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Epidemiology's 350th Anniversary: 1662–2012

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Abstract

Between 1600 and 1700, sudden, profound, and multifarious changes occurred in philosophy, science, medicine, politics, and society. In an extremely convulsed century, these profound and convergent upheavals produced the equivalent of a cultural big bang, which opened a new domain of knowledge acquisition based on population thinking and group comparisons. In 1662, when John Graunt applied—for the first time—the new approach to the analysis of causes of death in London, he gave epidemiology a singular date of birth. This was exactly 350 years ago.

Is epidemiology really exactly 350 years old? You may ask: only 350 years? What about Hippocrates, the "father of epidemiology" who lived 2500 years ago? Or you may skeptically observe that epidemiology cannot be that old because John Snow, the "founder of epidemiology," was born only 200 years ago. You may also wonder whether the origins of any scientific discipline can be captured by a single birth date. Does physics, biology, or mathematics *have* a birth date? Is not epidemiology, such as these other sciences, the result of a historical process with well-defined milestones?

I cannot discuss how physics, biology, or mathematics was born, but epidemiology has a characteristic that differentiates it neatly from these other sciences: its mode of knowledge acquisition requires the prior existence of a concept of "population." Without an understanding that populations are more than aggregates of individuals, the comparison of groups of people makes no sense. And without group comparisons, there is no epidemiology.

Many aspects of human intelligence and medicine's ambitions have conspired against the emergence of population thinking. First, population thinking is not intuitive: it is not immediately obvious why the study of populations gives access to knowledge that is inaccessible from the study of individuals. This is in contrast with the trial-and-error approaches of Archimedes or Galileo, which make much more intuitive sense. Second, until recently, doctors were not attracted by population thinking. For most of recorded history, they have aspired to understand and treat individual patients on the basis of exact knowledge. To aggregate information from individual patients inevitably means the loss of some distinguishing information because no two persons get sick in exactly the same way for exactly the same reasons.

As a matter of fact, historians have not yet identified a doctor of antiquity or the Middle Ages, in Asia or in Europe, who grouped patients to obtain supraindividual information,

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even though many of those doctors made eminent contributions to the evolution of the clinical sciences. For 4000 years, from the emergence of physicians until well into the 19th century, all civilized medical systems shared an approach to health and disease that can be characterized as holistic. This “antique” holistic medicine, to differentiate it from its modern revivals, considered health to be the result of a complex equilibrium between the human body and the constitution of a geographical area, that is, almost everything in the universe.[1] The symptoms of a patient were viewed as a result of a specific imbalance in this complex equilibrium. Doctors used all they knew about their patients to characterize this imbalance, and eventually to propose ways to correct it. In modern terms, this would be equivalent to explaining a patient’s symptom (eg, abdominal pain) based on innumerable factors (eg, season, phase of the moon, personal temperament, wind direction) and all their multiway interactions. Holistic medicine focused on individuals and was incompatible with epidemiology. This was the case even in its most rational, nonreligious forms, such as Hippocratic medicine.[2,3] Hence, at least until the 17th century, medicine did not use a concept of “exposure” (contextual factors were viewed as increasing a person’s susceptibility to certain types of symptoms, but not as direct causes of symptoms) or a concept of “disease” that would stand out as the common diagnosis of a group of patients. Each patient was different.

The term antique holistic medicine is not derogatory. On the contrary, antique holistic doctors aspired to a personalized medicine that we continue to strive for today. It was in fact a humble retreat from these high goals—an acceptance of our ignorance of the exact determinants of individual health—that shook the foundations of the entrenched holistic–individualistic approach and ultimately gave birth to epidemiology.

Historically, epidemiology did not emerge progressively. It existed in 1662, but not in 1661. Epidemiology sprang from a singular event triggered by simultaneous and profound movements away from holism in several spheres of philosophy, science, medicine, and society. These movements were concentrated in a few decades of the 17th century and powerfully converged in 1662, exactly 350 years ago. Let us review the components of this explosive mixture of social and intellectual ferment leading to 1662.

