

# Exploring Hospital Distribution Using ArcGIS

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Spatial analysis has a wide range of applications in health care, from managing beds in a facility to global health risk assessment. This exercise looks at the distribution of hospitals in the contiguous United States relative to population. You have the following specific objectives:

1. Quantify hospital density within each HSA.
2. Compare hospital density in California (or another region) with that of the contiguous United States.
3. Compare the population characteristics of regions with high hospital density to the entire contiguous United States.
4. Present your analysis as a map.

This exercise assumes that you know the basics of using ArcGIS—how to start a map session and navigate in the ArcCatalog environment. You will need ArcGIS 8.1 or 8.2 with at least an ArcView license. No extensions are required. If you want a hard-copy of your map, you will need access to a printer.

The data consists of points showing hospital locations and polygons describing HSAs. Although HSAs are polygons that usually follow county lines, they sometimes cross state boundaries. Both point and polygon data are stored as feature classes in a feature dataset within a personal geodatabase.

## Downloading and Exploring the Data

Download the sample data archive from the *ArcUser Online* Web site and copy it to your computer. Create a new folder called `health_analysis` and unzip the archive into it.

## Exploring Data in ArcMap

Start a new ArcMap session and open the map document `hospitals_density.mxd` located in `./../<your directory>/health_analysis/`. There are two layers in this document. Zoom and pan to explore the distribution of hospitals in different regions of the U.S.

## Exploring Data in ArcCatalog

Start an ArcCatalog session and navigate to `./../<your directory>/health_analysis/` which contains `hospitals_density.mxd` and the `usa_health` geodatabase. Look at how the geodatabase structure is organized. The base

data is stored as feature classes in a feature dataset called `health_data`. An empty feature dataset named `analysis` will hold the results of your data analysis. There is also a stand-alone feature class, `STATES`, that is not in a feature dataset, and two stand-alone tables, `h10k_p_stats` and `population_stats`. Two layer files, `hospital.lyr` and `STATES.lyr`, are stored outside of the geodatabase.

You may also click on the Preview tab and the Metadata tab to get more detailed information about these data. The metadata includes the URL for the National Atlas from which the HSA boundaries were derived. (Note that not all fields in the metadata are complete.)

## 1. Quantify Hospital Density Within Each HSA.

The rest of the work in this tutorial will be performed in ArcMap so you can close ArcCatalog after inspecting the sample data. As you work through the exercise, remember to save your work often!

### Performing a spatial join to connect the hospitals to the HSAs

Performing a spatial join to connect the hospitals to the HSAs is the first step in quantifying hospital density within each HSA. You will join each record from the point features (`hospitals`) to the polygon features (`HSAs`) that contains those points.

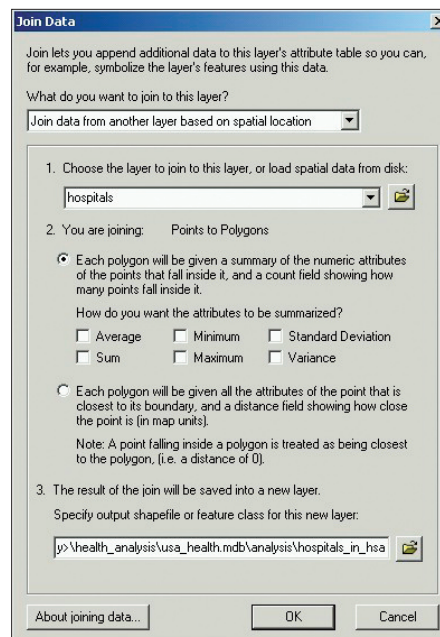
1. In the Table of Contents in ArcMap, right-click the HSA layer and choose Joins and Relates > Join... from the context menu.

2. In the Join Data dialog box, select Join Data from Another Layer Based on Spatial Location. For each of the steps listed in this dialog box, make the following selections:

■ In step 1, select `hospitals` as the layer to join.

■ In step 2, accept the default and do not check any boxes. This is because the hospitals do not have any usable attributes.

■ In step 3, convert the new layer to feature class in a personal geodatabase. Click the browse button and select personal geodatabase feature class for Save as Type: box. Open `./../<your directory>/health_analysis/usa_health.mdb/analysis` and name the feature



*Perform a spatial join to hospitals to the HSAs.*

class `hospitals_in_hsa`.

3. Right-click on the `hospitals_in_hsa` layer and choose Open Attribute Table. In the attribute table, note that the field called `Count_` indicates how many points fall within that polygon and that some HSAs do not contain any hospitals.

