long-distance vision acquire telescopic eyes—*i.e.*, ability to see and interpret structure of distant objects. Sailors and rangemen possess this ability to a marked degree.

(*b*) *Visual Estimates.*—1. *Estimate of Distance.* This judgment is based upon a combination of at least two sensations or perceptions: (*a*) Sensation of the accommodation required to focus the image of the object upon the retina; (*b*) the sensation of the convergence required to direct the two visual lines at the same object in the binocular vision. These sensations are examples of muscular sense. One estimates these muscular efforts instinctively. Upon these instiactive estimates one bases his judgment of the distance of an object. But other considerations may enter in to assist in the estimate of distance. For example, a movement of the head or body causes a displacement of nearer objects in the background formed by more distinct objects; one learns by experience how much this displacement should be for given distances, and bases his judgment accordingly. The known size of an object is an important factor in the estimate of its distance. In this estimate one instinctively measures the image and compares it with the image of the same object at a short distance.

2. *Estimate of Size.* This judgment is based upon two perceptions: (1) The size of the image, and (2) the distance of the object. Various other considerations may enter in to modify the judgment.

The subject of visual illusions belongs more properly to psychology than to physiology, and will, therefore, not be discussed here. *Winfield S. Hall.*

VITAL STATISTICS.—Vital statistics constitute the science of numbers as applied to the life history of communities (Newsholme). The French term "demographie" is nearly synonymous with vital statistics. One of the highest living authorities (Körösi) defines vital statistics as the science of the physical life of human society.

The principal data with which vital statistics are concerned are the following: (1) Population; (2) marriages; (3) births; (4) sickness; (5) deaths.

The significance or value of vital statistics lies very largely in the relation of these data to each other and to the various sub-groups into which they are usually classified; namely, the sexes, ages, conjugal condition, residence, occupation, race, season of the year, and, in the case of deaths and sickness, the causes of the same.

In the following paper upon vital statistics the writer has made free use of the data which were obtainable from the New England States, and especially from the State of Massachusetts, since these States constitute almost the only group of States in the Union which have had a fairly complete system of registration during a period of several years, Maine being the last one of the New England States to adopt a system of registration, which she did in 1892.

Reference is also made to the vital statistics of other states and countries as occasion requires.

POPULATION.—An accurate knowledge of the number of the population forms the basis of all vital statistics. For example, a comparison of the numbers of deaths in any given community with those in any other community has no significance unless the number living in each community out of which these deaths occurred is also known.

Our knowledge of the numbers of the people living in any civilized country is obtained from the census, an enumeration made at stated periods, usually at ten-year intervals. In modern times the first census was taken in Sweden in 1749. The first census of the United States was taken in 1790, and the first in England in 1801. Few census enumerations were made in any country with sufficient details as to age, sex, and race to satisfy the purposes of sanitarians and those interested in life insurance, until the latter part of the nineteenth century.

In the United States the census is taken decennially during the month of May in the years divisible by ten. It is especially desirable in a country where the population is subject to constant changes in consequence of the variable factor of migration that census enumerations should be made oftener than once in ten years. Hence a few States (Massachusetts, Rhode Island, and Michigan) take an intermediate census, which gives the advantage of a new starting-point from which to make estimates of population in intercensal years.

Various methods are adopted for estimating the population in intercensal years:

1. In a community where a strict record of emigration and immigration is kept, and a complete system of registration of births and deaths is also enforced, the population may be accurately calculated by balancing the difference between the births and deaths and the increase or decrease due to migration. This is done in the city of Berlin and in New Zealand, but is impracticable in most countries on account of the deficiency in the necessary data.

2. Other methods occasionally adopted consist of estimates based upon the number of assessed polls in a city, the number of names in a city directory, the number of children of certain ages enrolled in the schools, or the number of new inhabited houses. None of these, however, can be deemed to be reliable.

3. We may assume that the annual increase during the present decade will be one-tenth of the total increase in the last decade. By this method a city of 50,000 inhabitants in 1890, increasing to 60,000 in 1900, should have 65,000 in 1905 and 70,000 in 1910. By this method, however (that of arithmetical progression), no allowance is made for the fact that the increase increases. There is a steadily increasing number of persons each year who attain marriageable ages and become parents.

4. The method now generally adopted in most countries is that which is advised and employed by the registrar-general of England, which assumes that the same rate of increase will continue as that which prevailed in the preceding period, *i.e.*, that the population increases in geometrical progression.

The following example illustrates this principle: If the census population of a city was 50,000 in 1890 and had increased to 60,000 in 1900, what is its estimated population in 1905?

Find the rate of increase from 1890 to 1900.

