

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
Wednesday 24 January 2018

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:**

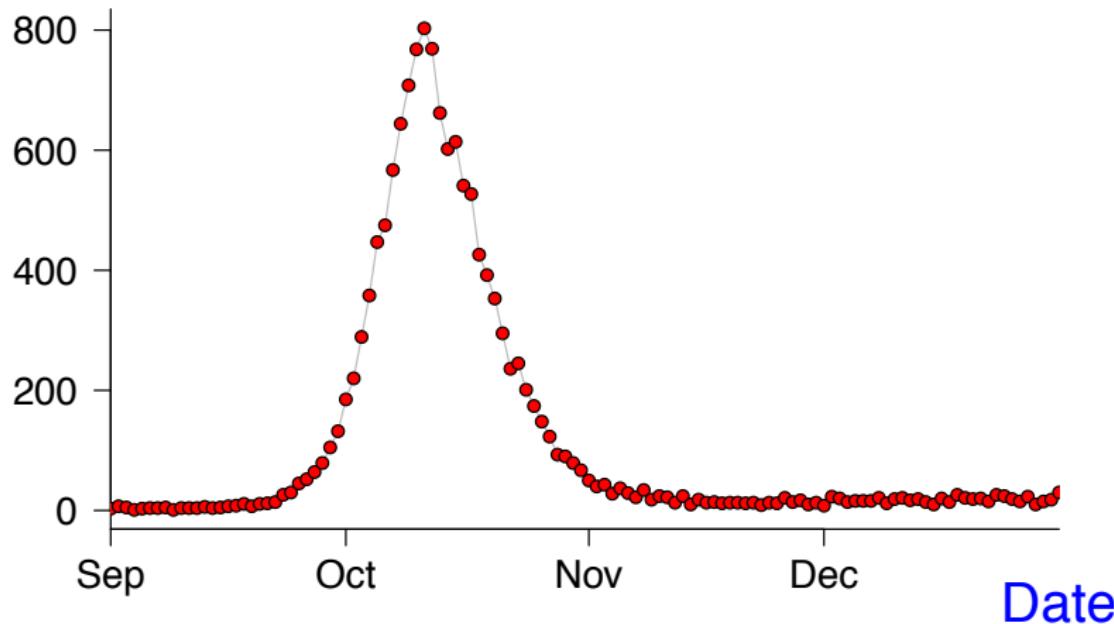
Due Monday 5 February 2018 in class (and by e-mail) at 11:30am.

- **Midterm test:**

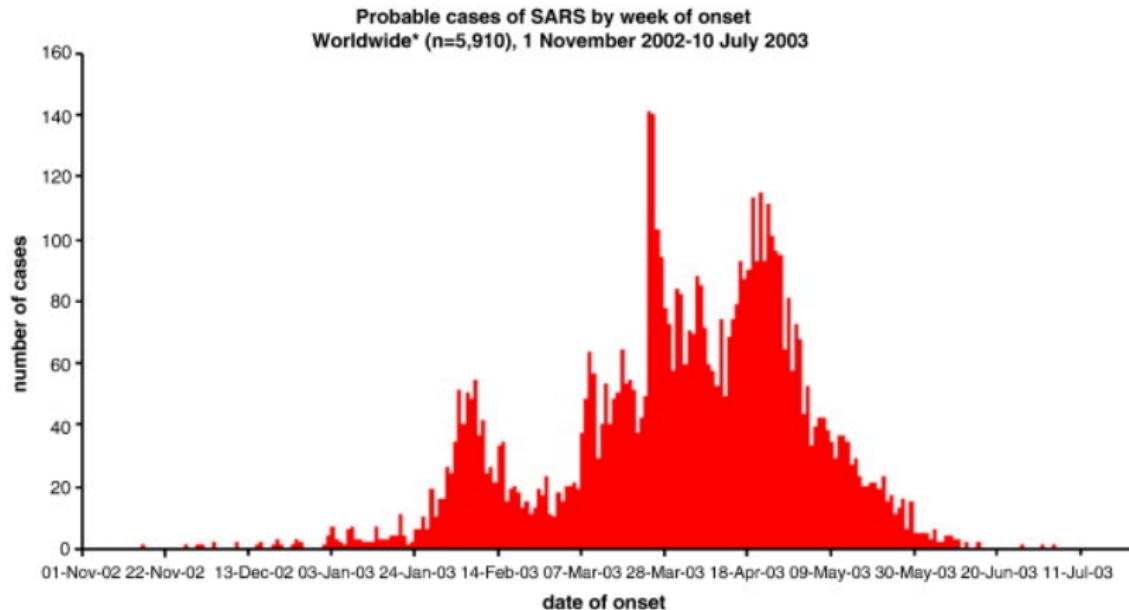
- *Date:* week of 5–9 March? or 12–16 March?
- *Time:* TBA
- *Location:* TBA

