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# **John Snow & the Cholera Epidemic in Mid-19th Century London: 7 Datasets With Documentation for Use in GeoDa**

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## Overview

John Snow's quest to discover how cholera was transmitted during the mid-19th century in London has become a classic case for teaching spatial data analysis, causal inference, scientific reasoning, quasi-experimental research design, and spatial epidemiology. Our goal at the [University of Chicago's Center for Spatial Data Science](#) has been to make various existing datasets related to the famous Broad Street pump and South London cases available [in one place](#) for teaching and learning exploratory spatial data analysis via our [GeoDa software](#). This document contains the documentation for these seven datasets we are (re-)sharing, including content, sources, and modifications we undertook.

The reason we compiled existing data on Snow cases is to illustrate the process of generating explanatory insights with spatial data and make it easy to replicate this analysis in GeoDa for teaching purposes. John Snow applied scientific reasoning to develop and test hypotheses about the nature and communication of cholera (for details, see our [summary video](#) and our [story map](#)). To replicate and understand some of the insights Snow gained during and after the epidemic, we prepared scripts with instructions for teaching and learning spatial analysis in GeoDa, which can be found [here](#).

These datasets were brought together from several subsequent sources, based on Snow (1855, maps 1 and 2). In some cases, we modified the spatial boundaries, as explained below. Easily accessible data pertain to the famous Broad Street pump case: Individual cholera deaths in the RHist package compiled by Waldo Tobler in 1994 (dataset 1), and cholera deaths aggregated to buildings and blocks (datasets 2+3), shared by Robin Wilson (2011) and Arribas-Bel et al. (2017). To illustrate spatial outliers with local cluster statistics, we modified the blocks file to add a building near the Broad Street pump (the parish workhouse) that had few cholera deaths because the inmates drank water from their own well. In addition, we used the pump locations shared by Wilson (2011) to generate two new datasets that aggregate cholera deaths in concentric rings around pump locations (datasets 5+6).

The datasets related to the Broad Street pump case are limited in that they contain very few variables: the count or rate of cholera deaths and calculations based on deaths (such as distance to nearest pumps). Since more variables are needed to illustrate exploratory spatial data analysis in GeoDa, we also integrated data at the London subdistrict level from the South London investigation that Tom Coleman prepared (2019; 2020) based on Snow (1855). We are grateful to Tom Koch for sharing the boundary files prepared for his Koch with Denike (2006) analysis. We used them (without any attribute data) as our starting point and then worked with the original maps and consulted with Peter Vinten-Johansen and Tom Coleman to adjust the boundaries, which what we are sharing with Coleman's (2019; 2020) attribute data (dataset 7); all the modifications are outlined in this document. The spatial boundaries for these subdistricts were previously not publicly available in electronic format.

The table below provides an overview of the seven datasets available for download. Subsequent sections discuss each dataset, starting with a brief description of the data, a screenshot of the data in GeoDa, and a list of variable names and descriptions, and potential modifications of the data. We document each modification of the subdistrict boundaries in additional detail.

### Table: Overview of Data

This table summarizes the main characteristics of the 7 datasets, including name, content, and sources, as well as the number of observations and variables. It also indicates where we added modifications.

## Overview of 7 Spatial Data Files: John Snow and the Cholera Epidemic

Screenshot	File # and name	Description	Case	Type	N	Var.	Contemporary Source	Original Source	License
	1. deaths	Individual deaths	Broad St Pump	Point	578	4	Tobler 1994, Arribas-Bel et al. 2017	Snow 1855 (Map 1)	GPL
	2. deaths_by_bldg	Deaths aggregated to buildings	Broad St Pump	Point	250	8	Wilson 2011, Arribas-Bel et al. 2017	Snow 1855 (Map 1)	Unknown
	3. deaths_by_block	Deaths aggregated to blocks	Broad St Pump	Polygon	40	3	Wilson 2011, Arribas-Bel et al. 2017. <b>Added workhouse by CSDS</b>	Snow 1855 (Map 1)	Unknown
	4. pumps	6 pumps in the Broad St area	Broad St Pump	Point	6	4	Wilson 2011, Arribas-Bel et al. 2017	Snow 1855 (Map 1)	Unknown
	5. deaths_by_bsrings	Deaths aggregated to 5m rings around Broad St pump	Broad St Pump	Polygon	60	6	Tobler 1994, Wilson 2011, Arribas-Bel et al. 2017. <b>Rings + calculations by CSDS</b>	Snow 1855 (Map 1)	GPL
	6. deaths_by_otherrings	Deaths aggregated to 10m rings around other pumps	Broad St Pump	Polygon	35	6	Tobler 1994, Wilson 2011, Arribas-Bel et al. 2017. <b>Rings + calculations by CSDS</b>	Snow 1855 (Map 1)	GPL
	7. subdistricts	London subdistricts as of 1855 with data	Grand Experiment	Polygon	28	28	Data by Coleman 2019. Original boundaries by Koch and Denike 2006 (no data). <b>Modified boundaries by CSDS.</b>	Snow 1855 (Map 2)	BSD 2

### List of Resources

**Data to Download:** <https://geodacenter.github.io/data-and-lab//snow/>

**Story Map:** <https://bit.ly/3mSGZiS>

**Video:** <https://bit.ly/365giRY>

**GeoDa Scripts:** [https://geodacenter.github.io/data-and-lab//data/geoda\\_scripts\\_snow.pdf](https://geodacenter.github.io/data-and-lab//data/geoda_scripts_snow.pdf)

