

Paper 162-31

Using Contour Plots to Promote EHR Use in Physician Offices

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ABSTRACT

The role of a quality improvement organization (QIO) is to assist healthcare providers in making successful and meaningful changes in the way care is delivered and in improving outcomes of that care. While traditional activities in this role addressed specific clinical indicators, the QIO role has evolved to include the promotion of Health Information Technology (HIT) and the use of Electronic Health Records (EHR), especially in the physician office setting.

Contour plots provide a two-dimensional display of three-dimensional data. Traditional uses of contour plots include display of elevation, concentration, velocity, non-linear regression displays, and time histories of data in both geographic and non-geographic applications. While SAS provides the ability to create contour plots with SAS/GRAPH and SAS/IML, the new ODS graphics applications add value to this ability by adding this feature to the Kernel Density Estimation (KDE) procedure. The KDE procedure is a non-parametric technique for density estimation using a known density function (kernel) and averaging this across the observed data points to create a smooth approximation. This estimate is written to a SAS data set, which can then be used for plotting or analysis. In this application, the KDE procedure is combined with ODS graphics to create the contour display. Kernel density estimation allows the graphical display of distribution trends for physician office practices and practice size. This paper applies this application to Virginia.

Examples were developed with version 9.1.3 of SAS executing on a Windows 2000 platform. SAS Version 9.1 is required for the ODS experimental graphics extensions. Examples are not platform-specific and can be adapted by both beginning and advanced SAS users.

INTRODUCTION

The Virginia Health Quality Center (VHQC), three-time winner of U.S. Senate Productivity and Quality Award for Virginia, functions as both a health care quality improvement organization and a patient safety organization. The VHQC assists healthcare providers in making successful and meaningful changes in the way care is delivered and in improving outcomes of that care, especially for the Medicare community of Virginia.

Services provided by the VHQC include: 1) health care safety and quality improvement; 2) medical case review; 3) professional credentials verification; 4) health education; and 5) analytic services. The VHQC currently collaborates with all acute care and critical access hospitals and invites all physician offices, home health agencies, nursing homes, and other Virginia healthcare organizations to participate in the improvement of health care quality.

In an effort to maximize available resources, spatial and longitudinal analyses are used to identify: 1) spatial distributions of providers; 2) spatial distribution of HIT and technology infrastructures; 3) patterns of HIT usage; and 4) patterns of healthcare quality within this framework.

APPLICATION

Quality improvement focus areas have been identified by the Centers for Medicare & Medicaid Services (CMS) for all settings of health care. For the physician office setting, QIOs are tasked with the promotion of the adoption of EHR systems and information technology in small-to-medium sized physician offices. [The Medicare Prescription Drug and Modernization Act of 2003](#) (H.R. 1-263) encourages the use of health information technology to manage the clinical care of beneficiaries. The expectation is that greater reliance on technology will enhance access to patient information, decision support, and reference data, as well as improving patient-clinician communications.

This information technology initiative offers an integrated approach to improving care for Medicare beneficiaries in the areas of diabetes, heart failure, coronary artery disease, hypertension, osteoarthritis, and preventive care. By educating physician offices on EHR system solutions and alternatives, as well as providing implementation and quality improvement assistance, physician offices will have the information necessary to migrate easily from paper-based health records to EHR systems that suit the needs of their office.

It is essential that work in this area be cost-effective. It would be impossible to work with all physician office practices; therefore, practices must be selected carefully to allow for the diffusion of information and knowledge and for the recruiting of physician champions for this effort. Information about the current health care infrastructure, including trends of change over time, is essential to this effort. The applications presented in this paper are part of an effort to understand these complexities for the state of Virginia.

Health care and health care service data as depicted in these examples are for illustration only, were generated for the purpose of this paper, and are not intended to depict any actual results.

KERNEL DENSITY ESTIMATORS

In their simplest form, kernel density estimators are smoothed histograms. While a histogram restricts observations to only one group--or in these examples, one geographic location--kernel estimators allow observations to be included in more than one group. It can be thought of as a window that slides over the data. The kernel function weights the data passing through the window on its relative distance to the center of the window. Smoothness is determined by the window interval. These characteristics make this applicable to applications looking at provider changes in regions, because regional boundaries are artificial and not determinant of service or service area.

The single most important factor in determining the performance of a kernel density estimator and the shape of the resulting kernel density estimate is the choice of bandwidth matrix. Since the bandwidth matrix can be thought of as the variance of the kernel function, it controls both the spread and the orientation of the kernel. The examples below use the Sheather-Jones plug-in method. Other options are simple normal reference (SNR), Silverman's rule of thumb (SROT), and over-smoothed (OS).

