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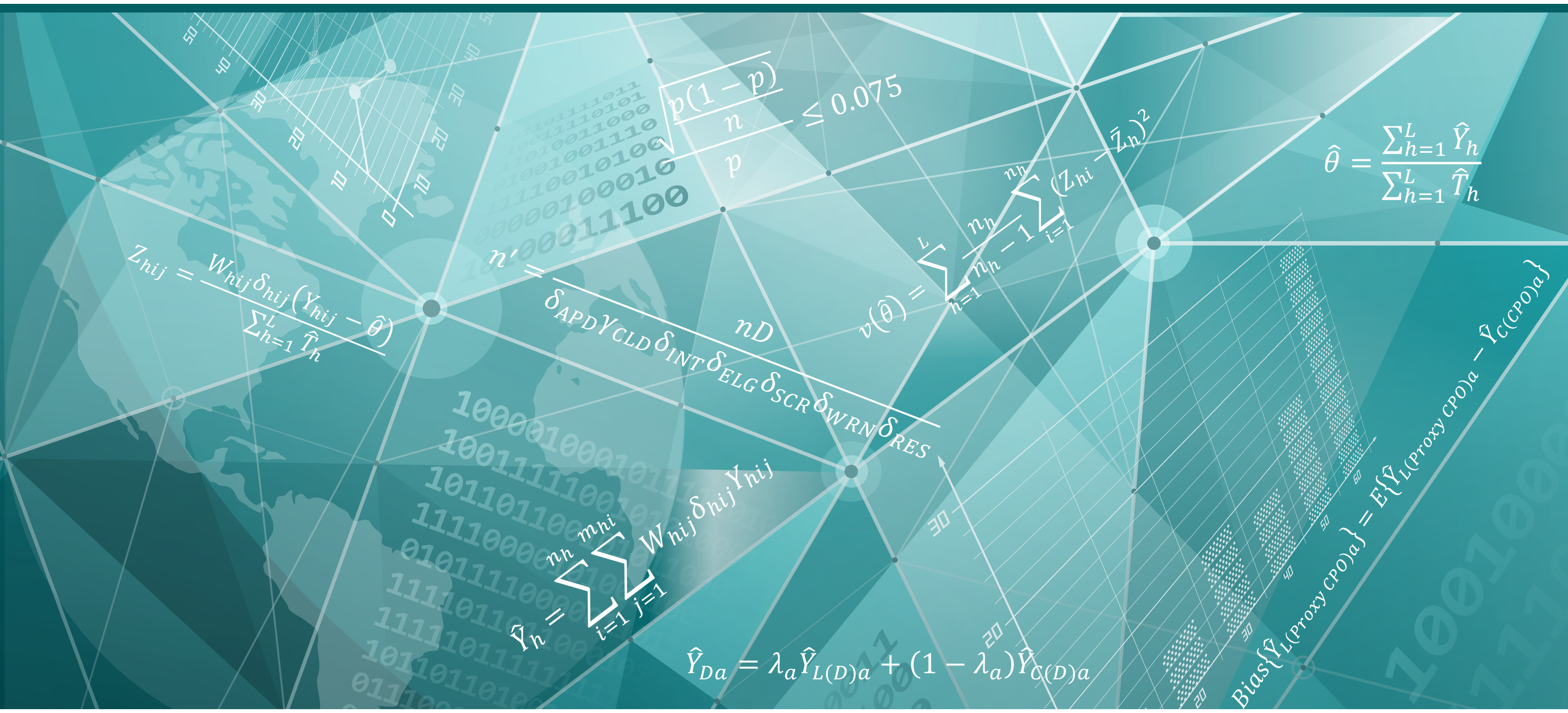

National Center for Health Statistics Data Presentation Standards for Rates and Counts

Data Evaluation and Methods Research

Centers for Disease Control and Prevention
National Center for Health Statistics

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Data Evaluation and Methods Research

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Center for Health Statistics

Hyattsville, Maryland
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Acknowledgments

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National Center for Health Statistics Data Presentation Standards for Rates and Counts

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Abstract

Background

The National Center for Health Statistics (NCHS) shares information on a broad range of health topics through various publications. These publications must rely on clear and transparent presentation standards that can be broadly and efficiently applied. Standards are particularly important when indicators of precision cannot be included alongside the estimates, such as for some large, cross-cutting reports and for shorter communications on social media.

Objective

This report describes the NCHS data presentation standards for rates and counts.

Results

The multistep NCHS data presentation standards for rates and counts are based on a minimum sample size and the relative width of a confidence interval (CI). Specific criteria for rates and counts, including the CI calculations used, differ between vital statistics and health surveys and may differ according to the source of the denominator.

Conclusion

The NCHS data presentation standards for rates and counts will be applied to all NCHS publications. Using these standards, some estimates will be identified as unreliable and suppressed, and some estimates will be flagged for statistical review. For reports where estimates are evaluated individually, a particular estimate that does not meet the NCHS data presentation standards for rates and counts could be identified as unreliable but not be suppressed if it can be interpreted appropriately in the context of subject-specific factors and report objectives.

Keywords: confidence interval • sample size • degrees of freedom • health surveys • vital statistics • population estimates

Introduction

The National Center for Health Statistics (NCHS) collects, analyzes, and distributes information on a broad range of health topics through a variety of publications, databases, and tables. Some data products present information based on a single NCHS data system, while others summarize information from many NCHS data systems. These reports and data products may include estimates on a wide range of topics or focus on a particular health outcome. Some of these products may only provide supporting information separately from an estimate, such as its standard error (SE) or confidence interval (CI), because of space and format constraints. Examples include some large reports, some data visualizations, and social media content (1,2). As a result, NCHS reports and other products must rely on clear and transparent presentation criteria that can be broadly and efficiently applied whenever caution should be given to a particular estimate because it may be unreliable.

Statistical standards for data presentation vary across agencies, data systems, and data products (3,4). Differences among standards can be, in part, attributed to each data system's unique features and constraints. Standards also change over time, due to changes in the purpose and scope of the data's use, the capability of a user to carefully review published estimates, the ability to provide explanatory text discussing the precision of the published estimates, and advances in statistical methodology.

In 2017, NCHS released the "National Center for Health Statistics Data Presentation Standards for Proportions" (4), which described the criteria and the reasoning supporting the criteria, by which NCHS would determine whether to publish a proportion (or percentage) in its reports and other products. Standards were developed to identify estimates with sufficiently high statistical reliability for presentation, where reliability was determined using sample size and CI thresholds. Proportions, or percentages (proportions multiplied by 100%), are the most common statistics produced at NCHS.

Rates and counts are also widely disseminated by NCHS, principally in two areas: vital statistics, including rates and counts for deaths and births (5,6), and health care visits, including rates and counts for hospitalizations and ambulatory care visits (7,8). Additionally, counts of the number of people with specific health outcomes—including health conditions, risk factors, and access to care measures—can be produced from household surveys, including the National Health Interview Survey (NHIS) (9), National Health and Nutrition Examination Survey (NHANES) (10), and National Survey of Family Growth (NSFG) (11).

This report describes the NCHS data presentation standards for rates and counts, including details about rates and counts produced from the National Vital Statistics System (NVSS) and the National Health Care Surveys. Because underlying statistical distributions differ between NVSS- and survey-based estimates, such as those from health care surveys or other sample surveys, standards are given separately for these cases. In addition to statistical reliability, data confidentiality and disclosure risks affect the ability to present estimates. For example, subnational and, in some cases, national counts of deaths and births based on fewer than 10 events are suppressed to protect confidentiality (12). Confidentiality and disclosure standards are handled separately and are outside the scope of these standards.

Rates are more complicated than proportions. Consequently, this report and the resulting standards require more technical detail of the statistical methods compared with the previous report on standards for proportions. The Appendixes contain supporting technical material for the standards: Appendix I provides mathematical details for the CIs used in the standards, and Appendix II provides links to the technical documentation for NCHS surveys and selected U.S. Census Bureau surveys where guidance can be obtained on calculating survey design effect (DEFF), among other survey-specific information. An evaluation of the standards for vital statistics and health care surveys under different scenarios, including the CI thresholds used in the standards, is discussed in a separate NCHS report (13). Although the standards were not evaluated for other sample surveys such as NHIS, NHANES, or NSFG, they are intended to apply to all survey-based rate and count estimates produced by NCHS.

Key Concepts

What is a rate?