CRISIS OF THE 17TH CENTURY AND THE PLAGUE

The first feature of the 17th century relevant to the emergence of epidemiology is the availability of population data about causes of death, in particular deaths from plague. The 17th century was an especially troubled time in Europe.[4] A severe economic recession had produced famines, misery, sicknesses, and epidemics. There were terrible, complicated wars, including the Thirty Years’ War. There were many social and political revolutions. Most failed, yet the Spanish Empire collapsed, and, during the English Civil War, King Charles I was beheaded. To reign in political instability, states began to assume political and military prerogatives that had previously belonged to local powers. However, these emerging absolutist states faced a major obstacle: plague.

After the Black Death of 1348 to 1350, outbreaks of plague recurred in Europe with increasingly tight periodicity between the 14th and the 17th centuries.[5] These outbreaks became extremely disruptive to both political and economic life. Wealthy people, politicians, magistrates, and even doctors fled cities with each return of the plague. Soldiers were likewise securely sheltered in the countryside. Administrative and political institutions were paralyzed, with no authorities to quell rioting and looting.

The kings of England attempted to reduce the chaos that accompanied each outbreak of plague by monitoring the plague’s progress. The Church of England was mandated to install a surveillance system for plague deaths at the level of local parishes. These first health-related population data were the famous London Bills of Mortality.[6] Elderly women, sometimes assisted by surgeons, identified cases by investigating the houses where deaths had occurred.[7] This information was routed by the local parish clerk to the clerk of London, where it was printed and sold on a weekly basis. Thus, when those who were financially able to move out of London read in the Bills that plague deaths had seized the poor parishes, they could organize an ordered retreat, hopefully limiting the extent of the mayhem.

The Bills of Mortality played a decisive role in the birth of epidemiology because they became available for analysis as a series of health data collected in a relatively similar way, on a weekly basis, over several decades since 1603.

NEW IDEAS IN PHILOSOPHY, SCIENCE, AND MEDICINE

The second relevant feature of the 17th century was a simultaneous blossoming of fresh ideas in philosophy, science, and medicine, leading to new concepts of “exposure” and of “disease,” and a drive away from the complexity of holistic thinking. The new worldview was compatible with population thinking and group comparisons.

A modern concept of exposure was formulated by Francis Bacon. In his health research agenda designed to prolong human life, he encouraged investigating the role of determinants that epidemiologists still study today: height and weight, date of birth, food, diet, behavior, exercise, housing, heredity, and medical treatments.[8]

Thomas Sydenham,[9](p.92) meanwhile, made a decisive contribution to a concept of outcome. In the signs and symptoms shared by different sick people, he saw the manifestation of generic “diseases” with characteristic natural histories. Patients with the same disease could then be grouped and compared.

In addition, the drive toward simplification was best expressed by René Descartes in 1646.[10] He proposed an approach to science and knowledge, now known as reductionism, that abruptly parted ways with the complexity of ancient holism. Descartes’ central idea was to simplify working hypotheses, consider one factor at a time, ignore interactions, and rely on evidence rather than speculations.

In the holistic approach, a multiplicity of interacting causes divided populations into individuals. In the reductionist approach, individuals could be grouped according to a shared disease or a shared exposure, and then compared. Reductionism focused on one exposure and one outcome, as well as, eventually, sets of confounders.

Today, the qualifier “holistic” has positive connotations whereas the qualifier “reductionist” does not, especially in the context of medicine. Holistic medicine considers the complaints of the “entire” (*holos* in Greek) person, whereas reductionist medicine focuses on a symptom or on a diseased organ. However, medicine was holistic for 4000 years before it became reductionist. Reductionism was the indispensable step toward the implementation of group comparisons and, with it, the emergence of epidemiology.

OBSERVATIONS ON THE BILLS OF MORTALITY

The availability of population data and the development of a reductionist approach, combining Baconian and Cartesian ideas, created the conditions for the crucial step: the application of population thinking to health data.