If P = the population at the census of 1890, and if P^1 = the population at the census of 1900, and if R = the rate of increase; then

$P^1 = P + R^n$ in the n^{th} year.

$\text{Log } P^1 = \log P + 10 \log R.$

$\frac{1}{10}(\log P^1 - \log P) = \log R.$

$\frac{4.7781513 - 4.6989700}{10} = .0079181 = \log R.$

Then $P_{1905} = P_{1900} R^5.$

$\text{Log } P_{1905} = 4.7781513 + 5(.0079181) = 4.8177419 = \log$ of 65,727, the estimated mean population for 1905.

In the foregoing formula r may be taken as the ratio of increase, R being equivalent to 1 + r.

By the same method the same city should have an estimated population of 72,000 in 1910, instead of 70,000 which would result from the application of the arithmetical method.

None of the foregoing methods can be depended upon to give accurate results in all cases, since irregularities affecting the different factors which control the population are always likely to occur. In one decade a town may experience a rapid growth in consequence of immigration, prosperous times, and a high birth rate, while in the next decade one or all of these factors may be decidedly changed. A quinquennial census is very desirable, especially in American States, where migration is an important though very variable factor.

Registration of Marriages, Births, and Deaths.—Unfortunately, in by far the majority of the States of the Union no complete system of registration exists, and consequently no accurate knowledge of the vital statistics of such States can be had until state legislation shall have so far advanced as to make registration compulsory.

A law was enacted in the Massachusetts colony in 1639, requiring registration of marriages, births, and deaths, but it was not until more than two centuries

later (1842) that the law was so perfected as to require collection and publication of the returns by some central authority. Connecticut followed in 1848, and Rhode Island in 1853, and there are at present nine or ten States which have sufficiently effective registration laws to enable these States to furnish accurate information relative to the marriages, births, and deaths which occur within their limits.

Improvements have been introduced in these States and in the principal cities in recent years for the purpose of perfecting the returns and of substituting the new classification of Bertillon for that of Dr. Farr, which had prevailed for half a century. Much improvement is still desirable in the direction of certificates of death, wherein indefinite and defective terms are too often used to define the causes of death. It is highly important that careful instruction should be given upon this subject in all medical colleges. (See *Death Certification.*)

The registration of sickness and the compulsory notification of infectious diseases furnish valuable information as to the prevalence of certain forms of illness among the people. But the former has scarcely ever been applied to the general population except in Michigan, where returns from a limited number of physicians have secured information from a State having a sparsely settled population. By a recent law in England, compulsory notification is also now applicable to all cases of lead, arsenic, phosphorus, and anthrax poisoning when contracted in workshops or factories.

The infectious diseases to which compulsory notification applies in England are smallpox, cholera, diphtheria, membranous croup, erysipelas, scarlet fever, typhus and typhoid fever, and puerperal fever, and also any infectious disease "to which the act has been applied by the local authority in manner provided by the act." (See *Notification of Infectious Diseases.*)

The registration of disease often furnishes definite information which cannot be obtained from the registration of deaths alone, since the fatality of different diseases varies very much. For example, the fatality of measles is usually from one to two per cent. of the cases, while that of typhoid fever is from fifteen to twenty per cent. The fatality of any disease may also vary from year to year. Some diseases which seriously affect the population are not very fatal in certain countries, while in other countries they are much more so. It is only, therefore, through the information obtained by comparing the data of the registration of diseases with that of the registration of deaths that the fatality of such diseases can be determined.

For example, the number of cases of malarial fever notified to the public health authorities in Italy in the months of September and October, 1902, were 58,787 and constituted sixty-four per cent. of all cases of illness notified from all causes (*i.e.*, of infectious diseases), in those months, and the deaths from the same cause were much greater in proportion to the number of cases than they were in more northern countries where malarial fever is less prevalent and less severe in type.

Laws and ordinances requiring similar notices of infectious diseases from attending physicians are now in force in the more densely settled and older States and in many cities of this country, and the tendency is constantly toward improvement and extension of the practice into more sparsely settled districts. In England a fee is usually granted for each notice, but this is not the usual custom in America.

MARRIAGES.—Marriages are usually notified by the officiating clergyman, magistrate, or other person legally authorized to marry. They are usually stated numerically as a ratio per thousand of the total population, as a marriage rate, *e.g.*, 9.5 per thousand, which is also equivalent to nineteen per thousand (persons married), the number of persons married being twice the number of the marriages.

A more accurate method would be to reckon the marriage rate as a ratio of the number of unmarried persons living, of marriageable ages. The marriage rate is usually higher in the cities and towns than it is in the rural districts.

