Precision and sample-size analysis for confidence intervals

`ciwidth`

January 23, 2020

Overview

- Introduction
  - Precision and sample-size analysis
  - Overview of **`ciwidth`**
  - Inference using confidence intervals
- Examples
  - One population mean
  - One population variance
  - Two paired means
  - Two independent means
  - Sensitivity analysis
  - Custom tables and precision graphs
  - Adding your own methods to **`ciwidth`**
- Summary

Introduction to precision and sample-size analysis

Precision and sample-size analysis

- Hypothesis tests for inference
  - Test that a population parameter of interest is equal, or smaller, or larger than a specified value
  - Power analysis estimates the required sample size for a future study to ensure that the test will have higher power (chance) to detect when the parameter estimate is different from the specified value

Precision and sample-size analysis

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  - Test that a population parameter of interest is equal, or smaller, or larger than a specified value
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- Confidence intervals for inference
  - Estimate an interval for the population parameter
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Precision and sample-size analysis

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- Confidence intervals for inference
  - Estimate an interval for the population parameter
  - Precision analysis estimates the required sample size for a future study to ensure that the estimated interval will have the desired precision so that it is not too wide
- Like hypothesis tests, confidence intervals are data dependent and so their precision will vary across samples
- Use precision and and sample-size analysis to account for the variability, and plan a study with the desired precision
- Precision and sample-size analysis for confidence intervals is analogous to power and sample-size analysis for hypothesis tests

Precision and sample-size analysis

- How many subjects would be required to ensure that the confidence interval for the mean is no wider than 2?
- If we only have enough resources to include 40 subjects in our study, what kind of precision would we expect our confidence interval to have?
- How would this precision change as we increase our sample size to 50, 60, and 70?
- The **`ciwidth`** command will help you answer these questions and more

Overview of `ciwidth`

- Perform precision and sample-size analysis for confidence intervals
  - Population mean
  - Population variance
  - Comparison of means from independent samples
  - Comparison of means from paired samples
- Compute
  - Sample size
  - CI precision
  - Probability of CI precision
- Perform sensitivity analysis
  - Present results graphically or in a table
  - Customize graphs and tables
- Add your own method
  - Easily create tables and graphs as you would with official **`ciwidth`** commands

Computation of a confidence interval

Confidence intervals

- Computation
  - Confidence level
    - 95%, 97%, other
  - Sample size
    - How many participants can you afford to have in your study?
  - Standard deviation
    - How did weight loss vary in the sample?

Confidence intervals

- Computation
  - Confidence level
    - 95%, 97%, other
  - Sample size
    - How many participants can you afford to have in your study?
  - Standard deviation
    - How did weight loss vary in the sample?
- Precision
  - Measured by the CI width
  - Ensured by the probability of CI width

Confidence interval for a population mean

A 100*(1- α)% CI:

$$[\ \bar{x} - t_{n\text{-}1,1\text{-}\alpha/2}\left(\frac{s}{\sqrt{n}}\right),\ \bar{x} + t_{n\text{-}1,1\text{-}\alpha/2}\left(\frac{s}{\sqrt{n}}\right)\ ]$$

α = significance level

s = sample standard deviation

n = sample size

Confidence interval for a population mean

A 100*(1- α)% CI:

$$\left[\ \bar{x} - t_{n\text{-}1,1\text{-}\alpha/2}\left(\frac{s}{\sqrt{n}}\right)\ ,\ \bar{x} + t_{n\text{-}1,1\text{-}\alpha/2}\left(\frac{s}{\sqrt{n}}\right)\ \right]$$

$^{1}/_{2}$ width　　　　$^{1}/_{2}$ width

α = significance level

s = sample standard deviation

n = sample size

Confidence interval for a population mean

$$\left[\ \bar{x} - t_{n-1,1-\alpha/2}\left(\frac{s}{\sqrt{n}}\right),\ \bar{x} + t_{n-1,1-\alpha/2}\left(\frac{s}{\sqrt{n}}\right)\ \right]$$

Sample mean	Width	Sample mean ± half-width	95% Confidence interval
5	10	5-5, 5+5	0 ——— 10
5	8	5-4,5+4	1 ——— 9
5	4	5-2, 5+2	3 ——— 7