John Graunt, a businessman admitted to the Royal Society, published a book in 1662 entitled *Natural and Political Observations Made Upon the Bills of Mortality.* In it, Graunt[11] summarized the analyses of 50 years of data extracted from the Bills of Mortality. The "political observations" mentioned in the title dealt with questions such as the size of the London population and the appropriateness of monogamy. The "natural observations" involved mortality from various causes and from the plague, in particular.

In his analysis of the Bills, Graunt literally had to start from scratch. To make sense of the 50 years of weekly bills, maybe 2500 sheets originating from "several great confused Volumes," he produced the first known tables of health data.[6] An example is shown in Figure 1. Figure 2 is a plot of some of Graunt's tabulated data. The shark-toothed evolution of plague deaths is quickly apparent to our modern minds. There were years with plague and others without. Some outbreaks were horrendous. In 1625 alone, Graunt computed that, after correction for misclassified plague deaths, the plague had killed 46,000 people—about 38,000 more than all other causes of death together.

However, this irregularity of plague outbreaks was what Graunt would have expected. He knew by experience that the plague had erratic behavior. What Graunt must have found much more surprising is a phenomenon that could not have been observed previously: the regularity of mortality from causes other than plague.

Imagine you are John Graunt. What would be your perception of the occurrence of death if you had never seen mortality statistics? Death on an individual level is haphazard and unpredictable. Why would death be regular and predictable on a population level? Even today, this question has no simple answer. Graunt may not have been able to explain it, but he was clearly fascinated by the predictable trends observed in his population data. He wrote,

> Among the several Casualties some bear a constant proportion unto the whole number of Burials; such are Chronical diseases, and the diseases, whereunto the City is most subject.[11 (II:19)]
>
> The Chronical Diseases shew the ordinary temper of the Place, so that upon the proportion of Chronical Diseases seems to hang the judgment of the fitness of the Country for long Life.[11 (II:15)]

The terminology is Baconian, but we are witnessing here the first report of observations derived from population health data. Graunt realized that some knowledge can be acquired only at the population level. Regularity of the causes of death during periods when London was free of epidemics provided a stable, "expected" number of deaths that he could then compare with the number observed during plague years. These comparisons also allowed him to identify outbreaks of specific causes of deaths, check the quality of the parish reports, and detect misclassifications of causes of death. Suddenly, Graunt had access to a feast of new information with which he jubilantly addressed an array of political and natural questions that had up to that time been unanswerable. This explains why, in Kenneth Rothman's words, "with this book Graunt added more to human knowledge than most of us can reasonably aspire to in a full career."[12]

Graunt's analyses gave him a clue to the origin of the plague. He observed that the irregularity of death rates distinguished the plague from the "chronical" causes of death. In 17th-century London, tuberculosis killed about 2000 people a year. Plague was different, it took 46,000 lives in 1625 and zero 4 years later. For Graunt, the contrast between the irregularity of plague deaths, which he described using deaths per week, and the regularity of the deaths from chronic diseases suggested that plague had an environmental origin:

> [T]he Contagion of the Plague depends more upon the Disposition of the Air, then upon the Effluvia from the Bodies of Men. Which also we prove by the sudden

> jumps, which the Plague hath made, leaping in one Week from 118 to 927: and back again from 993 to 258: and from thence again the very next Week to 852. The which effects must surely be rather attributed to change of the Air, then of the Constitution of Mens bodies. [11] (IV:11–12)

In Graunt's time, the Black Death was thought to have been provoked by a specific alignment of planets, and then transmitted by miasms (fetid gases) that emanated from the bodies of the sick and contaminated susceptible people who inhaled them. Hence, the habit of some doctors to fill long leather beaks with dry flowers and odoriferous plants, and place them under their nose when they attended plague patients (Figure 3). Graunt's analysis pointed to an environmental and fluctuating cause for the plague. Plague outbreaks were not synchronized with astrological (eg, specific planet alignments) or political (eg, coronations of kings) events.