- For the NCHS data presentation standards for rates and counts, a rate is defined as the number of events for a population for a given time period (numerator) divided by a count of the population at risk during that time period (denominator) and expressed per population size.
  - For most NCHS dissemination purposes, the term **crude rate** refers to an overall rate for all ages or for broad age categories, such as all adults over age 18, while **age-adjusted rates** are mathematically adjusted to a standard population (14,15).
  - **Age-specific rates** are the number of events among people of a specified age or age group divided by a count of the population of people in that age group for a given time period.
- In contrast with proportions, which are constrained to be from 0 to 1 (or from 0% to 100% when expressed as percentages), rates are not always constrained by an upper bound.
  - For death rates, which are usually expressed per 100,000 population, the event (death) can only occur once. Because the numerator is a subset of the denominator, the upper bound would be 100,000/100,000 = 1.
  - For other rates, including health care visit rates and birth rates, multiple events can occur for the same person. As a result, such rates can be larger than 1.

What are the specific components of the definition of a rate?

- The **population** can be the U.S. resident population or a subset of the U.S. population, such as the U.S. civilian noninstitutionalized population, defined by factors like race and ethnicity, age group, and geographic location.
- The **number of events (numerator)** for the population of interest over the time period is calculated or estimated from vital records, a survey, or another source.
- The **time period** is typically 1 year for NCHS annual estimates. However, shorter or longer time periods could be applied to the definition, such as quarterly rates or multiyear rates.
- The **population at risk (denominator)** during the time period typically corresponds to the population of interest.
  - For most rates produced by NCHS, the population at risk is based on census decennial population files, including the decennial estimates and the postcensal and intercensal estimates that are calculated from decennial estimates (5–8). In these cases, the denominator is relatively free of random variation; see "A. Sources of variation."
  - The population at risk can also be a count obtained from a population survey, such as the U.S. Census Bureau's American Community Survey (ACS) (16) or NHIS (17). In

these cases, the sampling variability of the denominator needs to be considered when calculating SEs and other measures of uncertainty for rates.

A. Sources of variation

Both the numerator and denominator may be subject to several **sources of variation**. When either the numerator or denominator count is estimated from a survey, it will be subject to **sampling variability**. Even when the actual number of events in the numerator or the size of the population at risk in the denominator is recorded and free from sampling variability, **natural (or stochastic) variability** exists in the realized values (18). For a numerator or denominator that is enumerated from vital statistics and free of sampling variability, the number of events (as in deaths or births) will be assumed to arise from a Poisson distribution (5,6,19). For a denominator that is enumerated from a decennial census or a postcensal or intercensal population estimate, some natural variability may exist in the realized value; however, such random variation will be negligible and will not be considered in calculations.

Rates and Counts at NCHS

Counts produced by NCHS include numbers of deaths and births, numbers of visits to hospitals and other health care settings, and, in some cases, numbers of people with specific health outcomes, including health conditions, risk factors, and access to care measures. Counts of deaths and births from NVSS are obtained from registers of events. Counts of visits from the National Health Care Surveys, and counts of people with specific health outcomes from population health surveys, are estimated using appropriate methods for sample surveys; examples are available elsewhere (7,8).

Rates regularly calculated from NVSS and the National Health Care Surveys include birth and death rates and health care visit rates, respectively. In many cases, the rates are published alongside corresponding counts. For most NVSS rates produced at NCHS, the denominator is a decennial census or postcensal or intercensal population estimate, which is relatively free of random variation. However, for rates for some subpopulations, including Hispanic subpopulations, and for some demographic groupings, such as by education level, the population estimates are calculated from a survey, such as ACS or the U.S. Census Bureau's Current Population Survey (CPS). In these cases, the sampling variability in the corresponding denominator needs to be considered when calculating SE and other measures of uncertainty around the rate (19).

Rates from the National Health Care Surveys typically include visit rates to hospitals and health care providers (7,8). The counts in the numerators obtained from the National Health Care Surveys are estimated using appropriate statistical methods for complex surveys. Like rates from NVSS, the denominators for rates from the National Health Care Surveys are mostly decennial census or postcensal or intercensal population estimates. However, condition-specific visit rates can also be calculated for a population at risk that is estimated from a complex survey. In these cases, the sampling variability needs to be included in calculations.

NCHS Presentation Standards for Rates and Counts

Previous Guidelines

NCHS has used previous standards and guidance for determining whether to present rates and counts (3,4). These criteria, reviewed for vital statistics and the National Health Care Surveys in the following sections, relied on sample sizes and measures of variance, most often relative standard errors (RSEs) and often adjusted for survey DEFFs for estimates from surveys. RSE is calculated as SE divided by the estimate and multiplied by 100%.

Vital statistics

Before the release of the current standards, the presentation guidance for NVSS was to suppress rates with fewer than 20 events in the numerator when using population denominators that were decennial census or postcensal or intercensal population estimates (5,6). This 20-event threshold for vital rates corresponds to an RSE of 23% for a Poisson-distributed count variable. For a Poisson variable, SE is the square root of the number of events.

For rates using census population denominators estimated from CPS or ACS where the sampling variability needs to be considered, RSE of the rate was used to determine its reliability for presentation. Rates with an RSE of 23% or more were suppressed or flagged for internal review (20).

Age-adjusted death rates followed the guidelines above and were presented if the number of events on which the rate was based was 20 or more, or when populations were estimated from surveys where RSE was less than 23% (5).

National Health Care Surveys

At NCHS, health care surveys account for nearly all rates produced and distributed from survey data. Denominators for most of these rates are decennial census or postcensal or intercensal population counts. Historically, rates from the National Health Care Surveys were suppressed when based on a sample size less than 30, that is, fewer than 30 sample observations in the numerator. Rates were flagged as unreliable if RSEs were greater than 30%. Combined, these criteria were known as the “30/30 rule” (7,8). Rates with survey-based numerators from health care surveys and survey-based population denominators had been uncommon, so decisions for these cases were developed on a case-by-case basis.

Similarly, counts were suppressed when based on fewer than 30 sample observations and flagged as unreliable if the RSE was greater than 30%.

New Standards

Table A summarizes the NCHS presentation standards for rates and counts for each component: sample size, CI, and degrees of freedom (*df*). Figures 1 and 2 illustrate the steps needed to determine whether to present rates with or without sampling variability.

Specific components of NCHS data presentation standards for rates and counts are detailed in the following sections.

Sample size standard

Sample size is an important indicator of an estimate's precision and, when evaluating the statistical reliability of a rate, sample size is relevant for both the number of events (numerator) and the population at risk (denominator).

- The sample size is the number of observations, or events, used in the calculation of a rate or count. For vital statistics, the sample size is the number of vital events (births or deaths). For complex surveys, the sample size is the number of observations used in calculations of survey-based estimates and is sometimes referred to as the **nominal sample size** to distinguish it from other measures, such as the effective sample size used for surveys.
- For complex surveys, the **effective sample size** is defined as the (nominal) sample size divided by the DEFF. DEFF is the relative change in variance due to the complex survey design relative to a hypothetical simple random sample of the same size (21). The effective sample size is more informative than the nominal sample size for complex surveys because it incorporates information about the design, which has important implications for statistical power and reliability of estimates.
- When the number of events or population estimates are estimated from a complex survey using sample weights, such as from the National Health Care Surveys, NHIS, or ACS, the **sample-weighted estimates** of the number of events or population are not the same as the corresponding nominal sample sizes or effective sample sizes. In these cases, nominal sample sizes and effective sample sizes are used to determine reliability, not the sample-weighted estimates of the events or population; see "B. Design effect."