P&I Mortality, Philadelphia, 1918

P&I Deaths

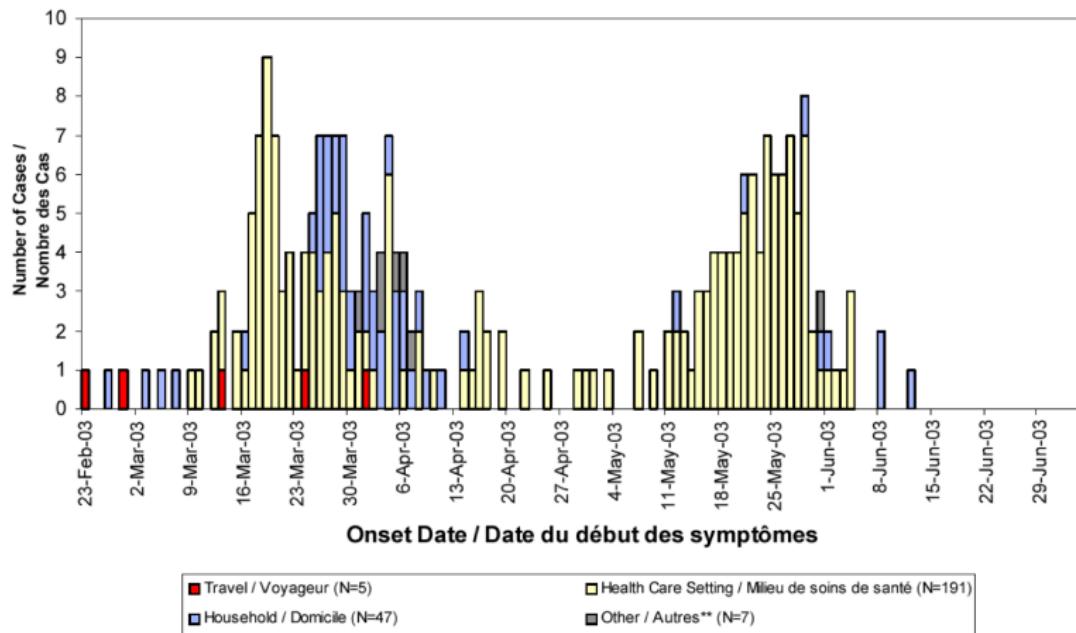


SARS in 2003 (Worldwide)



*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)

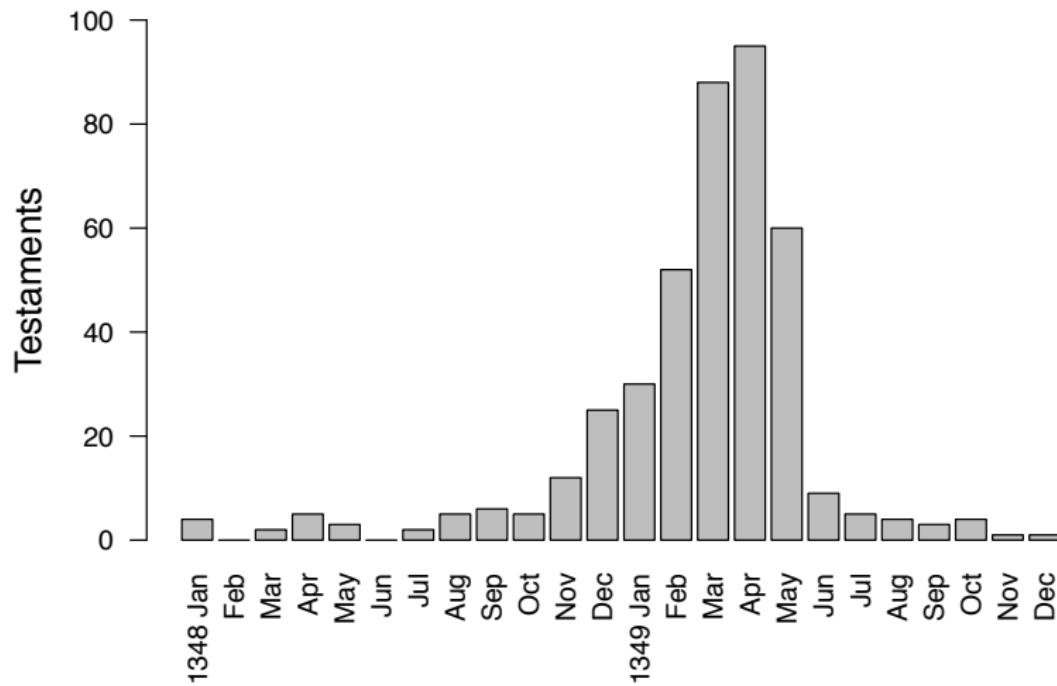


$N = 249$ (of 250 reported)

