

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:**

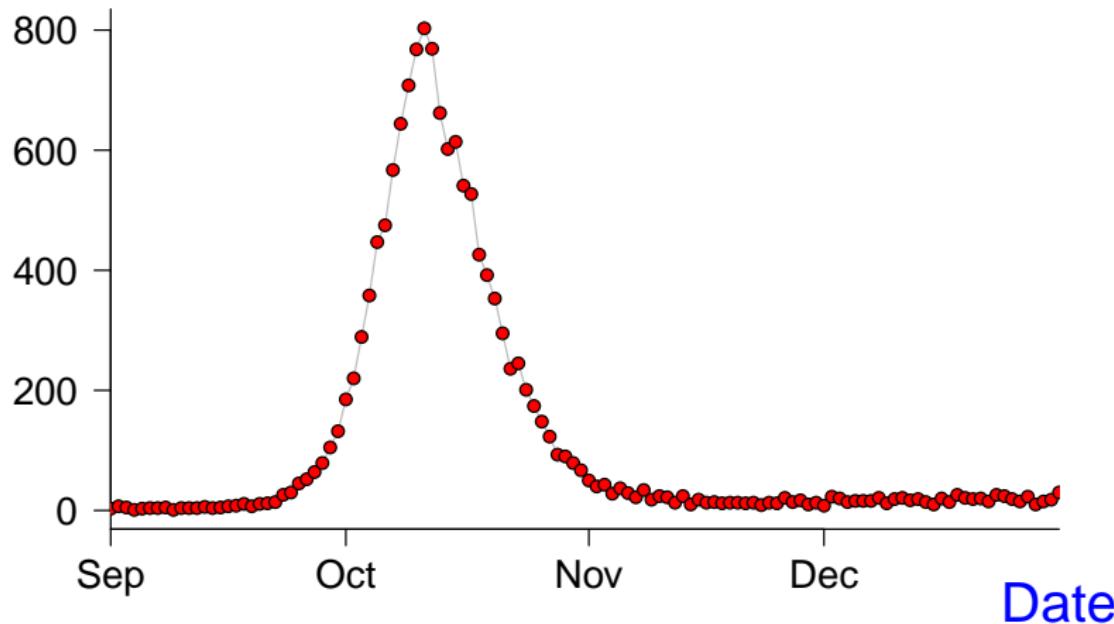
Due Monday 4 February 2019 in class (and by e-mail) at 10:30am.

- **Midterm test:**

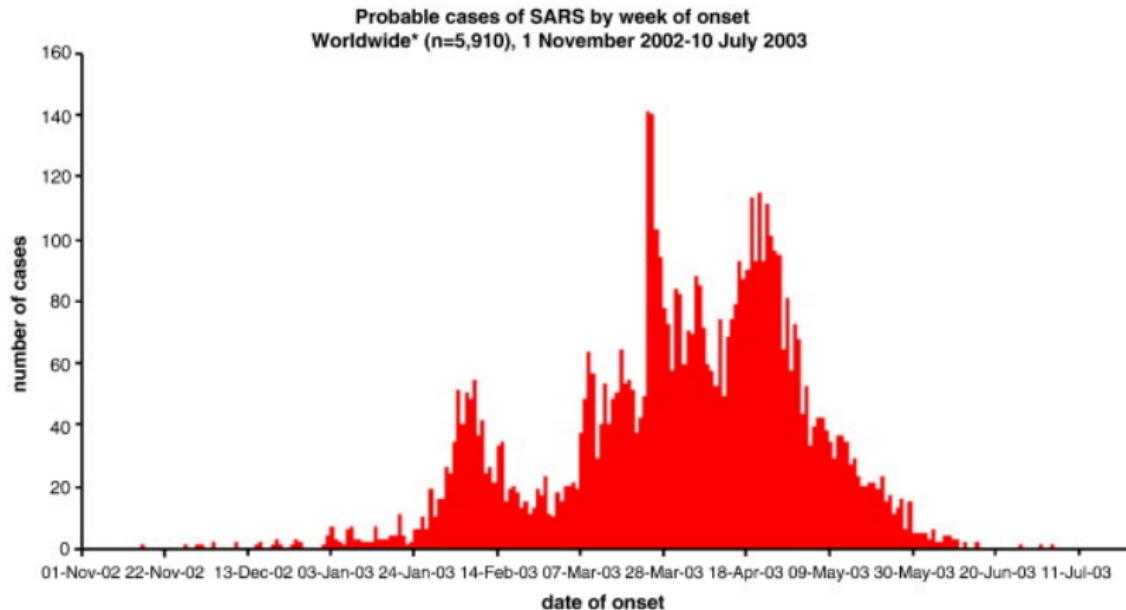
- *Date:* Monday 11 March 2019
- *Time:* 9:30am–11:20am
- *Location:* Hamilton Hall 410

