at fixed time points. If time stamps with random
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