

8 Epidemic Data



Mathematics
and Statistics

$$\int_M d\omega = \int_{\partial M} \omega$$

Mathematics 4MB3/6MB3 Mathematical Biology

Instructor: David Earn

Lecture 8
Epidemic Data
Monday 21 January 2019

Announcements

- Thanks everyone for doing the contributions survey for Assignment 1.
- Don't stress about the ratings about each other's contributions. The issue is whether some group members did not pull their weight. If somebody didn't try and others had to pick up the slack, that person should be penalized. I will not penalize somebody because they tried but felt they didn't contribute as much to the final document as they could have. Do try to even out the work across the assignments.
- Make sure everyone in your group gets a chance to be in control of the \LaTeX for one assignment.

More Announcements!

- **Assignment 2:**

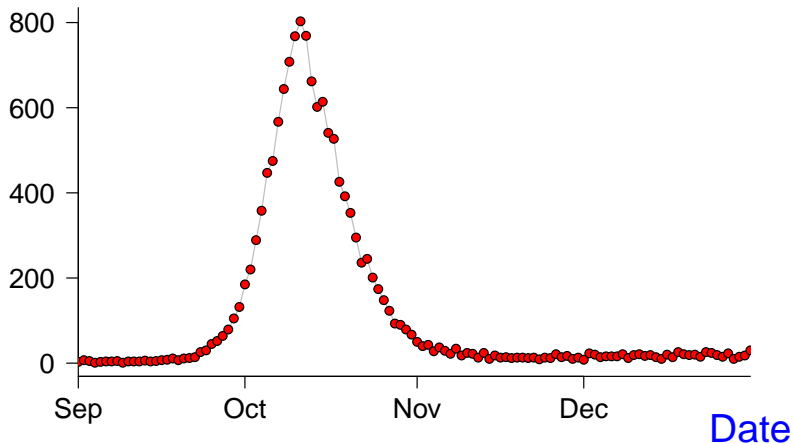
Due Monday 4 February 2019 in class (and by e-mail) at 10:30am.

- **Midterm test:**

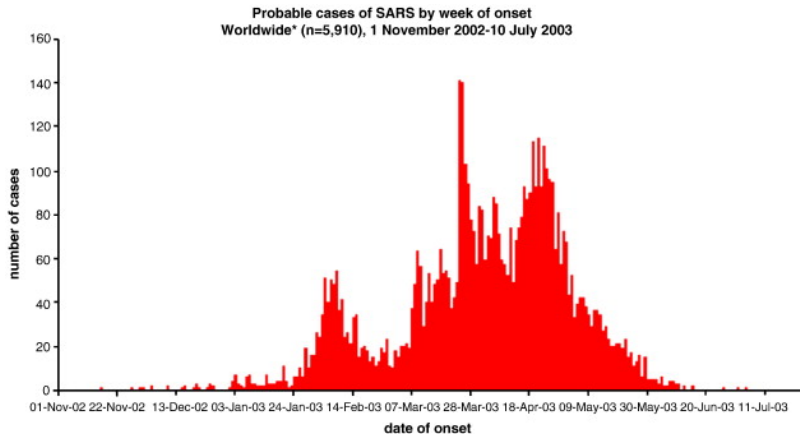
- *Date:* Monday 11 March 2019
- *Time:* 9:30am–11:20am
- *Location:* Hamilton Hall 410

P&I Mortality, Philadelphia, 1918

P&I Deaths

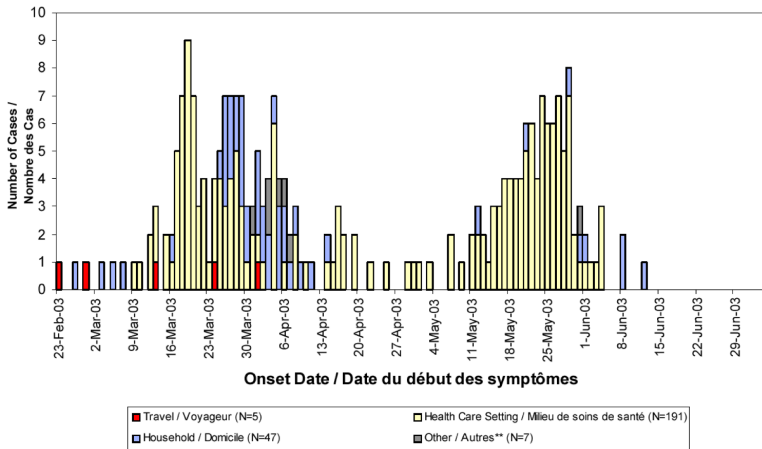


SARS in 2003 (Worldwide)



*This graph does not include 2,527 probable cases of SARS (2,521 from Beijing, China), for whom no dates of onset are currently available.