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	6
Aged	50
Ague	1
Apoxyxie	2
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. Alban Woodlaine	16 15	St. George Bosophilane	16 1	St. Martin Ludgate	12 10
Albionnes Baring	40 34	St. George in St. Paul's	16 6	St. Martin Orgar	3 3
Albionnes Chichester	41 41	St. James Duke place	27 23	St. Martin Outwich	6 5
Albionnes Hoyleane	7 17	St. James Garlickhitche	16 13	St. Martin Vintry	44 44
Albionnes Little	3 17	St. John Bowie	11 10	St. Michael Fridayes	4 4
Albionnes Newgate	3 17	St. John Evangelist	12 9	St. Michael Oldham	4 4
Albionnes the Wal	33 28	St. Katharine Coleman	20 12	St. Michael Buffawne	10 7
S'w'chings	13 5	St. Katharine Creechard	14 29	St. Michael Cornhill	4 3
S'w' Andrew Hubbard	16 44	St. Lawrence Jewry	5 5	St. Michael Coneylane	15 12
S'w' Andrew Mercer	20 44	St. Mary Abbatelane	14 10	St. Michael Queenhithe	25 23
S'w' Andrew Werderle	18 22	St. Mary Aldermanbury	16 33	St. Michael Querne	4 3
S'w' Ann Blackfriars	57 30	St. Mary Fotheringay	5 4	St. Michael Royal	10 9
S'w' Antholme Parfis	7 4	Margrave Parfis	5 3	St. Michael Woodlaine	6 3
S'w' Antholme Parfis	11 10	St. Margrete Lothbury	7 6	St. Michael Brendene	4 4
S'w' Antholme Parfis	13 10	St. Margrete Mofes	1 1	St. Nicholas Acon	4 2
S'w' Antholme Parfis	13 10	St. Margrete Newgate	18 13	St. Nicholas Colehale	2 2
S'w' Benet Fynche	12 7	St. Mary Abbatelane	12 12	St. Nicholas Olaves	9 8
S'w' Benet Gracechurch	4 2	St. Mary Abchurch	12 12	St. Olave Hartfurd	1 1
S'w' Benet Paulwharf	15 7	St. Mary Aldermanbury	14 14	St. Olave Jewry	13 14
S'w' Benet Shereches	2 1	St. Mary Aldemary	4 4	St. Olave Newgate	7 4
S'w' Bonh' Billingh'z	8 8	St. Mary le Bow	1 1	St. Pancras Cripplegate	4 4
S'w' Chappel Chappel	44 59	St. Mary le Bow	6 6	St. Peter Cheape	1 1
S'w' Chappel Chappel	10 10	St. Mary Newgate	10 10	St. Peter Cornhill	6 6
S'w' Chappel Chappel	10 10	St. Mary Olde	10 10	St. Peter Paulwharf	10 10
S'w' Dianes Backborow	9 2	St. Mary Mounteane	4 4	St. Peter Poy	1 1
S'w' Danfus East	18 24	St. Mary Somersesse	4 4	St. Steven Colemanfie	33 28
S'w' Edmund Lumbreith	3 1	St. Mary Savynge	5 5	St. Steven Wallbrouke	3 2
S'w' Echelborow	7 4	St. Mary Woolchurche	7 7	St. Thomas Adelphie	6 5
S'w' Faith	8 6	St. Mary Woolnoth	7 7	St. Thomas Paule	10 9
S'w' Fister	8 6	St. Martin Irenaeengiane	2 2	Trinity Parfis	10 9
S'w' Gabriel Fincharch	3 3				
Confir'd in the 7 Parishes within the Wall	39	Buried	1149	Plague	948
St. Andrew Holborn	173 151	St. Bowbelle Aldgate	371 338	Sextuors Southwark	364 352
St. Bartholomew Graue	157 151	St. Bowbelle Billingsgate	353 121	S. Sepulchre Parfis	117 95
St. Bartholomew Leie	7 75	St. Dunstans Well	59 59	St. Thomas Southwark	40 20
St. Bridge	92 67	St. George Southwark	140 153	Trinity Minories	24 20
Brudewell Precentor	33 23	St. Giles Copelegene	196 200	At the Pethole	8 8
St. Boulph Alderigton	71 64	St. Olave Southwark	378 201		
St. Gabriel Fincharch	3 3				
Confir'd in the 16 Parishes without the Wall	45	Buried, and as the 7 Parishes	2258	Plague	1012
S'w' Cotes in the Brads	95 78	Lambeth Parfis	49 39	St. Mary Abbatelane	35 31
S'w' Gentry Parfis	14 12	St. Leonard Shoreditch	95 91	St. Mary Whitechapel	38 30
S'w' James Clerkenwe	48 48	St. Margarete Remyndene	128 106	Rochdale Parfis	21 18
S'w' Kath. near the Tower	153 99	St. Mary Newington	81 81	Soppy Parfis	67 63
Confir'd in the 12 Parishes in Middlesex and Surr	40	Buried	1623	Plague	1469
S'w' Clement Danes	13 8 10	St. Martin in the fields	209 143	St. Margaret Woffinbarrie	309 297
S'w' Paul Covenard	155 164	St. Mary Savoy	119 16	Verreyt at the Pethole	4 4
Confir'd in the 5 Parishes in the City and Liberties of Woffinbarrie	18	Buried	620	Plague	590