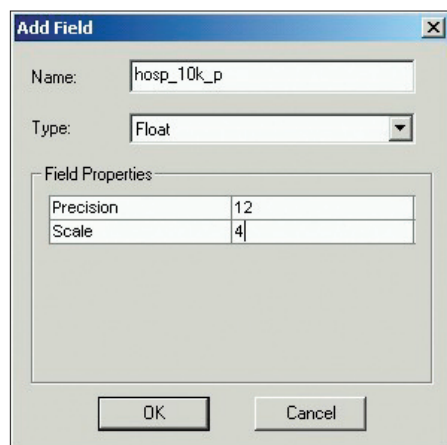
4. HSAs that do not contain hospitals will show a NULL value in the `Count_` field. To avoid working with NULL values, replace the NULL values with zeros. Right-click on the `Count_` header and choose Calculate Values. In the Field Calculator, type “is null” and click OK. Click the Show: Selected button to display only the records with NULL values that were just selected. Right-click on the `County_` header and choose Calculate Values. In the Field Calculator, type 0 in the text field and click OK. The `Count_` field will be populated with 0s.

### Add a new field and calculate number of hospitals per 10,000 people

Although calculating persons-per-hospital would reflect an intuitive measurement of how many people each hospital must serve, the

**What You Will Need**

- ArcGIS (ArcView, ArcEditor, or ArcInfo license)
- Sample data downloaded from *ArcUser Online*



0 values in the Count\_ field could skew your analysis. Calculating persons-per-hospital for HSAs by dividing Population by Count\_, the values would yield 0 for HSAs without hospitals. This isn't correct—there are not zero people per hospital, but many people in some HSAs that have no hospitals.

For the purposes of statistical analysis, a count of hospitals-per-person will provide a more objective measurement. However, just doing a raw calculation of Count\_/Population would produce very small numbers with lots of decimal places. Instead, you will calculate how many hospitals there are for each 10,000 people in an HSA.

1. The Attributes of hospitals\_in\_hsa table should still be open. Click the Options button at the bottom of the attribute table window and select Add Field from the menu.

2. In the Add Field dialog box, name the new field hosp\_10k\_p (short for “hospitals per 10,000 people”) and select Float as the type. Set Precision at 12 and Scale at 4. For additional information on these field parameters, see the online help. Click OK.

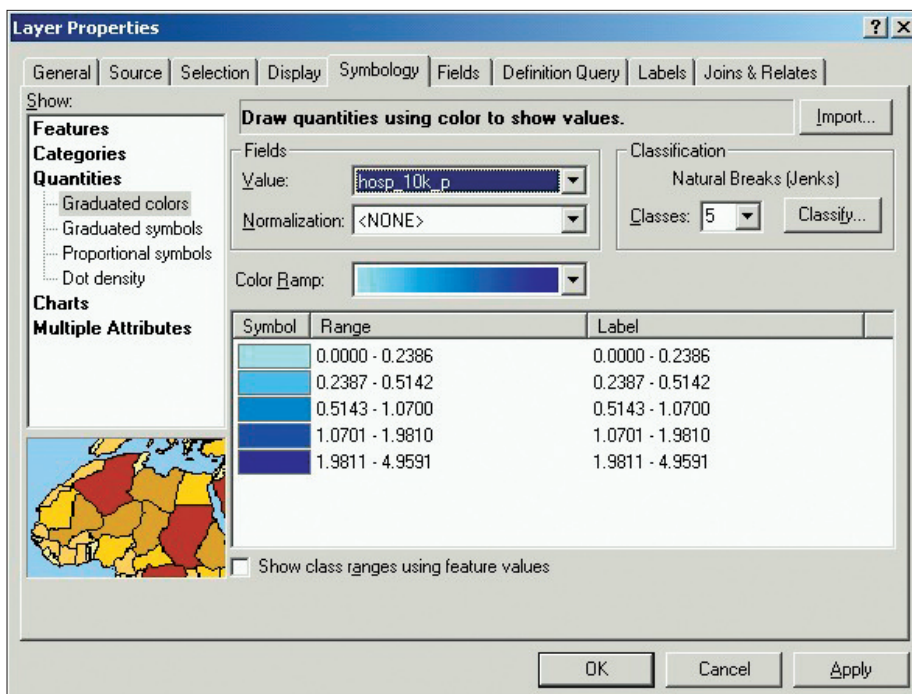
3. Right-click on the new hosp\_10k\_p field and choose Calculate Values. Ignore the warning about calculating outside an edit session and click Yes.