IMPACT OF GRAUNT'S OBSERVATIONS

Graunt's book may have been a giant leap for epidemiology, but it was a much smaller step for society as a whole, at least in the short run. This work did not affect the practice of medicine or abolish beliefs in astrology. There are nonetheless several reasons to believe that this publication did not go unnoticed. First, the book sold well enough to justify several publications in the 17th century. Second, written in the aftermath of the Restoration of the English monarchy, the book was explicitly intended to help the government better manage societal and health-related questions. His conclusion was the following:

> That a clear knowledge of all these particulars, and many more, whereat I have shot but at rovers, is necessary in order to good, certain, and easie Government, and even to balance Parties, and factions both in Church and State. But whether the knowledge thereof be necessary to many, or fit for others, then the Sovereign, and his chief Ministers, I leave to consideration.[11] (last paragraph of The Conclusion)

Third, by a puzzling coincidence, the last great epidemic of London took place in 1665. Could the subsequent disappearance of the plague in any way be related to the publication of Graunt's book? For example, did Graunt's quantitative demonstration that plague outbreaks were apparently related to a fluctuating environmental factor stimulate public authorities to more rigorously control the traffic of boats and people coming from plague-ridden areas? Some historians have stressed the role of quarantine and cordons sanitaires after 1662 in the withdrawal of the plague from Europe,[13] but other theories involve a change in the rat population (rat fleas transmit the plague) or the replacement of wooden houses by brick ones, which more effectively separated humans from rats.[5,14]

Whatever its immediate consequences, the 1662 publication by Graunt combined population thinking and comparisons of population data across time, in an unprecedented fashion, and one that bears the unmistakable hallmarks of epidemiologic thinking. The book was the culmination of an extraordinary convergence of historical events, including strong political will; new ideas in philosophy, science, and medicine; and the availability of population health data that were necessary for epidemiology to emerge. A line of thought that had been literally inconceivable became suddenly compelling. This was 350 years ago.

Acknowledgments

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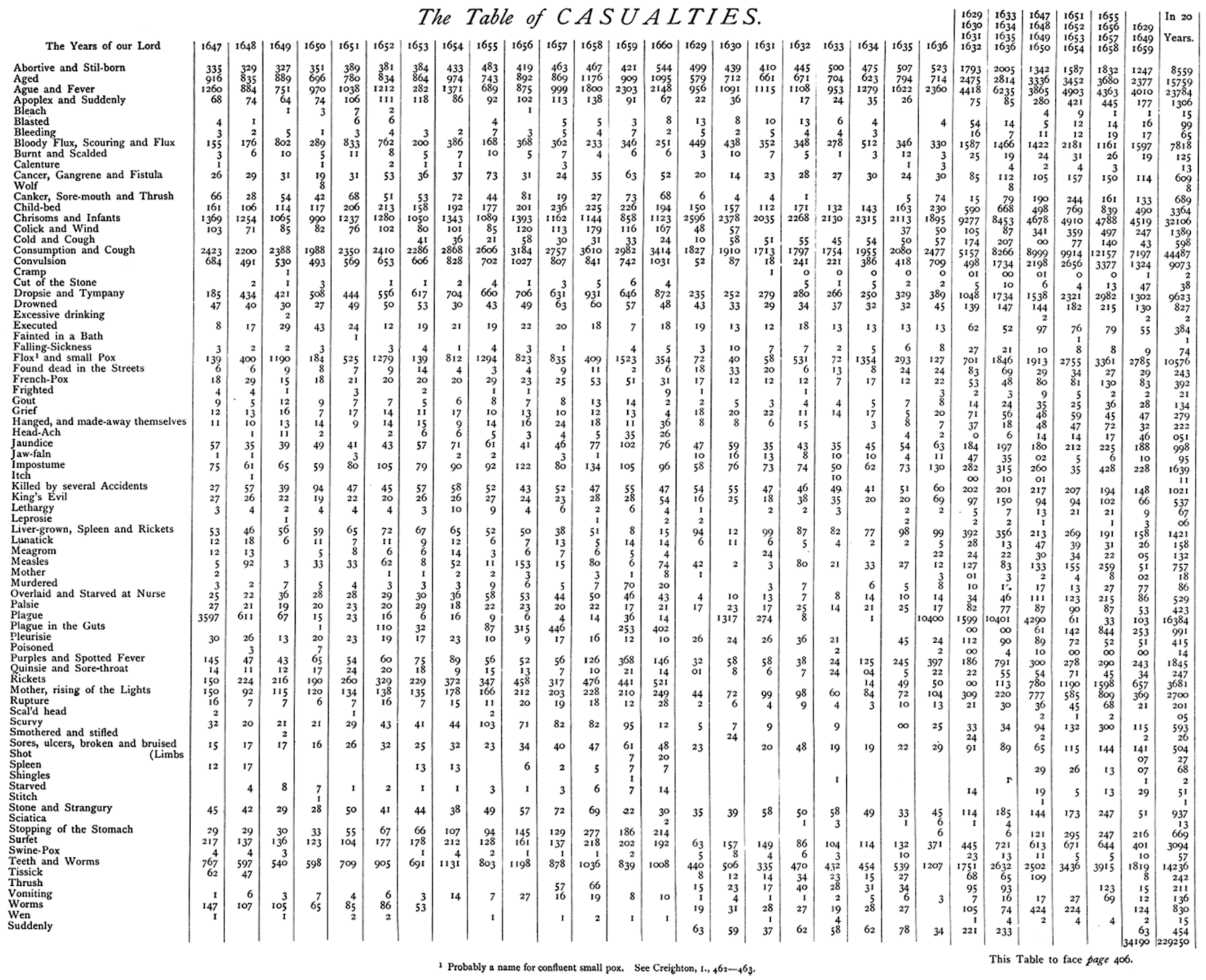