Conditions which affect the marriage rate are: (1) High or low cost of living; (2) unequal distribution of the sexes at marriageable ages; and (3) prolonged war.

During the Civil War the marriage rate of Massachusetts fell from 19.62 (persons married) per thousand population in the five years preceding the war (1855–60) to 18.66 in the war period (1861–65), and rose again to 20.96 in the five years immediately following the war.

Fecundity of Marriage.—The marriages in any year give rise to births which are recorded during the following twenty years or nearly so. The division of the sum of these births by the marriages would express the fecundity of the marriages, but it is impossible to follow each family and count the children, hence some ready method must be adopted for estimating the fecundity. In a stationary population in which the marriages do not increase from year to year, the births of any year might be divided by the marriages of the same year to obtain the desired result; but the marriages are constantly increasing, hence the births of a given year must be divided by the marriages of a previous year. This interval in Sweden is six years, and Dr. Farr assumes a similar period for England. In the twenty-eighth registration report of Michigan (1894), Dr. Wilbur assumes a mean period of five years, and states that, "for convenience, comparison of births may well be made with the marriages of the preceding five-year period, and with little sacrifice of accuracy." The mean period for the foreign-born is slightly longer than that for the native-born.

In the New England States the number of births to each marriage among those of foreign birth is nearly twice as great as among those of native birth, the average number among natives during the past half-century being about 2.2 and among the foreign born 4.4 to each marriage.

Divorces.—It is customary in some States and countries to publish the statistics of divorces in connection with other registration returns. The divorces are usually reckoned as a proportion of the marriages of the same year. Under the rule, however, that a class or group of facts is best compared with those out of which such class or group is taken, the divorces might more reasonably be compared with the marriages of an earlier period, the time being estimated from the average duration of marriages among the divorced. In New England this time is about eleven and a half years.

BIRTHS.—Births are usually reckoned as a rate per thousand of the living population. But, since the proportion of women of child-bearing ages varies much in different communities, this method is liable to error. Even if the proportion of women of child-bearing ages were equal, the comparison might not be free from error if in one population the proportion of single women were much higher than in the other.

The following example illustrates this point:

	Birth rate per 1,000 inhabitants (1883–'87).	Birth rate per 1,000 women aged 15 to 45 years (1883–'87).
Bradford, Mass	21.5	74.7
Nantucket, Mass	15.8	70.5
Percentage excess of birth rate of Bradford over that of Nantucket	36%	6%

According to the ordinary method of reckoning, Bradford had a birth rate thirty-six per cent. higher than that for Nantucket, but a statement of the birth rate "per thousand women aged fifteen to forty-five" shows an excess in Bradford of only six per cent.

Bradford was, at the time of the foregoing estimate, a rural town in which the population was subject to ordinary conditions, the population in 1885 being 3,106. Nantucket was an island community, living under extraordinary conditions, its population of nearly 10,000 in

1840 having been seriously depleted by the migration of persons of young and producing ages, so that the ratio of women aged fifteen to forty-five was considerably below the average. The years to which these figures apply are the five years 1883–87, the approximate mean population of the period being that of the census of 1885. The mean annual births for the five years (1883–87) constitute the other factor.

On the other hand, if a population with an unusually high birth rate be considered, like that of Holyoke, other conditions are found to prevail. In Holyoke, during the same five years (1883–87), the mean annual birth rate was 43.3 per thousand, or twice that of Bradford and nearly thrice that of Nantucket, while the birth rate per thousand women of child-bearing ages (147.7 per thousand) was also twice that of those towns during the same period. In this instance the high birth rate was undoubtedly due to the existence among the population of a large number of French Canadians of young and producing ages, whose fecundity is proverbial.*

The birth rate in most civilized countries in the past half-century has shown a gradual tendency to decline (see table on page 263). This diminution appears to have been caused in most countries by postponement of marriage to more mature years and by a larger proportion of celibacy. In France this diminution has become so serious as to reduce the birth rate in a few recent years to a lower point than the death rate, and to awaken apprehensions as to the future stability of the population.

The chief cause of the diminution of the birth rate, according to Newsholme, is "the deliberate and voluntary avoidance of child-bearing on the part of a steadily increasing number of married persons."

Stillbirths.—The term births as heretofore used implies living births. Stillbirths, in conformity to general usage, are considered in a separate category, since, as births, they add nothing to the living population, never having lived in the sense of having a separate existence. For similar reasons, as deaths they subtract nothing from the living population and are not included in the death rate.

The deaths of still-born males are usually from 25 to 50 per cent. greater in number than those of females. In the forty years 1856–95 there were registered in Massachusetts 31,656 male still-born children and 21,202 females of the same class. These all together constituted 2.96 per cent. of all births living and dead in the same period.