4. In the Field Calculator, type in the following equation. The parentheses are critical.  $[Count\_]/([Population]*0.0001)$

5. You should get a range of values between 0 and 4.95, with most values being less than 1.0. If these values look right, close the table and return to the main ArcMap window.

A recap of what you have just done—you added a new field that can store decimal values and calculated values for this field that indicate the number of hospitals per 1/10,000th of the population in each HSA.

Add a field to the hospitals\_in\_hsa attribute table to store calculations of hospitals per 10,000 persons.



Symbolize the values just calculated for hospitals per 10,000 persons using graduated color.

### Symbolizing Zero Data Separately

Next you will symbolize zero values in the data and choose a classification method for the remaining data.

1. In the Table of Contents, right-click on the hospitals\_in\_hsa layer and choose Properties. In the Layer Properties dialog box, click on the Symbology tab.

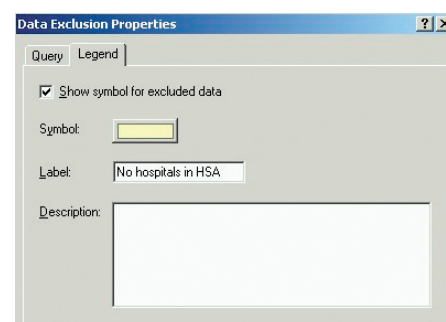
2. In the left column below Show:, click Quantities then select Graduated Color.

3. In the Fields section, choose the hosp\_10k\_p field from the drop-down box next to Value as the field to classify on. You can accept the default color scheme or change it. Use a color scheme other than yellow or red monochromatic so the hospitals and excluded values will remain visible.

4. Click the Classify button. In the Classification dialog, click the Exclusion button to bring up the Data Exclusion Properties dialog box.

5. Click on the Query tab and enter the expression  $Hosp\_10k\_p = 0$ . This will ensure that HSAs with no hospitals will be symbolized separately from the rest of the HSAs.

6. Still in the Data Exclusion Properties dialog box, click on the Legend tab. Check the box next to Show Symbol for Excluded Data and use a light yellow color. Type No Hospi-



Use the Exclusion dialog box to apply a query that will separate out HSAs with no hospitals and symbolize them differently.

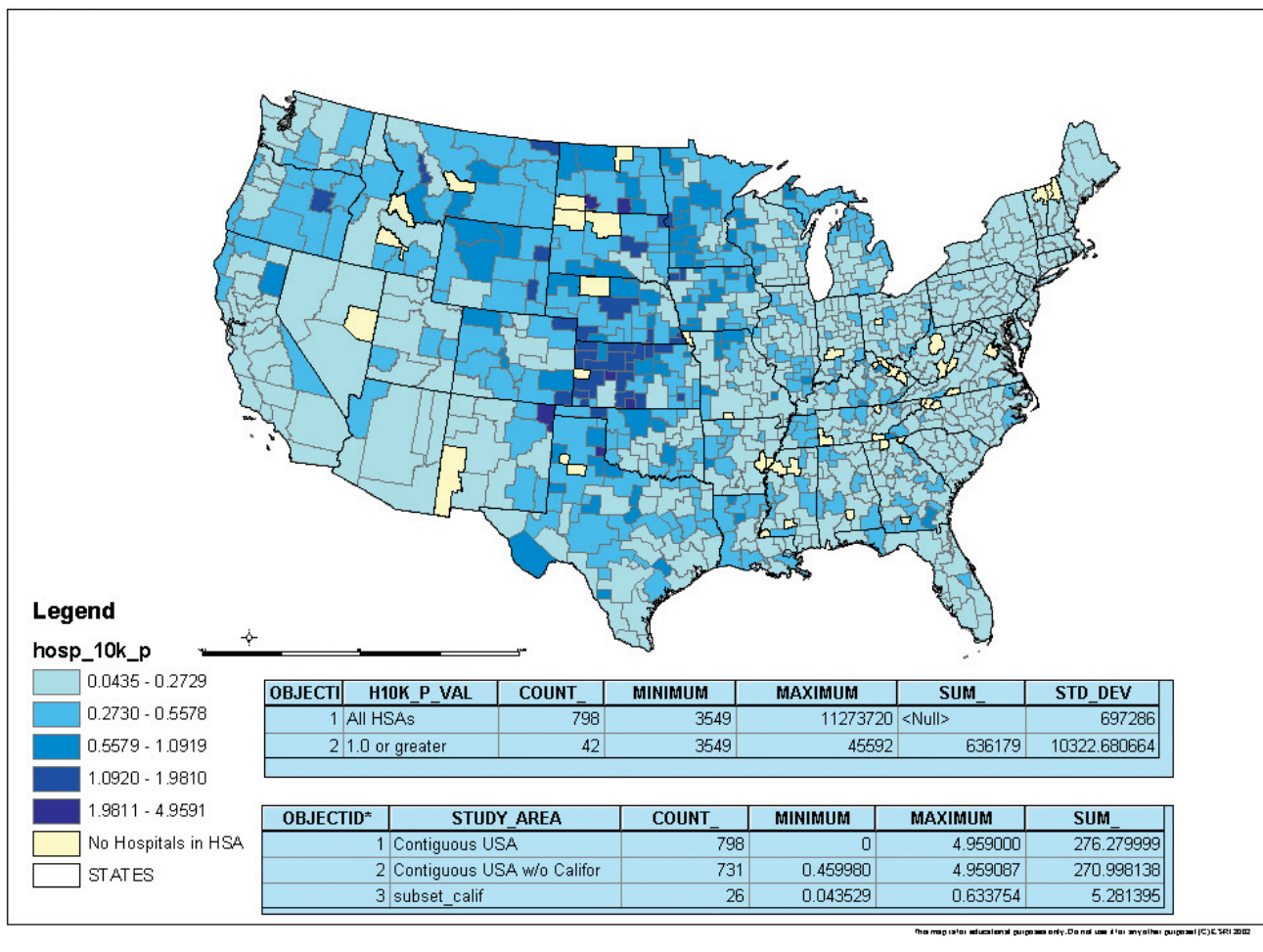
tals in HSA in the Label box.