The Table of CASUALTIES.

The Years of our Lord	1647	1648	1649	1650	1651	1652	1653	1654	1655	1656	1657	1658	1659	1660	1629	1630	1631	1632	1633	1634	1635	1636	1629 1630 1631 1632	1633 1634 1635 1636	1647 1648 1649 1650	1651 1652 1653 1654	1655 1656 1657 1658	1629 1649 1659	In 20 Years.
Abortive and Stil-born	335	329	327	351	389	381	384	433	483	419	463	467	421	544	499	439	410	445	500	475	507	523	1793	2005	1342	1587	1832	1247	8559
Aged	916	835	889	696	780	834	864	974	743	892	869	1176	909	1095	579	712	661	671	704	623	794	714	2475	2814	3336	3452	3680	2377	15759
Ague and Fever	1260	884	751	970	1038	1212	282	1371	689	875	999	1800	2303	2148	956	1091	1115	1108	953	1279	1622	2360	4418	6235	3865	4903	4363	4010	23784
Apoplex and Suddenly	68	74	64	74	106	111	118	86	92	102	113	138	91	67	22	36		17	24	35	26		75	85	280	421	445	177	1306
Bleach			1	3	7	2				1															4	9	1	1	15
Blasted	4	1			6	6			4		5	5	3	8	13	8	10	13	6	4		4	54	14	5	12	14	16	99
Bleeding	3	2	5	1	3	4	3	2	7	3	5	4	7	2	5	2	5	4	4	3			16	7	11	12	19	17	65
Bloody Flux, Scouring and Flux	155	176	802	289	833	762	200	386	168	368	362	233	346	251	449	438	352	348	278	512	346	330	1587	1466	1422	2181	1161	1597	7818
Burnt and Scalded	3	6	10	5	11	8	5	7	10	5	7	4	6	6	3	10	7	5	1	3	12	3	25	19	24	31	26	19	125
Calenture	1			1		2	1	1			3										1	3		4	2	4	3		13
Cancer, Gangrene and Fistula	26	29	31	19	31	53	36	37	73	31	24	35	63	52	20	14	23	28	27	30	24	30	85	112	105	157	150	114	609
Wolf				8																				8					8
Canker, Sore-mouth and Thrush	66	28	54	42	68	51	53	72	44	81	19	27	73	68	6	4	4	1			5	74	15	79	190	244	161	133	689
Child-bed	161	106	114	117	206	213	158	192	177	201	236	225	226	194	150	157	112	171	132	143	163	230	590	668	498	769	839	490	3364
Chrisoms and Infants	1369	1254	1065	990	1237	1280	1050	1343	1089	1393	1162	1144	858	1123	2596	2378	2035	2268	2130	2315	2113	1895	9277	8453	4678	4910	4788	4519	32106
Colick and Wind	103	71	85	82	76	102	80	101	85	120	113	179	116	167	48	57					37	50	105	87	341	359	497	247	1389
Cold and Cough							41	36	21	58	30	31	33	24	10	58	51	55	45	54	50	57	174	207	00	77	140	43	598
Consumption and Cough	2423	2200	2388	1988	2350	2410	2286	2868	2606	3184	2757	3610	2982	3414	1827	1910	1713	1797	1754	1955	2080	2477	5157	8266	8999	9914	12157	7197	44487
Convulsion	684	491	530	493	569	653	606	828	702	1027	807	841	742	1031	52	87	18	241	221	386	418	709	498	1734	2198	2656	3377	1324	9073
Cramp			1														1	0	0	0	0	0	01	00	01	0	0	1	2
Cut of the Stone		2	1	3		1	1	2	4	1	3	5	6	4				5	1	5	2	2	5	10	6	4	13	47	38