B. Design effect

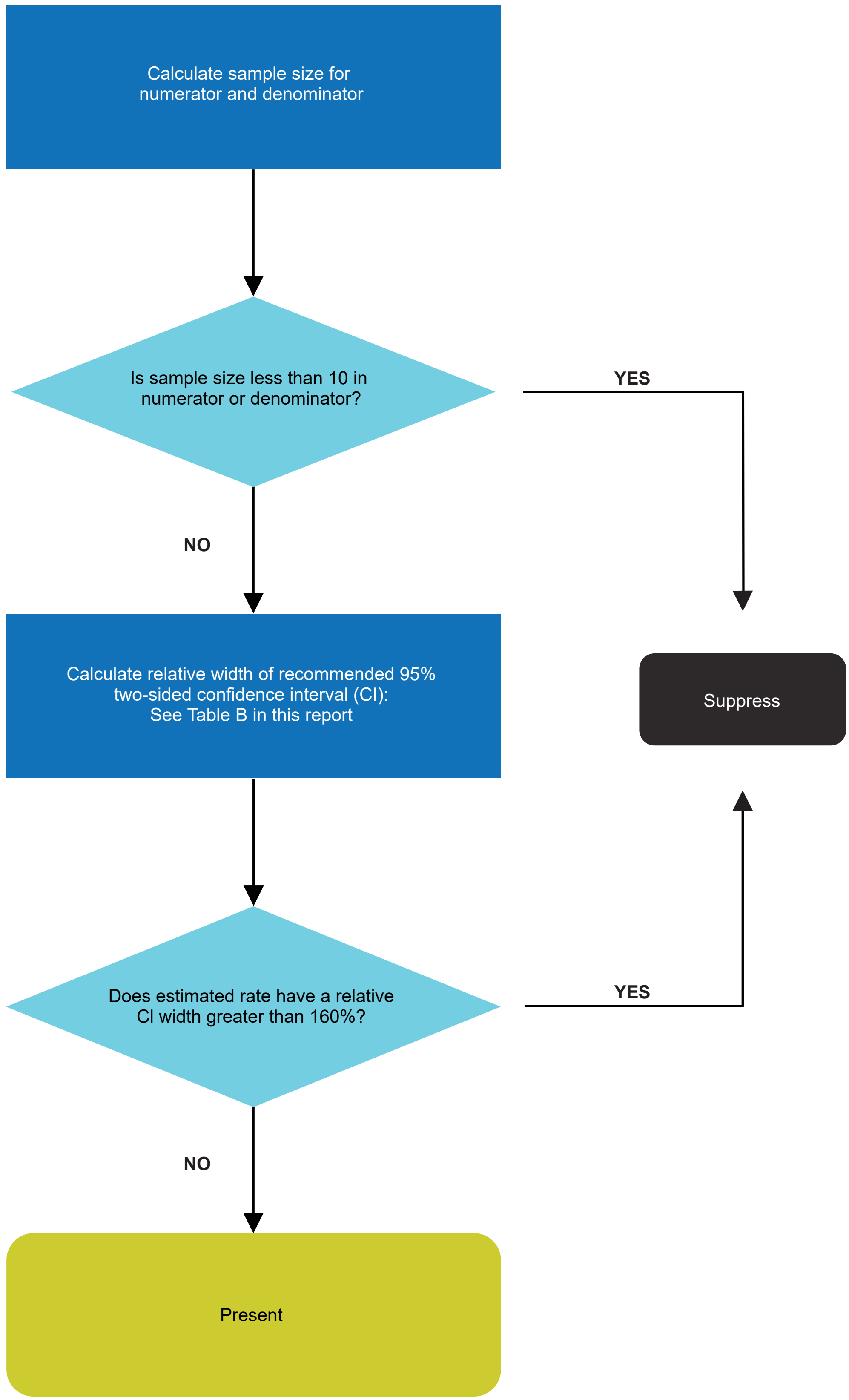
The design effect (DEFF) measures the impact of the complex sample design on variance estimates. If DEFF = 1, then design-based variance is the same as the variance under simple random sampling. Most National Center for Health Statistics surveys have DEFF greater than 1, which means that the effective sample size is less than the number of observations or events. If DEFF is less than 1, then the effective sample size is greater than the number of observations or events, and the nominal sample size is used instead of the effective sample size to assess statistical reliability. DEFF can vary depending on the health outcome or condition that is being measured, as in geographic distribution, as well as by population subgroups, as in age or race and ethnicity. Some statistical packages by default calculate DEFF of the row, or ROW DEFF, based on the row percentage in frequency or cross-tabulation tables (22,23). However, TOTAL DEFF is preferred for rates because the numerator is a total estimate.

Table A. National Center for Health Statistics standards for rates and counts

Statistic	Standard for rates	Standard for counts
Sample size threshold	Estimated rates should be based on a minimum sample size and effective sample size (when applicable) of 10 in both numerator and denominator.	Estimated counts should be based on a minimum sample size and effective sample size (when applicable) of 10.
Confidence interval (CI)	If the sample size criteria are met, calculate a 95% two-sided CI using the appropriate method and obtain its relative width. Estimated rates should have a relative CI width of 160% or lower.	If the sample size criteria are met, calculate a 95% two-sided CI using the appropriate method and obtain its relative width. Estimated counts should have a relative CI width of 160% or lower.
Degrees of freedom	When applicable for complex surveys, if the sample size and CI criteria are met for presentation and degrees of freedom are fewer than 8 for either numerator or denominator, then the rate should be flagged for statistical review by the clearance official. This review may result in presentation or suppression of the rate.	When applicable for complex surveys, if the sample size and CI criteria are met for presentation and degrees of freedom are fewer than 8, then the count should be flagged for statistical review by the clearance official. This review may result in presentation or suppression of the count.

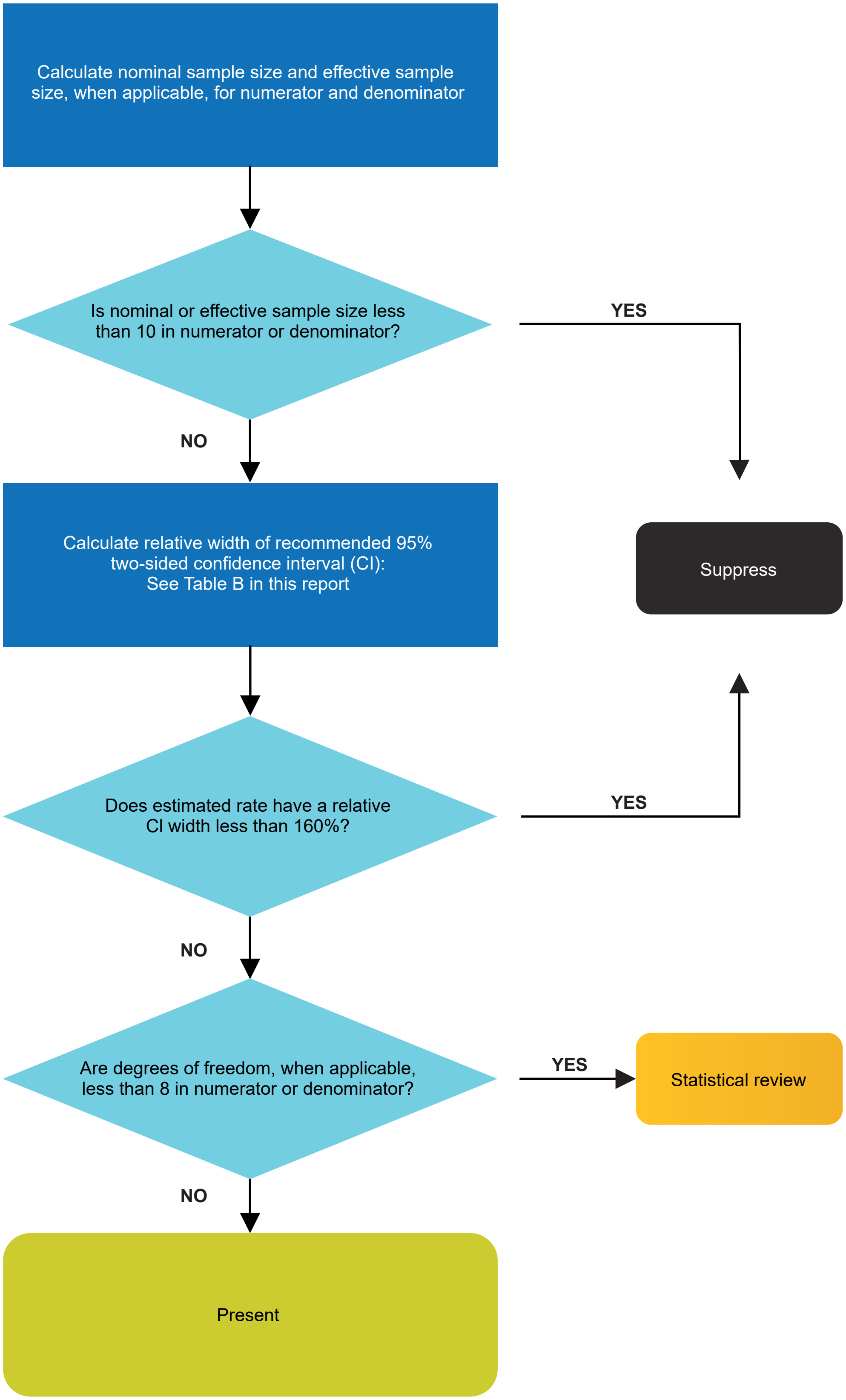
SOURCE: National Center for Health Statistics.

Figure 1. Presentation standards for rates without sampling variability



NOTE: Rates without sampling variability are rates developed from vital statistics involving populations calculated from decennial census or postcensal or intercensal estimates, and period- and cohort-linked infant mortality rates where the denominator is live births.
SOURCE: National Center for Health Statistics.