CONTOUR PLOTS

Contour plots are any graphical display that uses contour lines or patterns to represent levels of magnitude of a contour variable plotted on the horizontal and vertical axes. While these plots are commonly used for additional dimensions such as elevation or velocity, they can be adapted for other multivariate data display needs for both geographic and non-geographic applications.

The examples below show how these plots can assist in identifying physician offices with characteristics that make them good candidates for EHR adoption, and for collecting information on the EHR characteristics rated important by these offices. Two types of contours are illustrated below. The first is a filled contour, or a graduated color contour, where the color levels are determined by the data and do not need to be symmetrical. The second type is a contour line plot, which sets the levels as contour rings and displays the data in relationship to the pre-set contour levels.

EXAMPLE ONE-- REGIONAL CONTOURS: PROVIDER/BENEFICIARY

This example uses zip code level data to show distribution patterns for beneficiaries and providers for the five major healthcare regions in the state. Knowing this distribution helps target the information campaign. The bivar statement is used to list variables in the input data set for which bivariate kernel density estimates are to be computed; method is set to Sheather-Jones.

The color scheme used in this example is the ODS graphic contour default. Each ODS graphic has an associated style template. To modify the color scheme or other graphics attributes, use a style= option on the ods html statement to select another template. Alternatively a new color scheme and/or graphics attribute set can be created using Proc Template. Other attributes that can be modified include:

- Font and legend characteristics;
- Axis and grid lines, including color, style and thickness;
- Start neutral and end color for contours; and
- Graph width, height, background and foreground color.

Partial code for the example is listed below.

```
ods listing close;
ods html;
ods graphics on;

proc kde data=physicians method=sjpi;
    bivar bene provider / plots=contour;
    by region;
run;

ods graphics off;
ods html close;
ods listing;
```

A close examination of these contours shows variation by region in the distribution of providers and the number of beneficiaries, as well as a relationship between the number of providers in an area and the number of beneficiaries. See the graphic contour output for the five regions below. The regional contours show the advantage of this type of display, especially when there is more than one "peak" in the data.

Contour Output:

Figure 1A: Region One

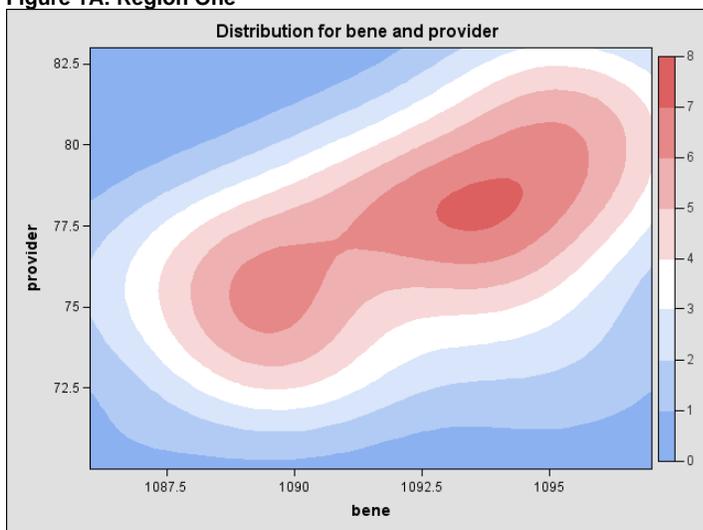


Figure 1B: Region Two

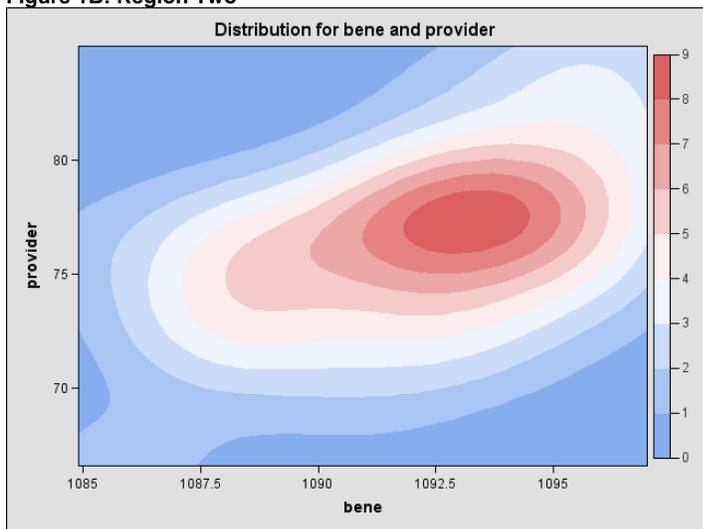


Figure 1C: Region Three

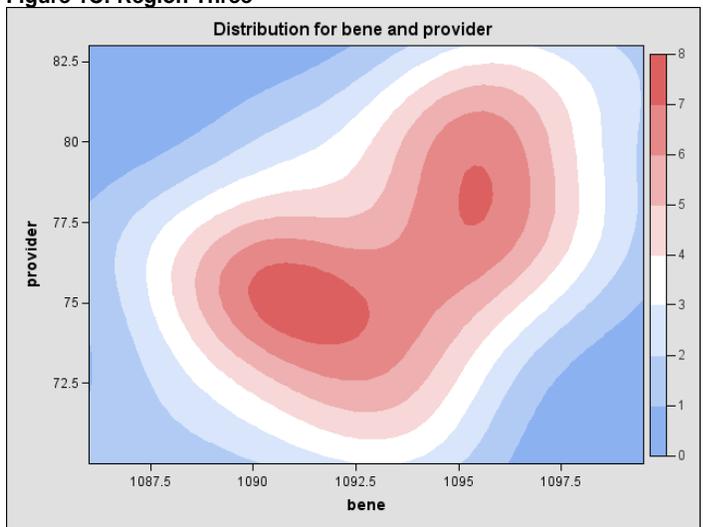


Figure 1D: Region Four

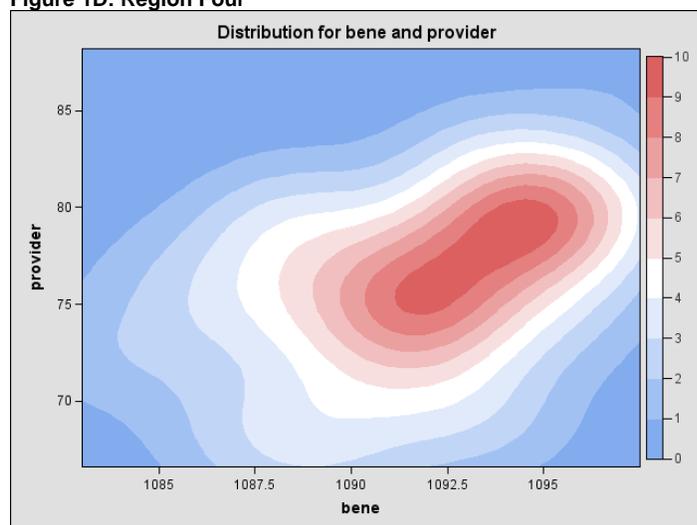
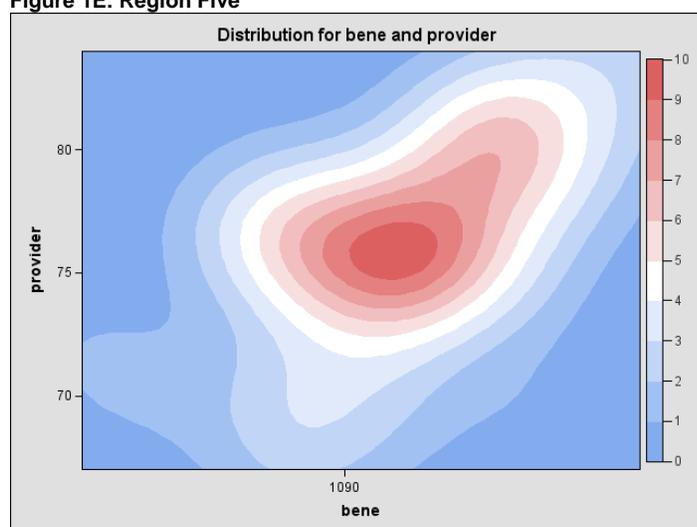


Figure 1E: Region Five

**EXAMPLE TWO – NON-KDE CONTOURS: SAS/IML**

The CONTOUR and GCONTOUR modules included with SAS/IML are used here to create a contour plot matrix to display additional provider information. The CONTOUR module is used to generate confidence ellipses and assumes bivariate normal data. GCONTOUR draws these confidence ellipses.

