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Infant Mortality

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Introduction

Infant mortality rates have often been used as health status indicators, particularly for international comparisons (1). However, it is generally recognized that infant mortality is not a valid indicator of the overall health status of a nation or community. Infant mortality rates are very useful for identifying problems with the health status of infants and mothers, as well as possible problems in the delivery of health care and related services to these groups in a community. The use of infant mortality rates at the local planning level is unfortunately limited by yearly fluctuations in the rates which are purely random (that is, unrelated to characteristics of the infants, mothers, environment, etc.). This stability problem will be discussed in more detail below.

In 1976, Joel Kleinman authored this article on infant mortality as the second note in the series *Statistical Notes for Health Planners*. Dr. Kleinman's contributions to the field of maternal and child health statistics were extensive and exceptional. His untimely death, in May 1991, left a void among his colleagues at NCHS and in the larger scientific community.

This article is as relevant today as when it was originally published. We have updated some of the tables and figures, but the text is essentially his. We feel that this is a fitting tribute to Joel.

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The factors that influence infant mortality rates are many (2): race (3), sex, multiple birth (4), residence, birth weight (5), gestational age (6), age of mother (7), birth order (8), prior pregnancy outcome (9), socioeconomic status (10,11), maternal smoking (12), and prenatal care (13–15).

Infant mortality rates for white births and all other births have declined rapidly since the early part of the 20th century. After a period of reduced decline in the 1950's to mid 1960's, an accelerated decline occurred through about 1981. During the 1980's, there appeared to be a slowdown in the infant mortality decline (16). However, there are wide variations within the United States. For example, the U.S. mortality rate in 1988 for black infants (17.6 per 1,000 live births) was 107 percent higher than the corresponding rate for white infants (8.5 per 1,000) (17). In addition, substantial geographic variations exist across the United States (18) and within small areas of large cities (19). This variation is especially important for planning purposes.

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Definitions

In order to provide comparable reporting of birth and death data, precise definitions of terms need to be agreed upon. The National Center for Health Statistics has recommended the American Academy of Pediatrics (AAP) and the American College of Obstetricians and Gynecologists (ACOG) definition of a live birth. According to the AAP and ACOG definition, a live birth is "the complete expulsion or extraction from the mother of a product of human conception, irrespective of the duration of pregnancy, which after expulsion or extraction, breathes or shows any other evidence of life, such as beating of the heart, pulsation of the umbilical cord, or definite movement of voluntary muscles whether or not the umbilical cord has been cut or the placenta is attached. Heartbeats are to be distinguished from transient cardiac contractions; respirations are to be distinguished from fleeting respiratory efforts or gasps (20)." This definition thus distinguishes a live birth from a fetal death, which is defined as "death prior to the complete expulsion or extraction from the mother of a product of human conception, fetus or placenta, irrespective of the duration of pregnancy; the death is indicated by the fact that, after such expulsion or extraction, the fetus does not breath or show any other evidence of life, such as beating of the heart, pulsation of the umbilical cord, or definite movement of the voluntary muscles. Heartbeats are to be distinguished from transient cardiac contractions; respirations are to be distinguished from fleeting respiratory efforts or gaps. This definition excludes induced terminations of pregnancy (20)."

Most states use minimum periods of gestation to define fetal deaths (20). Table 1 shows the fetal death registration requirements for each State.

Infant deaths are usually divided into two categories according to age:

- Neonatal deaths are those which occur during the first 27 days of life.
- Postneonatal deaths are those which occur between 28 days and 1 year of age.

Mortality rates are then defined as follows (in the definitions, "period" refers to a calendar year or combinations of more than 1 calendar year):

$$\text{Infant mortality rate per 1,000 live births (IMR)} = \frac{\text{number of infant deaths during a period}}{\text{number of live births during the same period}} \times 1{,}000$$

$$\text{Neonatal mortality rate per 1,000 live births (NMR)} = \frac{\text{number of neonatal deaths during a period}}{\text{number of live births during the same period}} \times 1{,}000$$

$$\text{Postneonatal mortality rate per 1,000 (PNMR)} = \frac{\text{number of postneonatal deaths during a period}}{\text{number of live births during the same period}} \times 1{,}000$$

In an alternative method, the denominator for the postneonatal mortality rate is calculated by subtracting the number of neonatal deaths from the number of live births. This denominator more accurately defines the population at risk of dying in the postnatal period (20).