**Snow Data (Tom Coleman):** <https://github.com/tscolemans/SnowCholera>

**Snow 1855 Map:** <https://bit.ly/341fbQH>

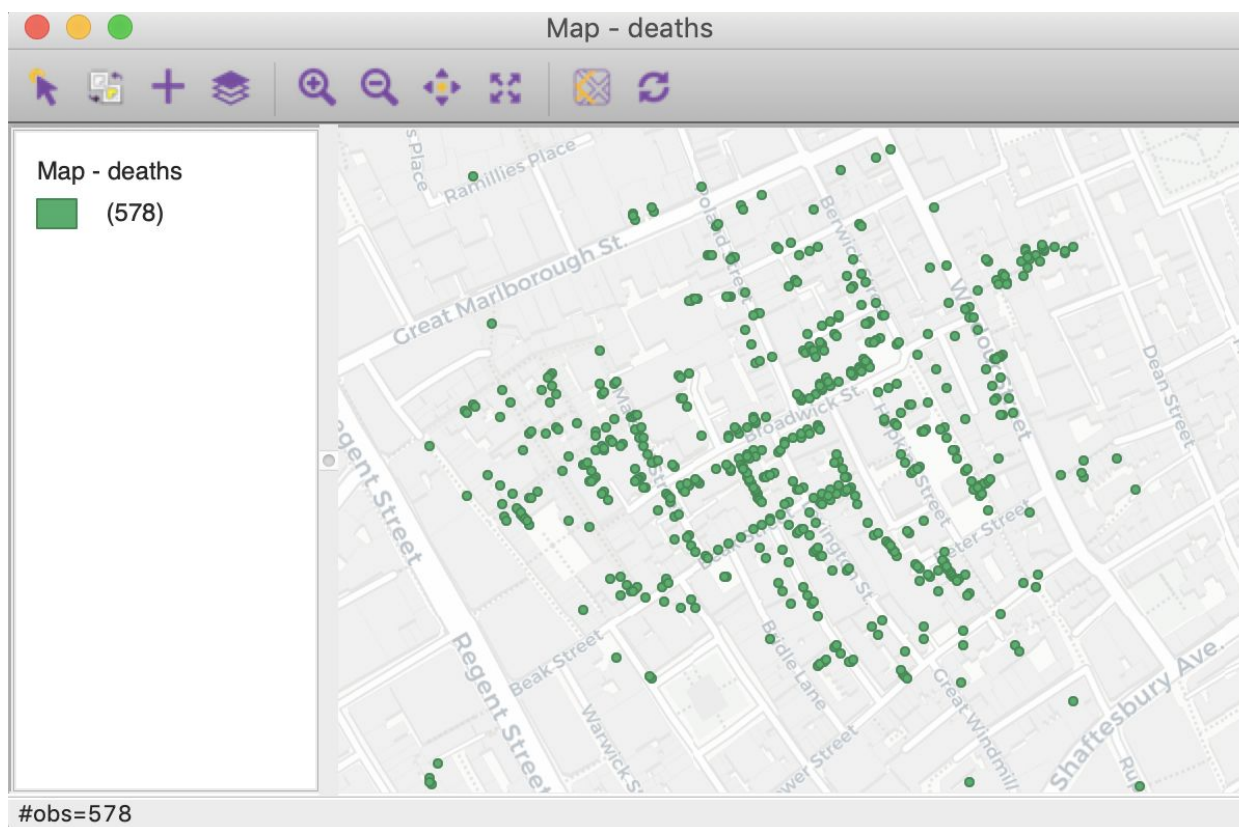
**GeoDa Download:** <https://geodacenter.github.io/>

## 7 Datasets

### Deaths (Broad Street pump)

#### 1. Individual cholera deaths ('deaths')

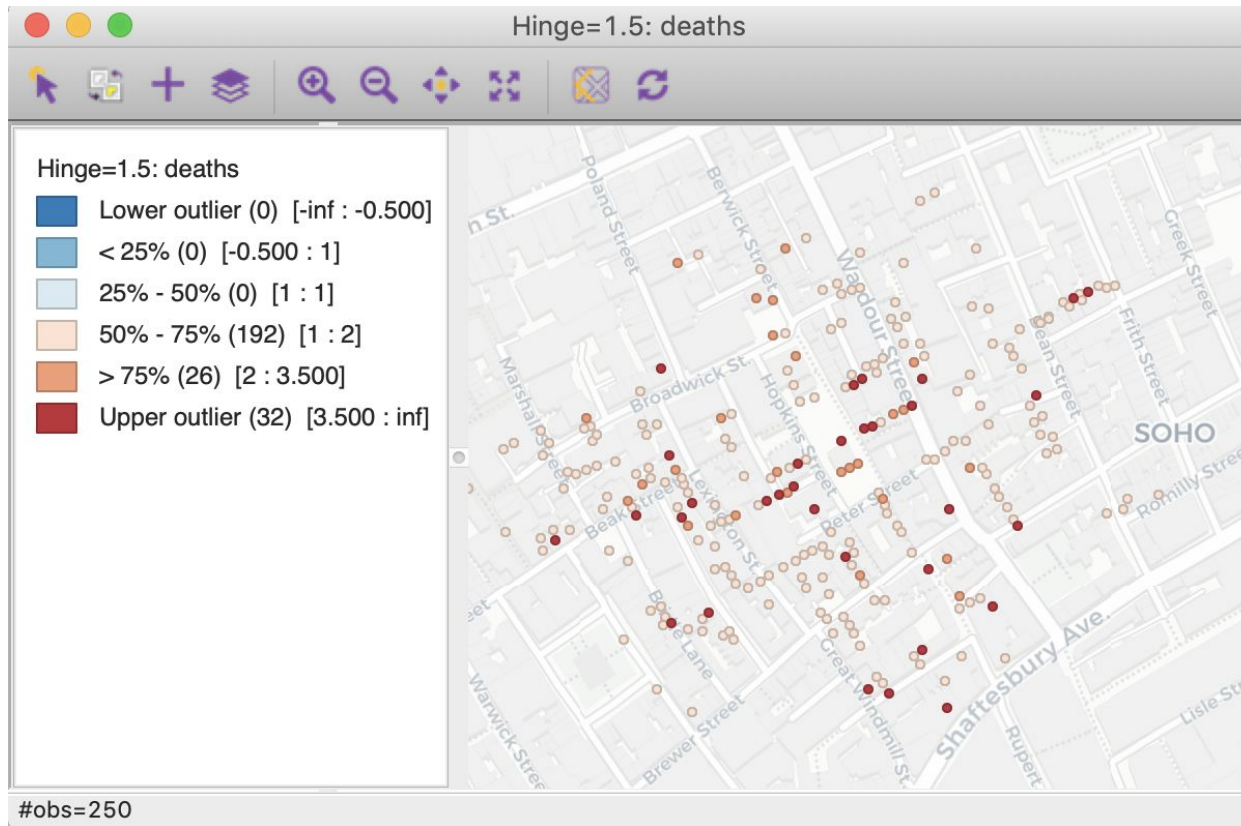
This dataset contains 578 individual deaths occurring during the 1854 cholera epidemic compiled by Tobler (1994). We used the projected version distributed through Arribas-Bel et al. (2017). Deaths are recorded as points and are located in the cholera field surrounding the Broad Street pump. Besides the ID and the coordinates of each point, the dataset includes a categorical variable called 'cl' which indicates which of the 6 pumps is closest (by pump ID) (see [pumps](#)).



Variable name	Description
ID	ID
lon	Longitude
lat	Latitude
CL	Creates categories depending on which pump is closest (see 'pumps' dataset)

## 2. Cholera deaths aggregated by building ('deaths\_by\_bldg')

This dataset contains 250 points that correspond to buildings where cholera deaths were recorded near the Broad Street pump. These data were shared publicly by Wilson (2011). The variables include an ID for each building, its coordinates, and a death count. We added the following variables: an ID for the closest pump, as well as the distance to it and to the Broad Street pump (in meters), and, finally, a dummy variable that classifies observations in terms of whether the Broad Street pump was the closest pump.

