Researchers track and analyze smallpox epidemics over three centuries

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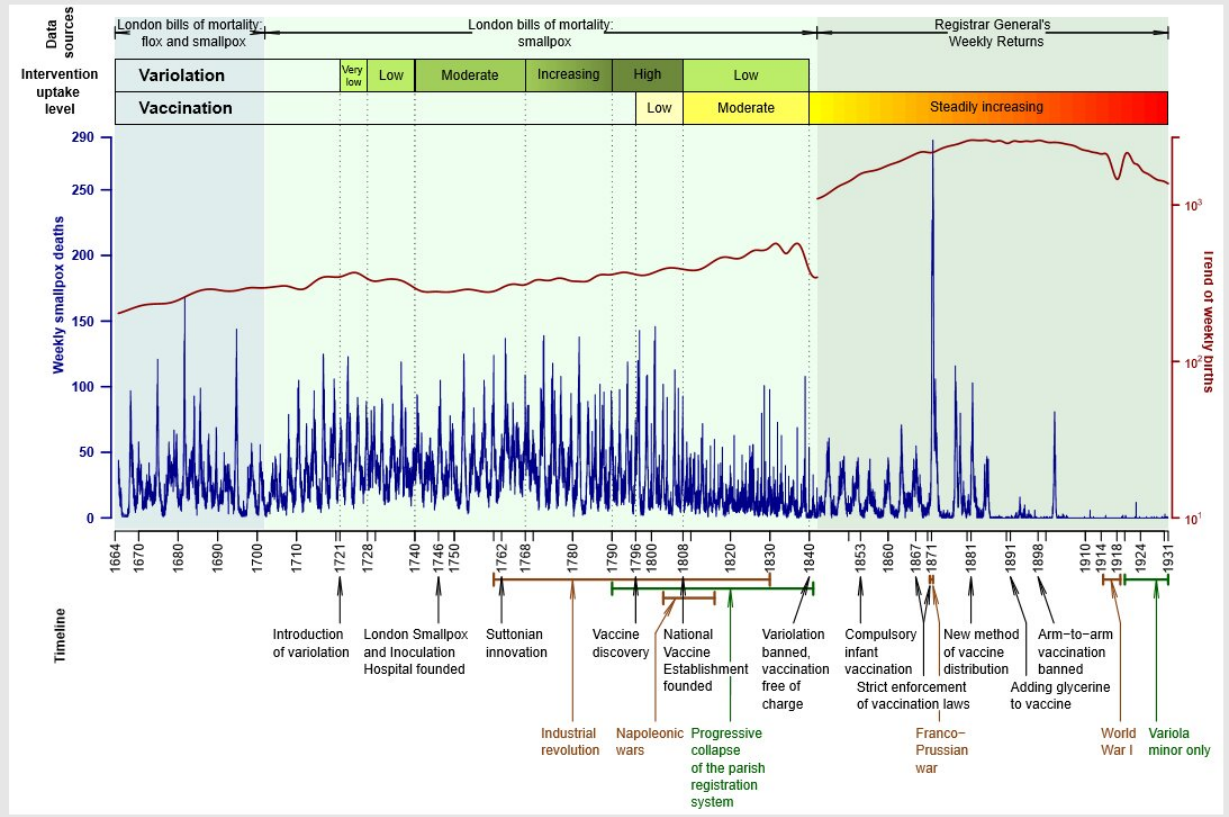


Smallpox deaths (blue) in London, England, 1664--1930, and the long-term trend of weekly births (red). Credit: Olga Krylova and David J.D. Earn

Researchers from McMaster University have studied and analyzed thousands of weekly records documenting the deaths of smallpox victims

in London, England over the span of nearly 300 years.

The analysis provides new and rare insights into the ecology of infectious disease, establishing that the time between epidemics, the size of the outbreaks, and even the season when the epidemics occurred, changed over the centuries.

Smallpox was one of the most devastating viral diseases ever to strike humankind, killing about three out of every 10 people who were infected. Those who survived were frequently left disabled, blind or disfigured. Until the 19th century, smallpox was thought to have accounted for more deaths than any other single infectious disease, even plague and cholera.