The definition of fetal mortality presents some problems due to difficulties in obtaining the appropriate data as well as variations among the states in reporting practices. "Standard Terminology for Reporting of Reproductive Health Statistics in the United States" (20) recommends the following definitions of rates related to fetal mortality:

$$\text{Fetal mortality rate per 1,000 live births plus fetal deaths (FMR)} = \frac{\text{fetal deaths of 500 grams weight or more during a period}}{\text{number of live births plus fetal deaths of 500 grams or more weight during the same period}} \times 1{,}000$$

$$\text{Perinatal mortality rate per 1,000 live births plus fetal deaths (PMR)} = \frac{\text{fetal deaths of 500 grams weight or more plus infant deaths under 7 days during a period}}{\text{number of live births plus fetal deaths of 500 grams weight or more weight during the same period}} \times 1{,}000$$

Most states now report fetal deaths based on gestational age (Table 1). However, birth weight can be more accurately measured than gestational age. It is recognized that States will not be able to translate data from gestational age to weight immediately, and, for comparative purposes, it is often desirable to know fetal death rates for varying gestational time periods. Therefore, the collection of both weight and gestational age is recommended to allow for these comparisons (20). When calculating fetal mortality rates bases upon on gestational age, the following definitions are recommended (20,21):

$$\text{Fetal mortality rate per 1,000 live births plus fetal deaths (FMR)} = \frac{\text{fetal deaths of 28 weeks or more gestation during a period}}{\text{number of live births plus fetal deaths of 28 weeks or more gestation during the same period}} \times 1{,}000$$

$$\text{Perinatal mortality rate per 1,000 live births plus fetal deaths (PMR)} = \frac{\text{fetal deaths of 28 weeks or more gestation plus infant deaths under 7 days during a period}}{\text{number of live births plus fetal deaths of 28 weeks or more gestation during the same period}} \times 1{,}000$$

Recently it has been suggested (12, 18) that the notion of perinatal mortality be extended to include late fetal plus infant deaths. This is called the **feto-infant mortality rate** (16):

$$\text{Feto-infant mortality rate per 1,000 live births plus fetal deaths} = \frac{\text{fetal deaths of 28 weeks or more gestation plus infant deaths during a period}}{\text{number of live births plus fetal deaths of 28 weeks or more gestation during the same period}} \times 1{,}000$$

Table 1. Minimum period of gestation for which fetal-death registration is required, by State, 1988

State	Minimum period of gestation for which fetal-death registration is required	State	Minimum period of gestation for which fetal-death registration is required
Alabama	20 weeks or more	Missouri	20 weeks or more gestation or birth weight of 350 grams or more
Alaska	20 weeks or more	Montana	20 weeks or more
American Samoa	All products of human conception	Nebreska	20 weeks or more
Arizona	20 weeks or more[1]	Nevada	20 weeks or more
Arkansas	All products of human conception	New Hampshire	20 weeks or more gestation or birth weight of 350 grams or more
California	20 weeks or more	New Jersey	20 weeks or more
Colorado	All products of human conception	New Mexico	Birth weight of 500 grams or more
Connecticut	20 weeks or more	New York City	All products of human conception
Delaware	20 weeks or more	New York State	All products of human conception
District of Columbia	20 weeks or more or birth weight of 500 grams or more	North Carolina	20 weeks or more
Florida	20 weeks or more	North Dakota	20 weeks or more
Georgia	All products of human conception	Ohio	20 weeks or more
Guam	20 weeks or more	Oklahoma	20 weeks or more
Hawaii	All products of human conception	Oregon	20 weeks or more[3]
Idaho	20 weeks or more gestation or birth weight of 350 grams or more	Pennsylvania	16 weeks or more gestation
Illinois	20 weeks or more	Puerto Rico	5 months or more gestation
Indiana	20 weeks or more	Rhode Island	All products of human conception
Iowa	20 weeks or more	South Carolina	20 weeks or more gestation or birth weight of 350 grams or more
Kansas	Birth weight in excess of 350 grams	South Dakota	Birth weight of 500 grams or more
Kentucky	20 weeks or more gestation or birth weight of 350 grams or more	Tennessee	Birth weight of 500 grams or more[4]
Louisiana	20 weeks or more gestation or birth weight of 350 grams or more	Texas	20 weeks or more
Maine	All products of human conception	Trust Territory of the Pacific	All products of human conception
Maryland	20 weeks or more[2]	Utah	20 weeks or more
Massachusetts	20 weeks or more gestation or birth weight of 350 grams or more	Vermont	20 weeks or more[5]
Michigan	20 weeks or more gestation or birth weight of 400 grams or more	Virginia	All products of human conception
Minnesota	20 weeks or more	Virgin Islands	All products of human conception
Mississippi	20 weeks or more gestation or birth weight of 350 grams or more	Washington	20 weeks or more
		West Virginia	20 weeks or more
		Wisconisn	20 weeks or more gestation or birth weight of 350 grams or more
		Wyoming	20 weeks or more

