# Chapter 10
# Regression-Based Methods of Phase-I Monitoring Surgical Performance Using Risk-Adjusted Charts:
## An Overview

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## ABSTRACT

*Monitoring medical processes gained importance and researchers attempted to reduce death rates by quick detection mortality rate of surgical outcomes in recent years. The patient time until death (survival time) depends on risk factor of each patient, which reflects the patients' health condition prior to surgery. Ignoring differences in risk factors among specific patients, risk adjusted control charts could be considered as a corrective tool to minimize false alarms related to inhomogeneity in patients' health condition. A number of risk adjusted charting procedures have been developed on both phase I & II monitoring of aforementioned outcomes. This chapter will review both models and focus on phase-I risk-adjustment models in medical setting with a particular emphasis on monitoring for surgical context and describe each method's unique properties.*

## INTRODUCTION

Continuous improvement of healthcare systems requires the measuring and understanding of process variation. It is important to eliminate extraneous process variation wherever possible, while moving well-defined metrics toward their target values. Within this context, statistical process control (SPC) charts are very useful tools for studying important process variables and identifying quality improvements or quality deterioration. The role of patients in the definition of service quality can be considered as key competitive criteria. As a result, service providers are trying to apply quality assessment tools that sig-

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nificantly emphasis on customer orientation (Houshmand et al., 2016). A control chart is a chronological time series plot of measurements of important variables. The statistics plotted can be averages, proportions, rates, or other quantities of interest. In addition to these plotted values, upper and lower reference thresholds called control limits are plotted. These limits are calculated using process data and define the natural range of variation within which the plotted points almost always should fall. Any points falling outside of these control limits therefore may indicate that all data were not produced by the same process, either because of a lack of standardization or because a change in the process may have occurred. Such changes could represent either quality improvement or quality deterioration, depending on which control limit is crossed. Control charts are thus quite useful both for monitoring if processes get worse and for testing and verifying improvement ideas (Faltin, Kenett, & Ruggeri, 2012).

Statistical monitoring for effective detection of the deteriorated mortality rate of surgical outcomes has increasingly attracted researchers' attention. Such detection can be further used to assist root cause identification and decision-making for surgical operation improvement. In order to more effectively detect the performance anomalies that go beyond the natural variability of surgical operations, the risk factor of each patient, which reflects the patient's health condition prior to surgery, must be taken into account (Paynabar, Jionghua, & Yeh, 2012). Drawing comparisons between Regression-based methods of phase-I monitoring surgical performance using risk adjusted charts is the main purpose of this chapter which hasn't been done before. This analysis is implemented by reporting key features of each work in the given context that could be considered beneficial hints for future work. The remainder of the chapter is structured as follows. In research methodology, the main properties of referenced articles are given. Background includes literature review on risk-adjusted charts from which four phase-I models are chosen and surveyed in selected methods. Finally, comparing different methods & discussion contains comparison between selected models presented in previous section and expresses discussion about strengths and weaknesses of each work that leads to recommendations for future study at the CONCLUSION & FUTURE WORK sections.

## BACKGROUND: RISK-ADJUSTED CHARTS

Unlike monitoring of processes in the manufacturing industry, the monitoring of surgical performances is different and presented a unique problem because the patients are not homogeneous and hence the necessity of risk-adjustment. The Parsonnet scoring system (Parsonnet, Dean, & Bernstein, 1989) is widely used for estimating the risk of death of a patient who undergoes a cardiac operation. A competing scoring system was developed by Roques et al. (1999). Based on a patient's gender, age, morbid obesity, blood pressure, etc. integer scores are given and the total score is called the Parsonnet score. A Parsonnet score is an integer that ranges from 0 to 100; hence it is a discrete random variable. A small Parsonnet score represents a small risk and a high score represents a high risk.

Although monitoring the time until an event clearly has important applications in many fields, recent studies on the subject of health care monitoring focus on controlling a surgical process using risk-adjusted charting procedures, where the control limits are calculated typically based on a historical set of data. The analysis of historical data is referred to as Phase-I, whereas the prospective monitoring of future data is referred to as Phase-II monitoring. The control limits of charting procedures in a Phase-II monitoring to be accurate must be derived based on data taken from a process that is in control. However, the objective of a Phase-I study is to first remove out-of-control points from a historical dataset. The 'cleaned'