

THE BALANCE OF POPULATION DURING HISTORICAL TIME*

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IT is now widely appreciated that world population is increasing and that many serious problems are arising as a result.

From 800 A.D. onwards there have been several factors enabling the size of the European population to increase—an increase in the area of land cultivated, improvements in agricultural technology, improvements in transport enabling food to be transported from the Mediterranean and later from across the Atlantic to North Europe, conscious efforts to improve hygienic conditions especially after 1850, but first making their impact around 1900, and finally, after the major part of the mortality had disappeared, effective antibiotic and chemo-therapy. Checks to population growth have been wars, acting largely through infection and famine, famines due to climatic changes and infections, especially bubonic plague. Social conditions have also had some effects, through the delays in the age at marriage, in reducing population increase, but it is only in the twentieth century that contraception has played any important role in controlling population.

Changes in mortality have been dominant, until the last half century, in the dynamics of the population of Europe.

Since world population movements depend only on births and deaths, we consider fertility and mortality. We illustrate by examples that man's capacity to increase is great and then pass on to consider mortality. The subject is large and we can expect to touch only briefly on the topics raised. It is convenient to study the countries bordering the North Sea because there is much available information about them. We may especially point to the long official statistical series of Sweden and to the careful researches that have been carried out on parish records, particularly in Sweden, France, Germany, Switzerland and the United Kingdom.

FERTILITY AND FECUNDITY

It has become the practice to refer to *fecundity* as the power to produce offspring and *fertility* as the actual bringing forth of children. For technical reasons, rates of fertility are usually computed with respect to the female population. It is rare to find a population in any age or place in which the fecundity is fully realized; for example, there are unmarried women, including those in religious orders, the widowed, servants and slaves, and there may be an erratic distribution of the sexes

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in the country to be considered. We may take, as examples of fertility, the numbers of births for mothers who reached the end of their childbearing around 1950. We find that in England and Wales, the mean number of births was 2·55, in Scotland 2·94, in Australia, 3·19, in Japan, 5·29, in Italy 5·44 and in Brazil 7·27 per mother. The average number per woman passing through adult life would be rather less but it is clear that a mean of six births per woman is attainable. Striking figures are available in Eaton and Mayer (1953 and 1954) for women living in the United States of America and Canada belonging to the Hutterite sect. There are only 15 surnames for the members of the sect, which has grown in numbers from 443 in 1880 to 8,542 in 1950, corresponding to ratios between successive generations of 2·7. Only 1·3 per cent of women in 1950 were "never married" at the age of 45 years; over 20 per cent of the population was under the age of five years in 1950! Fifty per cent of the women each bore more than 10 children.

With better health, particularly with the passing of tuberculosis as a leading cause of death, and with more efficient obstetrics one could expect a higher fecundity under civilized conditions. Although it is sometimes stated that fecundity is lowered by civilization, no good evidence has been brought forward to support this latter view, according to *The Royal Commission on Population* in the United Kingdom reporting in 1949.

Before the introduction and widespread use of efficient contraception in this century the most effective checks to population were delayed and broken marriages and mortality, particularly mortality of infants and children.

The mathematical theory of population growth has been properly worked out only in this century. It considers ideal populations (i.e. mathematical models or constructs) to which are applied schedules of fertility and mortality rates. The most important of the findings of the theory are that with such hypotheses, the age distribution of the population tends to a stable form and that the total number in the population increases or decreases in a fixed ratio annually. The ratio between the numbers of successive generations is, therefore, fixed. The more difficult cases, where the rates are allowed to vary over time, can also be computed; the conclusions of the theory are sometimes in conflict with practical or common-sense views on the problem, alas often held in high places in the academic world and elsewhere. The main conclusions of the theory recall the notion of T. R. Malthus (1766 to 1834), who wrote about a "geometric" rate of increase, or compound interest law. Malthus was a trained mathematician and some of his chapters read well even now.