[1]If gestational age is unknown, weight of 350 grams or more.

[2] If gestational age is unknown, weight of 500 grams or more.

[3]If gestational age is unknown, weight of 400 grams or more, or crown-heellength of 28 centimeters or more.

[4]If weight is unknown, 22 completed weeks gestation or more.

[5]If gestational age is unknown, weight of 400 or more grams, 15 or more ounces.

SOURCE: National Center for Health Statistics. Vital statistics of the United States,1988, vol. II, mortality, part A. Washington: Public Health Service, 1991.

Cause-specific and race-specific rates

Since deaths are classified by cause and particular causes may point to problems amenable to planning intervention, certain cause-specific death rates are sometimes of interest. An infant mortality rate specific to a particular cause (X) is defined as

$$\text{IMR }(X) \text{ per 100,000 live births} = \frac{\text{Number of deaths due to cause } X \text{ during a period}}{\text{Number of live births in the same period}} \times 100{,}000$$

Of course, the rate may be limited to a certain age group in which case it becomes both cause- and age-specific. The crucial point is that the denominator be defined as the population at risk of death (that is, every case counted in the denominator should have a chance of appearing in the numerator).

Since the infant mortality rate (and related measures) varies by many characteristics of the mother and infant, an area's infant mortality rate will depend upon the composition of its childbearing population. One of the most important characteristics is race. Figure 1 defines race-specific rates and gives an example of how an area's total infant mortality rate may be misleading. Thus, when comparing areas or planning for services to meet the needs of high-risk groups, it is important to examine race-specific rates.

Sources of data

As is evident from the definitions in the previous section, two items are needed in order to produce infant and perinatal mortality data: deaths (neonatal, postneonatal, and fetal) and births. Birth data can serve alone as useful health status indicators. For the purpose of providing denominators for infant mortality, it is sufficient to know that birth data are available on the same geographic basis as mortality data.

A complete description of the sources and classification of mortality data is given in the *Vital Statistics of the United States, 1988* (21). The basic information is obtained from the death certificate. Various forms of mortality data for the United States can be obtained from the National Center for Health Statistics (22–24).

Published annual tabulation (most recently for 1988) are also available for counties and urban places within

$$IMR\ (Race\ X) = \frac{\text{Number of deaths among infants of specific race during a period}}{\text{Number of live births to mothers of specified race during the same period}}$$

The following are race-specific infant mortality rates for the United States for 1984-1986, based on the NCHS's national birth/infant death linked files:

Race	Number of births	Number of infant deaths	Infant mortality rate per 1,000 live births
Total	11,186,950	115,377	10.3
Chinese	47,422	297	6.3
Japanese	23,455	59	6.5
White	8,990,377	78,751	8.8
American Indian or Alaskan Native	100,996	1,360	13.5
Black	1,737,738	31,848	18.3
All other	286,962	2,968	10.3

Note that the total infant mortality rate is a weighted average of the race- specific rates:

$$10.3 = \frac{47{,}422 \times 6.3 + 23{,}455 \times 6.5 + 8{,}990{,}377 \times 8.8 + 100{,}996 \times 13.5 + 1{,}737{,}738 \times 18.3 + 286{,}962 \times 10.3}{11{,}186{,}950}$$

Figure 1. Race-specific infant mortality rates.

counties (25). More recent data and data for subcity units (for example, census tracts) may be available from State and local health departments (19).

Linked birth and infant death files

Almost all of the States routinely link their birth and infant death certificates. The potential for using such data is even greater because information about the infants who died is available from the birth certificate as well as the death certificate. For example, birth certificates in most States include data on the month of pregnancy in which prenatal care began. By comparing this item for mothers of infants who died with other mothers, more direct information becomes available about whether prenatal care is accessible to high-risk mothers. It also makes it possible to determine for a particular area which maternal factors present the greatest potential for infant mortality. Programs directed at such women may then be initiated.