SARS in 2003 (Toronto)

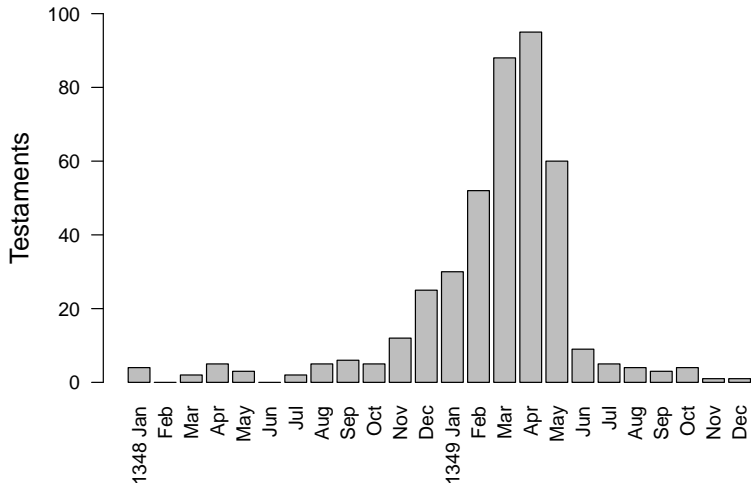


$N = 249$ (of 250 reported)

Some SARS Facts

- High case fatality
 - 1918 flu $< 3\%$
 - SARS $> 10\%$
- Long hospital stays
 - Mean time from admission to discharge or death:
~ 25 days in Hong Kong
- 8098 probable cases, 774 deaths
- How bad would it have been if it had not been controlled?

The Black Death in London, England, 1348–1349



London Bill of Mortality, 26 Sept to 3 Oct 1665

The Diseases and Casualties this Week.	
Frighted	11
Goat	1
Griping	1
Griping in the Guts	1
Jaundies	25
Impothame	8
Infants	2
Kingfevil	9
Misgroome	1
Plague	56
Purples	2
Rickets	10
Riting of the Lights	13
Rupture	4
Scurvy	5
Spotted Feaver	65
Stilbenen	10
Stone	1
Stopping of the stomach	6
Suddenly	1
Surfeit	36
Teeth	11
Thrush	3
Tifick	1
Vomiting	1
Winding	4
Wormes	12
Plague	5533
Males	68
Females	78
In all	146
Males	3212
Females	3248
In all	6460
Decreased in the Burials this Week	1837
Parishes clear of the Plague	7
Parishes Infected	123

The Afize of Bread set forth by Order of the Lord Mayor and Court of Aldermen, A penny Wheaten Loaf to contain Nine Ounces and a half, and three half-penny White Loaves the like weight.

London 4 ^r . From the 26 of September to the 3 of October. 1665			
	How Many	How Many	How Many
St Andrew Woodhouse	16	St George Broadstreet	1
St Andrew Woodhouse	40	St Gregory St Pauls	26
St Andrew Woodhouse	1	St Helens	6
St Andrew Woodhouse	41	St James Duke street	17
St Andrew Woodhouse	17	St James Garlickhithe	10
St Andrew Woodhouse	17	St John Baptist	11
St Andrew Woodhouse	18	St John Evangelist	10
St Andrew Woodhouse	18	St John Zatchary	12
St Andrew Woodhouse	13	St Katharine Coleman	10
St Andrew Woodhouse	13	St Katharine Creechwell	14
St Andrew Woodhouse	13	St Lawrence Jewry	2
St Andrew Woodhouse	4	St Lawrence Poonery	14
St Andrew Woodhouse	16	St Leonard Eastcheap	3
St Andrew Woodhouse	20	St Leonard Fothering	16
St Andrew Woodhouse	20	St Magnus Parish	5
St Andrew Woodhouse	57	St Margaret Leabury	7
St Andrew Woodhouse	4	St Margaret Marton	1
St Andrew Woodhouse	4	St Margaret Newfishstreet	13
St Andrew Woodhouse	4	St Margaret Patton	4
St Andrew Woodhouse	4	St Mary Abchurch	7
St Andrew Woodhouse	15	St Mary Aldermanbury	14
St Andrew Woodhouse	15	St Mary Aldemary	4
St Andrew Woodhouse	8	St Mary le Bow	11
St Andrew Woodhouse	44	St Mary le Strand	6
St Andrew Woodhouse	1	St Mary Oldchurch	1
St Andrew Woodhouse	1	St Mary Hill	11
St Andrew Woodhouse	2	St Mary Mounsham	4
St Andrew Woodhouse	2	St Mary Somerschurch	44
St Andrew Woodhouse	23	St Mary Spaying	38
St Andrew Woodhouse	3	St Mary Woolchurch	1
St Andrew Woodhouse	2	St Mary Woolchurch	4
St Andrew Woodhouse	8	St Mary Woolchurch	7
St Andrew Woodhouse	8	St Martin Ironmongers	2
St Andrew Woodhouse	3		