P&I Mortality, Philadelphia, 1918

P&I Deaths

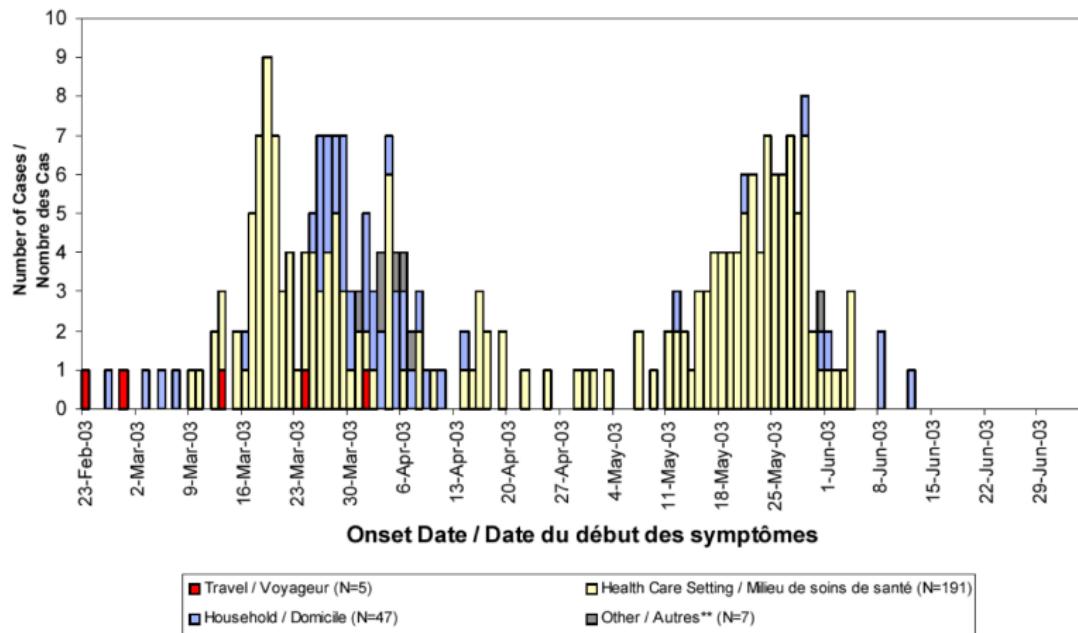


SARS in 2003 (Worldwide)



*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)