Sex of Living Births.—The ratio of males to females among all births, living and dead, varies in different countries within quite narrow limits, and is usually from 104 to 107 males to each 100 females.

The following figures show the relation of the sexes at birth in different countries for a ten-year period (1871–80):

BIRTHS OF MALES TO 1,000 FEMALES.

German Empire*	1,062	Holland	1,063
Switzerland	1,063	England†	1,038
Austria	1,067	Denmark	1,058
Italy	1,071	Sweden	1,060
France	1,063	Norway	1,061
Belgium	1,058	Massachusetts‡	1,066

* The figures for the German Empire are for the years 1872–80.
† Stillbirths not included in the figures for England, which probably accounts for its difference from the other figures.
‡ The statistics for Massachusetts are for the forty years 1856–95.

The foregoing figures are the average results of over 50,000,000 births which occurred in the countries named. This difference in the number of each sex at birth partially disappears in the first years of life in consequence of the higher mortality of boys.

Plural Births.—Plural births occur with considerable regularity, those of twins constituting from a little less to a little more than one per cent. of all births, while triplets constitute a little more than one-one hundredth of one per cent. of all births. The following observations of births in several countries show slight differences in these ratios; they are the result of observations upon over twenty million births in the countries named:

RATIO OF PLURAL BIRTHS.

	Twins in 1,000 labors.	Triplets in 1,000 labors.
Switzerland*	12.2	0.12
Prussia*	12.2	.13
Bavaria*	12.4	.15
Austria*	11.7	.15
Italy*	12.1	.15
France*.	9.8	.11
Sweden*	14.4	.17
Massachusetts, 1856-95	9.2	.13

* "Die Bewegung der Bevölkerung," Bern, 1885.

Illegitimacy.—In all countries where registration exists a certain proportion of the births are found to be illegitimate.

So far as the States of the Union are concerned, there is no very definite information to be had upon this point.

From such sources as are obtainable it does not appear probable that the percentage of illegitimacy in the United States is as great as that of other countries. The statistics of the large cities, and especially of those which contain foundling asylums and lying-in hospitals, show larger percentages than the rural districts.

The following table presents the illegitimate birth rates deduced from over thirty million births in the countries named:

ILLEGITIMACY IN DIFFERENT COUNTRIES.*

	Illegitimate births per 1,000 births.		Illegitimate births per 1,000 births.
The German Empire	88	England	48
Austria	140	Denmark	102
Italy	73	Sweden	101
France	74	Norway	85
Belgium	75	Switzerland	50
Holland	32	Massachusetts (1856-91)	13

* "Die Bewegung der Bevölkerung in der Schweiz," Bern.

DEATHS.—Death rates are calculated in proportion to every thousand of the living population, the unit of time being a year. This unit is employed when death rates for shorter periods (a week or month) are stated. They represent the number who would die out of each thousand of the population if the same death rate were to continue throughout the year.

The following is the best plan for obtaining the weekly death rate with accuracy:

The correct number of weeks in a year being 52.18,* if the population of a city is 250,000 and the number of deaths in a given week is 95, then the death rate for that week is 19.8:

$$\frac{250,000}{52.18} = 4,791. \qquad \frac{1,000}{4,791} = 0.2087;$$

0.2087 is the factor by which the deaths for each week, in the case of city of 250,000 inhabitants, must be multiplied.

Therefore, $95 \times 0.2087 = 19.826$ or 19.8. This is the crude death rate.

Various corrections are required to insure accuracy, the most important factors being the deaths in public institutions, visitors, and the influence of age and sex, all of which vary in different communities. The inmates of a public institution, hospital, asylum, sanitarium, prison, or state almshouse in a given city, town, or district may consist almost wholly of persons belonging to other districts. All deaths of outsiders occurring in such institutions should, therefore, be subtracted, and all deaths of inhabitants occurring in outside institutions should be added in estimating the death rate. The living population, so far as it is derived from outside sources, should also be excluded, as well as the deaths of such persons, in making up an estimate of death rates, in order to make the death rate approximately correct. In many of the Rocky Mountain health resorts, as well as others of the South and West, it is also customary to exclude the deaths of visitors in making up the death rate.

The Relation of the Death Rate to the Birth Rate.—While a high birth rate in a single year may be contributory to a high death rate in the same year and year following, it does not follow that a continuously high birth rate will be productive of a correspondingly high death rate. It is true that the death rate of children under five is very much higher than that of the general population, but if a high birth rate continues for several years it then increases the ratio of the total population at ages when the mortality is at its lowest point, and thus lowers the general death rate.