Limitations of the data

Registration and classification

Since the original sources of the data are the persons completing the birth and death certificates, there is potential for variations in registration of births and deaths, completeness and validity of certain items on the certificate, and classification of cause of death. As far as completeness of registration of births and infant deaths is concerned, it is generally believed that this presents no problems (18). Registration of fetal deaths, however, does pose a problem (21). State requirements for registration of fetal deaths vary according to the minimum period of gestation used. Due to difficulties in determining the period of gestation it is likely that underregistration occurs, especially for fetal deaths near the lower limit of required registration. In addition some live-born infants who die very shortly after birth may be erroneously recorded as fetal deaths.

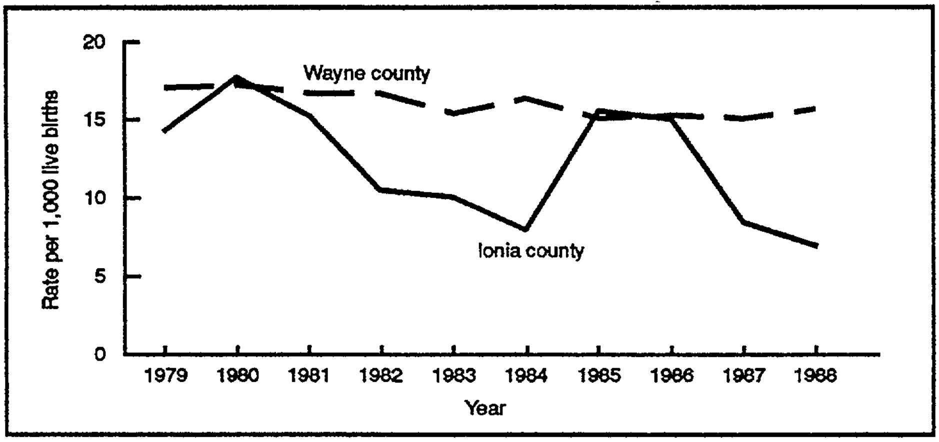

Figure 2. Effects of chance variation on the estimation of infant mortality rates.

Cause-of-death classification also presents problems because a large portion of infant deaths occurs during the first few days of life. Nearly half of all infant deaths are classified in general "catchall" categories, such as "other conditions originating in the perinatal period" and "extreme immaturity." Thus, one should be very cautious when using cause-specific rates. This is especially true when comparing cause-specific rates among areas with very different provider characteristics, since the cause-of-death information varies among physicians by specialty, age, etc.

Stability

An area's observed infant mortality rate should be considered an estimate of the true underlying mortality rate.[a] As is the case with any estimate, the infant mortality rate is subject to chance variation. If the area has very few births, the observed infant mortality rate may be very different from the true rate. Thus if two areas are compared in a given year and one (or both) of the area's rates is based on a small number of births, it would not be unusual to find the comparison reversed the following year. An example is shown in figure 2 where Ionia County's infant mortality rate in 1984 (8.0) was about half that of Wayne County's rate (16.4). The next year Ionia's rate (15.6) was slightly higher than Wayne County's rate (15.1). However, nothing has really changed. The small number of births in Ionia County resulted in very imprecise estimates of Ionia's infant mortality rate.

Thus, a method is needed to assess the adequacy of the observed infant mortality rate as an estimate of its true value. The most common method is the use of confidence intervals, which is explained in detail in the appendix. Basically, a 95-percent confidence interval is defined so that the probability is 95 percent that the true rate is included in the interval. If the interval is very wide, the true rate is not known with much precision. The interval generally becomes narrower as the number of births upon which the rate is based increases. Two common methods of increasing the numbers of births are to combine years and to combine smaller areas into larger ones. This will almost always be necessary. For example, during the 5-year period 1969–73, 35 percent of 3,073 U.S. counties had confidence intervals which were so wide that their infant mortality rates were meaningless.

Although aggregation over years and areas permits the computation of stable rates, there is a loss of information. Combining heterogeneous areas to obtain a stable rate may be more misleading than helpful. Combining years involves the assumption that in each of the years the ranking of the areas is the same, that is, annual changes in the rates are the same for all areas.