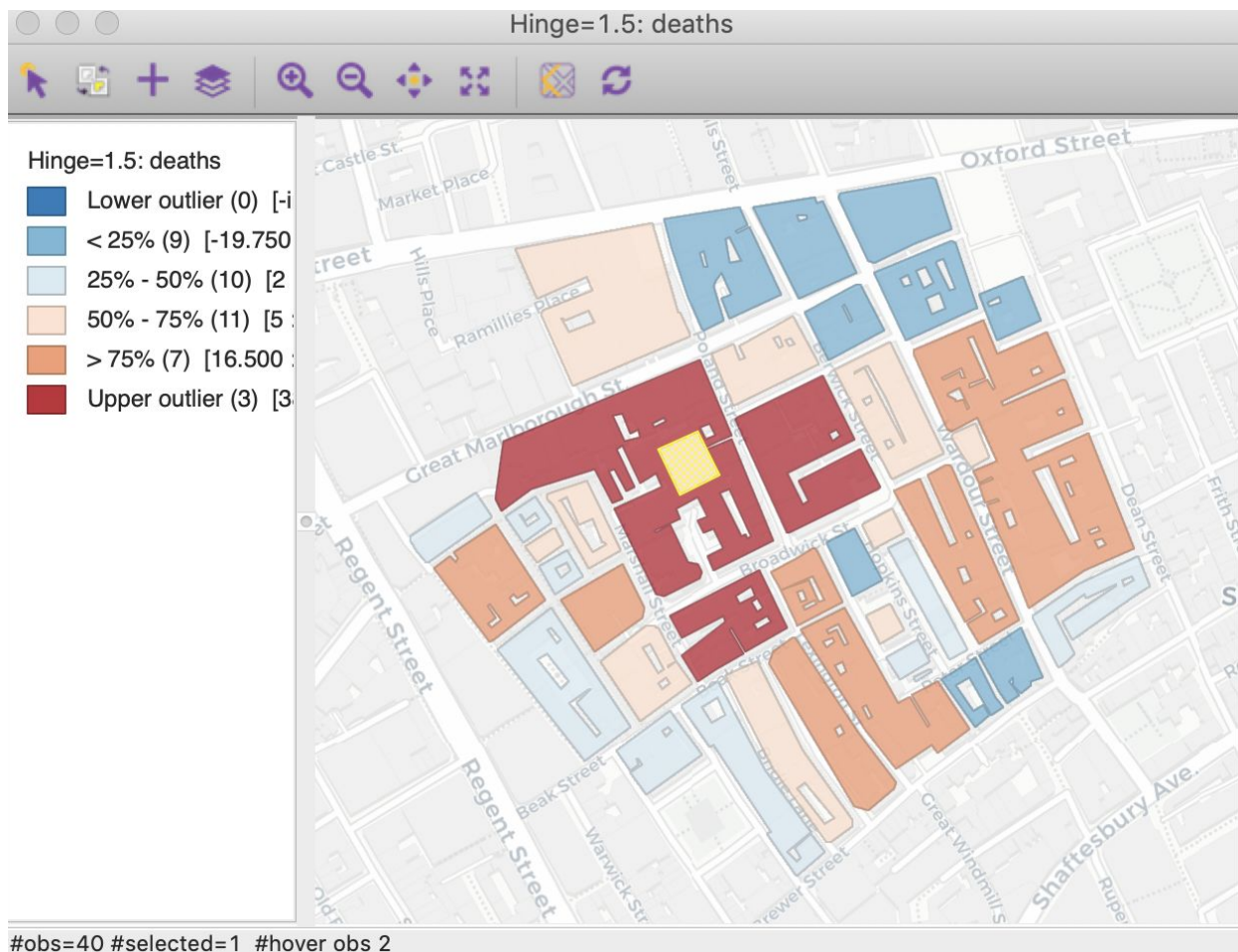


Variable name	Description
ID	ID
x	X coordinates (in meters)
y	Y coordinates (in meters)
deaths	Number of deaths per building
pumpID	ID of the nearest pump (see 'pumps' dataset)
distpump	Distance to the nearest pump (in meters - see 'pumps' dataset)
distBSpump	Distance to Broad St pump (in meters - see 'pumps' dataset)
BSpump	Create categories depending on whether the Broad Street pump is closest (1) or not (0)



### 3. Cholera deaths aggregated by block ('deaths\_by\_block')

This dataset contains housing blocks, in the form of polygons, which aggregate cholera deaths in the vicinity of the Broad Street pump. Originally, 39 observations were provided by Wilson (2011), with an ID for the polygons, a death count and the death density (in terms of population). We also created one additional observation (ID=1) to account for a particular building where John Snow found that people did not drink water from the Broad Street pump (the workhouse depicted in yellow in the map below).