The Effect of Age and Sex Distribution upon the Death Rate.—Two cities, towns, or districts which are entirely alike in their climate, density of population, and sanitary conditions may have very different death rates, on account of differences in the age and sex constitution of their populations.

The population under five years of age may have a death rate of 60 per 1,000, and that of persons over sixty-five years of age may be as high as 80 or 90 per 1,000, while that of adults from twenty to sixty years of age may be only 12 per 1,000. It is therefore plain that a predominance of children under five years of age, or of persons over sixty-five, will raise the general death rate, while an excess of persons between twenty and sixty will lower it.

MASSACHUSETTS—DEATHS TO 1,000 LIVING AT EACH OF TEN GROUPS OF AGES, 1899–1901.

	All ages.	0 to 5.	5 to 10.	10 to 15.	15 to 20.	20 to 25.	25 to 35.	35 to 45.	45 to 55.	55 to 65.	All over 65.
Males	18.3	58.4	4.7	2.8	4.7	6.7	8.0	10.5	16.3	31.7	88.6
Females	16.7	48.0	4.6	2.9	4.4	5.9	7.3	9.4	14.2	26.5	82.8

ENGLAND—1881–90.

	All ages.	0 to 5.	5 to 10.	10 to 15.	15 to 20.	20 to 25.	25 to 35.	35 to 45.	45 to 55.	55 to 65.	65 to 75.	All over 75.
Males	20.3	61.6	5.4	3.0	4.3	5.7	7.8	12.4	19.4	34.7	70.4	162.7
Females	18.1	51.9	5.3	3.1	4.4	5.5	7.4	10.6	15.1	28.4	60.4	148.0

Again, an excess of males will tend to raise the death rate, while an excess of females lowers it, since, as shown in the accompanying tables, the death rate of females at all ages except from ten to twenty years is less than that of males. While it is proper, therefore, to compare the death rate of a given city for any year with that of a previous year, provided there were no material changes in the population in the intervening years, it is not safe to compare the general or crude death rates of one city with those of another without taking account of the differences in the ages and sex constitution of the populations of such cities. It is for this reason that the death rates of the older cities of the Atlantic coast cannot safely be compared with those of newly settled Western districts, where young adults between the ages of fifteen and forty-five are in excess of numbers.

In the following table the age and sex constitution of two cities are compared with that of the State at large, as an illustration of these differences. In the State at large the sexes in 1900 were in the ratio of 48.75 per cent. of males to 51.25 females, or 1,051 females to 1,000 males, while that of Boston was in the proportion of 1,040 females to 1,000 males, and that of Salem 1,109 females to 1,000 males.

CENSUS OF 1900. AGE DISTRIBUTION.

Ages.	Massachusetts		Boston.		Salem.	
	Males.	Females.	Males.	Females.	Males.	Females.
Under 5 years	505	501	510	512	530	520
5 to 10 years	457	456	437	435	506	473
10 to 15 years	407	411	378	377	411	427
15 to 20 years	411	437	356	397	405	449
20 to 25 years	461	534	467	565	449	519
25 to 35 years	921	995	1,076	1,074	842	920
35 to 45 years	704	708	780	744	631	710
45 to 55 years	470	492	462	478	448	523
55 to 65 years	222	334	253	289	286	377
All over 65 years	224	286	148	213	220	328
Unknown	23	11	35	14	13	13
	4,875	5,125	4,902	5,098	4,741	5,259
	10,000		10,000		10,000	

In Newton there were 1,234 females to 1,000 males, but in Gloucester the males predominated, there being only 873 females to 1,000 males in that city. These differences are determined largely by the character of the industries conducted in the different cities.

With reference to ages, there were in Massachusetts in 1900 52.45 per cent. of the population between twenty and fifty-five years of age, in Boston 56.46 at the same ages, but in Salem only 50.42 per cent.

Again, there were in Massachusetts 11.36 per cent. of persons over fifty-five years of age, in Boston 9.03 per cent., and in Salem 12.11 per cent.

In Boston the children under fifteen constituted 26.49 per cent. of the population, but in Holyoke those of the same age were 33.12 per cent. of the population.

All these differences have an effect upon the death rate according to the preponderance of persons at healthy ages.

Method of Correction for Age and Sex Distribution.—The method shown in the following table has been adopted by the registrar-general of England, and has been indorsed by other statisticians, notably by Körösi, whose method requires less calculation since he advises only four age periods for correction instead of eleven, as in the English tables. The periods recommended by Körösi are as follows: All under one year; all from one to twenty years; all from twenty to fifty years; all over fifty years. He also advises that the population of Sweden be taken as a standard of distribution, Sweden being a very healthy population. Dr. Ogle suggests the adoption of a combined standard, made from the seven principal European nations. The English tables employ the population of England and Wales as a standard, and in the following table (on page 250) the writer has referred each of the cities to the population of Massachusetts as a standard of comparison.