The stability issue is especially important when comparing areas or determining whether "real" changes have occurred over time within an area. In these situations confidence limits should be used to assess the magnitude of the differences. Two areas (or two time periods for one area) can be compared by using the absolute difference in their rates (D=r1–r2) or by the ratio of their rates (R=r1/r2). The latter measure of change is usually preferred since it allows for comparison of areas or time over a wide range of rates. For example, in 1940 the U.S. white infant mortality rate was 43.2 per 1,000. By 1965 the rate had dropped to 21.5, a decrease of more than 20 per 1,000. Clearly the rate cannot be expected to drop by 20 per 1,000 again by 1990. However, it does make sense to express the 1940–65 decrease as 43.2/21.5=2.01 (i.e., the 1940 rate was 2.0 times the 1965 rate), and compare the 1965–90 ratio with the 1940–65 ratio. In fact the 1988 rate is 8.5, which gives a ratio of 21.5/8.5=2.53, which is higher than 2.01 and more comparable than the two differences (21.7=43.2–21.5 and 13.0 = 21.5–8.5). The ratio of two rates is closely related to the proportional difference, which is defined as either D/r1 = 1–1/R or D/r2–R-1.

Another indication of the usefulness of the ratio (or relative risk as it is sometimes called) occurs when rates are being used for evaluation. If the infant mortality rate is being monitored over time as additional resources are being phased

[a]The model implied here is that the number of infant deaths in an area varies by chance depending upon the number of births and the probability of infant death (the "true" infant mortality rate). As the number of births increases the chance component becomes less important and the observed infant mortality rate is a better estimate of the true rate.

into a community, the absolute changes in infant mortality rate will almost always decrease, suggesting diminishing returns to the investment of resources. However, the relative changes in mortality may even be increasing.[b]

Differences between numerator and denominator data

Since infant mortality rates are usually calculated by comparing infant deaths to live births during the same year instead of by following the cohort of births to determine the cohort's mortality experience,[c] the numerator and denominator in the rate may relate to different populations. For example, an urban renewal project may result in a rapid, sudden change in the characteristics of an area's population. In this case the infant deaths during the year would be compared with a very different population of births for that year and the rate could be misleading. These types of population shifts should be kept in mind when analyzing small area mortality rates.

In addition, the source of information for the numerator is the death certificate while the source for the denominator is the birth certificate. Lack of comparability in certain items has been noted in special studies that have compared birth and death certificates for the same infant. This problem need not occur, however, in analyses of linked birth and infant death files. This is because information on race and other sociodemographic characteristics for deaths and surviving infants is obtainable from the live birth data on the linked file.

Relevance

Planning

Although an area's infant mortality rate (and its components) may be "explained" by the demographic and socioeconomic characteristics of the area, the need for maternal and infant care programs in a area with high rates is evident. The form that these programs take should be determined in part by infant mortality and other related data. Take, for example, an area with unusually high neonatal mortality. If the area had no intensive care nurseries, it may be in need of such services. On the other hand, if the area already had sufficient intensive care nurseries, the need might be more closely related to making prenatal care more accessible or to emphasizing the educational component of prenatal care. Similarly, high fetal mortality rates should indicate the need for more prenatal or even preconception care (although the completeness of fetal deaths registration should be kept in mind as a possible explanation). Cause-specific perinatal mortality data might be especially useful in suggesting genetic counseling linked to family planning.

Evaluation

Monitoring infant mortality over time is a potential method for evaluating the outcome of health programs directed at mothers and infants. There are, however, a number of problems which must be considered in using mortality data. One of these, the stability problem (p. 3–4), requires that several years of data be combined. Thus, results of an evaluation will not be available for immediate feedback.

Comparison with areas that do not have programs but that are similar in other characteristics to the areas with programs are also helpful to rule out the possibility of something other than the program being responsible for the decrease (25). If such areas are not available, the rates for larger units (for example, other cities, U.S. rural counties) may be used. In addition, some corrections to the raw rates for other variables (for example, based on multiple regression analysis) are often necessary.

Another point that should be considered is the use of specific components of infant mortality to evaluate particular programs. For example, the postneonatal mortality rate should be used to evaluate a program designed to reduce postneonatal mortality. If the infant mortality rate is used, any effects of the program might be overlooked since postneonatal mortality accounts for only one-third of infant mortality.