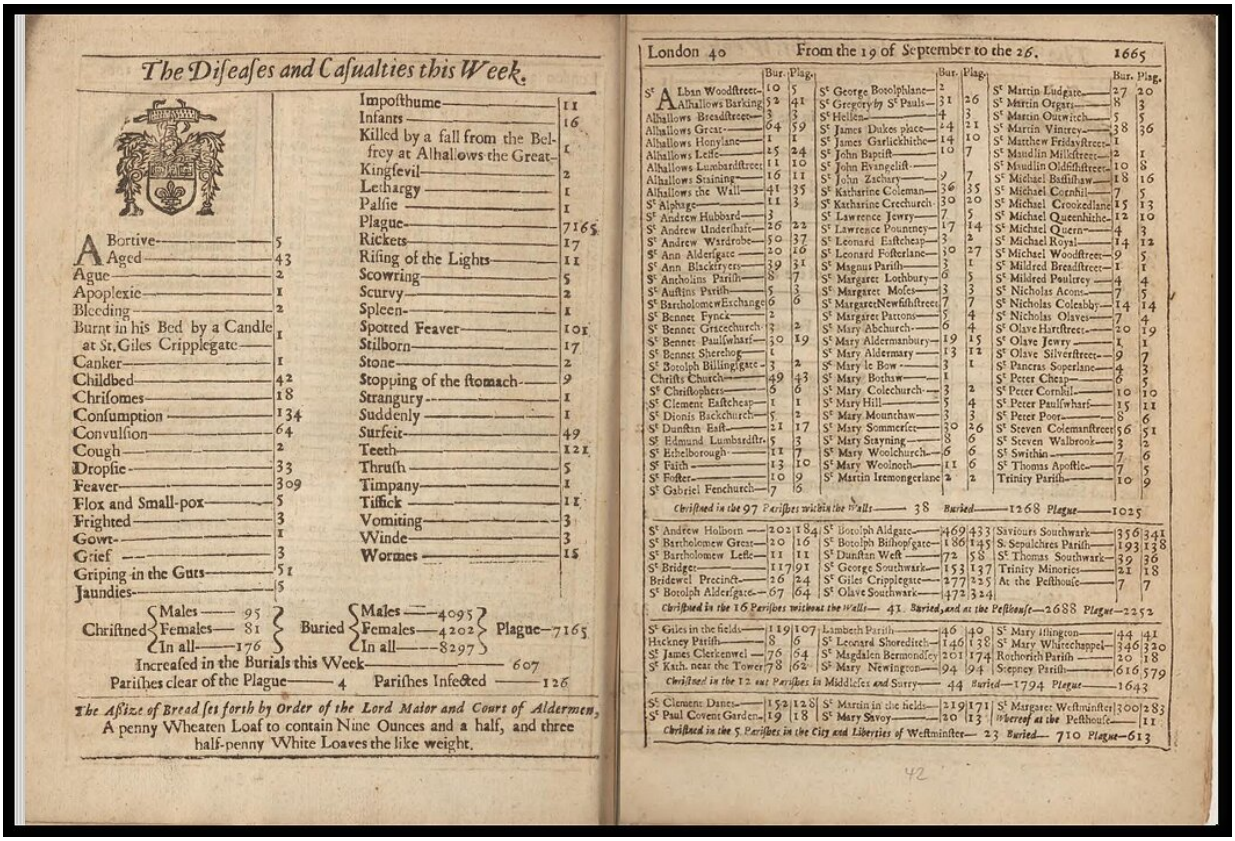
The World Health Organization recently celebrated the 40th anniversary of the eradication of smallpox, the most successful such campaign ever attempted. Smallpox is one of only two infectious diseases that have been wiped out by human efforts.

"The current COVID-19 pandemic has caused a surge of interest in the study of infectious disease transmission and how public health interventions could change the course of the pandemic," says author David Earn, a professor in the Department of Mathematics & Statistics at McMaster who specializes in modelling of infectious disease transmission.

"Our goal was to describe and make publicly available the weekly time series of smallpox mortality in London and to identify historical events that might have influenced smallpox dynamics over the centuries," he says.

For the analysis, outlined in the journal *PLOS Biology*, Earn and colleague Olga Krylova, studied and digitized more than 13,000 weekly

smallpox mortality records published in the London Bills of Mortality and the Registrar General's Weekly Returns from 1664 to 1930.



The Diseases and Casualties this Week.