In the following table the *standard death rate* signifies the death rate at all ages, calculated on the hypothesis that the rates at each of the ten-age periods in each city were the same as those of the States during the three years, 1899–1901. The death rate at all ages in the State during that period having been 17.48 per 1,000.

The *factor for correction* is the figure by which the crude or recorded death rate should be multiplied, in order to correct for variations of sex and age distribution.

The *corrected death rate* is the recorded death rate multiplied by the factor for correction.

* The birth rate of some of the lower counties of Eastern Canada in recent years has been as high as fifty-eight to sixty per one-thousand inhabitants.

* More accurately 52.17747, leap years being reckoned; but 52.18 is sufficiently accurate for practical purposes.

The *comparative mortality figure* represents the corrected death rate in each city, as compared with the recorded death rate in the State in 1900 taken as 1,000.

RECORDED AND CORRECTED DEATH RATES PER 1,000 PERSONS LIVING IN MASSACHUSETTS CITIES OF MORE THAN 25,000 INHABITANTS IN 1900.

Cities in the order of their corrected death rates.	Standard death rate.	Factor for correction for sex and age distribution.	Recorded death rate (1900).	Corrected death rate (1900).	Comparative mortality figure.
	1.	2.	3.	4.	5.
MASSACHUSETTS	17.48	1.000	18.23	18.23	1.000
Brockton	16.27	1.074	13.85	14.87	816
Malden	17.02	1.027	14.53	14.92	818
Newton	17.06	1.024	15.01	15.37	843
Haverhill	17.67	989	15.55	15.38	844
Somerville	17.30	1.010	15.67	15.83	868
Fitchburg	17.02	1.027	15.67	16.09	883
Chelsea*	17.77	984	16.42	16.16	886
Lynn	16.80	1.040	15.91	16.55	908
Gloucester	17.33	1.009	17.00	17.15	941
Cambridge	16.54	1.056	16.54	17.47	958
Springfield	17.31	1.010	18.93	19.12	1.049
Salem	17.95	974	19.86	19.34	1.061
Worcester*	16.56	1.056	18.33	19.36	1.062
Taunton*	16.89	1.035	19.43	20.09	1.103
Lowell	16.07	1.088	19.48	21.19	1.162
Boston*	16.26	1.075	20.08	21.59	1.184
New Bedford	17.07	1.024	21.19	21.70	1.190
Lawrence	16.09	1.086	20.40	22.15	1.215
Fall River	15.90	1.099	21.53	23.66	1.297
Holyoke	15.55	1.124	21.96	24.68	1.354

* Correction has been made in the four cities of Worcester, Taunton, Chelsea and Boston for deaths of non-residents occurring in sixteen public and private institutions, 119 deaths in Worcester, 79 in Taunton, 90 in Chelsea, and 419 in Boston.

The figures in the last column may be read as follows: After making approximate correction for differences of age and sex distribution, the same number of living persons that gave 1,000 deaths in Massachusetts in 1900 gave 816 in Brockton, 1,184 in Boston, 1,354 in Holyoke, etc.

The first column in the table is obtained by assuming that the mean mortality in Massachusetts in 1899–1901 prevailed in each of the twenty cities in the list.

The age and sex distribution of each city at the last census (1900) being known, the mean mortality in Massachusetts (1899–1901) is applied to the population thus constituted, producing as a result the series of death rates in column 1. The differences between the cities in this column are consequently caused only by the difference in age and sex distribution. As an example of the method of obtaining these *standard death rates*, the figures for Boston may be taken (see the following table). Here the total population of Boston in 1900 was 560,892. The whole number of calculated deaths was 9,122. The standard death rate for that year was therefore $\frac{9{,}122 \times 1{,}000}{560{,}892} = 16.26$ per 1,000, as shown in the foregoing table.

Now the mean annual death rate of Massachusetts for the three years 1899–1901 was 17.48. This ought to be the same as the calculated death rate for Boston, which was obtained by applying the mean annual death rate of the State at the different age groups to the population of Boston at these age groups.

But this standard death rate of Boston was lower, as shown in the table, which arises from the fact that the distribution of age and sex in the Boston population is more favorable than that of the State at large (see table, page 249).

The standard death rate being lower for Boston, must be raised in order to bring it into comparison with the death rate of the State; that is, it must be increased in the proportion of 16.26 to 17.48. This fraction $\frac{17.48}{16.26} = 1.075$. This number 1.075 is the factor for correction for age and sex distribution by which the crude or recorded death rate of Boston must be multiplied in order that it may be comparable with that of the State.