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[b]This could happen if the rate begins at 50 per 1,000, decreases to 30 at a second time period, and then to 15 at a third period. The absolute changes are 20 and 15, while the relative changes are 1.67 and 2. An advantage of the absolute change is that it is easily translatable into excess deaths or lives saved and this may be a more appropriate measure (especially when dealing with allocation of scarce resources). If there were 10,000 births at each period in the example cited above, the decrease from 50 to 30 resulted in 200 lives saved while the decrease from 30 to 15 resulted in 150 lives saved.

[c]Note, however, that linked birth/infant death files make it possible to analyze the infant mortality experience of birth cohorts.

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Appendix

Assessing stability of rates and changes in rates

As indicated on pages 3–4, an area's infant mortality rate (or any other rate) cannot be taken as the true rate for that area. It is an estimate and as such, its variability must be assessed. The simplest method for doing this is the computation of a 95-percent confidence interval. This interval is defined so that it has 95-percent probability of including the true rate. The formula and an example are given in figure 3. The computations shown are derived under the assumption that the number of deaths in an area has a Poisson distribution (27).

A useful rule is that any rate based on fewer than 20 cases in the numerator will have a 95-percent confidence interval which is about as wide as the rate itself (that is, from $0.5r$ to $1.5r$). Roughly speaking, this means all that can confidently be said about an area with 20 deaths out of, say, 1,000 live births is that the true rate is within 20 ± 10 per 1,000. Clearly this is not precise information. Of course for any rate based on more than 20 deaths, it is important to know the confidence limits in order to determine just how precisely the true rate is estimated.

On page 5, it was suggested that the ratio of two rates be used to compare areas or measure change in one area between 2-time periods. Figure 4 shows the formula for estimating 95-percent confidence limits for the ratio and gives an example. If the 95-percent confidence interval for the ratio of two rates does not include the value 1, the rates are significantly different at the 5-percent level.[d]

The formula given in figure 4 is valid only when the two rates are independent. This means that they refer to completely different areas or time periods: no birth or death which is included in one rate should be included in the other. In addition, the formula is valid only when the rate in the denominator is based upon more than 100 deaths.

Figure 5 gives the formula for obtaining a 95-percent confidence level for the difference between two independent rates. If this interval does not include zero, the rates

[d]This method of testing the significance of the difference between two rates will give slightly different results than the standard method (see Armitage and Berry, reference 26, pp. 123–25). However, the case with which confidence limits for the ratio are obtained by this method lead to the recommendation for its use.

Let r = rate per 1,000 (e.g., infant mortality rate)

n = denominator upon which rate is based (e.g., number of live births or number of live births plus fetal deaths)

The limits of the 95-percent confidence interval are:

upper limit: $r + 61.981 \sqrt{\frac{r}{n}}$

lower limit: $r - 61.981 \sqrt{\frac{r}{n}}$

For an area with 3 deaths and 100 live births:

$$r = \frac{3}{100} \times 1{,}000 = 30$$

$$61.981 \sqrt{\frac{r}{n}} = 61.981 \sqrt{\frac{30}{100}} = 33.948$$

upper limit: 63.948

lower limit: -3.948

In this case the limits are so wide that the interval (-4.0, 64.0) includes negative values, which are impossible. Suppose the numbers of births and deaths increased tenfold. Then $r = \frac{30}{1{,}000} \times 1{,}000 = 30$

$$61.981 \sqrt{\frac{r}{n}} = 61.981 \sqrt{\frac{30}{1{,}000}} = 10.735$$

upper limit: 40.735

lower limit: 19.265

The interval (19.3, 40.7) is much narrower than the one in the first situation, but it still shows that the area's true rate is not known with much precision.

Figure 3. Confidence intervals for rates.

are significantly different at the 5-percent level.[c] Note that the significance tests based on the two methods will occasionally give different results, that is, the confidence interval for the ratio might include one but the confidence interval for the difference might not include zero. If this happens it is safe to conclude that the two rates are not significantly different.

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[c]This method of testing the significance of the difference between the two rates will also give slightly different results than the standard method (see footnote d). The difference between the two is that in the significance testing approach one begins with the null hypothesis assumption that the two rates are equal and uses a pooled estimate of error, while in the confidence interval approach no such assumption is made.