Figure 2. Presentation standards for rates with sampling variability



NOTE: Rates with sampling variability include rates developed from vital statistics with population denominators from a sample survey, such as the American Community Survey; rates from health care surveys; and rates from population health surveys.
SOURCE: National Center for Health Statistics.

For effective sample sizes, documentation for specific surveys should be consulted when calculating DEFFs because recommended approaches can differ among surveys and for specific analytic purposes; see Appendix II. Further, methods may be updated with methodological developments and design changes. Because standard software can produce multiple DEFFs, users should consult the survey and software documentation to identify the appropriate DEFF. For the NCHS data presentation standards for rates and counts, based on an evaluation using two common methods for calculating DEFF, DEFFs for totals or counts are used.

As with crude or age-specific rates, when either the numerator or denominator for an age-adjusted rate is estimated using sample weights from a complex survey, the effective sample sizes should be calculated and evaluated along with the nominal sample sizes. As noted previously, age-specific nominal sample sizes and effective sample sizes should be used to determine reliability, not the sample-weighted estimates of the events or population in the age group.

When evaluating counts, as with rates, the estimated count can be the same as the corresponding sample size, but it also can be calculated using sample weights when obtained from a complex survey or adjusted using other analytic approaches. When the count is estimated from a complex survey, the effective sample size should be calculated and evaluated along with the nominal sample size. The sample-weighted estimate of the count is not used to determine statistical reliability.

For the standard, rate and counts should have nominal sample sizes (or effective sample sizes, when relevant) of 10 or more. For surveys, both the nominal and effective sample sizes should be evaluated, and the threshold of 10 or more applied to the smaller of the two values.

For crude and age-specific rates and counts from vital statistics, the threshold of 10 corresponds to an RSE of 33%, which is close to RSE-based thresholds of 30% historically used at NCHS. The previous threshold for vital statistics of a sample size of 20 was equivalent to an RSE of 23%. No similar equivalents exist between sample size and RSE for sample-size thresholds for age-adjusted and survey-based rates, because extra variation may exist due to other factors, such as the effect of population weights used for age adjustment or, for surveys, the variability of sample weights or other survey design features. As a result, additional criteria need to be met to ensure statistically reliable estimates.

Standard

When presenting estimated rates, the sample size (or effective sample size, when relevant) for the numerator and denominator should be 10 or greater. For counts, the sample size (or effective sample size, when relevant) should be 10 or greater. In instances where the effective sample size is greater than the sample size, the smaller sample size should be evaluated.

Confidence interval standard

Once the sample size thresholds are met, NCHS data presentation standards for rates and counts are based on the evaluation of relative 95% CI widths. The absolute width of 95% CIs for rates is not useful for presentation standards because, as mentioned previously, rates are not necessarily constrained by an upper bound and, unlike proportions or percentages, have variable standard population sizes (per 100,000 population, per 1,000 live births, or per 100 people per year, among others); see "C. Confidence interval."

C. Confidence interval

The width of a confidence interval (CI) provides an assessment of an estimate's precision. Technical definitions of CIs are available from many standard statistical texts, including Bickel and Doksum (24) and Casella and Berger (25). Generally, under repeated sampling, if an estimate such as a rate and its 95% CI are estimated from each sample, the true value of the rate is expected to be contained in 95% of the calculated intervals. Depending on the method used to calculate CI, the expectation of 95% coverage may not be attained for some intervals or under some conditions. Methods used to calculate a CI may lead to undercoverage if the true rate is contained in fewer than the expected number of intervals (less than 95%).

Unlike the NCHS data presentation standards for proportions, where the Clopper–Pearson CI is used once the sample size thresholds are met, for the data presentation standards for rates and counts, different approaches for calculating CIs are needed for vital statistics, complex health surveys, and different types of denominators to ensure 95% coverage. These CI calculation methods differ due to the underlying assumptions about statistical distributions and the sampling variability from complex surveys.

Table B summarizes CI calculations for different scenarios, which are detailed in Appendix I.

For all rates and counts, the standard is based on the relative width of the appropriate 95% two-sided CI. The width of the interval is the difference between the upper CI and the lower CI. The relative width of the CI is the length of the interval divided by the estimate multiplied by 100%.

A relative width of 160% or narrower is needed to present rates and counts. For vital statistics, a CI threshold of 135.9% using the approach outlined in the first row of Table B with the exact gamma interval directly corresponds to the sample size criterion of 10 or more events for crude and age-specific rates. Generally, no direct correspondence exists between the relative CI width criterion and the sample size criterion for age-adjusted vital rates, vital rates with extra variation due to use of ACS or CPS, and rates that include sample-weighted components from complex surveys. Simulations for age-adjusted all-cause mortality rates (13) suggest that a CI threshold of 160% for the Fay–Feuer gamma interval described in Table B corresponds to a numerator of 10 or more. Further, simulations modeled on National Ambulatory Medical Care Survey data (13) suggest that a CI threshold of 160% for the logarithmic Student's *t* CI described in Table B corresponds to a numerator as high as 30. As a result, both the relative width and sample size criteria are used to ensure statistically reliable estimates because of the lack of a one-to-one correspondence between them.

Appendix I contains the mathematical details of the CIs described in Table B. The evaluations and simulation studies mentioned above are documented in a separate NCHS report (13).

Standard

If the sample size (or effective sample size) criterion is met, then calculate the appropriate 95% two-sided CI for the data system and type of denominator. The relative width of CI is the width of the interval divided by the estimate multiplied by 100%. If the relative width of CI is 160% or less, then the rate or count should be presented.

Degrees of freedom standard

For complex sample surveys, the precision of the estimated variance is approximately related to the square root of *df* (26,27); see "D. Degrees of freedom."

Table B. National Center for Health Statistics standards for rates and counts: Confidence interval calculations, by data system and type of denominator

	Rates		Counts
Data system	Denominator	Confidence interval	Confidence interval
National Vital Statistics System	Relatively free of random variation and sampling error, when applicable	Calculate gamma interval where the lower limit is the 0.025 quantile of the standard gamma, where x = number of events and with parameters $\alpha = x$ and $\beta = 1$. The upper limit is the 0.975 quantile of the standard gamma, with parameters $\alpha = x + 1$ and $\beta = 1$. Apply Fay–Feuer approximation for age-adjusted vital rates.	Calculate gamma interval where the lower limit is the 0.025 quantile of the standard gamma, where x = number of events and with parameters $\alpha = x$ and $\beta = 1$. The upper limit is the 0.975 quantile of the standard gamma, with parameters $\alpha = x + 1$ and $\beta = 1$.
	Based on American Community Survey (ACS) or Current Population Survey (CPS), U.S. Census Bureau	Calculate a Student's *t* interval for logarithm of the rate, with variance estimated using method supplied with survey data source. Form confidence intervals (CIs) for age-adjusted rates using weighted combinations of age-specific estimates. Obtain CI for the rate by reverse transformation.	…
	Based on population surveys other than ACS or CPS and with sampling error or other source of random variation	Calculate a Student's *t* interval for logarithm of the rate with estimated variance supplied by survey data source. Form CI for age-adjusted rates using weighted combinations of age-specific estimates. Obtain CI for the rate by reverse transformation.	…
	Based on births file and subject to random variation, such as for period- or cohort-linked infant mortality	Calculate a Student's *t* CI for logarithm of the rate. Obtain CI for the rate by reverse transformation.	…
Complex health surveys	Relatively free of random variation and sampling error, when applicable	Calculate a Student's *t* CI for logarithm of the rate. Obtain CI for the rate by reverse transformation.	Calculate a Student's *t* CI for logarithm of the count. Obtain CI for the count by reverse transformation.
	Based on population surveys and with sampling error or other source of random variation	Calculate a Student's *t* CI for logarithm of the rate. Obtain CI for the rate by reverse transformation.	…

… Category not applicable.

SOURCE: National Center for Health Statistics.

D. Degrees of freedom

The degrees of freedom (*df*) for a complex sample survey are the independent pieces of information on which an estimate is based. Sample persons or establishments within a given primary sampling unit are not independent. In some complex, multistage surveys, *df* can be calculated by subtracting the number of clusters or strata from the number of primary sampling units (27,28).