In the short run it may be possible for food supplies to increase more rapidly than population. We will see in a later section that population has indeed outrun the food supply in the past.

THE PROGRESS OF MORTALITY

It is possible to give an account of the mortality in Australia since 1860, in England and Wales since about 1830 and in Sweden since 1750 or earlier. However,

comparisons over longer periods than these must include a discussion of catastrophic events, namely cataclysm, war, famine and plague—the scourges of the Four Horsemen of the Apocalypse—as well as the more “domestic” causes of death, the common infections, violent and accidental causes and the degenerative diseases. The causes of death are now treated in that order.

CATACLYSM

Latter (1968/9) in a number of *British Association* devoted to the study of cataclysm has given a table of some large disasters, from which may be cited: one million deaths in a flood in Honan Province, China, in 1931; 300,000 in a hurricane in Haiphong, North Vietnam, in 1881; 215,000 from a tsunami (tidal wave) in the Andaman Islands, 1876; 36,000 from the eruption of Krakatoa, 1883. This last occurred in an area of low population density and almost all its casualties were caused by the ensuing tsunami (tidal wave). The eruption of Santorini, 100 kilometres north of Crete, at about 1400 B.C., was a much greater eruption (Ninkovich and Heezen, 1965); it destroyed the northern coastal towns of Crete in giant tidal waves and ruined the agriculture by falls of ash. This seems to be the only example of the fall of a major power as a result of a natural disaster.

WAR

The Thirty Years' War, 1618–48, provides convenient examples of the effects of war on the population. It has been studied in numerous monographs from a copious documentation on the numbers of hearths, communicants, births and deaths, from the commissions of inquiry about 1650, from records of land taxes and so on. *Westermanns Atlas* provides an easily accessible map following the descriptions of Franz (1940) and Keyser (1941), publishing in Berlin. It is believed to give a substantially accurate account. According to Reinhard and Armengaud (1961) the tradition that the War had devastated Central Europe was combated by later theorists; Napoleon believed that a single night in Paris could fill all the gaps of the missing generations! However, the population losses over a large area of Europe were relatively larger than those due to the Black Death almost anywhere in the fourteenth century. Thus the diagram shows areas in Silesia, Mecklenburg, Pfalz, Württemberg and Western Bavaria in which more than two-thirds of the population had been lost. Between the Rhine and the Elbe losses fluctuated from one-third to two-thirds. Perhaps we can help the imagination by describing how these losses came about. Actual losses by battle were not a large proportion of the total. In the larger battles of war, each side would have a force of the order of twenty to thirty thousand. Large citizen armies were a later development of the Napoleonic wars. We must look to modes of death, other than battle casualties, especially since the population of Württemberg fell from 450,000 to 100,000 and yet it was not a theatre of operations but only a zone of passage. Troops taking up winter quarters would make raids to seize food supplies, which would provoke replies, and then make reprisals. Houses would be destroyed and farms abandoned. Crops would

not be sown. The confiscation of food would cause more distress than the destructions.

Some disasters came about in an accidental manner as Tolstoy would later claim for the burning of Moscow in the Napoleonic wars. Thus Tilly and his lieutenant, Pappenheim, took Magdeburg on the Elbe by storm on 20th May, 1631. The troops sought revenge for their long preparation and hardships and, although the townspeople had hindered the garrison in their preparations, there was a general massacre of the inhabitants and lightings of fires which consumed almost the whole town, including stored provisions. Almost all 20,000 inhabitants perished.

There were definite punitive and "prophylactic" killings. Thus at the battle on the River Lech on 15 April, 1632, Gustavus Adolphus achieved a spectacular victory. After the battle "Bavaria was deliberately devastated and its peasants slaughtered, partly to weaken the enemy, but also in a terrible spirit of revenge for the ravaging of the Protestant north" (page 338 of Beller, 1970).

Besides these violent deaths, there were many deaths due to famine and disease to be discussed later.