Abortive	5	Impostume	11
Aged	43	Infants	16
Ague	2	Killed by a fall from the Belfrey at Alhallows the Great	1
Apoplexie	1	Kingsevil	2
Bleeding	2	Lethargy	1
Burnt in his Bed by a Candle at St. Giles Cripplegate	1	Palsie	1
Canker	1	Plague	7165
Childbed	42	Rickets	17
Chrisomes	18	Rising of the Lights	11
Consumption	134	Scowring	5
Convulsion	64	Scurvy	2
Cough	2	Spleen	1
Dropsie	33	Spotted Feaver	101
Feaver	309	Stillborn	17
Flox and Small-pox	5	Stone	2
Frighted	3	Stopping of the stomach	9
Gowt	1	Strangury	1
Grief	3	Suddenly	1
Griping in the Guts	51	Surfeit	49
Jaundies	5	Teeth	121
		Thrush	5
		Timpany	1
		Tiffick	11
		Vomiting	3
		Winde	3
		Wormes	15

Christned: Males 95, Females 81, In all 176 — Buried: Males 4095, Females 4202, In all 8297 — Plague 7165

Increased in the Burials this Week 607

Parishes clear of the Plague 4 — Parishes Infected 126

The Assize of Bread set forth by Order of the Lord Major 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 40 — From the 19 of September to the 26. — 1665

	Bur.	Plag.
S^t Alban Woodstreet	10	5
Alhallows Barking	52	41
Alhallows Breadstreet	3	3
Alhallows Great	64	59
Alhallows Honylane	1	1
Alhallows Lesse	25	24
Alhallows Lumbardstreet	11	10
Alhallows Staining	16	11
Alhallows the Wall	41	35
S^t Alphage	11	3
S^t Andrew Hubbard	3	
S^t Andrew Undershaft	26	22
S^t Andrew Wardrobe	50	37
S^t Ann Aldersgate	20	16
S^t Ann Blackfryers	39	31
S^t Ancholins Parish	8	7
S^t Austins Parish	5	3
S^t Bartholomew Exchange	6	6
S^t Bennet Fynck	2	
S^t Bennet Gracechurch	3	2
S^t Bennet Paulswharf	30	19
S^t Bennet Sherehog	1	
S^t Botolph Billingsgate	3	2
Christs Church	49	43
S^t Christophers	6	6
S^t Clement Eastcheap	1	1
S^t Dionis Backchurch	5	2
S^t Dunstan East	21	17
S^t Edmund Lumbardstr.	5	3
S^t Ethelborough	11	7
S^t Faith	13	10
S^t Foster	10	9
S^t Gabriel Fenchurch	7	6
S^t George Botolphlane	2	
S^t Gregory by S^t Pauls	31	26
S^t Hellen	4	3
S^t James Dukes place	24	21
S^t James Garlickhithe	14	10
S^t John Baptist	10	7
S^t John Evangelist	9	7
S^t John Zachary	36	35
S^t Katharine Coleman	30	20
S^t Katharine Crechurch	7	5
S^t Lawrence Jewry	17	14
S^t Lawrence Pountney	3	2
S^t Leonard Eastcheap	30	27
S^t Leonard Fosterlane	3	1
S^t Magnus Parish	6	5
S^t Margaret Lothbury	3	3
S^t Margaret Moses	7	7
S^t Margaret Newfishstreet	5	4
S^t Margaret Pattens	6	4
S^t Mary Abchurch	19	15
S^t Mary Aldermanbury	13	12
S^t Mary Aldermary	3	1
S^t Mary le Bow	1	
S^t Mary Bothaw	3	2
S^t Mary Colechurch	5	4
S^t Mary Hill	3	3
S^t Mary Mountshaw	30	26
S^t Mary Sommerset	8	6
S^t Mary Stayning	6	6
S^t Mary Woolchurch	11	6
S^t Mary Woolnoth	2	2
S^t Martin Iremongerlane		
S^t Martin Ludgate	27	20
S^t Martin Organ	8	3
S^t Martin Ostwitch	5	5
S^t Martin Vintrey	38	36
S^t Matthew Fridaystreet	1	
S^t Maudlin Milkstreet	2	1
S^t Maudlin Oldfishstreet	10	8
S^t Michael Bassishaw	18	16
S^t Michael Cornhil	7	5
S^t Michael Crookedlane	15	13
S^t Michael Queenhithe	12	10
S^t Michel Quern	4	3
S^t Michael Royal	14	12
S^t Michael Woodstreet	9	5
S^t Mildred Breadstreet	1	1
S^t Mildred Poultrey	4	4
S^t Nicholas Acons	7	5
S^t Nicholas Coleabby	14	14
S^t Nicholas Olaves	7	4
S^t Olave Hartstreet	20	19
S^t Olave Jewry	1	1
S^t Olave Silverstreet	9	7
S^t Pancras Soperlane	4	3
S^t Peter Cheap	6	5
S^t Peter Cornhil	10	10
S^t Peter Paulswharf	15	11
S^t Peter Poor	8	6
S^t Steven Colemanstreet	56	51
S^t Steven Walbrook	3	2
S^t Swithin	7	6
S^t Thomas Apostle	7	5
Trinity Parish	10	9