Buried in the 97 Parishes within the Wall		39 Parishes		1149 Parishes		943	
St Andrew Holborn	173	St Bonhill Aldgate	371	St Andrew Southwark	364	St Andrew Southwark	352
St Andrew Holborn	17	St Bonhill Bishopsgate	153	St Andrew Southwark	137	St Andrew Southwark	95
St Andrew Holborn	7	St Dunston West	65	St Andrew Southwark	140	St Andrew Southwark	16
St Andrew Holborn	52	St George Southwark	140	St Andrew Southwark	153	St Andrew Southwark	11
St Andrew Holborn	33	St Giles Cripplegate	196	St Andrew Southwark	14	St Andrew Southwark	8
St Andrew Holborn	71	St Olave Southwark	378	St Andrew Southwark	281	St Andrew Southwark	8

Buried in the 16 Parishes within the wall				45 Parishes				2258 Parishes				1922			
St Giles in the fields	95	St Lambeth Parish	49	St Mary Abchurch	35	St Mary Abchurch	35	St Mary Abchurch	35	St Mary Abchurch	35	St Mary Abchurch	35	St Mary Abchurch	35
St Giles in the fields	10	St Leonard Shoreditch	25	St Mary Abchurch	191	St Mary Abchurch	191	St Mary Abchurch	191	St Mary Abchurch	191	St Mary Abchurch	191	St Mary Abchurch	191
St Giles in the fields	48	St Stephen Brompton	18	St Mary Abchurch	181	St Mary Abchurch	181	St Mary Abchurch	181	St Mary Abchurch	181	St Mary Abchurch	181	St Mary Abchurch	181
St Giles in the fields	5	St Mary Newington	81	St Mary Abchurch	81	St Mary Abchurch	81	St Mary Abchurch	81	St Mary Abchurch	81	St Mary Abchurch	81	St Mary Abchurch	81

Buried in the 12 new Parishes in Middlesex and Surrey		40 Parishes		1623 Parishes		1469	
St Clement Danes	11	St Martin in the Fields	109	St Margaret Westminster	309	St Margaret Westminster	297
St Paul Covent Garden	25	St Mary Savoy	19	St Margaret Westminster	17	St Margaret Westminster	17

Buried in the 5 Parishes in the city and Liberties of Westminster – 18 Parishes – 650 Buried – 590

Mortality Bills are typically handwritten

LONDON 29. From the 4. of July to the 11. of August 1665.