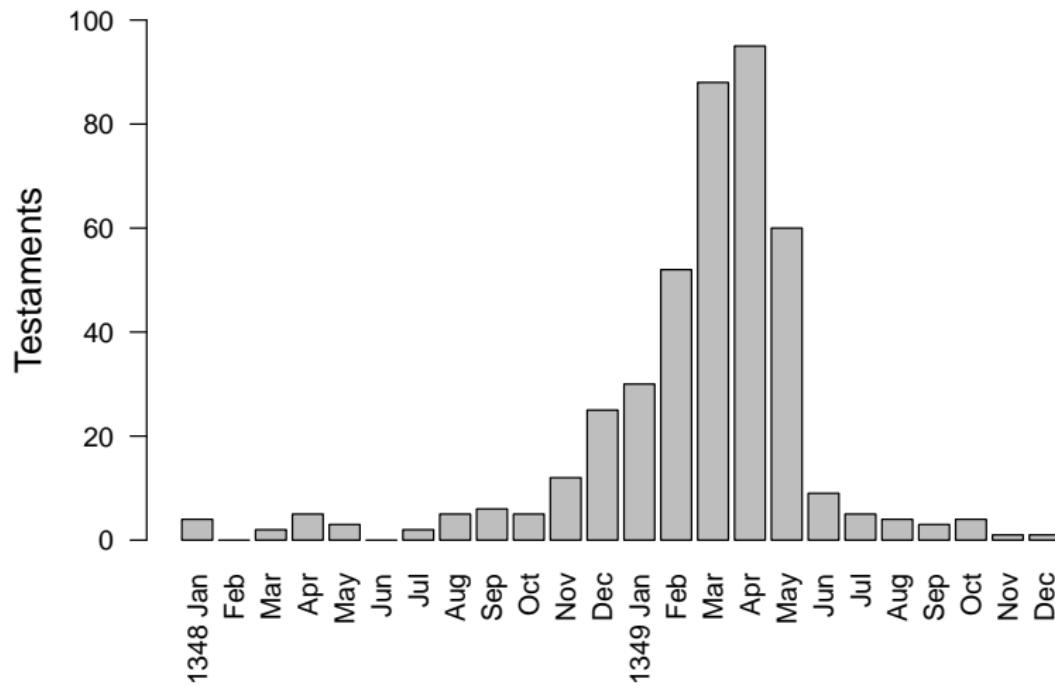


$N = 249$ (of 250 reported)

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,



Bortive	1
Aged	6
Ague	50
Apoxyxie	1
Chilblains	42
Chirfomes	11
Cold	1
Consumption	99
Convallion	63
Cough	1
Dropyle	22
Drown'd at St. Martin in the Fields	1
Feaver	268
Fiftula	2
Flor and Small-pox	4
Flux	1
Found dead in the Fields at St. Mary Iffington	1
Males	687
Christned Females	78
In all	146
Decreased in the Burials this Week	1837
Parishes clear of the Plague	7
Males	3212
Baried Females	3248
In all	6460
Plague— <u>5533</u>	