Using resulting SEs with low precision to assess estimated proportions may lead to poor measures of effective sample size and CI widths. Under certain conditions, the variance estimate is approximately proportional to a chi-squared distributed random variable, and the RSE of the variance obtained from a complex sample survey can be approximated as

$$100\sqrt{2\,/\,df} \quad [1]$$

From this expression, RSE of the estimated variance of a rate or count based on fewer than eight *df* will be 50% or higher. As a rule of thumb, *df* for a sample survey can be calculated as the number of primary sampling units (PSUs) minus the number of strata. This calculation is used in most NCHS surveys and implemented in survey software, although specific calculations can vary across software packages. Default calculations of *df* from survey software may not be appropriate for subgroups represented in only a subset of PSUs (for example, some racial and ethnic groups and region-specific estimates) and when calculating annual or survey cycle estimates using a multiyear or multicycle data file. In these instances, the relevant information should be extracted and *df* directly calculated to assess estimate precision. The calculation of *df* as a measure of precision for SE may not be applicable for all surveys (see survey-specific documentation in Appendix II) and does not apply to vital statistics. For additional information on *df*, see Valliant and Rust (26), Korn and Graubard (27), and the NHANES tutorial (28).

Standard

When applicable for complex surveys, *df* should be eight or higher. If *df* are fewer than eight, then the rate or count should be flagged for statistical review by the clearance official. This review will result in either the presentation or suppression of the rate or count.

Discussion

The NCHS data presentation standards for rates and counts will be applied to all NCHS publications and used by all NCHS analyses and resulting products. Using these standards, some estimates will be identified as unreliable and suppressed, particularly for large reports and tables. However, when the standards for rates and counts are used for shorter, more focused reports, specific estimates that do not meet the standards may be reported after being evaluated individually by the analyst and clearance official. Some estimates identified as unreliable based on the standards may be important and can be interpreted appropriately in the context of measures of precision and other subject-specific information. In these cases, the estimate could be presented. Because report objectives and subject-specific factors vary widely, justification for presenting an unreliable estimate should be provided by the analyst, and final determination should be made by the analyst and clearance official on a case-by-case basis. In all publications, unreliable estimates, whether presented or suppressed, should be identified with a footnote.

Many NCHS data products include SEs alongside the estimate so that data users can assess the precision of the point estimates, although some large cross-cutting reports and shorter publications do not. Whenever space permits, appropriate CIs should be provided, rather than just SEs, because CIs obtained using appropriate assumptions more accurately describe the variability than a typical Wald (or normal) CI calculated using the estimate and its SE.

Estimates from sample surveys with fewer than eight *df* should be flagged for statistical review because sufficient *df* are needed for reliable CIs. Statistical review by a clearance official of flagged estimates will consider factors such as the estimate's sample size, availability of alternative CI approaches, and *df*. The review will also consider the recommendations of the analyst, results of any supplemental or sensitivity analyses, the report's objectives and format (including the ability to present CIs or other measures of precision), and other estimates in the report. In some large reports, this process may be automated to ease the production process, with all flagged estimates suppressed without review. In all publications, estimates from sample surveys based on fewer than eight *df*, whether presented or suppressed, should be identified with a footnote.

Age-adjusted estimates are often produced for national statistics. Age adjustment allows for a comparison of outcomes between two groups with differing age distributions, since many health outcomes are highly correlated with age (14,15). Instances may occur in which the age-adjusted estimate will not meet the presentation criteria, but the crude estimate does, or vice versa. In these cases, the estimate that meets the presentation criteria will be shown, and the one that does not will be suppressed.

For the NCHS data presentation standards for rates and counts, a minimum sample size and effective sample size (when applicable) are needed for both the numerator and denominator. These minimums ensure the validity of the CI methods where coverage can be inadequate for small samples. From simulation results (13), small sample sizes were generally observed along with large interval widths. However, in some of these instances, the coverage of the CI was less than 95%.

These data presentation standards are appropriate for rates and counts. Standards for proportions were described previously (4). The NCHS standards were not developed to apply to other estimators, such as percentiles or means, or to model-based estimates other than those from the Poisson-distributed vital rates. Although the principles considered by the workgroup for rates and counts, and previously for proportions, can be considered for other estimators—including the evaluation of effective sample size, CIs, and *df*, when appropriate, to guide decisions—no specific thresholds for these estimators are provided by these standards. Further, alternative methods exist for calculating CIs for rates and counts, as well as more precise approximations to the variance of ratio X / Y, when simplifying assumptions (Appendix I) are not met. Thresholds for the CI standards were determined using the CI methods described in this report. Although other CI methods may be useful for other purposes, such as hypothesis testing or graphic display, the evaluations and simulations used to set the presentation thresholds may not be appropriate for these intervals.

In addition to precision, other factors not addressed here affect the quality of the estimates, including measurement error and response rates, and other dimensions of data quality, such as timeliness, relevance, granularity, and confidentiality. Effective understanding of data quality is essential for making data-driven decisions. The recent data quality framework issued by the Federal Committee on Statistical Methodology sets guidance on documenting and reporting data quality so that users can determine whether data are fit for their purpose, including the quality of data published as tabular estimates (29). Twelve quality dimensions within three domains of quality (utility, objectivity, and integrity) compose the Data Quality Framework. Consistent with the Data Quality Framework, particularly its dimension on accuracy, the NCHS data presentation standards for rates and counts are transparent criteria that allow data users to know that rates and counts produced by NCHS meet certain thresholds of statistical reliability.

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Appendix I. Sample Size and Confidence Interval Calculations for Rates and Counts

This appendix provides specific formulas and expressions used in the sample size and confidence interval (CI) presentation criteria for rates and counts reported in the National Center for Health Statistics (NCHS) vital statistics and health care surveys. Although some of the analytic steps may apply to rates and counts from other sources, including other population health surveys at NCHS, the underlying assumptions were determined only in the context of NCHS vital statistics and health care surveys.

Sample Size

For rates $R = X / Y$ that are estimated using $r = x / y$, the numerator, based on sample size n_x, is the number of events, and the denominator, based on sample size n_y, is the population at risk. When calculating the rate r, x and y may be the same as n_x or n_y, or they may be calculated using sample weights or other analytic weights. When either the numerator or denominator is estimated from a complex survey, the effective sample sizes, n_{x_eff} and n_{y_eff}, should be calculated. Rates for the total population or a specific population subset, such as adults aged 18 and over, are often referred to as crude rates.

Age-adjusted rates can be expressed as $r = \sum w_i r_i$, where $r_i = x_i / y_i$ are the age-specific rates for age groups $i = 1,2,\ldots,K$, and w_i denotes the relative proportions for age group i in the reference (standard) population. For age-adjusted rates, the corresponding numerator sample sizes n_{x_i} are the age-specific sample sizes, and the corresponding denominator samples sizes n_{y_i}, are the age-specific population sizes. The numerator sample size is the sum of the age-specific sample sizes, $\sum n_{x\_i}$, and the denominator sample size is the sum of the age-specific population sizes, $\sum n_{y\_i}$. For the crude rates, when either the numerator or denominator is estimated from a complex survey, the effective sample sizes for each age group, $n_{x\_eff\_i}$ and $n_{y\_eff\_i}$, should be calculated.

When calculating the sample size for a count, x may be the same as n_x or may be adjusted by sample weights or calculated using other analytic methods. For counts from a complex survey, the effective sample size is the number of observations in the sample adjusted by the design effect (DEFF) $n_{x\_eff\cdot\_i}$

Confidence Intervals

For the NCHS data presentation standards for rates and counts, different approaches for calculating CIs are used for vital statistics and complex surveys, as well as according to the source of the denominator, to ensure 95% coverage. These methods differ due to underlying assumptions about statistical distributions and the need to include sampling variability when calculating CIs.

CIs for Counts and Age-specific and Crude Vital Rates, Where Population Denominator is Free of Sampling Variability

When the numerator count is enumerated from vital statistics, the number of events (as in deaths or births) will be assumed to come from a Poisson distribution (5,6). When the population denominator count is a decennial census or postcensal or intercensal population estimate that is relatively free of sampling variability, it is treated as a constant without variation in calculations. Although the actual number of events or population denominator count is recorded and relatively free from sampling variability, natural variability exists in the realized value (18,30).