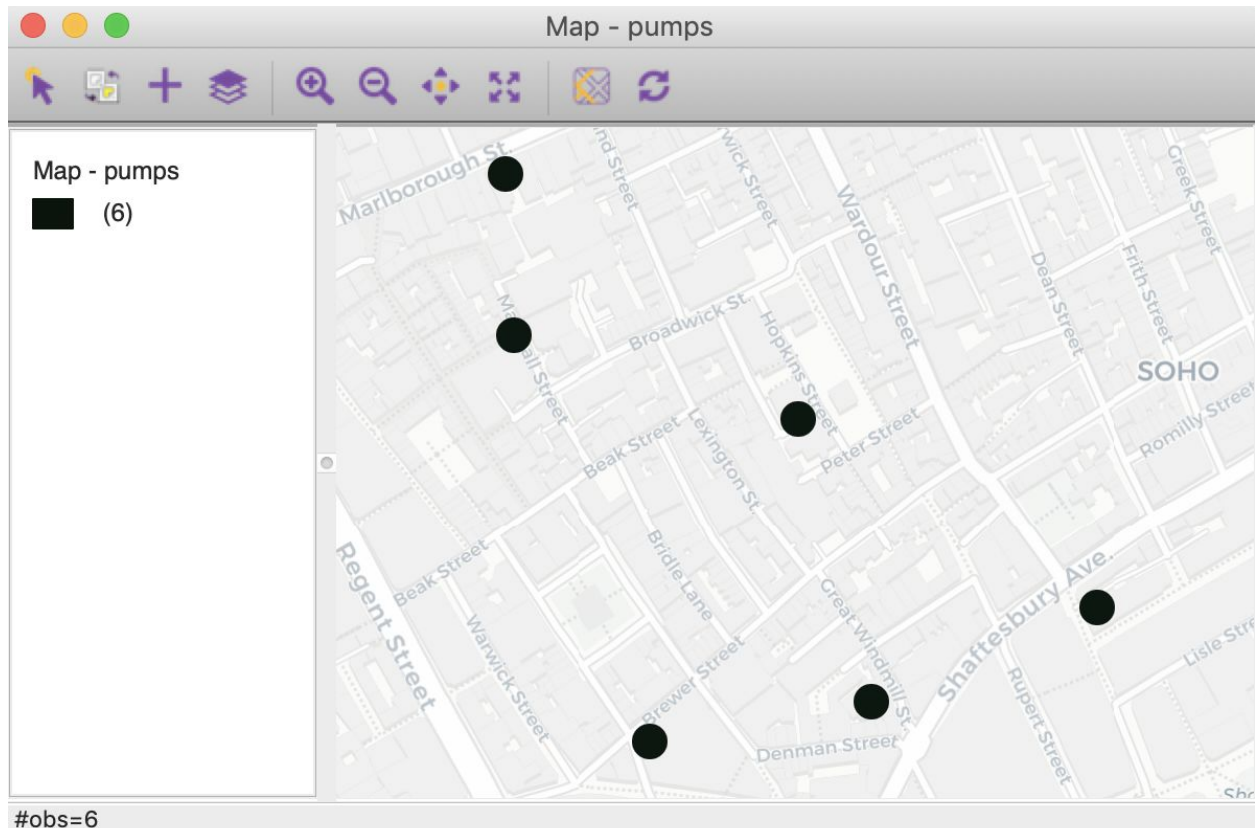


Variable name	Description
ID	ID
deaths	Number of deaths per polygon
deathdens	Number of deaths per polygon divided by population

## Pumps

### 4. Six pumps ('pumps')

This dataset contains six points that represent the Broad Street pump and the five pumps closest to it. Originally, the dataset compiled by Wilson (2011) consisted of eight observations, two of which were removed because they showed no deaths in their vicinity (see [deaths\\_by\\_otherrings](#)). We assume that the spatial extent of the deaths data does not include the other pumps. Variables include an ID for the pumps, their coordinates, and their names.

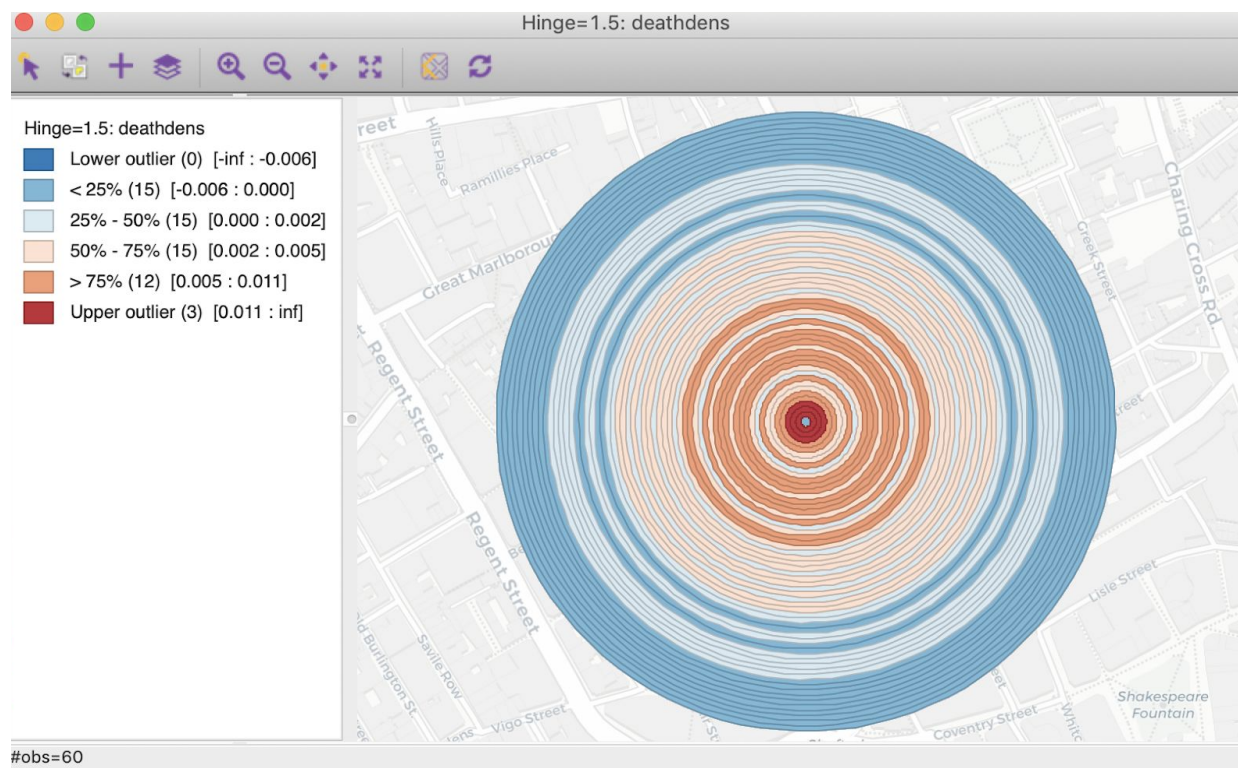


Variable name	Description
<b>ID</b>	Pump ID
<b>x</b>	X coordinates (in meters)
<b>y</b>	Y coordinates (in meters)
<b>name</b>	Name of the pump