London 45		From the 26 of September to the 3 of October,		1665	
Bar. Reg.	Bar. Reg.	Bar. Reg.	Bar. Reg.	Bar. Reg.	Bar. Reg.
St. Leon Woodforne	16 15	St. George Bosophilene	1 1	St. Martin Ludgate	12 10
Albionnes Baring	40 34	St. George in St. Paul's	16 25	St. Martin Orgar	3 3
Albionnes Gresse	41 41	St. James Duke place	27 23	St. Martin Outwich	6 5
Albionnes Hoyslane	7 17	St. James Garlickhitche	16 13	St. Martin Vintry	44 44
Albionnes Little	3 17	St. John Bow	11 10	St. Michael Fridayes	4 4
Albionnes Newgate	3 17	St. John Evangelist	10 10	St. Michael Oldhorne	4 4
Albionnes the Wal	33 28	St. Katharine Coleman	20 9	St. Michael Buffawen	10 7
S'w'lings	13 5	St. Katharine Creechard	14 29	St. Michael Cornhill	4 3
S' Andrew Hubbard	16 44	St. Lawrence Jewry	5 5	St. Michael Coneytane	15 12
S' Andrew Undershaft	20 44	St. Lawrence Jewney	14 10	St. Michael Queenhithe	25 23
S' Andrew Werches	18 22	St. Mary Aldermary	16 33	St. Michael Querne	4 3
S' Benner Blackfriars	57 30	St. Mary Aldermanbury	4 4	St. Michael Royal	10 9
S' Benner Fenchurch	7 4	St. Mary Billinge	5 3	St. Michael Woudborne	6 3
S' Benner Paribis	7 4	St. Mary Bow	7 6	St. Michael Brendford	4 4
S' Benner Parish	13 24	St. Mary Colechurch	1 1	St. Nicholas Acon	4 2
S' Benner Exchange	7 2	St. Mary Newgate	13 3	St. Nicholas Coleholy	2 2
S' Benner Fyneke	2 2	St. Mary Abchurch	1 1	St. Nicholas Olaves	9 8
S' Benner Gracechurch	4 2	St. Mary Aldermanbury	14 4	St. Olave Hartfurd	13 14
S' Benner Paulwharf	15 7	St. Mary Aldermanury	4 4	St. Olave Jewry	7 4
S' Benner Shereches	2 11	St. Mary Woolchurche	7 5	St. Olave Newfiche	4 4
S' Benner Southwark	8 8	St. Mary le Bow	1 1	St. Pancras Soperiane	1 1
S' Benner Billinge	14 59	St. Mary le Bow	6 6	St. Peter Cheape	1 1
S' Benner Cateches	8 8	St. Mary le Bow	1 1	St. Peter Cornhill	6 6
S' Benner Fenchurch	9 2	St. Mary Magdalene	1 1	St. Peter Paulwharf	10 10
S' Benner East	18 24	St. Mary Somerses	4 4	St. Peter Pover	1 1
S' Benner Lambreth	3 1	St. Mary Savynge	5 5	St. Steven Colemanfie	33 28
S' Benner Chichechur	7 4	St. Mary Woolchurche	7 7	St. Steven Walbrook	3 2
S' Faith	8 6	St. Mary Woolnoth	7 5	St. Thomas Aquin	6 5
S' Foster	8 6	St. Martin Irenaeus	2 2	St. Thomas Ariss	10 9
S' Gabriel Fenchurch	3 3	St. Martin Irenaeus	2 2	Trinity Parish	10 9
Certified in the 16 Parishes without the Wall—		39 Buried	1149 Plague	948	
S' Andrew Holborn	173 151	S' Bowbly Aldgate	371 338	Sextons Southwark	364 352
S' Bartholomew Graue	157 151	S' Bowbly Billinge	333 121	S' Sepulchre Parish	117 95
S' Bartholomew Le	7 75	S' Bowbly Well	59 59	S' Thomas Southwark	40 20
S' Bridge	92 67	S' George Southwark	140 153	Trinity Minotors	24 24
S' Bowbly Prencipal	33 23	S' Gilre Crispologe	196 200	At the Pelehouse	8 8
S' Bowbly Alderger	71 64	S' Olave Southwark	378 201		
Certified in the 16 Parishes without the Wall—		35 Buried, and in the 22 others—	2258 Plague	1912	
S' Caius in the Barde	95 78	Lambeth Parish	49 39	S' Mary Allington	35 31
S' Hosten Parish	14 12	S' Leonard Shoreditch	95 91	S' Mary Whitemarsh	38 30
S' James Clerkenwe	48 48	S' Margarete Remyndene	138 106	Rochdale Parish	21 18
S' Kath. near the Tower	153 99	S' Mary Newington	81 81	Soppy Parish	67 63
Certified in the 12 Parishes in Middlesex and Surr		40 Buried	1623 Plague	1469	
S' Clement Danes	13 8 10	S' Martin in the fields	109 143	S' Margaret Wellmifne	309 297
S' Paul Covenard	15 84 4	S' Mary Savoy	119 16	Verrey in the Petham	4 4
Certified in the 5 Parishes in the City and Liberties of Wellmifne		18 Buried	620 Plague	590	

