

Contents

<i>Preface</i>	<i>page</i> xiii
<i>Conversion table for imperial to metric units</i>	xiv
1 Introduction	1
1.1 What is a plague?	2
1.2 Four ages of plague	2
1.2.1 Plague at Athens, 430–427 BC	2
1.2.2 The plague of Justinian	5
1.2.3 The Great Age of plagues: the Black Death and thereafter	6
1.2.4 Bubonic plague in the 20th century	7
1.3 The dangers of emerging plagues	8
1.4 Populations and metapopulations	12
1.5 A cautionary note	14
1.6 Pioneers in the study of plagues	15
1.7 Objectives	18
2 Epidemiological concepts	21
2.1 Transmission probability	23
2.2 Secondary attack rate	23
2.3 Basic reproductive number, R_0	25
2.4 Virulence, R_0 and the case fatality ratio	27
2.5 Serial generation time: the Reed and Frost model	28
2.6 Contact rates	30
2.7 Decaying and driven epidemics	38
2.8 Time-series analysis of data	39

vi	<i>Contents</i>	
2.9	Lethal smallpox epidemics in London, 1650–1900: a case study	39
2.10	Mixing patterns	41
2.11	Open versus closed population dynamics	43
2.12	Spatial components of epidemic spread	44
3	The biology of bubonic plague	47
3.1	History and geographical distribution of bubonic plague	47
3.2	<i>Yersinia pestis</i>	51
3.3	The rodent host	53
3.4	Murine versus sylvatic phases	54
3.5	Black and brown rats	55
3.6	The role of the flea	57
3.7	Flea survival	58
3.8	Flea reproduction	59
3.9	Population dynamics of bubonic plague	61
3.10	Evolution of bubonic plague virulence	63
3.11	Spread of bubonic plague to humans	65
3.12	Clinical manifestations of bubonic plague in humans	66
3.13	The significance of pneumonic plague	68
3.14	Pathology	70
3.15	Case studies of the dynamics and epidemiology of bubonic plague in India in the 20th century	72
3.15.1	Mixed epizootics in Bombay City, 1905–6	72
3.15.2	Epidemiology of bubonic plague in India in the 20th century	74
3.15.3	Effects of population size	77
3.16	Conclusions: key points about the biology of bubonic plague	78
4	The Great Pestilence	81
4.1	Arrival of the Black Death in Europe	82
4.2	The plague in Sicily	82
4.3	Spread of the Black Death in continental Europe: a metapopulation pandemic	86
4.4	The pestilence arrives in England	88
4.5	The Great Pestilence moves through the Midlands to the north of England	91
4.6	Spread of the epidemic in northeast England	94

<i>Contents</i>	vii
4.7 The consequences of the Black Death in England	96
4.8 The Black Death: conclusions	98
4.8.1 Reservations expressed by Shrewsbury	98
4.8.2 The death toll of the Black Death in England	101
4.8.3 Epidemiological notes on the Black Death	103
4.8.4 Effects of malnutrition	105
4.9 Seasonality of the outbreaks of the Great Pestilence in different localities in England	105
4.10 Was the Black Death an outbreak of bubonic plague?	107
4.11 Plagues in England following the Great Pestilence: the 14th century	109
4.12 Age-specific mortality of four epidemics in the 14th century	111
4.13 Plagues in the 15th century	112
5 Case study: the plague at Penrith in 1597–98	115
5.1 Traditional account of events in the plague	116
5.2 Size of the population at Penrith	118
5.3 The three phases of the epidemic: the serial generation time and contact rate	119
5.4 Spread of the epidemic at Penrith	126
5.5 The epidemic during the first two phases: elucidation of the epidemiological characteristics of plague	126
5.6 Explosion of the epidemic in phase three	135
5.7 Age- and sex-specific mortality in the plague at Penrith	137
5.8 Wills and testaments of those who died in the plague at Penrith	140
5.9 Response of the population at Penrith after the plague	146
5.10 Classification of the epidemics of haemorrhagic plague	148
6 Pestilence and plague in the 16th century in England	149
6.1 The Sweating Sickness	149
6.2 Plagues in London in the 16th century	152
6.2.1 The first half of the century	152
6.2.2 Did plague become endemic in London during the second half of the 16th century?	154
6.2.3 Epidemics in London, 1542–1600	155
6.3 Plagues in central and southern England during the 16th century	165