Mortality Bills are typically handwritten

London - 29. From the 4 th of July to the 11 th of this same 1665.									
Buried	Plag.	Buried	Plag.	Buried	Plag.	Buried	Plag.	Buried	Plag.
St Alban Woodstreet	2	St Clement Eastcheap	1	St Margaret Newfisht	1	St Michael Crookedla.	4		
Alhallows Bark-	2	St Dionys Backchurch	1	St Margareta Patrons	1	St Michael Queenhithe	4		
Alhallows Breadtree		St Dunstans East	2	St Mary Abchurch	1	St Michael Queen—	7		
Alhallows Great	1	St Edmund Lumbardist.	2	St Mary Aldermanbury		St Michael Royal—			
Alhallows Honilanc-		St Ethelborough	2	St Mary Aldermanary		St Michael Woodstreet			
Alhal ows Less	1	St Faiths	1	St Mary le Bow		St Mildred Breadtree			
Alhallows Lombardstr.		St Gabriel Fenchurch		St Mary Bothaw		St Mildred Poultrey			
Alhallows Staining	1	St George Borophalne		St Mary Colechurch		St Nicholas Acons			
Alhallows the Wall	4	St Gregories by St. Paul	3	St Mary Hill		St Nicholas Coleabby			
St Alphege	1	St Hellen	2	St Mary Mag. Milkstr.		St Olave Harttree			
St Andrew Hubbard		St James Dukes place	1	St Mary Mag. Oldfisht		St Olave Jewry			
St Andrew Underhaft	3	St James Garlickhithe	1	St Mary Mounthaw		St Olave Silverstreet	4	1	
St Andrew Wardrobe		St John Baptis		St Mary Summerse	2	St Pancras Soperlane			
St Anne Alderfaire	1	St John Evangelist		St Mary Staining		St Peter Cheap			
St Anne Blackfriers	7	St John Zichary		St Mary Woolchurch		St Peter Cornhil			
St Ancholies Parish		St Katharine Coleman	1	St Mary Woolnoth		St Peter Paulisharf			
St Aufins Parish	1	St Katharine Creechur.		St Martins Iremongerl.		St Peter Poor			
St Barthol. Exchange		St Lawrence Jewry		St Martins Ludgate	2	St Steven Colemanstr.	2		
St Benner Fynck		St Lawrence Pountney		St Martins Orgars		St Steven Walbrook			
St Benner Gracechurch	2	St Leonard Eastcheap		St Martins Outwich	1	St Swithin	2		
St Benner Paulisharf	7	St Leonard Fosterlane		St Martins Vintrey	1	St Thomas Apostle	1		
St Benner Sherehog		St Magnus Parish	1	St Matthew Frydaystr.		Trinity Parish			
St Boroloph Billinggate		St Margaret Lothbury		St Michael Balliflaw	5	St Vedast alias Fosters			
Christ Church		St Margaret Moses		St Michael Cornhil					
St Christopher	6								
<i>Christened in the 27 Parishes within the walls</i>									
				Buried		86	Plague		28
St Andrew Holborn	66	St Boroloph Aldergate	11	St George Southwark	13	4	St Sepulchres Parish	117	81
St Bartholomew Great	4	St Boroloph Aldgate	24	St Giles Cripplegate	103	47	St Thomas Southwark	7	5
St Bartholomew Less		St Boroloph Bishopgate	57	St Olave Southwark	20		Trinity Minories		
St Bridge	24	St Dunstan West	19	St Saviour Southwark	21	1	At the Pesthouse	6	6
Bridewell Preinct	1								
<i>Christened in the 15 Parishes without the walls</i>									
				Buried		473	Plague		273
Christ Church		St Kath.near the Tower	7	St Mary Islington	3	2	St Paul Shadwell		
St John at Hackney	1	Lambeth Parish	7	St Mary Newington	3		Rotherhithe Parish	7	3
St Giles in the Fields	268	St Leonard Shoredrich	21	St Mary Whitechappel	16	3	Stepney Parish	47	1
St James Clerkenwel	5	St Magdalen Bermond.	14						
				Buried		455	Plague		286