## 5. Cholera deaths aggregated by Broad Street pump rings ('deaths\_by\_bsrings')

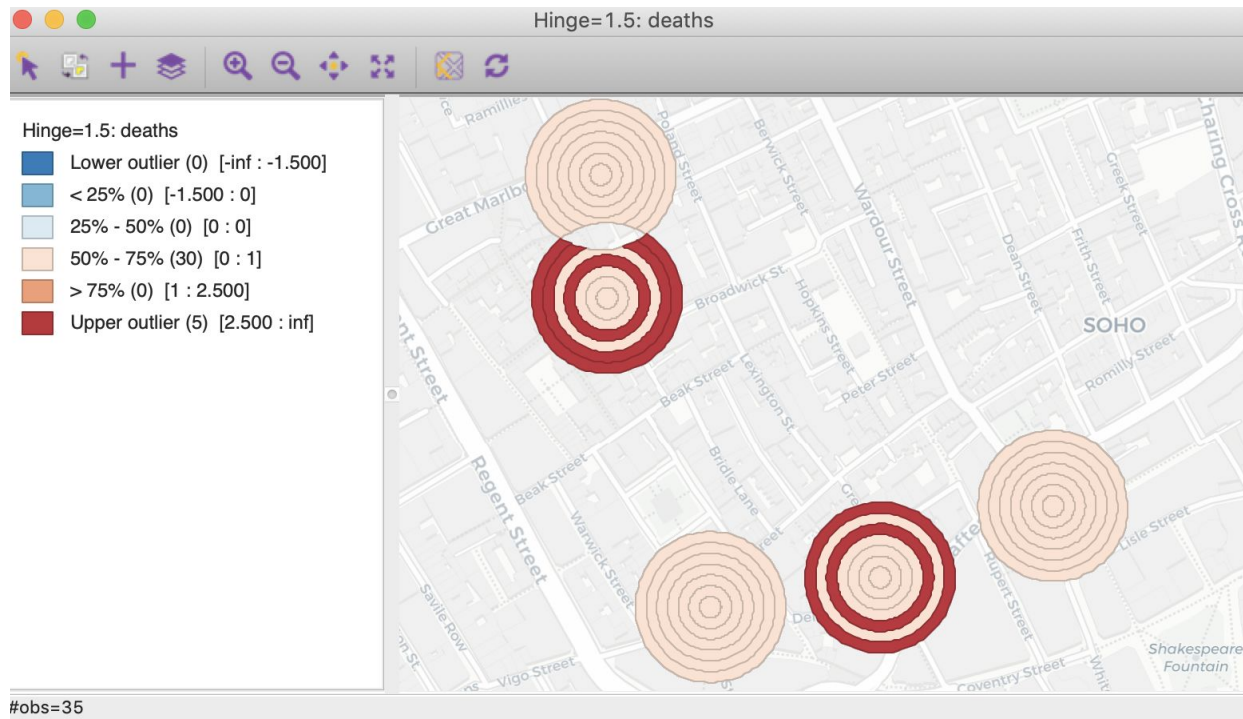
This dataset combines two of the previous datasets: Individual cholera deaths (see [deaths](#)) and the Broad Street pump, extracted from the 6 pumps dataset (see [pumps](#)). We created 60 polygons that represent rings that start at the location of the Broad Street pump and progress in 5-meter increments around the pump. We created these rings in QGIS to compare them in terms of cholera deaths; thus, the dataset contains the number of deaths per ring. Since the outer rings cover more area than the inner rings, we also included the ring area in square meters. This variable was used to create another one for death density, i.e. deaths per square meter, shown below.



Variable name	Description
<b>ID</b>	ID
<b>area</b>	Area (in squared meters)
<b>deaths</b>	Number of deaths per ring
<b>deathdens</b>	Number of deaths per ring divided by area

## 6. Cholera deaths aggregated by other pump rings ('deaths\_by\_otherrings')

This dataset combined the same two datasets: Individual cholera deaths (see [deaths](#)) and the five pumps other than the Broad Street pump, extracted from the 6 pumps dataset (see [pumps](#)). The dataset contains 35 polygons which represent seven rings that progress in 10-meter increments from each of the 5 pumps (see [deaths\\_by\\_bsrings](#)). Its variables include an ID for the rings and for the pumps, respectively, the coordinates of the pumps, the cholera death count per ring, and the distance from each ring to the closest pump.



Variable name	Description
<b>ID</b>	ID
<b>pump_ID</b>	ID of corresponding pump
<b>x</b>	X coordinates of corresponding pump (in meters)
<b>y</b>	Y coordinates of corresponding pump (in meters)
<b>dist</b>	Distance to pump (in meters)
<b>deaths</b>	Number of deaths per ring