Dropsie and Tympany	185	434	421	508	444	556	617	704	660	706	631	931	646	872	235	252	279	280	266	250	329	389	1048	1734	1538	2321	2982	1302	9623
Drowned	47	40	30	27	49	50	53	30	43	49	63	60	57	48	43	33	29	34	37	32	32	45	139	147	144	182	215	130	827
Excessive drinking			2																						2			2	2
Executed	8	17	29	43	24	12	19	21	19	22	20	18	7	18	19	13	12	18	13	13	13	13	62	52	97	76	79	55	384
Fainted in a Bath					1																					1			1
Falling-Sickness	3	2	2	3		3	4	1	4	3	1		4	5	3	10	7	7	2	5	6	8	27	21	10	8	8	9	74
Flox[1] and small Pox	139	400	1190	184	525	1279	139	812	1294	823	835	409	1523	354	72	40	58	531	72	1354	293	127	701	1846	1913	2755	3361	2785	10576
Found dead in the Streets	6	6	9	8	7	9	14	4	3	4	9	11	2	6	18	33	20	6	13	8	24	24	83	69	29	34	27	29	243
French-Pox	18	29	15	18	21	20	20	20	29	23	25	53	51	31	17	12	12	12	7	17	12	22	53	48	80	81	130	83	392
Frighted	4	4	1		3		2		1	1				9	1			1				3	2	3	9	5	2	2	21
Gout	9	5	12	9	7	7	5	6	8	7	8	13	14	2	2	5	3	4	4	5	7	8	14	24	35	25	36	28	134
Grief	12	13	16	7	17	14	11	17	10	13	10	12	13	4	18	20	22	11	14	17	5	20	71	56	48	59	45	47	279
Hanged, and made-away themselves	11	10	13	14	9	14	15	9	14	16	24	18	11	36	8	8	6	15		3	8	7	37	18	48	47	72	32	222
Head-Ach		1	11	2		2	6	6	5	3	4	5	35	26							4	2	0	6	14	14	17	46	051
Jaundice	57	35	39	49	41	43	57	71	61	41	46	77	102	76	47	59	35	43	35	45	54	63	184	197	180	212	225	188	998
Jaw-faln	1	1			3			2	2		3	1			10	16	13	8	10	10	4	11	47	35	02	5	6	10	95
Impostume	75	61	65	59	80	105	79	90	92	122	80	134	105	96	58	76	73	74	50	62	73	130	282	315	260	35	428	228	1639
Itch		1																	10				00	10	01				11
Killed by several Accidents	27	57	39	94	47	45	57	58	52	43	52	47	55	47	54	55	47	46	49	41	51	60	202	201	217	207	194	148	1021
King's Evil	27	26	22	19	22	20	26	26	27	24	23	28	28	54	16	25	18	38	35	20	20	69	97	150	94	94	102	66	537
Lethargy	3	4	2	4	4	4	3	10	9	4	6	2	6	4	1		2	2	3		2	2	5	7	13	21	21	9	67
Leprosie			1									1		2	2						2		2	2	1		1	3	06
Liver-grown, Spleen and Rickets	53	46	56	59	65	72	67	65	52	50	38	51	8	15	94	12	99	87	82	77	98	99	392	356	213	269	191	158	1421
Lunatick	12	18	6	11	7	11	9	12	6	7	13	5	14	14	6	11	6	5	4	2	2	5	28	13	47	39	31	26	158
Meagrom	12	13		5	8	6	6	14	3	6	7	6	5	4			24					22	24	22	30	34	22	05	132
Measles	5	92	3	33	33	62	8	52	11	153	15	80	6	74	42	2	3	80	21	33	27	12	127	83	133	155	259	51	757
Mother	2					1	1	2	2	3		3	1	8	1							3	01	3	2	4	8	02	18
Murdered	3	2	7	5	4	3	3	3	9	6	5	7	70	20			3	7		6	5	8	10	[illegible]	17	13	27	77	86
Overlaid and Starved at Nurse	25	22	36	28	28	29	30	36	58	53	44	50	46	43	4	10	13	7	8	14	10	14	34	46	111	123	215	86	529
Palsie	27	21	19	20	23	20	29	18	22	23	20	22	17	21	17	23	17	25	14	21	25	17	82	77	87	90	87	53	423