But handwriting is usually very clear

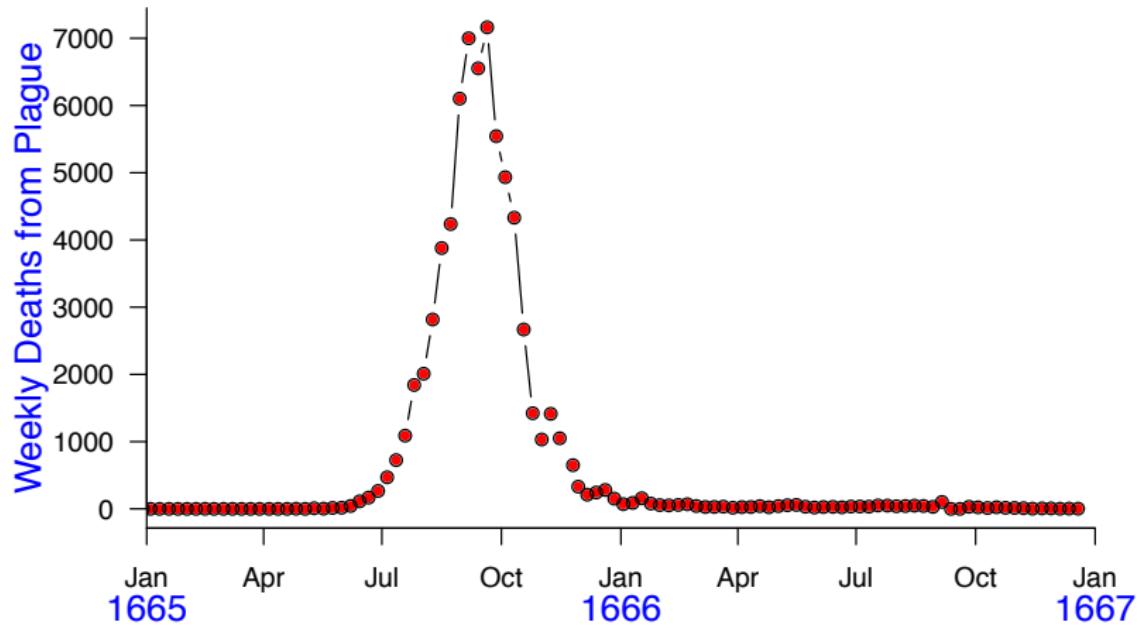
A historical ledger page from London, dated 29th [unclear]. The page is divided into columns for location, burials, and plague cases.