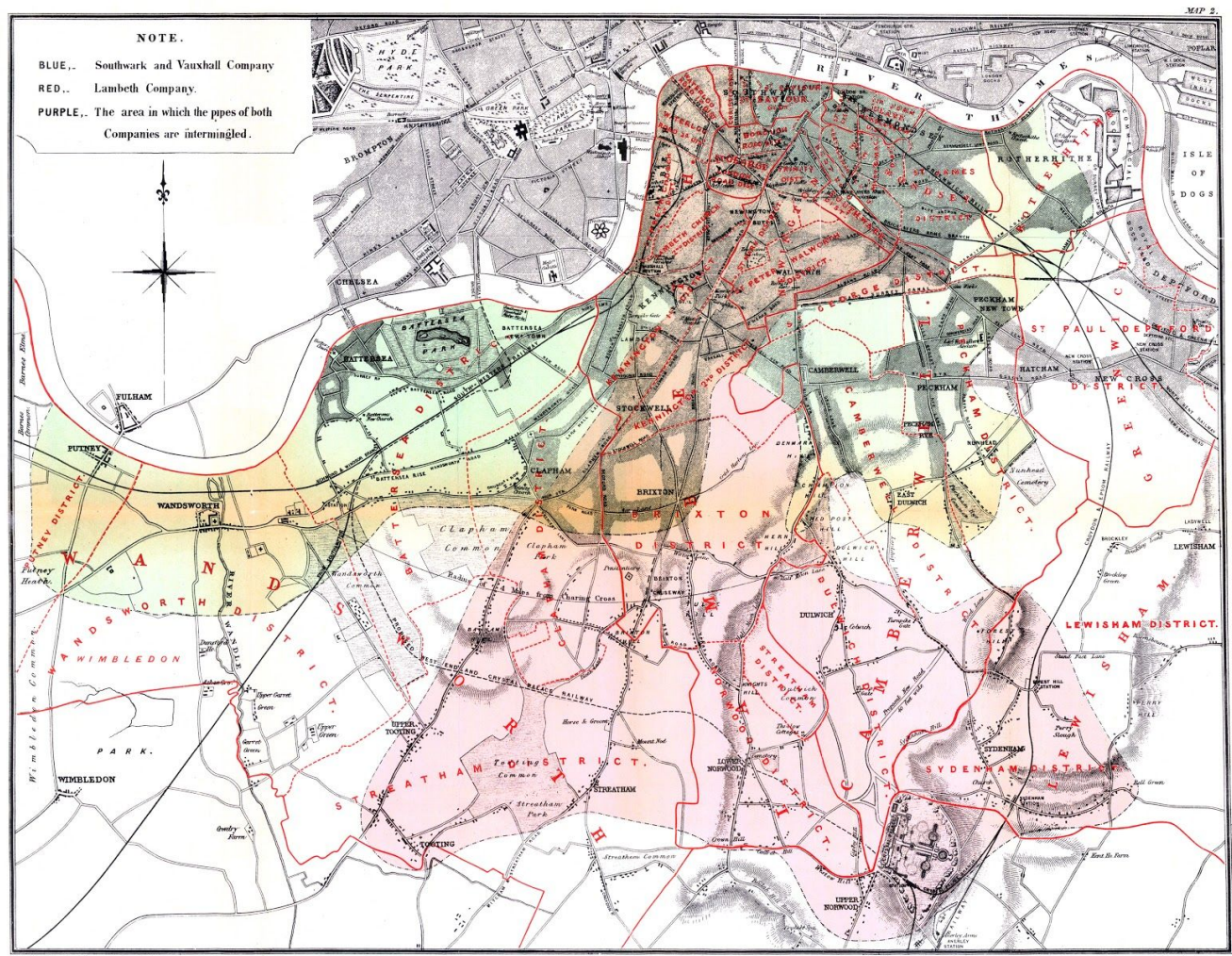


## Subdistricts (South London natural experiment)

### 7. The 28 subdistricts ('subdistricts')

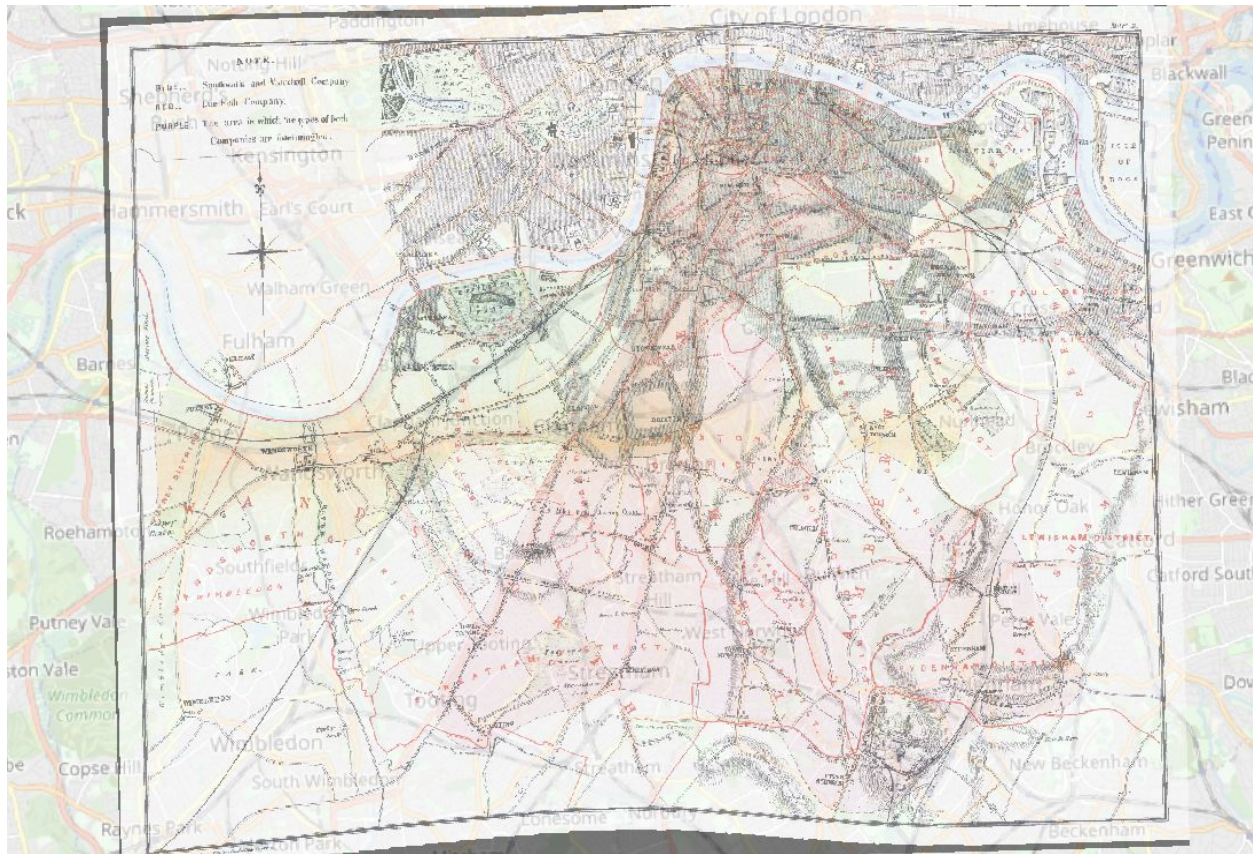
Since GeoDa is primarily designed for the exploratory analysis of variables associated with spatial areas, we decided to include a dataset related to Snow's investigation of the natural experiment in South London. The rich set of attribute data we wanted to use for this purpose was prepared by Tom Coleman (2019; 2020). We used the spatial boundary files from Koch and Denike (2006) and modified these boundaries after consulting the original maps and the historian Peter Vinten-Johansen (2020).

The South London subdistricts we refer to are shaped by the boundaries in John Snow's Map 2, which appeared in his 1855 report (Snow 1855). You can access this map [here](#).



We georeferenced the original Snow map in QGIS. By adding almost 30 control points, the location of the map was very close to that of its actual features. Here is what the outcome looked like in QGIS on top of a current basemap:

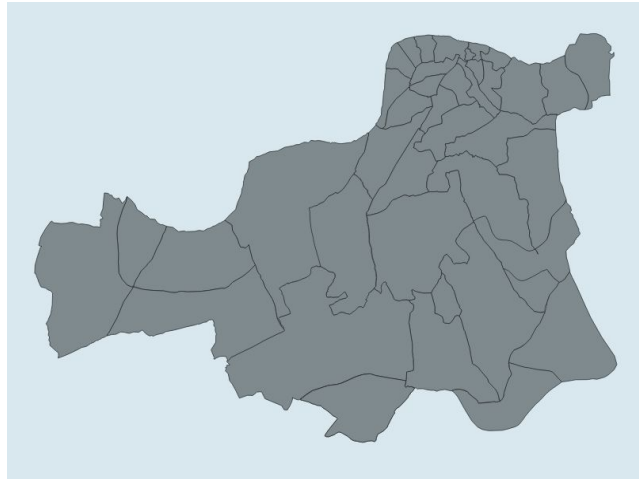




Map 2 includes 32 South London subdistricts in which the Southwark & Vauxhall (S&V) and the Lambeth water companies supplied piped water in 1854. S&V was the sole provider in 12 subdistricts and Lambeth was the sole provider in 4 subdistricts; active pipes from both companies existed in 16 subdistricts (either the entire subdistrict or a portion of it). You can see an adaptation of Table XII from Snow (1855:90) at the end of this section.