FAMINE AND METEOROLOGY

Famine is also caused by floods, droughts and local events and through secular changes in climate. As an example of a local event, dependent however on a wide-spread epidemic in Europe and America, the Irish famine of 1845-51 was caused by an attack of the blight fungus on the potato crop (Woodham-Smith, 1964; Salaman, 1949). The famine caused an unnecessarily large mortality in Ireland, partly because the peasantry was so greatly dependent on the potato and partly because of the mishandling of the crisis by the landlords and the Westminster government. The actual causes of death were starvation, diarrhoea, dysentery, typhus, relapsing fever and cholera (Clements, 1967); the cholera cases were part of a general European epidemic.

Secular changes in climate have been important. The existence of the great Ice Ages is well known, but climatic variation in historical times has been a much neglected topic even in scientific circles until recently. However, there have been at least eight important climatic phases since the foundation of the earliest civilizations.

- (i) A severe cold period including the disappearance of the last major ice sheet in Scandinavia about 8000-7000 B.C. and passing into (ii).
- (ii) 4000-2000 B.C., the post-glacial climate optimum.
- (iii) A period of decline, 2000 B.C.-400 A.D.
- (iv) An optimum of climate, 400-1200 A.D.
- (v) A period of decline, 1200-1400 A.D.
- (vi) Partial recovery, 1400-1550 A.D.
- (vii) The Little Ice Age, 1550-1850 A.D.
- (viii) Partial recovery, 1850 A.D.-.

These eight headings are modified after Lamb (1966 and 1972).

The average winter temperature in a given area for some decades might be 3° Celsius higher in the optimal times than in the unfavourable. Of course, instrumental readings are only available over the last three hundred years but it has been possible to correlate temperature within this time with other observable features such as water freezing inside or outside houses, the behaviour of crops, the dates of the declarations of the wine harvest (Le Roy Ladurie, 1973), the type of vegetation, tree rings, the height of the tree line above sea level, the length of glaciers etc. and then to interpret old records and physical remains.

These climatic changes can be illustrated by historical events. We note the optimum of climate between 400 and 1200 A.D. with a peak about 800-1000 A.D., coinciding with a surge of population. Vineyards were found in England as far north as Herefordshire. This implies summer temperatures, perhaps 1 to 2°C. higher than today, freedom from May frosts and good Septembers. The Norsemen settled Iceland in 870 to 930 A.D. and Greenland in 985 A.D. in this climatic optimum. The early Norse burials were deep in ground which is now permanently frozen and in that era the North-West Passage had probably been open and Greenland could be circumnavigated. However, with the coming of the period of decline in 1200-1400 A.D., the Norse settlements perished in the late 14th century. In this period of decline there were cold wet summers and widespread crop failures, as in 1315-17 (Lucas, 1930) in England and elsewhere, and a general decline in population in Europe. From 1400 to 1550, there was a partial recovery and this is the period of the successful ocean exploration and the introduction of southern fruits into England. There followed the "Little Ice Age" of 1550-1850 and so the attempts at the North-East and North-West Passages in 1553 and 1585 were made at an unfavourable time. There were years of dearth in Scotland and Scandinavia in the 1590s, 1690s and 1780s. For example Trevelyan (1944) writes: "the last half dozen years of William's reign (i.e. the 1690's) had been the 'dear years' of Scottish memory, six consecutive seasons of disastrous weather when the harvest would not ripen. . . . Many parishes had been reduced to a half or a third of their inhabitants." 1696 was a year of famine in Scotland, in the parishes of Beauvais studied by Goubert (1960) and in Finland, in which there is good evidence for the loss of one-third of the population (Jutikkala, 1955). Tree growth rings were narrow in the 1690s. Records exist of the abandonment of farms in Iceland because of glaciers advancing over them in 1709 and the growing of cereals was discontinued there only to be resumed in the 1920s. Changes in the same direction were noted in other lands such as Norway, the regions around the Alps and the higher land in the British Isles. In a lighter vein, the Thames froze over eight times in the 1600s and six times in the 1700s (Lamb, 1966); one such year was 1684, immortalized in *Lorna Doone*, which later critics were to condemn as not being true to life. An auxiliary German cruiser, *Komet*, ran the North-East Passage in 1940, a time almost coinciding with the optimum of the recent partial recovery.