7. Click OK to close the Data Exclusion Properties dialog but leave the Classification Properties dialog box open for the next portion of the exercise.

Notice that in the Classification dialog, a new class has been added with a value of 0 and the symbology you specified. This will prevent 0 from being used in the classification algorithms that you will apply in subsequent steps, and also will display which HSAs do not have any hospitals.

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## Hospitals and Health Service Areas, Contiguous USA



Use the layout in the map document to display the analysis. Add the hospital density statistics as tables (shown here) or as screen captures of dialog showing histograms and statistic summary lists.

### Symbolizing the remaining data using different classification methods

In the Classification dialog box, you can accept the default classification of Natural Breaks or change it to one of the other classification methods. Notice how the class breaks on the histogram change. In particular, compare the results after applying the Natural Breaks, Quantile, and Equal Interval classification methods.

To see each of these on the map, click OK in the Classification dialog, then Apply in the Symbolology properties.

To change the classification, open the Classification dialog box just as you did when symbolizing the null value. This time you will not need to open the exclusion dialog. Choose the classification that portrays data to your liking and click OK in each of the dialog boxes. Click once on the hospitals\_in\_hsa layer to select it and click again and type in the text "Hospitals per 10,000 persons."

## 2. Comparing Hospital Density in California (or Another Region) With That of the Contiguous U.S.

ArcGIS provides the ability to get statistics on the selected features or records from any numeric field in a table. You will enter these statistics in a table and display the table on your map layout.

1. On the bottom left of the Table of Contents, click on the Source tab. Now, in addition to the layers, there are also two tables—h10k\_p\_stats and population\_stats. You will enter statistical data into these tables.

2. If the Editor toolbar is not already active, make it visible by choosing View > Toolbars > Editor.

3. On the Editor toolbar, click on the Editor menu and choose Start Editing. If you get an error, check the properties for the file and/or folder to be sure they are not set as read-only.

4. Add the STATES layer, /.../<your directory>/health\_analysis/states.lyr, to

the map document either by using the Add Data button, choosing File > Add Data from the main menu, or by dragging it in from ArcCatalog.

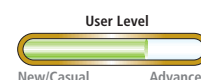
5. Make the only STATES layer selectable by choosing Selection > Set Selectable layers from the main menu. Click the Clear All button, then check the box next to STATES and close the dialog box.

6. Using the select features tool, click on California to select it. You can analyze density for any state that interests you but all references in this exercise will use California.