Buried, Plag.		Buried, Plag.		Buried, Plag.		Buried, Plag.					
St Alban Woodstreet	2	1	St Clement Eastcheap	1		St Margaret Newfishst					
Alhallows Bark			St Dionis Backchurch	2		St Margaret Pattons					
Alhallows Breadstreet	1		St Dunstons East	2		St Mary Abchurch	1				
Alhallows Great			St Edmund Lombardst.	2		St Mary Aldermanbury					
Alhallows Honilane	1		St Ethelborough	2		St Mary Alde mary					
Alhallows Lumbardst.	1		St Faiths	1		St Mary le Bow					
Alhallows Staining	4	3	St Gabriel Fenchurch	1		St Mary Bothaw					
Alhallows the Wall	1		St George Botolphlane	2	1	St Mary Colechurch					
St Alphage	1		St Gregories by St, Paul	1		St Mary Hill					
St Andrew Hubbard	3		St Hellen	2	1	St Mary Mag. Milkstr.					
St Andrew Underthafe	1		St James Dukes place	1		St Mary Mag. Oldfishst					
St Andrew Wardrobe	7		St James Garlickhithe	1		St Mary Mounthaw					
St Anne Aldersgate	1		St John Baptist	1		St Mary Summerset	2	1			
St Anne Blackfyers	1		St John Evangelist	1		St Mary Staining					
St Antholiers Parish.	7	6	St John Zichary	1		St Mary Woolchurch					
St Austins Parish	1		St Katharine Coleman	1		St Mary Woolnoth					
St Barthol, Exchange	1		St Katharine Creechur.	1		St Martins Iremongerl.					
St Bennet Fynck	1		St Lawrence Jewry	1		St Martins Ludgate	2	1			
St Bennet Gracechurch	1		St Lawrence Pountney	1		St Martins Orgars					
St Bennet Paulwharf.	7		St Leonard Eastcheap	1		St Martins Outwich	1				
St Bennet Sherchog	1		St Leonard Fosterlane.	1		St Martins Vintrey	1				
St Borolph Billingsgate	1		St Magnus Parish	1		St Matthew Frydaystr.					
Christ Church	5	3	St Margaret Lothbury.	1		St Michael Bassishaw	5	4			
St Christophers			St Margaret Moses			St Michael Cornhil					
Christned in the Parishes within the walls				Buried				Plague			
				86				28			
St Andrew Holborn	6	40	St Borolph Aldergate	11	9	St George Southwark	13	4	St Sepulchres Parish	117	81
St Bartholomew Great	7	4	St Borolph Aldgate	24	4	St Giles Cripplegate	105	49	St Thomas Southwark	7	5
St Bartholomew Leli.	3	4	St Borolph Bishopsgate	37	20	St Olave Southwark	20	6	Trinity Minories		
St Bridget	24	17	St Dunstan West	19	9	St Saviour Southwark	21	1	At the Pethouse	6	6
Bridewell Prencit	1										
Christned in the 15 Parishes without the walls				Buried				Plague			
				473				273			
Christs Church			St Kath. near the Tower	7	1	St Mary Islington	3	2	St Paul Shadwel		
St John at Hackney	1		Lambeth Parish	7		St Mary Newington	7		Rotherhich Parish	7	3
St Giles in the Fields	208	215	St Leonar d Shoreditch	21	13	St Mary Whitechappel	16	3	Stepney Parish	47	1
St James Clerkenwel	8	43	St Magdalen Bermond.	14							
Christned in the 15 Parishes in Middlesex and Surrey				Buried				Plague			
				455				280			

But handwriting is usually very clear



LONDON 29th

	Buried.	Plag.
St ALban Woodstreet	2	1
Alhallows Bark.	2	
Alhallows Breadstreet	1	
Alhallows Great —		