By multiplying the recorded death rates in column 3 by the factors for correction, the corrected death rates are obtained as given in column 4. These are the death rates which would have been recorded in each city had its population been identical, so far as age and sex distribution are concerned, with that of the State.

Ages.	Mean Annual Death Rate in Massachusetts, 1899–1901, per 1,000 Living at Each Group of Ages.		Population of Boston in 1900.		Calculated Deaths in Boston (1900).	
	Males.	Females.	Males.	Females.	Males.	Females.
0–5 years	58.41	48.00	28,628	28,733	1,672	1,379
5–10 "	4.74	4.60	24,495	24,401	116	112
10–15 "	2.84	2.88	21,202	21,160	60	61
15–20 "	4.70	4.43	19,965	22,289	94	99
20–25 "	6.71	5.94	26,159	31,661	176	188
25–35 "	7.96	7.31	60,362	60,242	481	440
35–45 "	10.48	9.42	43,748	41,717	458	393
45–55 "	16.26	14.20	25,910	26,816	421	381
55–65 "	30.96	26.51	14,145	16,231	438	430
65 and over	88.60	82.78	8,301	11,919	735	987
Unknown	.....	.....	1,967	801		
			274,922	285,970	4,652	4,470
			560,892		9,122	

This principle in vital statistics is specially applicable to those towns from which, in consequence partly of local conditions, the young and vigorous portion of the population has emigrated, as in the case of Nantucket, Mass., which in 1840 had a population of 9,012; but this number had diminished to 3,142 in 1885. Of this population of 3,142, only 43.8 per cent. were between the ages of twenty and fifty-five, when the death rate is low, as compared with 52.4 per cent. at the same ages in the State at large. The percentage of the population who were over fifty-five (at which ages the death rate is high) was 29.6, as compared with only 11.4 in the State at large in the same census year. As a consequence, Nantucket in that year should be credited with a standard death rate of 27.02, a factor for age and sex correction of 0.733. The crude or recorded death rate of the town was 33.74 per thousand, the corrected death rate 24.73, and the comparative mortality figure 1,261.

According to F. L. Hoffmann, the fallacy of disregarding the effect of age distribution is shown in a recent United States Government report, wherein it is stated that "the significance of the annual *rate of death* from disease in the Philippines (17.2 per thousand) may be better appreciated by comparison with the rates in some of our well-known American cities. Mr. Root gives a table showing the annual death rates of Washington, Boston, etc., together with the mortality rate from disease of soldiers in the Philippines. Even a moment's reflection would have made it clear that a comparison of the death rate of soldiers, mostly of ages from eighteen to thirty, could not properly be made with the mortality of the general population at all ages. Even a comparison with the general death rate of cities, at ages from fifteen to forty-five, which, according to the then available census of 1890, was 10.9 per thousand, would not have been accurate, in that soldiers represent a carefully selected class of physical risks in contrast to the general population, which includes the sick and otherwise physically impaired. The only accurate method of comparison which could have been suggested to the Secretary of War by the surgeon-general of the army would have been the average mortality rate from disease of soldiers in the United States army previous to the war with Spain.

But by this method the argument advanced by Mr. Root could not have been proven, for, according to the annual reports of the surgeon-general, the mortality of soldiers from disease during the five years, 1891–95, was at the rate of 4.3 per thousand, while during 1896 the rate was 3.8, and during 1897 it was 3.1. In other words, the mortality of soldiers in the Philippines from disease was four times as great as the mortality from disease of United States soldiers under conditions of peace." (F. L. Hoffmann, in Transactions of American Statistical Association, December, 1902, p. 198.)

INFANT MORTALITY.—The mortality of infants under one year of age should not be compared with the general population, since the relative number of living infants varies much in different communities. A more correct method is to compare the deaths of infants one year old with the living infants of the same age. It has not been found practicable, however, by ordinary census methods to find the number of infants with accuracy. This is shown by the census figures of almost any State or country for the first five years of life.

For example, the figures for Massachusetts in the state census of 1885 and the United States census of 1900 were as follows:

NUMBER OF CHILDREN LIVING AT CERTAIN AGES.

Years.	State Census (1885).	U. S. Census (1900).
0–1 year	35,888	60,492
1–2 years	27,327	53,943
2–3 "	40,353	56,257
3–4 "	38,061	56,678
4–5 "	36,706	54,867

In the foregoing table the numbers of children found who were under two years of age, but over one year, were less in each census than those who were a year older as well as less than those who were a year younger. But since immigration does not largely affect the numbers at these early ages, we should naturally expect to find a diminishing series beginning with the first year of life, the deaths making the numbers for each successive year of life less and less. This error appears in the eighth census also, and in order to obtain the number of infants under one year correctly it is necessary to calculate a redistribution of these early years, or, what is preferable, to use the births as a standard.