7. Next select the HSAs that are in that state by choosing Selection > Select by Location from the main menu.

8. Use the fields and operators in this dialog box to create the statement "I want to: select features from the following layers: hospitals\_in\_hsa that: have their center in the features in this layer: states." Keep Use Selected Features checked and click Apply, then CLOSE.





| STUDY_AREA_NAME    | COUNT | MIN | MAX   | SUM    | MEAN  | STD_DEV |
|--------------------|-------|-----|-------|--------|-------|---------|
| Contiguous USA     | 798   | 0   | 4.959 | 276.28 | 0.346 | 0.497   |
| USA w/o California |       |     |       |        |       |         |
| subset_calif       |       |     |       |        |       |         |

Figure 1: Form for recording hosp\_10k\_p statistics

| H10K_P_VALUE   | COUNT | MIN  | MAX      | SUM | MEAN   | STD_DEV |
|----------------|-------|------|----------|-----|--------|---------|
| All HSAs       | 798   | 3549 | 11273720 |     | 306956 | 697286  |
| 1.0 or greater |       |      |          |     |        |         |

Figure 2: Form for hospitals\_in\_hsa statistics

9. All of the HSAs in California should be selected. Open up the attribute table for hospitals\_in\_hsa. In the table, right-click on the column heading for the hosp\_10k\_p field and choose Statistics from the context menu. A window with a histogram and numerical statistics will appear. Copy (by hand) the statistics from this window into the subset\_calif line on the form shown in Figure 1.

10. Close the statistics window, then open the h10k\_p\_stats table and enter the statistics just copied into the appropriate cells by clicking in the cell and typing the value.

11. Minimize the h10k\_p\_stats table and open the attribute table for hospitals\_in\_hsa. In the table window, click the Options button and choose Switch Selection to select all of the HSAs that are NOT in California. Right-click on hosp\_10k\_p and get statistics for this set. Restore h10k\_p\_stats and repeat the process of entering the statistics from hospitals\_in\_hsa.

What do these results mean? Note that California has a lower mean and also a much lower range between the minimum and maximum values than the rest of the nation. This might suggest that hospitals in California are more evenly distributed among HSAs than elsewhere in the U.S.

### 3. Compare Population Characteristics of High Hospital Density Regions to the U.S. as a Whole

If you use the Natural Break classification, you will see that there is a break right around 1.0 hospitals/10,000 people. Most HSAs have fewer hospitals than this. You can run some simple statistical queries to characterize high hospital density HSAs.

1. The attribute table of hospitals\_in\_hsa should still be open. Click on Options and choose Select by Attributes. Create a new selection based on the query below. Click Apply after typing in this expression. `[hosp_10k_p] = 0`

2. This query will yield 41 records. Close the

Select by Attributes dialog box.

3. Move (or minimize) the table and look at the map to see where the selected HSAs are located. For the most part, they are located in rural areas of the midwestern states.

4. In the table, right-click on the field heading for the Population field and choose Statistics from the context menu. Enter the statistics into the form shown in Figure 2.

5. Close the statistics window and then open the population\_stats table and enter the statistics into the appropriate cells by clicking in the cell and typing the value.

6. What you will find is that areas with the highest hospital density have a much lower population than the HSA average. Assuming that a place that is called a hospital provides a mandatory minimum standard of health care, it appears that basic health care is well distributed in the USA regardless of population.

7. When you have finished entering all the statistics, click Editor > Stop Editing on the Editor toolbar. Click Yes to save your edits.

### 4. Making a Map Showing Your Analysis

A map layout document has already been created for you. To view it, choose View > Layout View from the main menu. There are several

ways to add statistics to this layout. Before adding the statistics tables to your layout, open each table, click the Options button, choose Appearance and make any changes to font style and size and resize the table if necessary. Choose Options > Add to Layout to insert the table into the layout.

Another method to add the table statistics is to open each table document and get the field statistics as described above. With the statistics window open, make a screen capture of the active window by pressing Alt + Print Screen. Close the statistics window. Right-click in the layout and choose Paste to add the screen capture image from the clipboard to the layout. You can then move the image and add text to it by choosing Insert > Text from the main menu.

In addition to printing the map layout, you can export the map to Adobe portable document format (PDF) so that it can be easily printed by others who do not have GIS software or exported to Windows bit map (BMP) or tagged image format (TIF) for use in Microsoft Office applications.

### Conclusion

This tutorial provides an example of spatial analysis using the core functionality of ArcGIS. You can apply these techniques to other geographic problems using different data or you can continue to use statistics, classification methods, and subsets to further explore the sample data. **AU**

## Moving to ArcGIS

### Learn Keyboard Shortcuts for ArcScene

These shortcuts work when the Navigate tool is enabled.

| Task   | Shortcut                                       |
|--|--|
| Center on Target                               | Hold Control while left-clicking mouse         |
| Zoom to Target                                 | Hold Control while right-clicking mouse        |
| Enable Animated Rotation                       | Hold Control + Shift while left-clicking mouse |
| Help Start Animated Rotation for Large Dataset | Use Shift key                                  |

Change the flight speed for the Fly tool using the Page Up and Page Down keys. Page Up increases speed; Page Down decreases it.