But handwriting is usually very clear

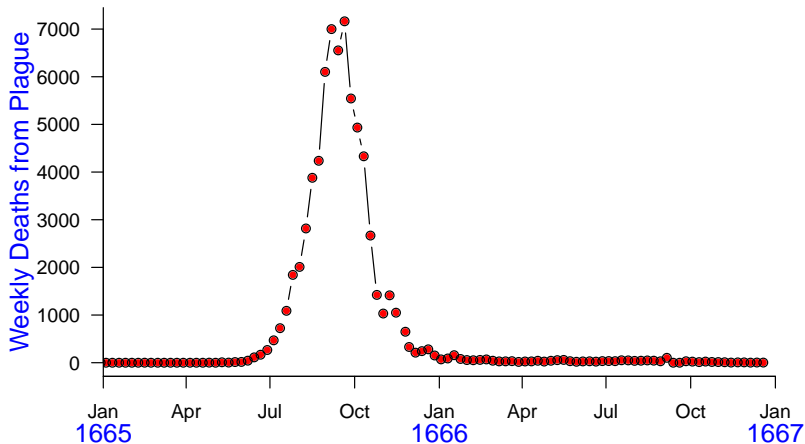
St Christophers

Christned in 97 the Parishes

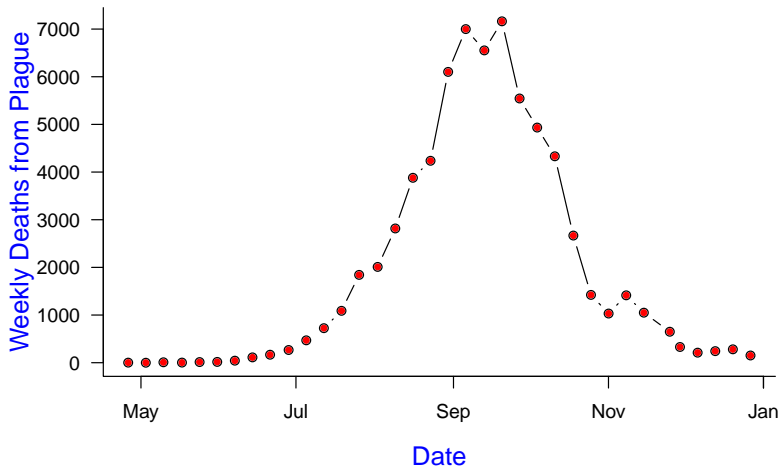
St Andrew Holborn	66	40	St
St Bartholomew Great	7	4	St
St Bartholomew Less			St
St Bridget	24	17	St
Bridewel Precinct	1	1	