Let

r_1 = rate for period 1 (or area 1)

d_1 = number of deaths for period 1 (or area 1)

r_2 = rate for period 2

d_2 = number of deaths for period 2

$R = r_1 / r_2$

Then the limits of the 95-percent confidence interval are

$$\text{upper limit:} \quad R + 1.96R \sqrt{\frac{1}{d_1} + \frac{1}{d_2}}$$

$$\text{lower limit:} \quad R - 1.96R \sqrt{\frac{1}{d_1} + \frac{1}{d_2}}$$

Consider the following example:

Year	*Number of infant deaths*	*Number of live births*	*Infant mortality rate per 1,000*
1961-65	200	5,000	40
1966-70	100	4,000	25

$$R = \frac{40}{25} = 1.6$$

$$1.96R \sqrt{\frac{1}{d_1} + \frac{1}{d_2}} = 1.96\,(1.6)\,(.1225) = .384$$

upper limit: 1.6 + .384 = 1.984

lower limit: 1.6 - .384 = 1.216

Thus the rate in 1961-65 is from 1.22 to 1.98 times the 1966-70 rate with 95-percent confidence. Since this interval does not include 1, there was a statistically significant ($P<.05$) decrease in the area's infant mortality rate.

The confidence interval for the ratio of two independent rates can also be easily obtained from the confidence intervals for each rate. If the confidence intervals for each rate are

$$r_1 \pm 61.981 \sqrt{\frac{r_1}{n_1}} = r_1 \pm CL_1$$

$$r_2 \pm 61.981 \sqrt{\frac{r_2}{n_2}} = r_2 \pm CL_2$$

then the confidence interval for $R = \frac{r_1}{r_2}$ is

$$R \pm R \sqrt{\left(\frac{CL_1}{r_1}\right)^2 + \left(\frac{CL_2}{r_2}\right)^2}$$

Figure 4. Confidence intervals for the ratio of two independent rates.

r_1 = rate for period 1 (or area 1)

n_1 = denominator upon which r_1 is based

r_2 = rate for period 2 (or area 2)

n_2 = denominator upon which r_2 is based

$D = r_1 - r_2$

The limits of the 95-percent confidence interval are

upper limit: $D + 61.981 \sqrt{\frac{r_1}{n_1} + \frac{r_2}{n_2}}$

lower limit: $D - 61.981 \sqrt{\frac{r_1}{n_1} + \frac{r_2}{n_2}}$

Using the same example as in figure 4,

$D = 40 - 25 = 15$

$$\frac{r_1}{n_1} = \frac{40}{5{,}000} = .008$$

$$\frac{r_2}{n_2} = \frac{25}{4{,}000} = .00625$$

$$\sqrt{\frac{r_1}{n_1} + \frac{r_2}{n_2}} = \sqrt{.01425} = .1194$$

$$61.981 \sqrt{\frac{r_1}{n_1} + \frac{r_2}{n_2}} = 7.399$$

upper limit: $15 + 7.399 = 22.399$

lower limit: $15 - 7.399 = 7.601$

Thus the difference between the two rates is between 7.6 and 22.4 with 95-percent confidence. Since this interval does not include zero, the rates are significantly different at the 5-percent level.

The confidence interval for the difference between two independent rates can also be easily obtained from the confidence intervals for each rate. If the confidence intervals for each rate are

$$r_1 \pm 61.981 \sqrt{\frac{r_1}{n_1}} = r_1 \pm CL_1$$

$$r_2 \pm 61.981 \sqrt{\frac{r_2}{n_2}} = r_2 \pm CL_2$$

then the confidence interval for $D = r_1 - r_2$ is

$$D \pm \sqrt{CL_1^2 + CL_2^2}$$

Figure 5. Confidence intervals for the difference between two independent rates.

NCHS's Healthy People 2000 Staff Moved

The Healthy People 2000 staff of NCHS have moved to a new office on the sixth floor of the Presidential Building (Room 630, 6525 Belcrest Road, Hyattsville, MD, 20782. Our new telephone number is (301) 436–3548. You can reach the following staff members:

Mary Anne Freedman, *Special Assistant to the Director*
Susan Hawk, *Program Analyst*
Gail Jones, *Program Assistant*
Richard Klein, *Chief, Statistical Component Staff*
Shari Rapisardi, *Secretary*
Cheryl Rose, *Computer Specialist*
Kathleen Turczyn, *Health Statistician*
Jean Williams, *Systems Analyst*

In the next issue of *Statistics and Surveillance*, we plan a "Meet the Staff" article.