These fluctuations in climate are important. In the periods of decline, there were widespread famines showing that the population of Europe was at its limits under contemporary methods of agriculture.

For the development of population, there were important revolutions. First, the development of agriculture ensured a greater continuity of supplies and larger yields for a given human effort. Second, the development of power made possible the large city, in which most inhabitants worked for a money wage and were fed from the surrounding country. Later, rail and steam transport enabled food to be carried large distances and lessened also the worst fears of localized famines. Third, there have been steady improvements in agricultural techniques, first based on empirical reasoning but more recently based on the agricultural sciences and genetics.

EPIDEMICS AND DEARTH

Epidemics have often been associated with famines leading to a belief, "first dearth, then plague". However, plague, smallpox and influenza have flourished with or without famine. Dearth seems to reduce the ability of the individual to combat infection and, by destroying civil order, to aid the spread of infection. Thus according to Scrimshaw, Taylor and Gordon (1968), famine and malnutrition render the subject less capable of fighting a new infection and more likely to break down and succumb if the infection is of a chronic nature. Infants and growing children are particularly susceptible and what would be a minor bowel infection in a well nourished child may be fatal in a starveling. In times of famine, especially in those associated with war, there is a breakdown of the social order, in modern times of a centralized state but in past times of the manor or city. In medieval and modern times of famine, we find in the parish registers many deaths of wanderers from other parishes, who had hoped to escape to a famine-free area (Meuvret, 1946); they would not know that famine existed over a wide area and their condition would be miserable, for the towns would not admit them because they would bring more mouths to feed and perhaps infection. It seems that the sequence of events was often as follows: an actual shortage or prediction of grain shortage was followed by a rise in prices and consequent difficulties for the poor in obtaining grain. There would be wanderings and a dispersion of infections that otherwise might have remained quite localized. Typhus, bowel infections, measles and other common infections would be spread in this way. It appears from the parish records of the parishes of the Beauvaisis that the very old and the young were most affected. The infant mortality could rise to 70 per cent and childhood mortality was also very high. It is here that quite small changes in total food available in an area could have critical effects on the proportions of those born reaching adult life. Smallpox and bubonic plague possibly were not helped much by famine conditions.

EPIDEMIC AND INFECTIVE DISEASES

In the purely demographical and historical writings, rather too much emphasis is laid on the major plagues, such as typhus, smallpox, cholera, dysentery, malaria and bubonic plague. There is no doubt that any one of these was capable of causing many deaths even in our own century. However, some diseases now dismissed lightly

as "children's diseases", such as gastro-enteritis, scarlatina and measles, caused many deaths amongst children particularly last century. Even in Victoria in 1875 there were 1,541 deaths from measles. No trace of this event appears in local medical tradition, although this same epidemic was spread by an unhappy chance by fast cruiser to Fiji where a disastrous epidemic occurred, an event which is often recalled. Gastro-enteritis caused the death of over two per cent of infants in Australia up to as late as 1915. Such instances could be multiplied. As a result of these "minor" infections, the expectation of life at 10 years was higher than at birth in many communities and such conditions have persisted into this century in such countries as India.

Let us briefly mention some epidemiology theory, taking as an example measles. Measles is a virus disease with an incubation period of about 10 days if measured up to the first signs of catarrh or 14 days up to the appearances of the rash, and let us agree to say that the length of time between cases in any chain of infection is a fortnight. It is very contagious under favourable conditions, it sometimes attacks 100 per cent of the population—a well documented epidemic appeared in recent years in Greenland and every person of the whole district was attacked. Other measles epidemics of this explosive type have been reported from the Pacific Islands last century and from the Faeroes and other isolated areas.