Christned in the 16 Parishes

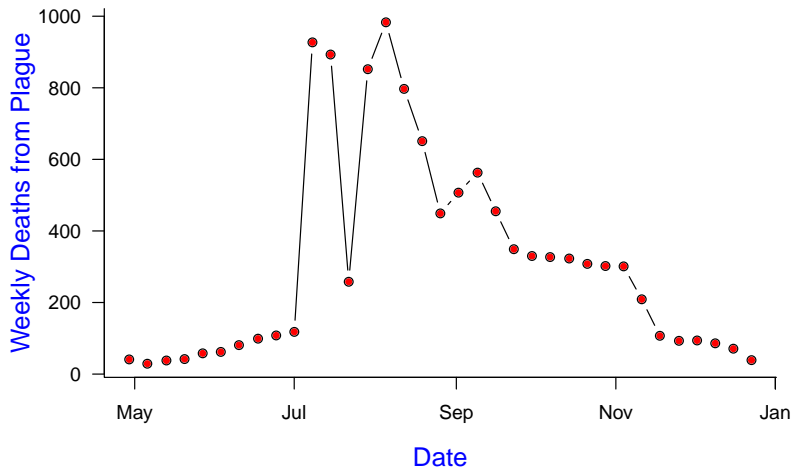
The Great Plague of London, 1665



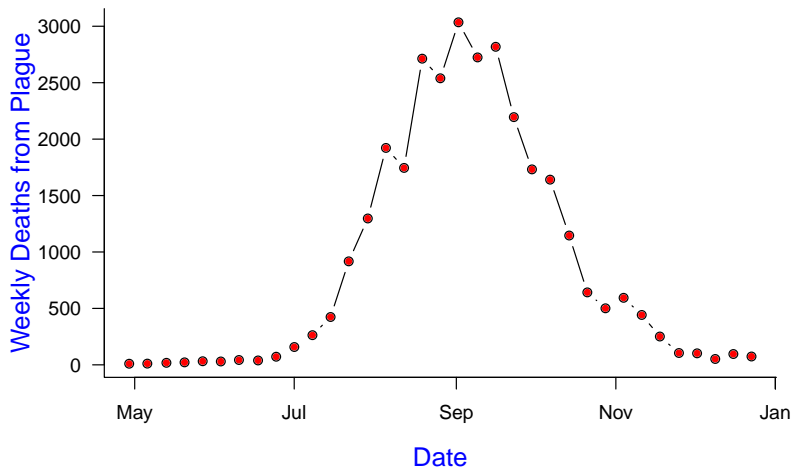
The Great Plague of London, 1665



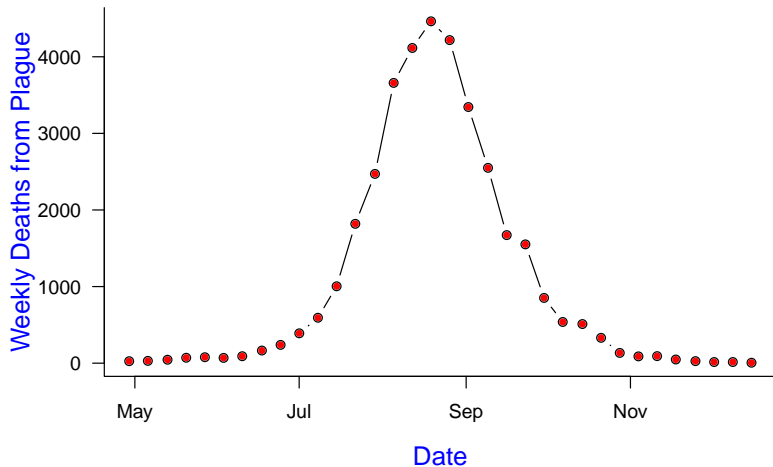
London Plague of 1593



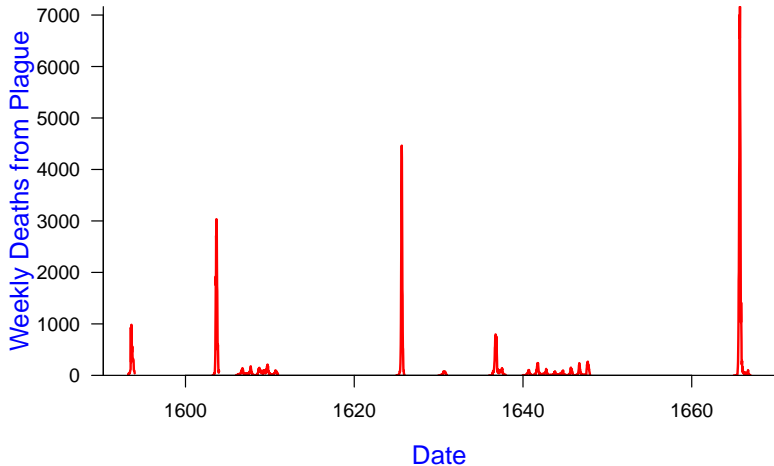
London Plague of 1603



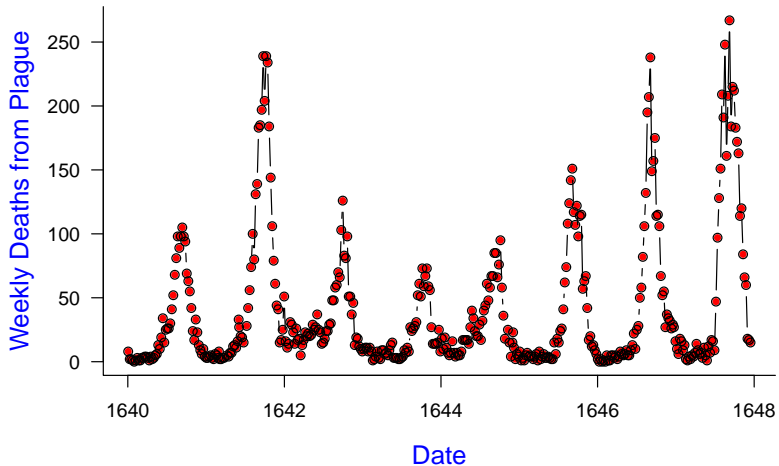
London Plague of 1625



Weekly Deaths from Plague in London, 1592–1666



Weekly Plague in London, 1640–1648



Some Plague Facts

- Plague epidemics recorded from Roman times to early 1900s.
- $\gtrsim 1/3$ Europe's population died in "Black Death" of 1348
 - ~ 300 years for the population to reach the same level.
- Recently (2011) established (at McMaster!) that the pathogen that caused The Black Death was *Yersinia pestis*

[Bos *et al.* 2011, *Nature* **478**, 506–510]

- More recently (2014) established (again at McMaster!) that the pathogen that caused The Plague of Justinian (541–543 AD) was *Yersinia pestis*

[Wagner *et al.* 2014, *Lancet Infectious Diseases* **14**, 319–326]

- *Y. pestis* still a concern?
Yes: Rodent reservoir, antibiotic-resistant strains, bioterrorism
- **Spatial data** for any plagues? Yes, for London in 1665...

Visualization of spatial structure of Great Plague

- GIS encoding of parish boundaries
- Overlay parish boundaries on more modern map for reference
- Colour parishes as they become infected
- Is there evidence for spatial spread or was the spatial pattern random?
- DE low-tech animation...
- CBC high-tech animation...
 - *The Nature of Things*, 21 August 2014.
<http://www.cbc.ca/natureofthings/episodes/secrets-in-the-bones-the-hunt-for-the-black-death-killer>