Mortality Bills are typically handwritten

But handwriting is usually very clear

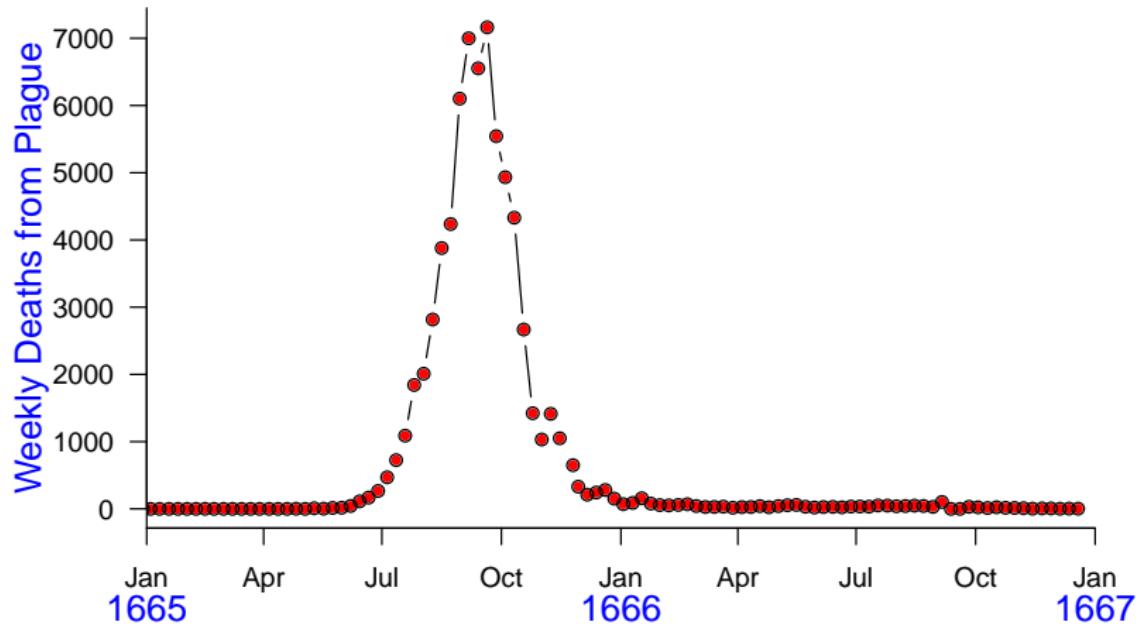
A historical ledger page from London, dated 29th [unclear]. The page is divided into columns for location, burials, and plague cases.

Location	Buried	Plag.
St Alban Woodstreet	2	1
Alhallows Bark-	2	
Alhallows Breadstreet	1	
Alhallows Great	1	

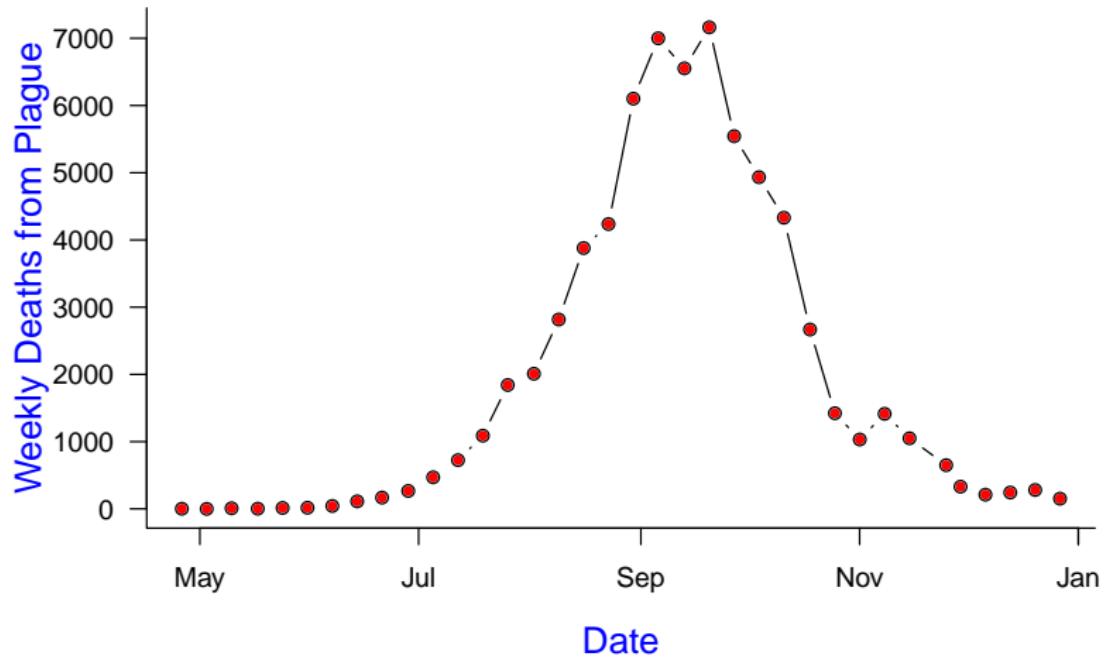
But handwriting is usually very clear

St Christopher's —————— Christened in 971 the Parishes :		
St Andrew Holborn ——————	66	40
St Bartholomew Great	+	+
St Bartholomew Less ——————		
St Bridget ——————	24	14
Bridewell Precept ——————	1	1
Christened in the 16 Parishes :		