To maintain such an infection as measles in a community, at least one infection every fortnight is needed to keep the epidemic going. If conditions are such that only one or two occur each fortnight, there is a definite probability that some chance factor will intervene and the chain of infections will be broken, so that we shall need, say, an average of 10 new cases a fortnight or 260 per year. But this corresponds to a minimum population of the order of 10,000. Now the epidemic cannot direct itself and from time to time there will be chance spread to hundreds of cases, thus needing a larger population. Spatial considerations point to further difficulties for the maintenance of the disease because each sub-population—for example the inhabitants along the banks of a coastal river of New South Wales—were not only effectively isolated from those of other regions but also they were broken up into smaller sub-aggregates, such as townships or farms. Measles, therefore, tended to die out in Australia. There are statistics, such as of Sweden, which show that these considerations are important in many other areas, indeed generally throughout the world. They apply particularly to the acute infections, where there are no chronic or carrier states, whereby the organism can survive in the host's body indefinitely. Infectious diseases are thus particularly affected when the probabilities of passing from person to person are lessened by deliberate quarantine-type action or by general, social or hygienic changes which have the same effect. It is possible that if the recent war in the Indian subcontinent had not occurred, smallpox would have been extinguished by now.

THE DECLINES IN MORTALITY

Many modern medical curricula give very little time to a consideration of the factors which have brought about the declines in mortality, even though the declines have produced many new economic and political problems throughout the world. Misconceptions on the importance of direct medical surgical intervention in the progress of mortality are widely held by historians, statisticians and medical theorists. We may cite the opinions of some historians.

H. J. Habakkuk (1953) complains that "Few generalizations are so well established in the books as that which ascribes the increase in the population of England and Wales in the second half of the eighteenth century to a fall in the death rate caused primarily by improvements in medicine, medical skill, and public health."

J. H. Plumb (1950) writes: "After 1740, however, there was a steady growth of the population due to a marked, if small, decline in the death rate. Almost certainly this was due to improved midwifery . . . and to the foundation of lying-in hospitals; the first kept the children alive, the second prevented them being exposed."

J. R. Hicks (1942) on p. 43 says: "It seems probable . . . that the more or less stable-sized populations which seem to have been the rule before 1750 were due to a combination of high birth rate with high death rate . . . The principal development which upset this primitive equilibrium was a marked fall in the death rate, due (beyond all doubt) to the improvements in sanitation and medical skill which were beginning to be effective in the north of Europe by the middle of the eighteenth century."

G. M. Trevelyan (1944) includes the three following quotations. On his page 341: "In the course of the Eighteenth Century the population of England and Wales rose from about five and a half millions when Queen Anne came to the throne, to nine millions in 1801. . . . The advance in population represented a rather larger birth-rate and a very much reduced death-rate. The survival of many more infants and the prolongation of the average life of adults mark off modern times from the past, and this great change began in the Eighteenth Century. It was due mainly to improved medical service." On his page 470: "the good doctors of Great Britain were responsible for the fact that between 1801 and 1831, the inhabitants of England, Wales and Scotland rose from eleven to sixteen and a half millions. On his page 562: "In the 'seventies and 'eighties (1870s and 1880s) . . . the death rate dropped with improvement of town sanitation and the constant progress of medical knowledge and practice."

These conclusions seem to rest on the researches of Griffith (1926) who concluded that "The birth rate rose from 1710 to 1790 but the rise was not as spectacular as the fall in the death rate from 1730 to 1810. The birth rate was contributing in an important way. The really important factor, however, is the fall in the death rate."

It is not a trivial matter, as Habakkuk (1953) points out, to decide whether there was a decline in mortality, for if it was considerable the Industrial Revolution could be regarded as a response to the challenge of an increasing population. Alternatively, the population changes could have been secondary to the industrial; contemporary opinion in the eighteenth century was, indeed, that the Industrial Revolution had increased the demand for labour leading to earlier marriages and higher fertility. It may also be possible that the two phenomena are due to some common antecedent cause.