These expressions use the following notation:

- Rate (usually multiplied by 100,000 and expressed as a rate per 100,000 population): $R = X / Y$
- Total number of events on which rate is based: X
- Total population on which rate is based: Y

As stated previously, the number of events X is assumed to be Poisson-distributed, with mean and variance given Y equal to λY where λ is the true underlying rate. Exact 95% CI limits for the rate can be derived using a well-known relationship between the Poisson and gamma distributions (31,32). Suppose $X = x$ events are observed in a population of size $Y = y$. Then a gamma-distributed random variable Z exists with mean $r = x / y$ and variance $v = x / y^2$ such that

$$\Pr\left(R \geq r\right) = \Pr(Z \leq \lambda)$$

As a result of this relationship:

- The lower limit $L(r)$ of the 95% CI is obtained from the 0.025-quantile of a gamma distribution with shape parameter $\alpha = x = r^2 / v$ and scale parameter $\beta = 1 / y = v / r$.
- The upper limit $U(r)$ of the 95% CI is obtained from the 0.975-quantile of a gamma distribution with shape parameter $\alpha = x + 1 = r'^2 / v'$ and scale parameter $\beta = 1 / y = v' / r'$ where the mean r' and variance v' are based on a unit increment to the observed number of events x:

$$r' = r + 1 / y = (x+1) / y$$

$$v' = v + 1 / y^2 = (x+1) / y^2$$

Quantiles of the gamma distribution can be calculated using commonly available spreadsheet programs or statistical software (Excel or SAS) that include an inverse gamma function, although users must ensure the correct parameterization is used, because some software programs may expect the rate $1/\beta$ instead of the scale parameter β to be supplied by the user. To avoid confusion, users should calculate the upper and lower CI limits using the standard gamma distribution (with $\beta = 1$), so that

- $L(r) = L(x) / y$ where $L(x)$ is the 0.025-quantile of a standard gamma with $\alpha = x$
- $U(r) = U(x+1) / y$ where $U(x+1)$ is the 0.975-quantile of a standard gamma with $\alpha = x + 1$

Note that the quantiles $L(x)$ and $U(x+1)$ in the last two formulas are also used to calculate the lower and upper limits of the exact 95% CI for the mean number of events E(X) when $X = x$.

In Excel, the function GAMMA.INV (probability, alpha, beta), with beta set to 1, returns the quantile of the standard gamma distribution for a given probability between 0 and 1. For 95% CI, the probability associated with the lower limit is 0.05/2 = 0.025, and with the upper limit 1 – (0.05/2) = 0.975.

CIs for Age-adjusted Vital Rates, Where Population Denominator is Free of Sampling Variability

No exact 95% CI for the true underlying age-adjusted rate λ' is known. Instead, an approximate 95% CI can be derived under the assumption that the Poisson-gamma relationship for crude rates holds approximately for age-adjusted rates as well (32).

These expressions use the following notation:

- Age-adjusted rate (usually multiplied by 100,000 and expressed as a rate per 100,000 population): $R' = \sum w_i R_i$
- Standard population weight: w_i, such that $\sum \quad = 1$
- Age-specific rate for the ith age group: $R_i = X_i / Y_i$
- Total number of events for the ith age group on which the age-specific rate is based: X_i
- Total population for the ith age group on which the age-specific rate is based: Y_i

Suppose $X_i = x_i$ events are observed for the age-specific populations, each of sizes $Y_i = y_i$. It is assumed that a gamma-distributed random variable Z exists with mean $r = \sum (w_i / y_i) x_i$ and variance $v = \sum (w_i / y_i)^2 x_i$ such that

$$\Pr(R' \leq r) \approx \Pr(Z \geq \lambda')$$

As a result of this assumption:

- The lower limit $L(r)$ of the approximate 95% CI is obtained from the 0.025-quantile of a gamma distribution with shape parameter $\alpha = r \quad v$ and scale parameter $\beta = v / r$.
- The upper limit *U(r)* is obtained from the 0.975-quantile of a gamma distribution with shape parameter $\alpha = r'^2 / v'$ and scale parameter $\beta = v' / r'$ where the mean r' is based on a unit increment to the observed number of deaths x_k in the age group with the largest value of w_i / y_i.

$$r' = r + \kappa = \sum (w_i / y_i) x_i + (w_k / y_k)(x_k + 1)$$

where $\kappa = max(w_i / y_i)$, and the variance is $v' = v + \kappa^2$.

This approach to calculating the upper CI for the age-adjusted rate is known to be overly conservative, but to date no other method has been able to maintain nominal coverage (coverage of 95% or more) in very sparse data (32–36).

As before, calculation of the upper and lower limits can use the standard gamma distribution ($\beta = 1$):

$$L(r) = \frac{L(r^2 / v)}{r / v} \qquad [2]$$

where $L(r^2 / v)$ is the 0.025-quantile of a standard gamma with $\alpha = r^2 / v$, and

$$U(r) = \frac{U(r'^2 / v')}{r' / v'} \qquad [3]$$

where $U(r'^2 / v')$ is the 0.975-quantile of a standard gamma with $\alpha = r'^2 / v'$.

CIs for Crude and Age-specific Vital Rates, With Population Denominator Estimates From American Community Survey or Current Population Survey

For rates where the population estimate used in the denominator is obtained from the American Community Survey (ACS) or the Current Population Survey (CPS), such as death rates for specified Hispanic subgroups, or by education level or marital status, CI can be calculated by adjusting the upper and lower bounds of the interval for the extra variation from the survey. This adjustment can be made for both crude and age-adjusted rates.

These expressions use the following notation:

- Rate (usually multiplied by 100,000 and expressed as a rate per 100,000 population): X / Y
- Total number of events on which rate is based: X
- Total population on which rate is based: Y

Let μ_Y and σ^2_Y denote the mean and variance of the denominator population Y. Let the number of events X be Poisson-distributed, with mean and variance equal to λ_X, and assume that X and Y are independent. Using first-order Taylor series approximations (also known as the delta method), the mean and variance are given by $\mathrm{E}(R) \approx \lambda_X / \mu_Y$ and

$$\mathrm{var}(R) \approx \left(\frac{\lambda_X}{\mu_Y}\right)^2 \left(\frac{1}{\lambda_X} + \frac{\sigma_Y^2}{\mu_Y^2}\right) \quad [4]$$

The sample mean and variance are calculated using the method of moments, yielding $r = x / y$,

$$v = \left(\frac{x}{y}\right)^2 \left(\frac{1}{x} + \frac{s_y^2}{y^2}\right) \quad [5]$$

$$\frac{v}{r^2} = \frac{1}{x} + \frac{s_y^2}{y^2} \quad [6]$$

where s_y^2 is the value of the design-based sample variance of denominator population Y evaluated at $Y = y$. Standard errors (SEs) for ACS estimates are published by the U.S. Census Bureau for selected population estimates for combinations of race and ethnicity, marital status, and education level groups, and by the number of years on which the rate is based (19,37).

The generalized variance function (GVF) model may sometimes be assumed, for example with CPS-estimated totals, simplifying the calculation of the relative variance for Y (19):

$$\frac{\sigma_Y^2}{\mu_Y^2} = f\left(a + \frac{b}{\mu_Y}\right) \quad [7]$$

Using the GVF model, the sample variance and sample relative variance of $R = X / Y$ are given by

$$v = \left(\frac{x}{y}\right)^2 \left[\frac{1}{x} = f\left(a + \frac{b}{y}\right)\right] \quad [8]$$

$$\frac{v}{r^2} = \frac{1}{x} + f\left(a + \frac{b}{y}\right) \quad [9]$$

For CPS-estimated totals, the parameters a and b are estimated by fitting a model to a group of related estimates and their estimated relative variances, and f is a factor that depends on whether the population estimate is based on demographic analysis or CPS and the number of years used.

The following $100(1-\alpha)\%$ CI that includes the extra sampling variability from the survey is recommended for crude and age-specific vital rates with population denominator estimates from ACS or CPS:

$$\exp\left\{\ln(r) \pm t_{\alpha/2,df}\sqrt{\frac{v}{r^2}}\right\} \quad [10]$$

The degrees of freedom (df) for the Student's t critical value $t_{\alpha/2,df}$ are given by $\min(x, n_y, n_{y\_eff}) - 1$, where n_y and n_{y_eff} are the sample size and effective sample size, respectively, from the survey. The CI just described is referred to as the logarithmic (log) Student's t CI.

CIs for Age-adjusted Vital Rates, With Population Denominator Estimates From ACS or CPS

For crude and age-specific rates where the population denominator is obtained from ACS or CPS, such as for specified Hispanic subgroups, or by education level or marital status, the CI for age-adjusted rates can be calculated by adjusting the upper and lower bounds of the interval for the extra variation from the survey.