Plague	3597	611	67	15	23	16	6	16	9	6	4	14	36	14		1317	274	8		1		10400	1599	10401	4290	61	33	103	16384
Plague in the Guts				1		110	32		87	315	446		253	402									00	00	61	142	844	253	991
Pleurisie	30	26	13	20	23	19	17	23	10	9	17	16	12	10	26	24	26	36	21		45	24	112	90	89	72	52	51	415
Poisoned		3		7															2			2	00	4	10	00	00	00	14
Purples and Spotted Fever	145	47	43	65	54	60	75	89	56	52	56	126	368	146	32	58	58	38	24	125	245	397	186	791	300	278	290	243	1845
Quinsie and Sore-throat	14	11	12	17	24	20	18	9	15	13	7	10	21	14	01	8	6	7	24	04	5	22	22	55	54	71	45	34	247
Rickets	150	224	216	190	260	329	229	372	347	458	317	476	441	521						14	49	50	00	113	780	1190	1598	657	3681
Mother, rising of the Lights	150	92	115	120	134	138	135	178	166	212	203	228	210	249	44	72	99	98	60	84	72	104	309	220	777	585	809	369	2700
Rupture	16	7	7	6	7	16	7	15	11	20	19	18	12	28	2	6	4	9	4	3	10	13	21	30	36	45	68	21	201
Scal'd head	2				1				2																2	1	2		05
Scurvy	32	20	21	21	29	43	41	44	103	71	82	82	95	12	5	7	9		9		00	25	33	34	94	132	300	115	593
Smothered and stifled			2													24							24		2			2	26
Sores, ulcers, broken and bruised (Limbs	15	17	17	16	26	32	25	32	23	34	40	47	61	48	23		20	48	19	19	22	29	91	89	65	115	144	141	504
Shot													7	20														07	27
Spleen	12	17					13	13		6	2	5	7	7											29	26	13	07	68
Shingles													1						1					1				1	2
Starved		4	8	7	1	2	1	1	3	1	3	6	7	14									14		19	5	13	29	51
Stitch				1																					1				1
Stone and Strangury	45	42	29	28	50	41	44	38	49	57	72	69	22	30	35	39	58	50	58	49	33	45	114	185	144	173	247	51	937
Sciatica														2				1	3		1	6	1	4					13
Stopping of the Stomach	29	29	30	33	55	67	66	107	94	145	129	277	186	214								6		6	121	295	247	216	669
Surfet	217	137	136	123	104	177	178	212	128	161	137	218	202	192	63	157	149	86	104	114	132	371	445	721	613	671	644	401	3094
Swine-Pox	4	4	3				1	4	2	1	1	1	2		5	8	4	6	3		10		23	13	11	5	5	10	57
Teeth and Worms	767	597	540	598	709	905	691	1131	803	1198	878	1036	839	1008	440	506	335	470	432	454	539	1207	1751	2632	2502	3436	3915	1819	14236
Tissick	62	47													8	12	14	34	23	15	27		68	65	109			8	242
Thrush											57	66			15	23	17	40	28	31	34		95	93			123	15	211
Vomiting	1	6	3	7	4	6	3	14	7	27	16	19	8	10	1	4	1	1	2	5	6	3	7	16	17	27	69	12	136
Worms	147	107	105	65	85	86	53								19	31	28	27	19	28	27		105	74	424	224		124	830
Wen	1		1		2	2			1		1	2	1	1			1		4				1	4	2	4	4	2	15
Suddenly															63	59	37	62	58	62	78	34	221	233				63	454
																												34190	229250