Christned in the 97 Parishes within the Walls — 38 — *Buried* — 1268 — *Plague* — 1025

S^t Andrew Holborn	202	184	S^t Botolph Aldgate	469	433
S^t Bartholomew Great	20	16	S^t Botolph Bishopsgate	186	145
S^t Bartholomew Lesse	11	11	S^t Dunstan West	72	58
S^t Bridget	117	91	S^t George Southwark	153	137
Bridewel Precinct	26	24	S^t Giles Cripplegate	277	235
S^t Botolph Aldersgate	67	64	S^t Olave Southwark	472	324

Christned in the 16 Parishes without the Walls — 43 — *Buried, and at the Pesthouse* — 2688 — *Plague* — 2252

S^t Giles in the fields	119	107	Lambeth Parish	46	40
Hackney Parish	8	6	S^t Leonard Shoreditch	146	138
S^t James Clerkenwel	76	64	S^t Magdalen Bermondsey	201	174
S^t Kath. near the Tower	78	62	S^t Mary Newington	94	94

Christned in the 12 out Parishes in Middlesex and Surry — 44 — *Buried* — 1794 — *Plague* — 1643

S^t Clements Danes	152	128	S^t Martin in the fields	219	171
S^t Paul Covent Garden	19	18	S^t Mary Savoy	20	13

Christned in the 5 Parishes in the City and Liberties of Westminster — 23 — *Buried* — 710 — *Plague* — 613

S^t Margaret Westminster	300	283
Whereof at the Pesthouse		11

Burials by cause for the week ending 26 September 1665, during the GreatPlague of London. Five deaths from "Flox and Small-pox" are listed. Credit: Public Domain Review, publicdomainreview.org/collection/londons-dreadful-visitation-bills-of-mortality

The data span an era starting before any public health practices were in place, then the introduction of variolation (a procedure that involved deliberately infecting a healthy individual with smallpox virus taken from a pustule or dried scab of a person suffering from the disease), then the discovery of a vaccine, and finally the decline of smallpox

mortality until the final smallpox death was recorded in London.

Some scientists have suggested recently that "variolation" with COVID-19 might be occurring as a beneficial side-effect of the use of masks.

"During the time period covered by the data, smallpox changed from a terrifying and unavoidable danger to an easily preventable infection. Introduction of better control measures, especially vaccination, naturally led to decreased smallpox mortality and eventually eradication," says Earn.

During the 267 years under analysis, London underwent major demographic and social changes, and there were a variety of historical events that may have had substantial impacts on smallpox dynamics.

"It is clear that the introduction of smallpox control measures—variolation and later vaccination—made eradication possible. Our analysis also suggests that greater use of control measures and changes in public health policies were correlated with changes in the frequency of the epidemics", says co-author Olga Krylova, a former Ph.D. student in the Department of Mathematics & Statistics at McMaster.

Other events that could potentially have impacted smallpox epidemics include wars and the Industrial Revolution, which was accompanied by urbanization and demographic transitions.

"Further research using mathematical models is needed to quantify the impacts of interventions and historical events on the smallpox outbreaks", says Krylova.

More information: Krylova O, Earn DJD (2020) Patterns of smallpox

mortality in London, England, over three centuries. *PLoS Biol* 18(12): e3000506. doi.org/10.1371/journal.pbio.3000506