SAS/IML software provides the user with a set of graphics commands called primitives from which to create customized graphical displays. In order to use these within SAS/IML it is necessary to have a SAS/GRAPH license. Graphics attributes such as color, thickness and style can be associated with each of these primitives or commands. Graphics primitives included in the contour example that follows are:

- GSTART – activates the graphics system;
- GOPEN – begins the new graph;
- GWINDOW – defines the coordinate space;
- GSCRIPT – writes multiple text strings with special character fonts;
- GSTRLEN – returns the graphics text lengths in a given font and for a given character height;
- GPORT – defines a viewport and causes the graph to appear in the center of the display;
- GPORTSTK – stacks the defined viewport onto and relative to the current viewport.;
- GPORTPOP – deletes the top viewport from the stack;
- GSET – sets attributes for graphics segments;
- GDRAW – draws a sequence of lines;
- GDRAWL – draws individual lines;

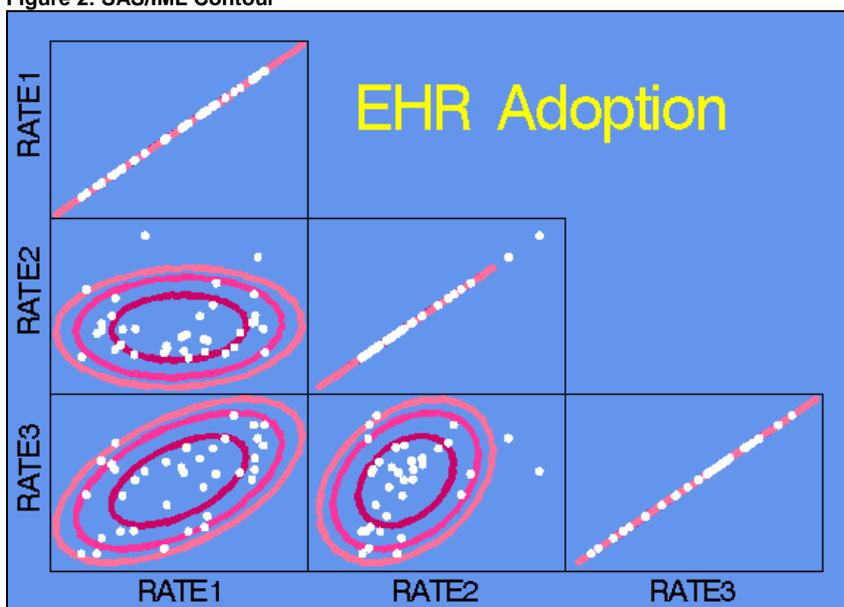
- GPOINT – marks points on graph with symbols; and
- GSHOW – displays the current graph.

This example compares rates of adoption for three characteristics or features of EHRs as a matrix of scatterplots. This technique is extremely useful for examining several variables at the same time, rather than in pairs. For the three variables displayed here, one contour plot is generated with each of the other variables as the dependent variable. Three variables are used in the example below; however, the technique is not limited by number of variables.

While data was generated for use with this example and therefore does not represent actual rates, EHR characteristics examined using this technique include:

- Ability to connect to administrative and billing records;
- Ability to store scanned documents;
- Ability to generate population reports;
- Ability to generate patient reminders; and
- e-prescribing capability.

Figure 2: SAS/IML Contour



Additional contour plots can be created with the SAS/GRAPH GCONTOUR procedure. This is especially suited for representing three-dimensional relationships and when the levels rather than the shape of the data are important. Proc GCONTOUR can be combined with Proc G3GRID when interpolation or smoothing of the data is desired.

CONCLUSION

This paper illustrates applications using contour plotting as part of an effort to understand the distribution of and services provided by physician offices as part of a campaign to promote HIT adoption. Through these and other applications, quality improvement campaigns can be focused on the areas of greatest impact within the state, allowing for the most efficient use of quality improvement dollars. SAS software, especially through the addition of ODS graphics, provides the flexibility and ease of use to identify these relationships and provides a foundation for further analyses to identify additional interactions and critical factors that can enhance the quality improvement process.

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ACKNOWLEDGEMENTS

Some data sets used were generated using SAS/STAT Proc SURVEYSAMPLE.

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Special thanks goes to VHQC Senior Scientist Leroy Thacker, Ph.D. for his assistance with preparation of data sets for this paper.

The analyses upon which this publication is based were performed under Contract Number 500-02-VA-03, funded by the Centers for Medicare & Medicaid Services, an agency of the U.S. Department of Health and Human Services. The content of this publication does not necessarily reflect the views or policies of the Department of Health and Human Services, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. Government. The author assumes full responsibility for the accuracy and completeness of the ideas presented. VHQC/PO/1-25-2006/248.

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