These expressions use the following notation:

- Age-adjusted rate (usually multiplied by 100,000 and expressed as a rate per 100,000 population): $R' = \sum w_i R_i$
- Standard population weight: w_i, such that $\sum w_i = 1$
- Age-specific rate for the ith age group: $R_i = X_i / Y_i$
- Total number of events for the ith age group on which the age-specific rate is based: X_i
- Total population for the ith age group on which the age-specific rate is based: Y_i
- Let μ_i and σ^2_i denote the mean and variance of the denominator population Y_i. Let X_i be independently Poisson-distributed, with mean and variance equal to λ_i. As before, the sample means and variances for R_i are given by $r_i = x_i / y_i$ and

$$v_i = \left(\frac{x_i}{y_i}\right)^2 \left[\frac{1}{x_i} + \frac{s_{y_i}^2}{y_i^2}\right] \quad [11]$$

where s^2_{yi} are the realizations of the design-based sample variances of the age-specific populations Y_i evaluated at $Y_i = y_i$.

If the GVF model can be assumed, as with CPS-estimated totals, the age-specific sample variances are calculated as

$$v_i = \left(\frac{x_i}{y_i}\right)^2 \left[\frac{1}{x_i} + f\left(a + \frac{b}{y_i}\right)\right] \quad [12]$$

Whether or not the GVF model can be assumed, the sample mean and variance for the age-adjusted rate are given by

$$r = \sum w_i r_i = \sum (w_i / y_i) x_i$$

and

$$v = \sum w_i^2 v_i = \sum (w_i / y_i)^2 (v_i / r_i^2) x_i^2$$

where the relative sample variances v_i / r_i^2 are calculated as shown.

As before, the following $100(1-\alpha)\%$ CI is recommended for age-adjusted vital rates with population denominator estimates from ACS or CPS and not assumed constant:

$$\exp\left\{\ln(r) \pm t_{\alpha/2,df}\sqrt{\frac{v}{r^2}}\right\} \quad [13]$$

The *df* for the Student's *t* critical value $t_{\alpha/2,df}$ are given by

$$df = min(\sum x_i, \sum n_{y\_i}, \sum n_{y\_eff\_i}) - 1$$

where $\sum x_i$ is the total number of events in the numerator and $\sum n_{y\_i}$ and $\sum n_{y\_eff\_i}$ are the denominator sample size and effective sample size, respectively. The CI just described is referred to as the log Student's *t* CI.

CIs for Age-specific and Crude Vital Rates, Where Denominator is Estimated From Another Population Survey

NCHS currently does not produce rates from vital statistics where the numerator is the number of events from vital statistics and the population estimate used in the denominator is obtained from a survey other than ACS or CPS. However, such rates could be considered for some purposes, such as the number of deaths for a particular cause per population with a certain condition, where the denominator would come from a population health survey such as the National Health Interview Survey (NHIS).

These expressions use the following notation:

- Rate (usually multiplied by 100,000 and expressed as a rate per 100,000 population): $R = X / Y$
- Total number of events on which rate is based: X
- Total population on which rate is based: Y

Let μ_Y and $\sigma^2{}_Y$ denote the mean and variance of the denominator population Y. Let the number of events X be Poisson-distributed, with mean and variance equal to λ_X, and assume that X and Y are independent. Using first-order Taylor series approximations (delta method) (25), the mean and variance are $E(R) \approx \lambda_X / \mu_Y$ and

$$\text{var}(R) \approx \left(\frac{\lambda_X}{\mu_Y}\right)^2\left(\frac{1}{\lambda_X} + \frac{\sigma_Y^2}{\mu_Y{}^2}\right) \quad [14]$$

The sample mean and variance for R are calculated using the method of moments, yielding $r = x / y$,

$$v = \left(\frac{x}{y}\right)^2\left(\frac{1}{x} + \frac{s_y^2}{y^2}\right) \quad [15]$$

and

$$\frac{v}{r^2} = \frac{1}{x} + \frac{s_y^2}{y^2} \quad [16]$$

where s_y^2 is the value of the design-based sample variance of denominator population Y evaluated at $Y = y$.

The following $100(1-\alpha)\%$ CI is recommended, for example, with $\alpha = 0.05$:

$$\exp\left\{\ln(r) \pm t_{\alpha/2,df}\sqrt{\frac{v}{r^2}}\right\} \quad [17]$$

The *df* for the Student's *t* critical value $t_{\alpha/2,df}$ are given by

$$df = min(x, n_y, n_{y\_eff}) - 1$$

where n_y and n_{y_eff} are the denominator sample size and effective sample size, respectively. The CI just described is referred to as the log Student's *t* CI.

CIs for Age-adjusted Vital Rates, Where Denominator is Estimated From Another Population Survey

Just as it may be of interest to consider crude and age-specific rates where the numerator is the number of vital events and the denominator is obtained from a survey other than ACS or CPS (such as NHIS), consider age adjusting such rates to obtain, for example, the age-adjusted number of deaths for a particular cause per population with a certain health condition.

These expressions use the following notation:

- Age-adjusted rate (usually multiplied by 100,000 and expressed as a rate per 100,000 population): $R' = \sum w_i R_i$
- Standard population weight: w_i, such that $\sum w_i = 1$
- Age-specific rate for the *i*th age group: $R_i = X_i / Y_i$
- Total number of events for the *i*th age group on which the age-specific rate is based: X_i
- Total population for the *i*th age group on which the age-specific rate is based: Y_i

Let μ_i and $\sigma^2{}_i$ denote the mean and variance of the denominator population Y_i. Let X_i be independently Poisson-distributed, with mean and variance equal to λ_i. As before, the sample means and variances for the R_i are given by $r_i = x_i / y_i$ and

$$v_i = \left(\frac{x_i}{y_i}\right)^2\left[\frac{1}{x_i} + \frac{s_{y_i}^2}{y_i^2}\right] \quad [18]$$

where $s^2{}_{yi}$ are the realizations of the design-based sample variances of the age-specific populations Y_i evaluated at $Y_i = y_i$.

The sample mean and variance for the age-adjusted rates are

$$r = \sum w_i r_i = \sum(w_i / y_i)x_i$$

and

$$v = \sum w_i^2 v_i = \sum(w_i / y_i)^2(v_i / r_i^2)x_i^2$$

As before, the following $100(1-\alpha)\%$ CI is recommended, for example, with $\alpha = 0.05$:

$$\exp\left\{\ln(r) \pm t_{\alpha/2,df}\sqrt{\frac{v}{r^2}}\right\} \quad [19]$$

The *df* for the Student's *t* critical value $t_{\alpha/2,df}$ are given by

$$df = min(\sum x_i, \sum n_{y\_i}, \sum n_{y\_eff\_i}) - 1$$

where $\sum x_i$ is the total number of events in the numerator and $\sum n_{y\_i}$ and $\sum n_{y\_eff\_i}$ are the denominator sample size and effective sample size, respectively. The CI just described is referred to as the log Student's *t* CI.

CIs for Infant Death and Infant Mortality Rates

For the final reports of deaths in the United States (5), including the infant death rate or death rate for infants under age 1 year, CI is calculated using the number of infant deaths in a calendar year as the numerator, and the census population of age under 1 year as of July 1 for that calendar year as the denominator, the latter being treated as a constant in calculations. For infant death rates, CI can be calculated as above for other vital rates.

For infant mortality rates (IMR) based on live births in the denominator, the numerator is the number of deaths of infants (under age 1 year) during a given time period, and the denominator is the number of live births during that period. For period-linked IMRs, the numerator is the number of deaths among infants in a given year, whether the birth occurred during that year or in the previous year, **which have been linked to their corresponding birth record**. The denominator for the period-linked IMRs is the number of births occurring during that year (38). For cohort-linked IMRs, the numerator is the number of deaths for infants born in a given year, whether the death occurred in the same year or the next year, **which have been linked to their corresponding birth record** (39). The denominator for cohort linked IMRs is the number of births in that year.

For IMRs and period- and cohort-linked IMRs, CI can be calculated using the following notation:

- IMR (usually multiplied by 100,000 and expressed as a rate per 100,000 live births): $R = X \quad Y$
- Total number of infant deaths on which the IMR is based: X
- Total number of live births on which the IMR is based: Y

Both the numerator and denominator can be assumed to follow Poisson distributions, with underlying rates λ_x and λ_y. As a result, first-order approximations (delta method) (25) for the mean and variance of the IMR can be calculated, assuming independence of the numerator and denominator. This approach is conservative, as X and Y will be positively correlated. Under the assumption of independence, dropping the covariance term makes the variance and resulting CI larger. Consequently,

$$E(R) \approx \lambda_x / \lambda_y$$

and

$$var(R) \approx \left(\frac{\lambda_X}{\lambda_Y}\right)^2 \left(\frac{1}{\lambda_X} + \frac{1}{\lambda_Y}\right) \quad [20]$$

The sample mean and variance for R are calculated using the method of moments, yielding:

$$r = x / y$$

$$v = \left(\frac{x}{y}\right)^2 \left(\frac{1}{x} + \frac{1}{y}\right) \quad [21]$$

$$\frac{v}{r} = \frac{1}{x} + \frac{1}{y} \quad [22]$$

Use of the following $100(1-\alpha)\%$ CI is recommended, as with $\alpha = 0.05$:

$$\exp\left\{\ln(r) \pm t_{\alpha/2,df}\sqrt{\frac{v}{r^2}}\right\} \quad [23]$$

The *df* for the Student's *t* critical value $t_{\alpha/2,df}$ are given by $df = min(x, y) - 1$. The CI just described is referred to as the log Student's *t* CI.