For the purpose of greater accuracy, the deaths under one year occurring in a calendar year should be compared with the births of an earlier period, since many of the infants under one year dying in any year were born in the previous year. For this reason it is customary to employ as a standard of comparison the births occurring in a year ending with June 30th, and to compare with this number the deaths under one year occurring in the calendar year ending December 31st.

Upon this basis, the infant mortality of Massachusetts during the twenty years, 1856–75, was 150.3 per thousand births, and that of the succeeding twenty years, 1876–95, was 161.2 per thousand, the mean of the forty-year period being 156.7. The births employed in this calculation were those which occurred during the period beginning July 1st, 1855, and ending June 30th, 1895; and the deaths under one year were those which occurred in the forty calendar years, 1856–95, inclusive.

The infant mortality of the five following years, 1896–1900, was respectively 167.7, 148.1, 149.1, 148.0, and 159. The infant mortality of cities is usually greater than that of the rural districts. In Massachusetts, in the ten years 1881–90, the infant mortality of the cities was 174.9 per thousand births, and that of the rural districts was 129.5. The following table presents the infant mortality of several countries:

INFANT MORTALITY.* DEATHS UNDER ONE PER 1,000 BIRTHS.

Countries.	Years.	Infant Mortality per 1,000 Births.	Countries.	Years.	Infant Mortality per 1,000 Births.
Ireland	1884–88	94	Italy	1884–91	192
Sweden	1881–90	97	Prussia	1886–92	207
Scotland	1885–90	120	Hungary	1884–87	212
England	1885–91	144	Austria	1886–87	246
Belgium	1881–91	159	Saxony	1886–92	281
France	1885–90	165	Bavaria	1879–88	287
Holland	1885–90	179			

* From paper by Dr. Eross, in Koch's Zeitschrift f. Hygiene, vol. 19, 1896, p. 371.

An important factor in relation to infant mortality is the method of feeding. The best information upon this point comes from the city of Berlin, where, for several years, all infants have been classified with reference to the method of feeding, so that the ratio of deaths of each class could be estimated.

The results of these observations extending over a series of years were as follows. Mortality per thousand infants under one year old in Berlin:* Among those who were fed on the mother's milk only, 7.4 per 1,000; on mother's milk and cow's milk, 21.4 per 1,000; on cow's milk alone, 42.1 per 1,000; on milk substitutes, 67.7 per 1,000; on cow's milk and milk substitutes, 125.7 per 1,000. These figures are the result of observations upon 65,720 deaths of infants under one year old in Berlin.

The health commissioner of Buffalo claims a large reduction in the infant mortality of that city by the suppression of the sale of nursing-bottles having long tubes attached and by other ordinances of a similar character.

Effect of Intemperance and Poverty upon Infant Mortality.—It is hardly necessary to assert the effect of these factors in the causation of infant mortality. In every country the records show their damaging effects. Cities in which intoxicating liquors are freely sold under license laws have a higher infant mortality than those cities in which such sale is forbidden by the popular vote. In the census year 1895, the infant mortality in the seventeen cities of Massachusetts in which licenses were granted was 174 per 1,000 births, while in the cities in which no licenses were permitted the infant mortality was only 122 per 1,000. In this estimate no account was taken of those few cities in which the sentiment of the voting population was so equally balanced that a change from license to no license, or *vice versa*, took place during the year in question.

The effect of poverty is shown in Dr. Billings' census volume relating to the vital statistics of certain cities, wherein the mortality of children under five years of age in one ward of a certain city inhabited by a poor class of residents was 157.1 per 1,000 living of the same age, while a neighboring wealthy district had a mortality of only 40.4 for the same class.

Again, the average pay of shoemakers is from sixty to ninety per cent. greater than that of cotton and woollen operatives. The infant mortality of the three shoe-manufacturing cities of Lynn, Haverhill, and Brockton for the ten years 1881–90 was 146.1, while that of the cotton factry cities Fall River, Lowell, and Lawrence for the same period was 227 per 1,000 births.

Effect of High Birth Rate.—That a high birth rate is not necessarily a concomitant of high infant mortality is shown by Dr. H. May in a letter to *Public Health* (March, 1903), in which he shows that while the birth rate had fallen in each of the following large cities, the infantile mortality had risen.

* International Statistical Bulletin, vol. ii., No. 2, p. 14.