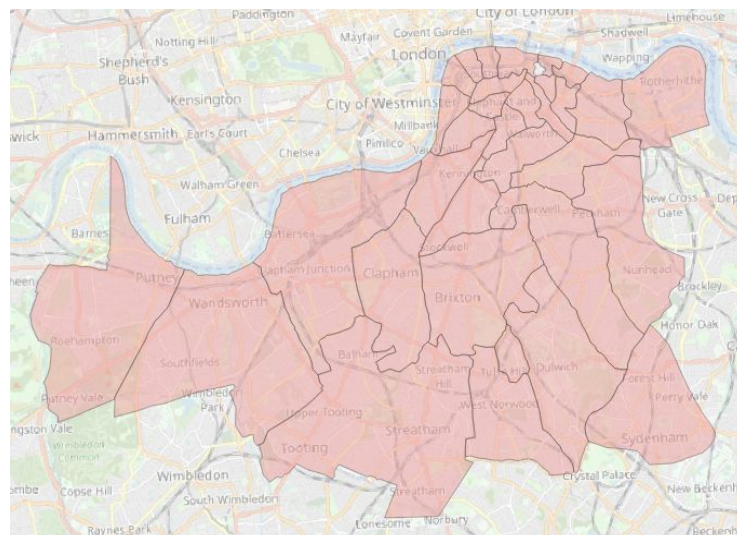
While we decided to keep the 32 subdistricts in this dataset, it should be noted that attribute data compiled by Coleman (2019) for a difference-in-differences comparison of cholera mortality during the 1849 and 1854 cholera epidemic in the watersheds of these two water companies is limited to only 28 of the subdistricts. In 1849, the Lambeth Company did not provide piped water to three subdistricts (Norwood, Streatham, and Sydenham) in which it was sole provider in 1854; in the fourth (Dulwich), no cholera deaths were recorded in 1854.

The spatial boundary files (without attribute data) that we used as initial input for the project were originally digitized by Koch and Denike (2006) and shared by the authors. Their original unprojected file, which consists of 41 observations, looks like this:



After overlaying Koch and Demike's 2006 shapefile with the 1855 map, we noticed mismatches between the boundaries of the spatial file and the reference map, particularly in subdistricts that were located near the edge of the map. Additionally, some of these subdistricts were stored as multi-polygons in QGIS. We also realized that the boundaries of some of the subdistricts reflected the extent of South London's watersheds instead of subdistrict registration borders. We therefore adjusted the 32 subdistrict boundaries of interest, as described below.

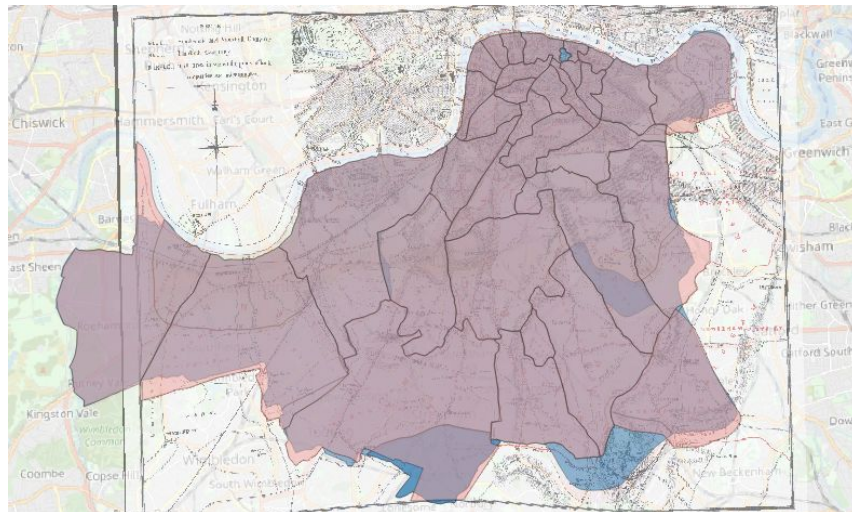
The boundaries of Putney, Wandsworth, Peckham, and Rotherhithe were extended to align them more closely with the 1855 map. In the case of Putney, we presume that its boundaries extend to the northwest. Snow's map does not show them since he was concerned with the extent of the watersheds, and we kept the end of the 1855 map as Putney's northwestern boundary. In total, we kept 31 polygons and one multipolygon ([Streatham](#), which consisted of a main area in the Wandsworth district and an exclave called Knight's Hill which was located within the Lambeth district). Streatham, as well as Sydenham, were redrawn by us with the QGIS software. The resulting (now projected) map looks as follows:



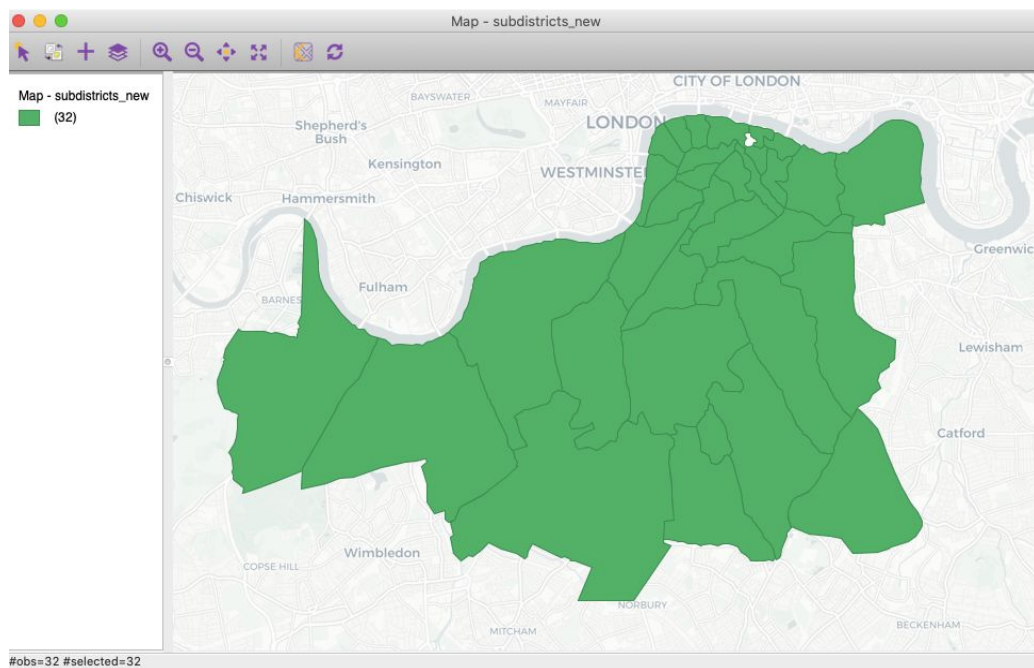


You will notice a small hole in the northeast quadrant which does not correspond to a residential area. This turns out to be Guy's Hospital, which was founded in 1721.

When running spatial weights, we noticed that three observations were neighborless. This sometimes happens during the digitization process if small gaps are left between areas and their neighbors. We fixed this problem in QGIS by cleaning the layer and obtained a final layer (in pink) which can be compared to the initial one (in blue) below. The maps on this page also display the 1855 map and a current London basemap as base layers.