Let us proceed from well-established work in the modern documented world and then make conjectures on the mortality of the past. For example, extensive tables and graphs of the total Australian mortality and life tables are available. The declines in mortality began about 1885, and affected first the pre-schoolchildren and later infants and schoolchildren. In the nineteenth century, acute infective disease dominated the variations in mortality from year to year. Before 1885, there had been great epidemics of measles and scarlatina, which disturbed the statistics in such a way that it would be illusory to pretend to determine trends. It may be noted that in this restricted area there are only a limited number of classes of disease which have to be considered. We have to account for the declines in the mortality from tuberculosis, the venereal diseases, other infective diseases, from violent and accidental causes and from the respiratory diseases, almost entirely infective.

Isolation, used in a very general sense to indicate factors which make more difficult spread from case to case, has been of importance, even of critical importance, in the infective diseases. *Surgery* has been of great value in the treatment of the results of trauma but has had little effect on mortality otherwise. In particular, surgery has been quite ineffective in controlling the mortality from cancer. *Drugs, synthetic chemicals and antibiotics* are now effective against most infections but in the Australian experience, such mortality had almost disappeared before their introduction. *Vaccination and quarantine* have protected the population against smallpox. *Immune therapy* has helped to lessen the mortality from diphtheria and tetanus. *Nutritional problems* have not been important in Australia. *Municipal services* have reduced the spread of disease by drinking water or by flies and food. The declines of mortality came earlier in Australia and New Zealand than in the United Kingdom and Europe generally, even though some authorities date back the declines in England and Wales to the middle of the nineteenth century. It is difficult to assign the credit to different factors in this decline but we may remark that there are a number of changes in social habits, housing and public health measures, which have rendered more difficult the passage of infective organisms from one person to another; there have also been changes in nutrition and living conditions, which have assisted the individual to resist infections.

In the longer experience of mortality recorded in Sweden, we find that epidemics of infective disease were important last century and these were often accompanied by harvest failures or famine conditions. It is difficult in reading the modern works

on the still older times not to believe that food supplies set an upper limit to the population in Europe, which was possibly close to the maximum possible under the agricultural technology of the times. Superimposed on this check by the food supply were the great wars and pestilences, one of which deserves a section to itself.

THE PLAGUE IN HISTORY

Good discussions of the epidemiology of *bubonic plague*, shortly *plague*, with adequate references can be found in the writings of Hirst (1953) and Baltazard (1960), and to them the reader is referred. Plague is to be regarded as a bacterial disease spread by insects among wild rodents. Under favourable climate conditions, the disease is spread to rats, especially the wild brown rat and the domestic black rat and becomes epidemic among them. The spread is by rat fleas. If these rats are in human habitations, some of the rat fleas may attack humans and thus a human epidemic, or even pandemic involving wide areas, may result. In exceptional circumstances, the spread may be from man to man via the nose and throat (the pneumonic plague). In the last few centuries the brown rat has tended to replace the black rat as the chief domestic species in London and elsewhere, but there is often doubt as to the proper identification of the species.

It is customary to take note of three great pandemics in historic times, although large plague epidemics have taken place in the intervening years. In the reign of Justinian, a great plague swept away perhaps half the inhabitants of the Byzantine Empire in the years from A.D. 542 to 565. Edward Gibbon, in the forty-third chapter of his *Decline and Fall of the Roman Empire* notes that the disease spread from Pelusium, Egypt, to Syria, Persia and the Indies, along the coasts of Africa and to the ports of Europe. This epidemic may have arisen from a focus in Ethiopia; here and in the foothills of the Himalaya are endemic sites of great antiquity. Gibbon quotes Procopius as believing that the spread was from the trade routes to the surrounding country. Perhaps 100,000,000 people died in this pandemic—about half the European and Byzantine populations.