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

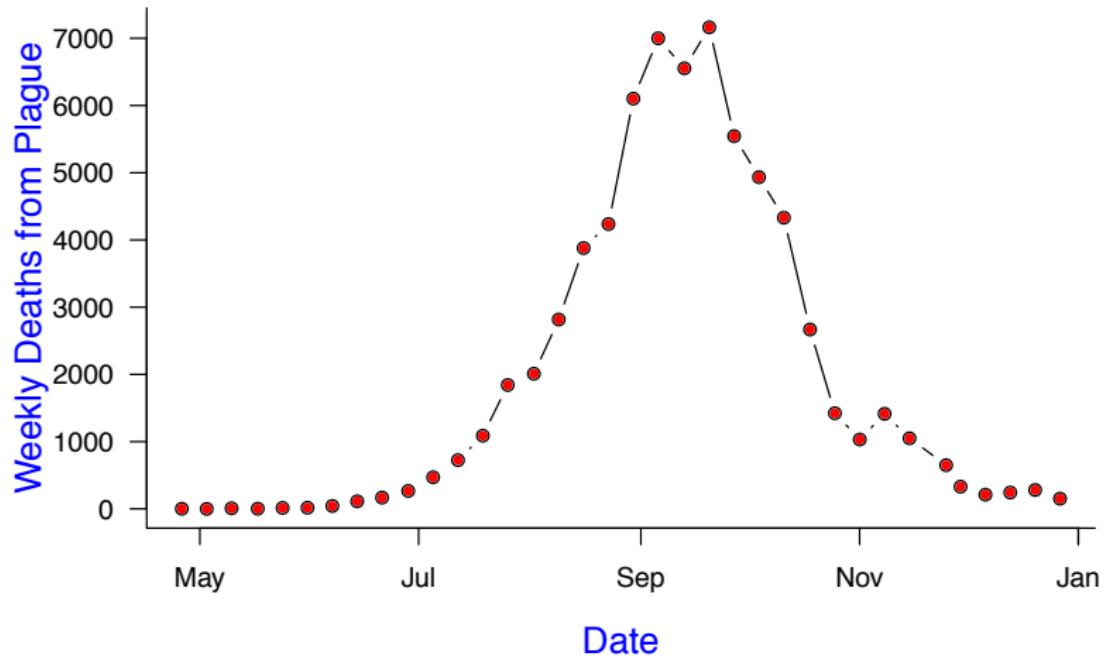
But handwriting is usually very clear

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