This is what the final layer looks like in GeoDa:





Variable name	Description
<b>dis_ID</b>	London district ID
<b>district</b>	London district
<b>sub_ID</b>	London subdistrict ID
<b>subdist</b>	London subdistrict
<b>pop1851</b>	Population for 1851
<b>pop_house</b>	Population per house
<b>supplier</b>	Water company suppliers that served the subdistrict
<b>supplierID</b>	Water company supplier ID
<b>perc_sou</b>	Proportion of the population that was served by the Southwark & Vauxhall company
<b>perc_lam</b>	Proportion of the population that was served by the Lambeth company
<b>perc_other</b>	Proportion of the population that was served by a company other than Southwark & Vauxhall or Lambeth
<b>lam_degree</b>	Creates categories for the proportion of the population that was served by the Lambeth company
<b>d_overall</b>	Number of deaths attributed to the cholera epidemic in the seven weeks ending August 26, 1854
<b>d_sou</b>	Number of deaths attributed to the cholera epidemic in the seven weeks ending August 26, 1854 for the Southwark & Vauxhall company
<b>d_lam</b>	Number of deaths attributed to the cholera epidemic in the seven weeks ending August 26, 1854 for the Lambeth company
<b>d_pump</b>	Number of deaths attributed to the cholera epidemic in the seven weeks ending August 26, 1854 originating in pump-wells
<b>d_thames</b>	Number of deaths attributed to the cholera epidemic in the seven weeks ending August 26, 1854 from water from the Thames River and ditches
<b>d_unasc</b>	Number of deaths attributed to the cholera epidemic in the seven weeks ending August 26, 1854 of unascertained origin
<b>rate_sou7w</b>	Southwark & Vauxhall cholera death rate per 10000 people in the seven weeks ending August 26, 1854
<b>rate_lam7w</b>	Lambeth cholera death rate per 10000 people in the seven weeks ending August 26, 1854 - Missing values are undefined and should not be converted to 0
<b>rate_oth7w</b>	Cholera death rate per 10000 people for 'other' category in the seven weeks ending August 26, 1854 - Missing values are undefined and should not be converted to 0
<b>deaths1849</b>	Number of deaths attributed to the cholera epidemic in 1849
<b>deaths1854</b>	Number of deaths attributed to the cholera epidemic in 1854
<b>rate1849</b>	Cholera death rate per 10000 people in 1849
<b>rate1854</b>	Cholera death rate per 10000 people in 1854
<b>pop1849</b>	Population for 1849
<b>pop1854</b>	Population for 1854
<b>rAvSupR_49</b>	Average supplier-region-specific cholera mortality rate per 10000 people in 1849
<b>rAvSupR_54</b>	Average supplier-region-specific cholera mortality rate per 10000 people in 1854
<b>pred_Snow</b>	Snow's cholera death count prediction (from his 1856 Table VI)
<b>pred_DiD49</b>	Cholera death count prediction from Difference-in-Difference regression analysis for 1849
<b>pred_DiD54</b>	Cholera death count prediction from Difference-in-Difference regression analysis for 1854

**The South London natural experiment**

[Adapted from Table XII in Snow (1855:90)]

<b>Subdistrict</b>	<b>Water supplier in 1854</b>
St. Saviour, Southwark	Southwark & Vauxhall
St. Olave	Southwark & Vauxhall
St. John, Horsleydown	Southwark & Vauxhall
St. James, Bermondsey	Southwark & Vauxhall
St. Mary Magdalen	Southwark & Vauxhall
Leather Market	Southwark & Vauxhall
Rotherhithe	Southwark & Vauxhall
Wandsworth	Southwark & Vauxhall
Battersea	Southwark & Vauxhall
Putney	Southwark & Vauxhall
Camberwell	Southwark & Vauxhall
Peckham	Southwark & Vauxhall and Lambeth
Christchurch, Southwark	Southwark & Vauxhall and Lambeth
Kent Road	Southwark & Vauxhall and Lambeth
Borough Road	Southwark & Vauxhall and Lambeth
London Road	Southwark & Vauxhall and Lambeth
Trinity, Newington	Southwark & Vauxhall and Lambeth
St. Peter, Newington	Southwark & Vauxhall and Lambeth
Waterloo Road, 1st	Southwark & Vauxhall and Lambeth
Waterloo Road, 2st	Southwark & Vauxhall and Lambeth
Lambeth Church, 1st	Southwark & Vauxhall and Lambeth
Lambeth Church, 2nd	Southwark & Vauxhall and Lambeth
Kennington, 1st	Southwark & Vauxhall and Lambeth
Kennington, 2nd	Southwark & Vauxhall and Lambeth
Brixton	Southwark & Vauxhall and Lambeth
Clapham	Southwark & Vauxhall and Lambeth
St. George, Camberwell	Southwark & Vauxhall and Lambeth
Norwood	Lambeth
Streatham	Lambeth
Dulwich	Lambeth
Sydenham	Lambeth

## Acknowledgements

Thank you to Tom Koch for sharing the spatial boundary file from Koch and Denike (2006) as well as other authors who publicly shared the Broad Street pump spatial files. We also gratefully acknowledge the support of Luc Anselin and the Center for Spatial Data Science.

## References

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- Coleman, T. (2019). *Causality in the Time of Cholera: John Snow as a Prototype for Causal Inference*. Working paper. Available at SSRN at <https://papers.ssrn.com/abstract=3262234>. Data can be downloaded from <https://github.com/tscoleman/SnowCholera> (last accessed September 2, 2020).
- Coleman, T. (2020). *John Snow, Cholera, and South London Reconsidered*. Working paper. Available on SSRN at <https://papers.ssrn.com/abstract=3696028>. Data can be downloaded from <https://github.com/tscoleman/SnowCholera> (last accessed September 2, 2020).
- Koch, T. and K. Denike (2006). Rethinking John Snow's South London study: A Bayesian evaluation and recalculation. *Social Science and Medicine*, 63(1), 271-283. Subdistrict boundary files provided by the author.
- Snow, J. (1855). *On the Mode of Communication of Cholera*. London, second edition, Map 1, available at <https://www.bl.uk/learning/images/makeanimpact/publichealth/large12735.html>.
- Snow, J. (1855). *On the Mode of Communication of Cholera*. London, second edition, Map 2, reprinted in Jefferson, Tom (2007), *Cattive acque. John Snow e la vera storia del colera a Londra*, Rome, Il Pensiero Scientifico Editore.
- Tobler, W. (1994). *Snow's Cholera Map*. <http://www.ncgia.ucsb.edu/pubs/snow/snow.html>. Data files were obtained from the HistData CRAN R package.
- Vinten-Johansen, P. (Ed.). (2020). *Investigating Cholera in Broad Street: A History in Documents*. Broadview Press.
- Wilson, R (2011). *John Snow's Cholera data in more formats*. <http://blog.rtwilson.com/john-snows-cholera-data-in-more-formats/>. Reprojected data can also be downloaded from Dani Arribas-Bel's 'reproducible john snow' BitBucket repository at [https://bitbucket.org/darribas/reproducible\\_john\\_snow/src/master/](https://bitbucket.org/darribas/reproducible_john_snow/src/master/).