The Black Death, the second of the great pandemics of plague, originated in central Asia according to tombstone evidence and then was spread along trade routes until it appeared on the shores of the Black Sea in 1346. From the Black Sea the infection was spread to Constantinople and then to Genoa, Venice and other European ports, and finally reached England in 1348. Many people have thought that the accounts of mortality had been exaggerated, but some numerical data, which have been analysed by Rees (1923), Gasquet (1893) and Russell (1948), show that not all the reports were exaggeration. Thus, from manorial documents Rees (1923) concluded that less than one-tenth of the population survived in some parts of England. England and Italy may have lost as much as half their population. Russell (1948) was also able to give mortality rates, from the records of the "inquisitiones post-mortem", conducted when the ownership of land was being

settled. A contemporary impression of the Black Death by John Clyn, Friar Minor of the Convent of Kilkenny, Ireland, may be quoted from Hirst (1953) :

That pestilence deprived of human inhabitant villages and cities, and castles and towns, so that there was scarcely found a man to dwell therein the pestilence was so contagious that whosoever touched the sick or dead was immediately infected and died ; and the penitent and the confessor were carried together to the grave . . . many died of boils and abscesses, and pustules on their shins (legs) and under their armpits ; others frantic with pain in their head, and others spitting blood ; . . . I . . . waiting for death till it come . . . so I have reduced these things to writing ; and lest the writing should perish with the writer, and the work together with the workman, I leave parchment for continuing the work, if haply any man survive, and any of the race of Adam escape this pestilence and continue the work which I have commenced.

There follows a single paragraph written in 1349 and the copyist's brief entry, *Videtur quod Author hic obiit* (Here it seems the author died).

The Great Plague took about three years to sweep over Europe and was followed by further waves up to about 1388. Plague tended to become concentrated in the great ports, and it became known that flight into the country often provided an effective escape. Hirst (1953) says that " in London, particularly, an exodus of the Court and upper classes of society into the countryside in plague time became part of the routine of social life ".

Helleiner (1967) believes that the population of Europe in 1500 was still below its size in 1300 or 1340; he mentions a well-documented account of the deaths in the city of Bremen, where the immediate toll of the plague was not less than 40 per cent. The demographic aftermath appears now to have been more serious than previously thought and the population of Europe in 1400 was possibly only half its size in 1340.

The third great pandemic of historic times began in the last decade of the nineteenth century and affected Asia in particular. It commenced in the Chinese province of Yunnan and reached Hong Kong in 1894, and later cases appeared throughout the world, including Sydney, Australia, where some important epidemiological studies were carried out by J. A. Thompson, Director-General of Health for New South Wales. It appears unlikely that bubonic plague will ever again threaten the human race as suitable measures can be taken against the movements of rats. However, it is equally unlikely that it will be eradicated from its foci in Asia, Africa and North America.

The progress of mortality since the passing of the great plagues can be divided into three phases—first, the elimination of famine and starvation as a major cause of death of children completed, according to Goubert (1960), around the year 1750 ; second, improvements in hygiene and the general conditions of life acting between 1850 and 1940 but only having their principal effects after 1900 ; third, the revolution in treatment brought about by the antibiotics and chemotherapy after 1940.

Quantitatively, there is little doubt that the importance descends from the first to the third group of causes in the European populations. On a world-wide basis, these three phases have been acting simultaneously in the developing countries and some modifications have to be made to the statement.

How are we to interpret the growth of population in Europe from say 800 A.D. to the present epoch? Clearing of the forests and the draining of marshes have extended the area under cultivation, while improved agricultural techniques and new crops have increased the yield of food per acre. Improved transport enabled agricultural products to be transported longer distances, so that large towns could arise obtaining their food from nearby country areas and later even from the New World after its opening up. Superimposed on these expansive factors were climatic variations of sufficient size, as we have pointed out above, to have considerable influence on the size of the harvest and then the two great pandemics of bubonic plague of Justinian's time and the Black Death. It seems possible that between the plagues the population approached the maximum that could have been maintained under the existing methods of agriculture and that large areas of Europe were in danger of famine if the crops failed in any particular year.

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