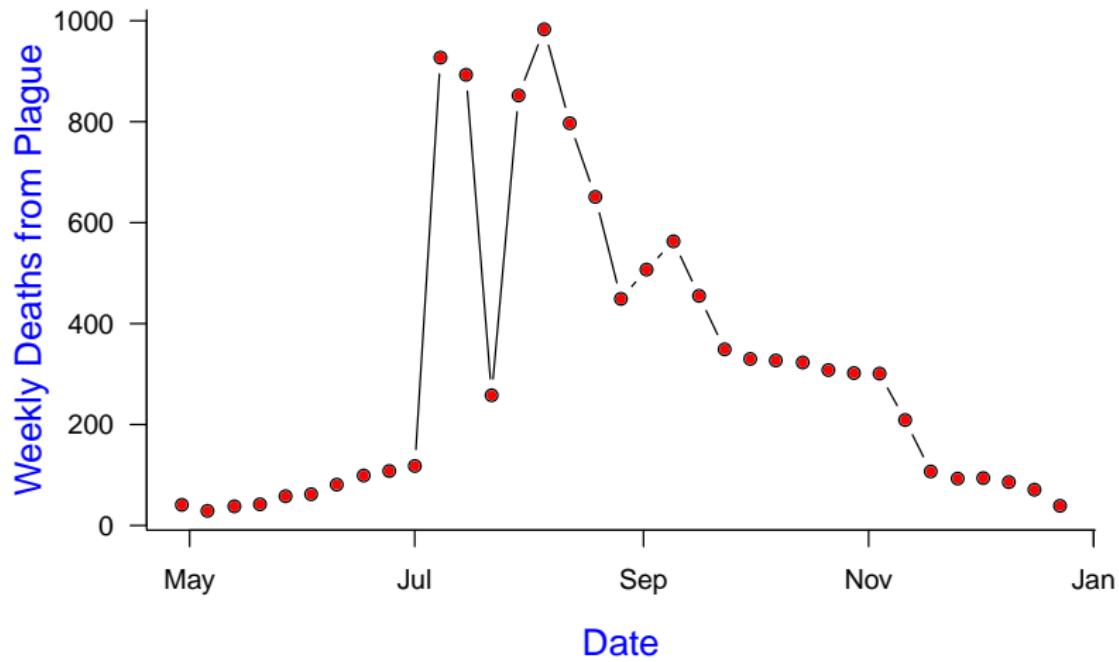
The Great Plague of London, 1665



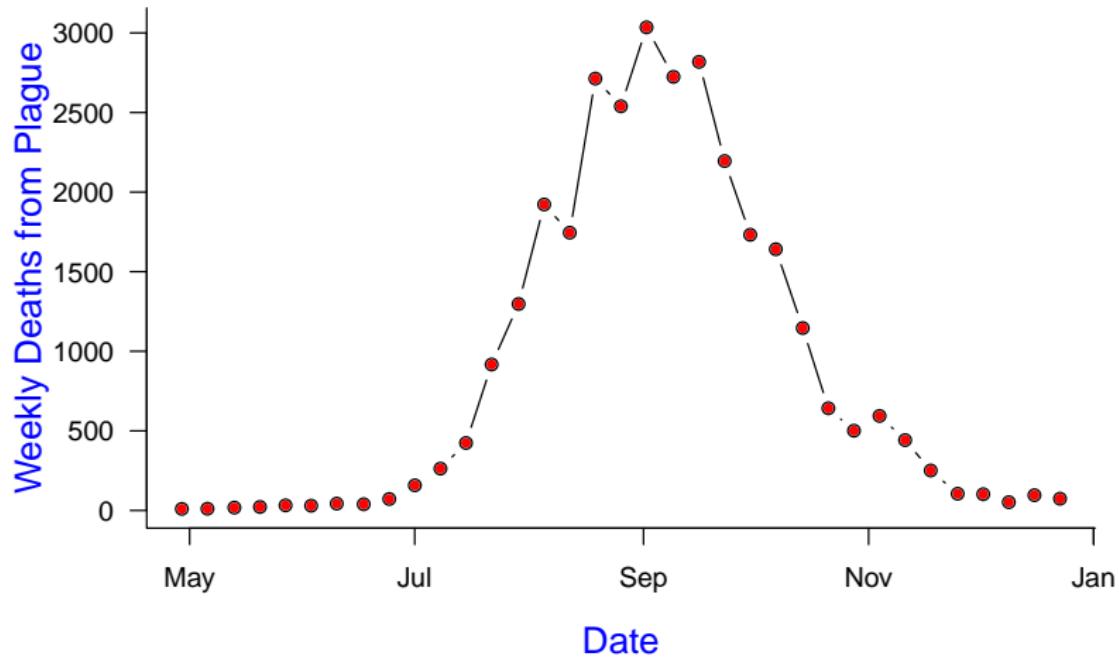
The Great Plague of London, 1665