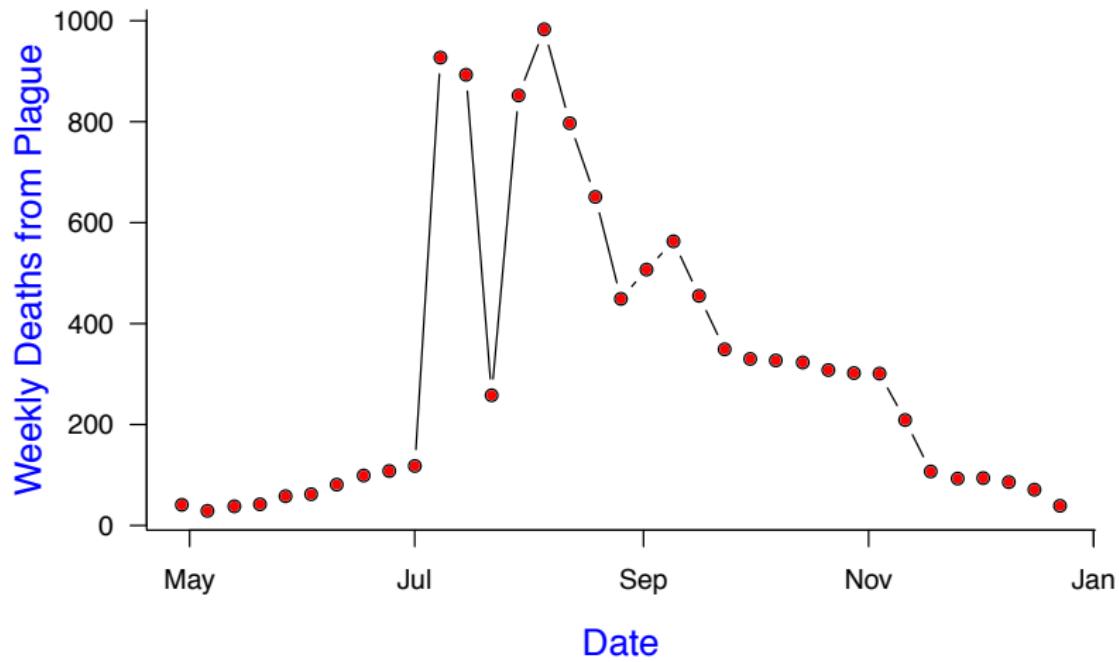
The Great Plague of London, 1665



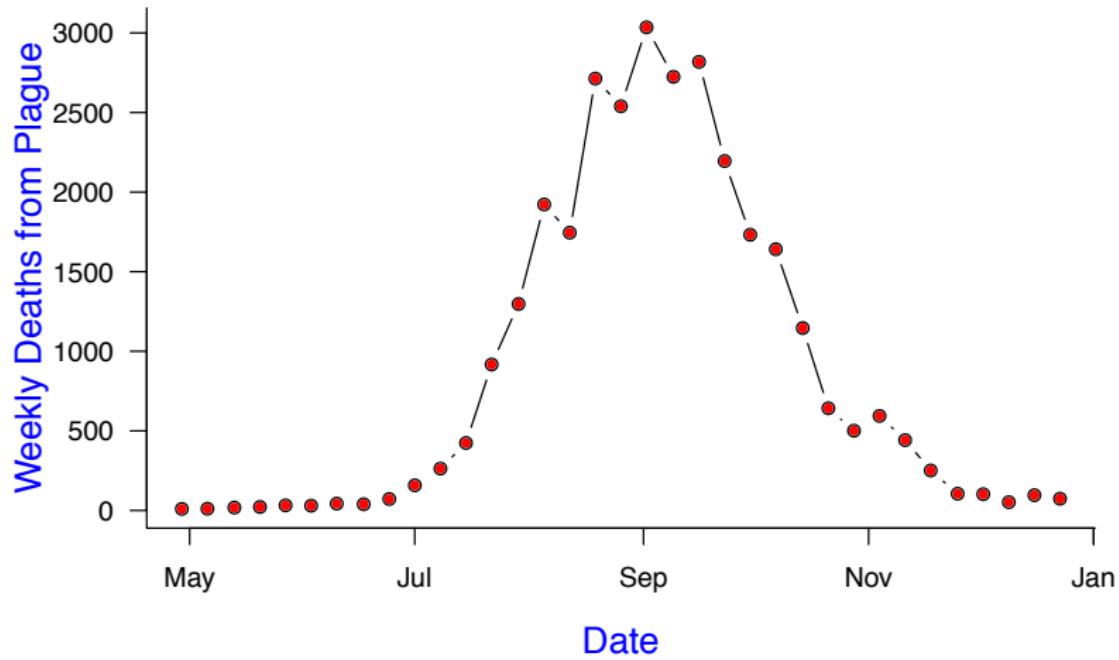
The Great Plague of London, 1665



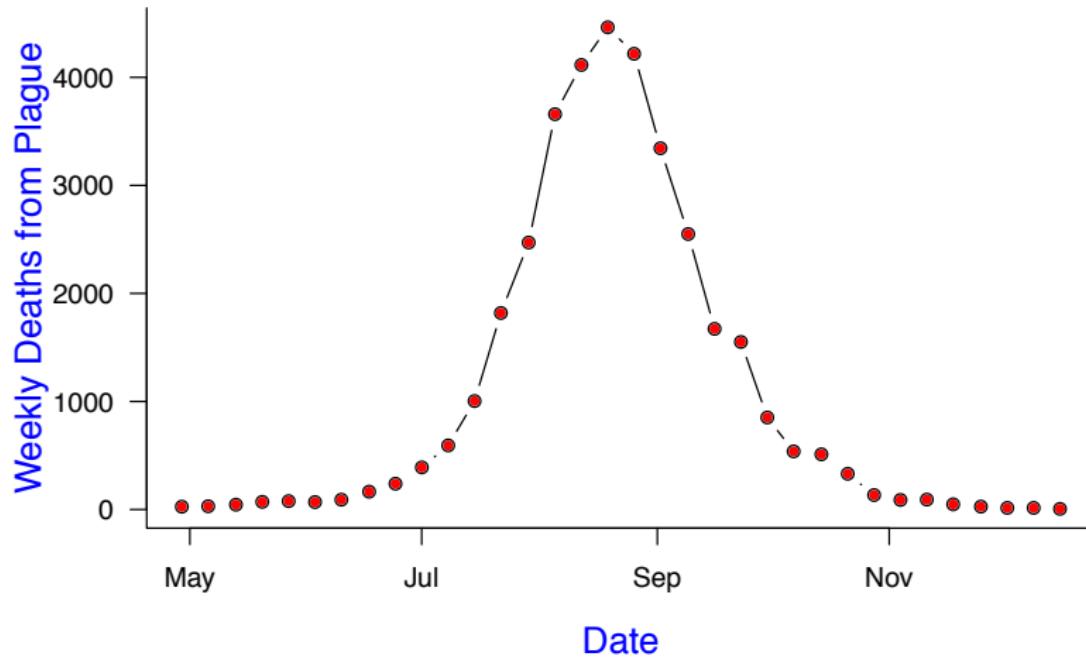