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[1] Probably a name for confluent small pox. See Creighton, I., 462—463.

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FIGURE 1.

"Table of Casualties" indicating causes of deaths in London for some years between 1629 and 1660, compiled from the Bills of Mortality. Reproduced from Hull 1899.[15](p.406–407)

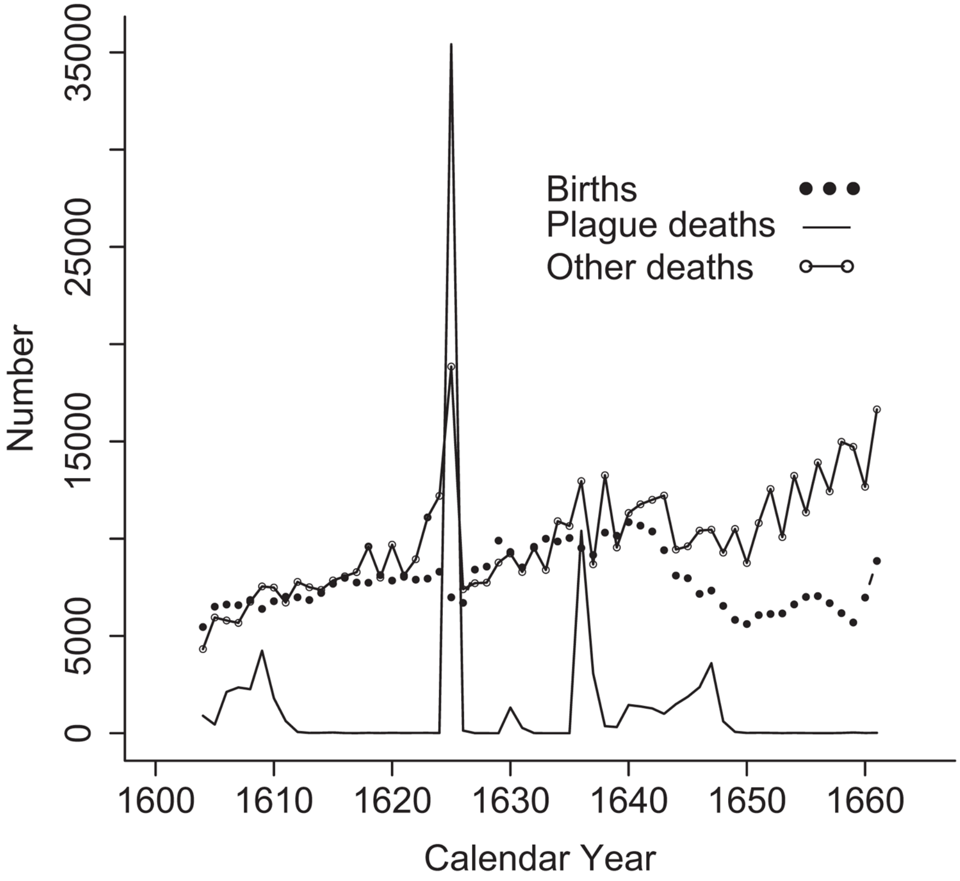

FIGURE 2.

Evolution of plague deaths, deaths from causes other than plague, and births in London between 1604 and 1661. Reanalysis of data from Graunt.[11]

FIGURE 3.

Plague doctor.[16]