CIs for Rates and Counts Estimated From Sample Surveys

The number of events obtained from health care surveys, such as the National Ambulatory Medical Care Survey, can be assumed to follow a Poisson distribution. However, for variance estimation, the design-based sampling distribution is generally used, along with asymptotic distributional assumptions (21,26). Based on evaluation of alternative distributional assumptions and implementations (Appendix II), the log Student's *t* CI, with adaptations for complex surveys, is used for the presentation standards for survey-based rates, including age-adjusted rates.

CIs for rates where the denominator population value *y* is free of sampling variability can be obtained using the following expression, where $\alpha = 0.05$:

$$\frac{1}{y}\exp\left\{\ln(x) \pm t_{\alpha/2,df}\sqrt{\frac{s_x^2}{x^2}}\right\} \quad [24]$$

In this expression, $df = min(\sum x_i, \sum n_{x\_eff})$ is the minimum of the sample size and effective sample size (when applicable). For complex surveys, $n_{x\_eff} = n_x / D_{x\_eff}$, where D_{x_eff} is the (possibly average) DEFF for *x* in that survey. The numerator sample SE value is s_x and *y* is the population value, assumed constant.

When the population estimate in the denominator is also obtained from a survey (with sampling error), the suggested CIs for rates can be obtained using the following expression, where $\alpha = 0.05$:

$$\exp\left\{\ln\left(\frac{x}{y}\right) \pm t_{\alpha/2,df}\sqrt{\frac{s_x^2}{x^2}+\frac{s_y^2}{y^2}}\right\} \qquad [25]$$

With the addition of the sampling variability from the denominator, $df = min(n_x\,,\, n_{x\_eff}\,, n_y\,,\, n_{y\_eff}) - 1$, s_x is the numerator sample SE value, and s_y is the denominator sample SE value.

As above, if both *X* and *Y* are estimated using a complex survey sample, then the sample sizes used to determine *df* should be the minimum of the sample size and effective sample size for each survey.

The CI expressions ignore possible correlation between *X* and *Y* that could arise from sample selection. Under the assumption that such correlation would be positive, the CI width will be larger (more conservative) when the correlation is ignored.

CIs for counts can be obtained by simplifying the above expressions and setting the denominator to a constant of 1 with terms defined as above, where $\alpha = 0.05$:

$$\exp\left\{\ln(x) \pm t_{\alpha/2,df}\sqrt{\frac{s_x^2}{x^2}}\right\} \qquad [26]$$

where $df = min\left(n_x\,,\, n_{x\_eff}\right)$, the minimum of the sample size and effective sample size (when applicable).

Appendix II. Design Effects for National Center for Health Statistics Surveys and Selected Census Surveys

Consulting the following documentation for surveys is recommended when calculating design effects (DEFFs), because suggested approaches can differ among surveys and for specific analytic purposes.

- **National Health and Nutrition Examination Survey**
  NHANES Survey Methods and Analytic Guidelines: https://wwwn.cdc.gov/nchs/nhanes/analyticguidelines.aspx
- **National Health Interview Survey**
  Data, Questionnaires and Related Documentation—Methods: https://www.cdc.gov/nchs/nhis/methods.htm
- **National Survey of Family Growth**
  Questionnaire, Datasets, and Related Documentation: https://www.cdc.gov/nchs/nsfg/nsfg_questionnaires.htm
- **National Health Care Surveys**
  https://www.cdc.gov/nchs/dhcs/dhcs_surveys.htm
- **American Community Survey**
  U.S. Census Bureau Methodology: https://www.census.gov/programs-surveys/acs/methodology.html
- **Current Population Survey**
  U.S. Census Bureau Methodology: https://www.census.gov/programs-surveys/cps/technical-documentation/methodology.html

Methods also may be updated with methodological developments and design changes. Standard software can produce multiple DEFFs, and users should consult the survey and software documentation to identify the appropriate DEFF. For National Center for Health Statistics data presentation standards for rates and counts, DEFFs for totals or counts are used. An evaluation comparing use of DEFF for totals and counts and DEFF for rows that shows better performance of DEFF for totals and counts is found in Talih et al. (13).

Vital and Health Statistics Series Descriptions

Active Series

Series 1. Programs and Collection Procedures
Reports describe the programs and data systems of the National Center for Health Statistics, and the data collection and survey methods used. Series 1 reports also include definitions, survey design, estimation, and other material necessary for understanding and analyzing the data.

Series 2. Data Evaluation and Methods Research
Reports present new statistical methodology including experimental tests of new survey methods, studies of vital and health statistics collection methods, new analytical techniques, objective evaluations of reliability of collected data, and contributions to statistical theory. Reports also include comparison of U.S. methodology with those of other countries.

Series 3. Analytical and Epidemiological Studies
Reports present data analyses, epidemiological studies, and descriptive statistics based on national surveys and data systems. As of 2015, Series 3 includes reports that would have previously been published in Series 5, 10–15, and 20–23.

Discontinued Series

Series 4. Documents and Committee Reports
Reports contain findings of major committees concerned with vital and health statistics and documents. The last Series 4 report was published in 2002; these are now included in Series 2 or another appropriate series.

Series 5. International Vital and Health Statistics Reports
Reports present analytical and descriptive comparisons of U.S. vital and health statistics with those of other countries. The last Series 5 report was published in 2003; these are now included in Series 3 or another appropriate series.

Series 6. Cognition and Survey Measurement
Reports use methods of cognitive science to design, evaluate, and test survey instruments. The last Series 6 report was published in 1999; these are now included in Series 2.

Series 10. Data From the National Health Interview Survey
Reports present statistics on illness; accidental injuries; disability; use of hospital, medical, dental, and other services; and other health-related topics. As of 2015, these are included in Series 3.

Series 11. Data From the National Health Examination Survey, the National Health and Nutrition Examination Surveys, and the Hispanic Health and Nutrition Examination Survey
Reports present 1) estimates of the medically defined prevalence of specific diseases in the United States and the distribution of the population with respect to physical, physiological, and psychological characteristics and 2) analysis of relationships among the various measurements. As of 2015, these are included in Series 3.

Series 12. Data From the Institutionalized Population Surveys
The last Series 12 report was published in 1974; these reports were included in Series 13, and as of 2015 are in Series 3.

Series 13. Data From the National Health Care Survey
Reports present statistics on health resources and use of health care resources based on data collected from health care providers and provider records. As of 2015, these reports are included in Series 3.

Series 14. Data on Health Resources: Manpower and Facilities
The last Series 14 report was published in 1989; these reports were included in Series 13, and are now included in Series 3.

Series 15. Data From Special Surveys
Reports contain statistics on health and health-related topics from surveys that are not a part of the continuing data systems of the National Center for Health Statistics. The last Series 15 report was published in 2002; these reports are now included in Series 3.

Series 16. Compilations of Advance Data From Vital and Health Statistics
The last Series 16 report was published in 1996. All reports are available online; compilations are no longer needed.

Series 20. Data on Mortality
Reports include analyses by cause of death and demographic variables, and geographic and trend analyses. The last Series 20 report was published in 2007; these reports are now included in Series 3.

Series 21. Data on Natality, Marriage, and Divorce
Reports include analyses by health and demographic variables, and geographic and trend analyses. The last Series 21 report was published in 2006; these reports are now included in Series 3.

Series 22. Data From the National Mortality and Natality Surveys
The last Series 22 report was published in 1973. Reports from sample surveys of vital records were included in Series 20 or 21, and are now included in Series 3.

Series 23. Data From the National Survey of Family Growth
Reports contain statistics on factors that affect birth rates, factors affecting the formation and dissolution of families, and behavior related to the risk of HIV and other sexually transmitted diseases. The last Series 23 report was published in 2011; these reports are now included in Series 3.

Series 24. Compilations of Data on Natality, Mortality, Marriage, and Divorce
The last Series 24 report was published in 1996. All reports are available online; compilations are no longer needed.

For answers to questions about this report or for a list of reports published in these series, contact:

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