London Plague of 1593



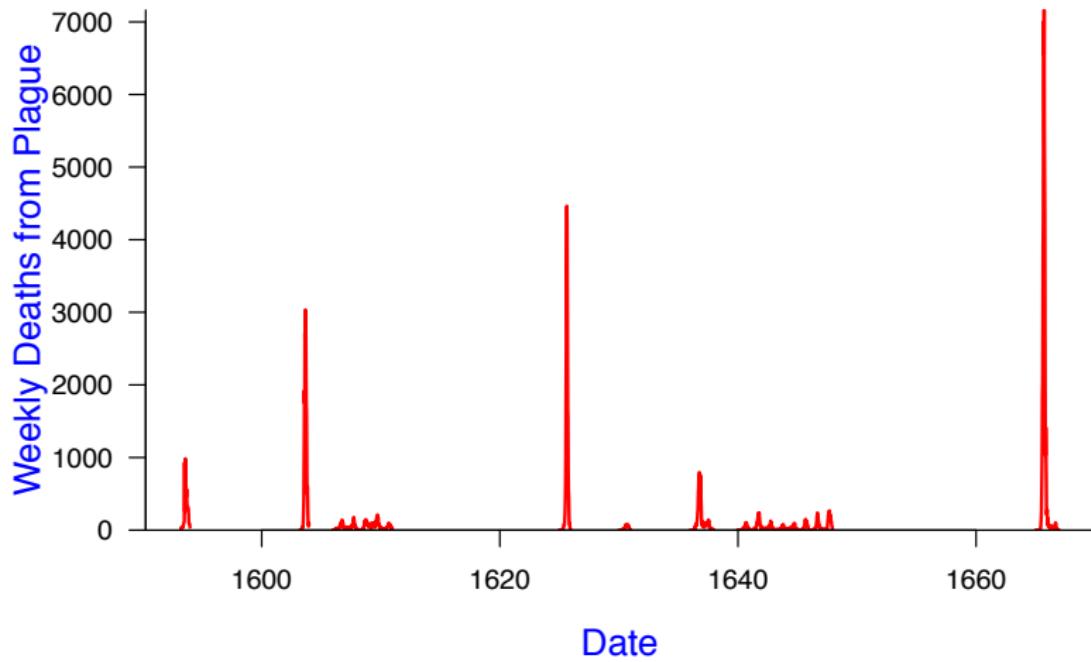
London Plague of 1603



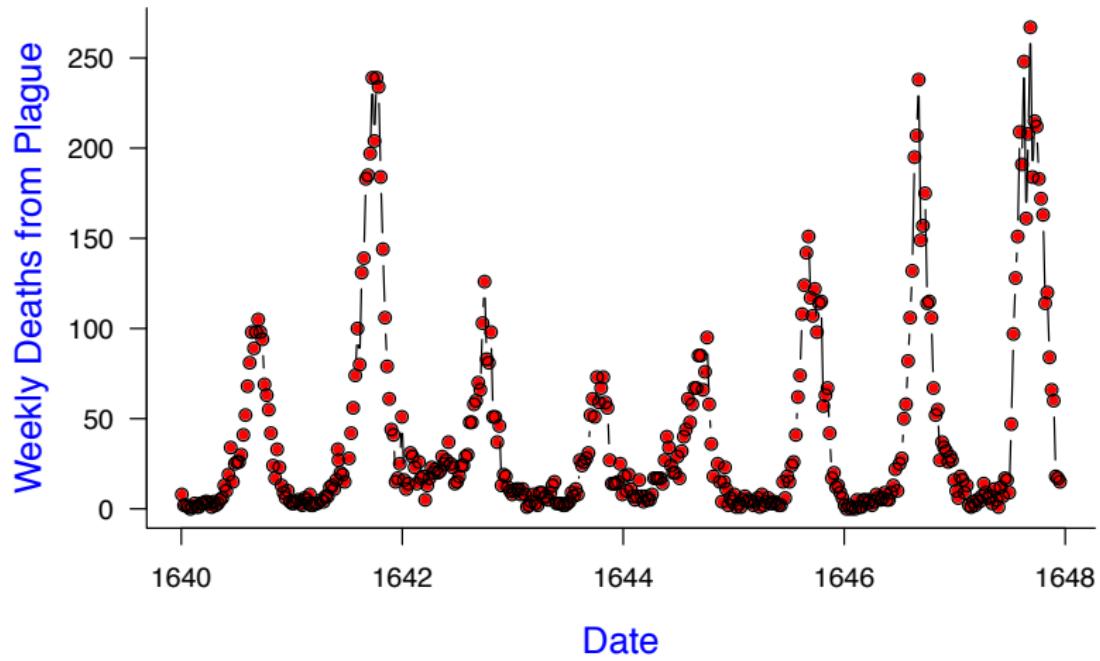
London Plague of 1625



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)