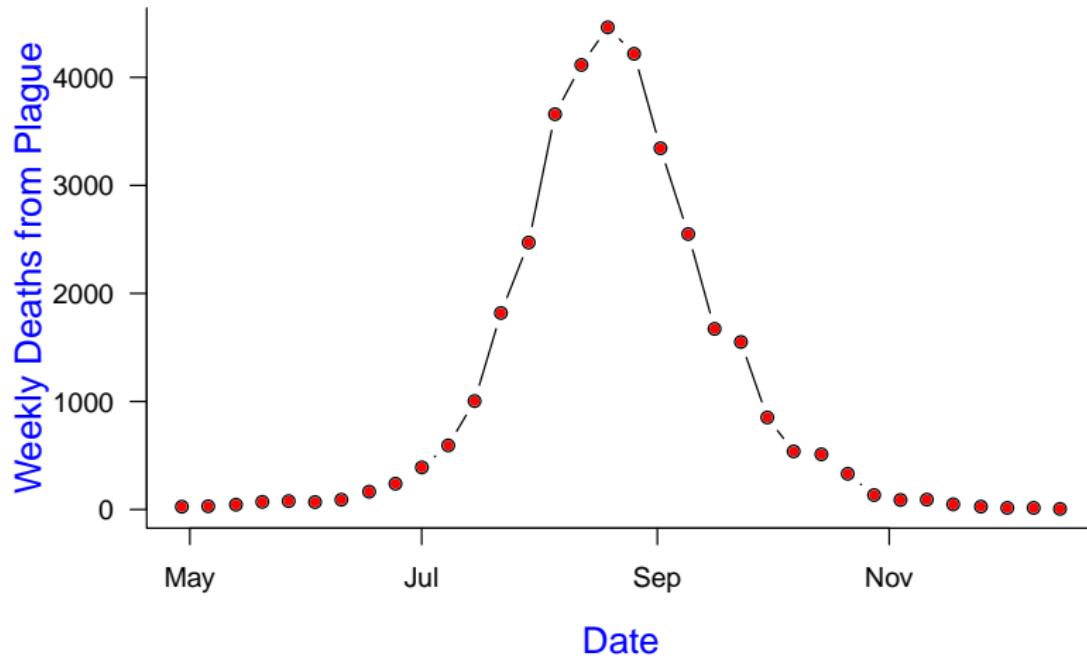
London Plague of 1593



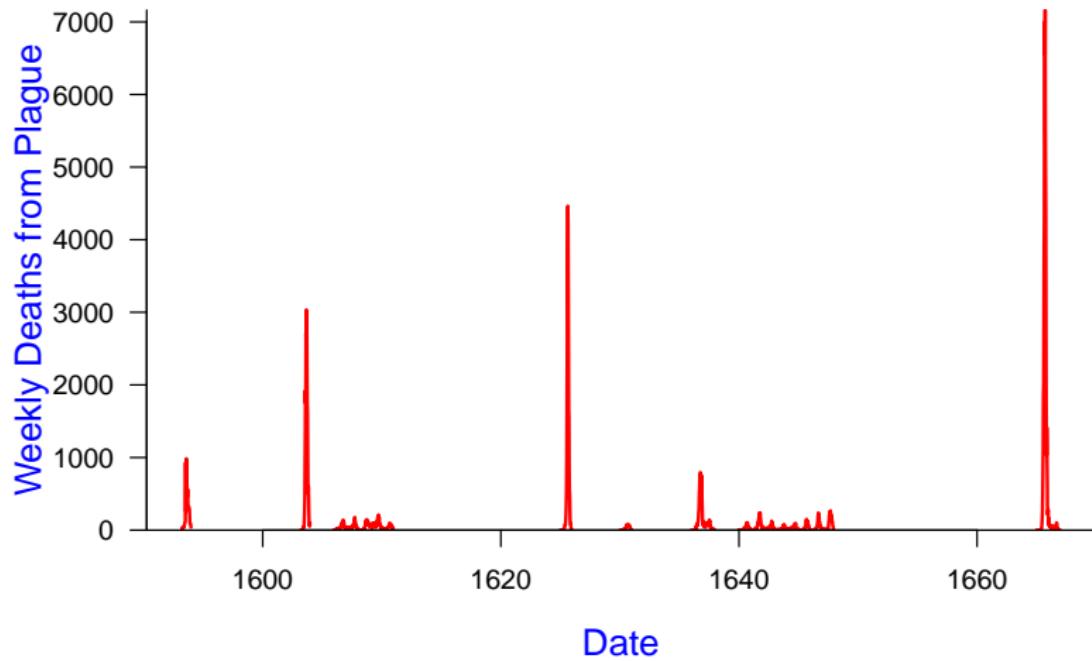
London Plague of 1603



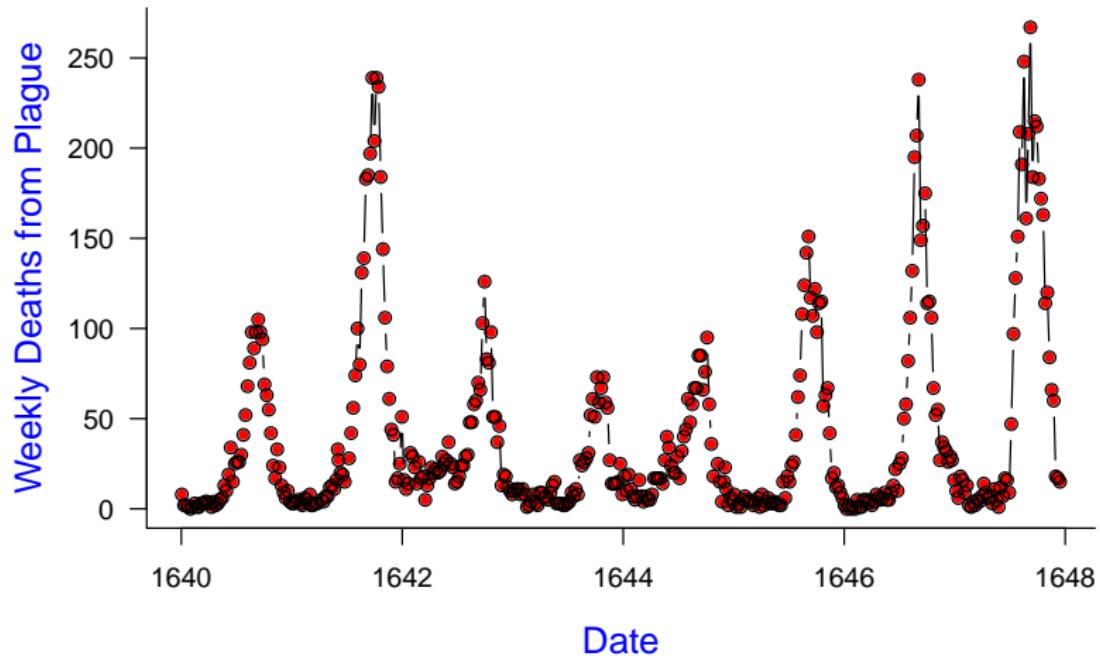
London Plague of 1625



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](http://www.cbc.ca/natureofthings/episodes/secrets-in-the-bones-the-hunt-for-the-black-death-killer)