viii	<i>Contents</i>	
6.4	Case study of the plague at Stratford-upon-Avon, 1564	170
6.5	Conclusions	173
7	Plagues in the 16th century in northern England: a metapopulation study	175
7.1	The first half of the 16th century	176
7.2	Plague and pestilence in the Northern Province, 1550–95	178
7.3	The plague of 1597–98 in northern England	181
7.4	Durham	182
7.5	The plague at Richmond	183
7.6	Plague arrives to the west of the Pennines	184
7.7	Carlisle	185
7.8	Minor outbreaks of the plague in the Eden Valley	186
7.9	Symptoms of the 1597–98 plague	189
7.10	Conclusions	190
8	Plagues in London in the 17th century	192
8.1	The outbreak in London in 1603	193
8.2	Plague in London after the epidemic of 1603	198
8.3	Plague in London in 1625	199
8.4	Recovery of the population of London after 1625	205
8.5	Plague in London in 1636	206
8.6	The Great Plague in London in 1665–66	211
8.6.1	Origins and spread of the epidemic	211
8.6.2	Seasonality and mortality	215
8.6.3	Signs and symptoms	217
8.6.4	Changes in virulence	220
8.6.5	Animals, clothing and wigs	221
8.6.6	Effect of the Great Fire of London	222
8.6.7	Identity of the first victim in households in plague epidemics in London	222
8.7	Dynamics of plague in London	223
9	Plagues in the provinces in the 17th century	225
9.1	The years 1603–5	226
9.1.1	Spread of the plague in the northeast	226
9.1.2	Chester as a focus	228
9.1.3	Plague at Manchester	234

<i>Contents</i>	<i>ix</i>
9.1.4 The Midlands and East Anglia	237
9.1.5 Southern England, 1603–5	239
9.2 The years 1609–11	239
9.3 The plague of 1625–26	240
9.4 The years 1630–37	243
9.5 Widespread plague in 1644–46	248
9.5.1 The northeast corridor	248
9.5.2 The West Country	249
9.5.3 East Anglia and the Midlands	250
9.6 The mid-17th century	250
9.6.1 Chester as a focus	251
9.6.2 Spread of the plague of 1665–66 through the metapopulation	255
9.7 Overview of plagues in England	258
10 Plague at Eyam in 1665–66: a case study	261
10.1 The traditional story of bubonic plague at Eyam	261
10.2 Origins of the plague at Eyam	263
10.3 The first phase of the epidemic	265
10.4 The second phase: maintenance of the epidemic through the winter	269
10.5 The third phase: explosion of the epidemic in summer 1666	275
10.6 Percentage mortality of the population during the epidemic	279
10.7 Public health measures during the plague at Eyam	280
10.8 The nature of the infectious agent	282
11 Continental Europe during the third age of plagues: a study of large-scale metapopulation dynamics	284
11.1 Frequency of epidemics in the metapopulation of Europe	284
11.2 Plagues in France: the endemic situation	286
11.2.1 Oscillations in the frequency of the occurrence of epidemics	286
11.2.2 The 17th century in France	292
11.2.3 Regional differences within the metapopulation of France	293
11.2.4 Plague centroids in France	295
11.2.5 Localities with a high frequency of epidemics	297

x	<i>Contents</i>	
11.3	Italy	303
11.3.1	Occurrence and frequency of the epidemics in Italy	304
11.3.2	Signs and symptoms	305
11.3.3	Analysis of the spread of epidemics	306
11.3.4	Plague epidemics in Italy	308
11.3.5	Conclusions	315
11.4	The Iberian peninsula	318
11.4.1	The major epidemics	318
11.4.2	Epidemics at Barcelona	324
11.5	Germany, Austria, Bohemia and Switzerland	328
11.6	The Benelux countries	331
11.7	Spread of the plague across Europe	331
12	The plague at Marseilles, 1720–22: an outbreak of bubonic plague?	338
12.1	Spread of the plague from Marseilles to the countryside	344
12.2	Spread of the plague at Aix and Apt	350
12.3	Spread of the plague at Mende and Marvéjols	350
13	Conclusions	352
13.1	The receptor for the entry of HIV	352
13.2	Was the same causative agent responsible for all the plagues in England from 1348 to 1666?	354
13.3	Was <i>Yersinia pestis</i> the infectious agent in the plagues?	356
13.4	Classification of the plague epidemics in the provinces in England	362
13.5	Seasonality of the epidemics	364
13.6	Density dependence of plague epidemics	366
13.7	Endemic versus epidemic plague	367
13.8	How were plagues initiated?	370
13.9	Spread of the plague through the metapopulation	371
13.10	Resistance, immunity and virulence	376
13.11	Medium-wavelength oscillation in the spread of the plague	378
13.12	Symptoms	379
13.13	Public health measures and the significance of the period of quarantine	381
13.14	Why did the plague disappear?	383

<i>Contents</i>	xi
13.15 What was the causative agent of haemorrhagic plague?	384
13.16 Co-existence of two plagues	389
13.17 Population recovery after the mortality crisis of a plague epidemic	389
13.18 Postscript	393
<i>References</i>	396
<i>Index</i>	410