Confidence interval for a population mean

$$[\ \bar{x} - t_{n\text{-}1,1\text{-}\alpha/2}\left(\frac{s}{\sqrt{n}}\right),\ \bar{x} + t_{n\text{-}1,1\text{-}\alpha/2}\left(\frac{s}{\sqrt{n}}\right)\ ]$$

Choose the values of the confidence level (100*(1-α)), sample standard deviation, and sample size

that will provide the desired level of precision, given the resources you have

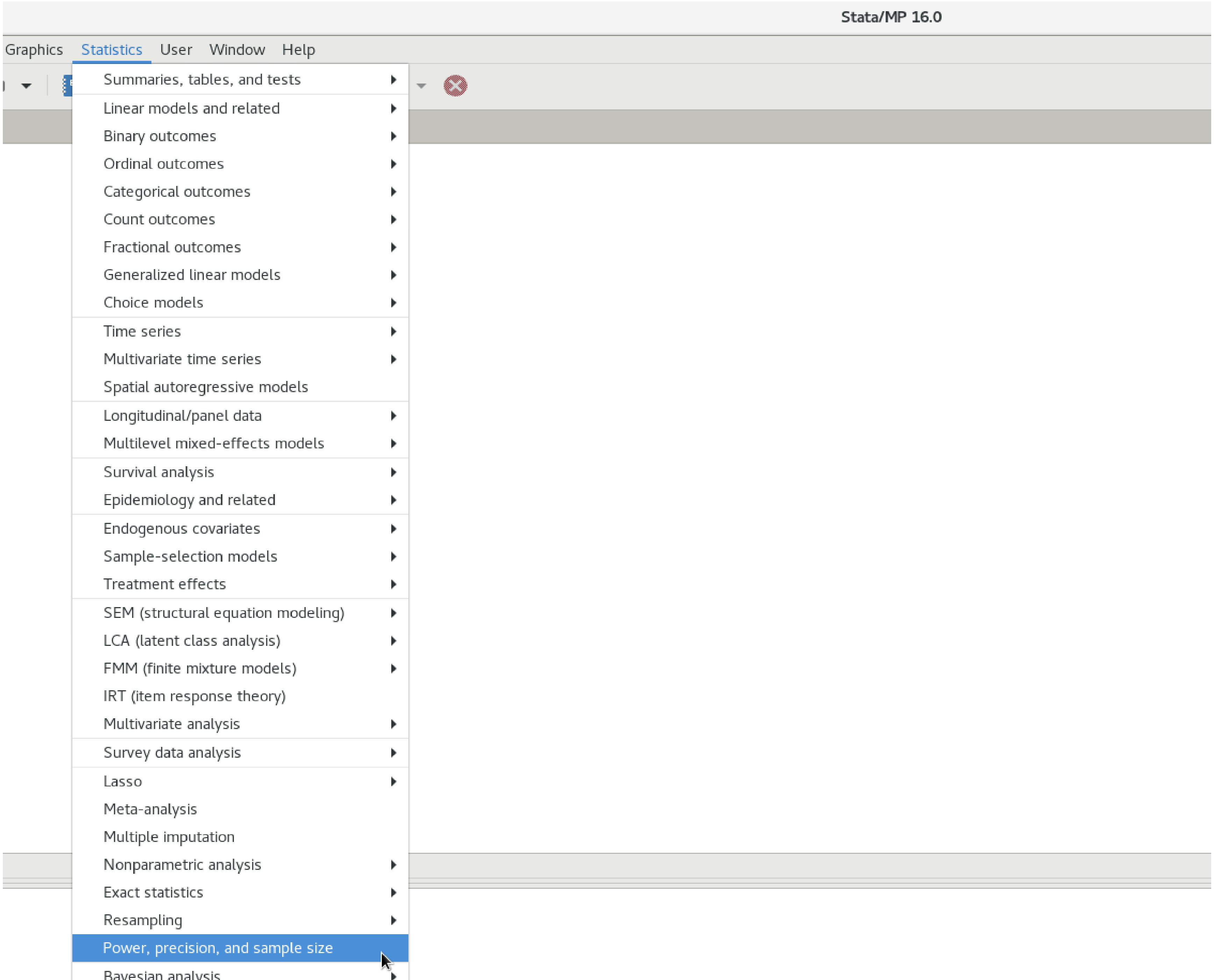
A first example

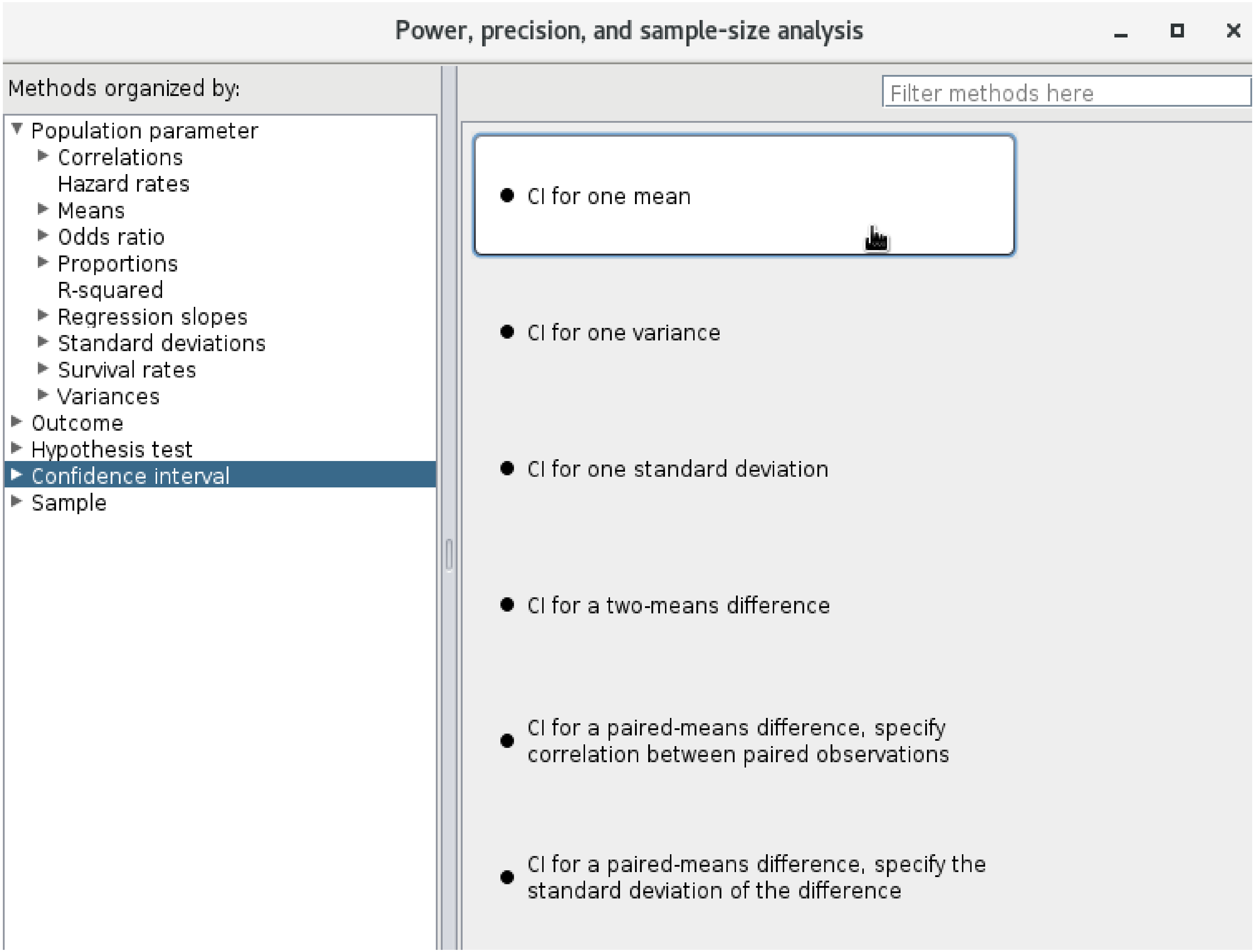
Precision analysis for a population mean

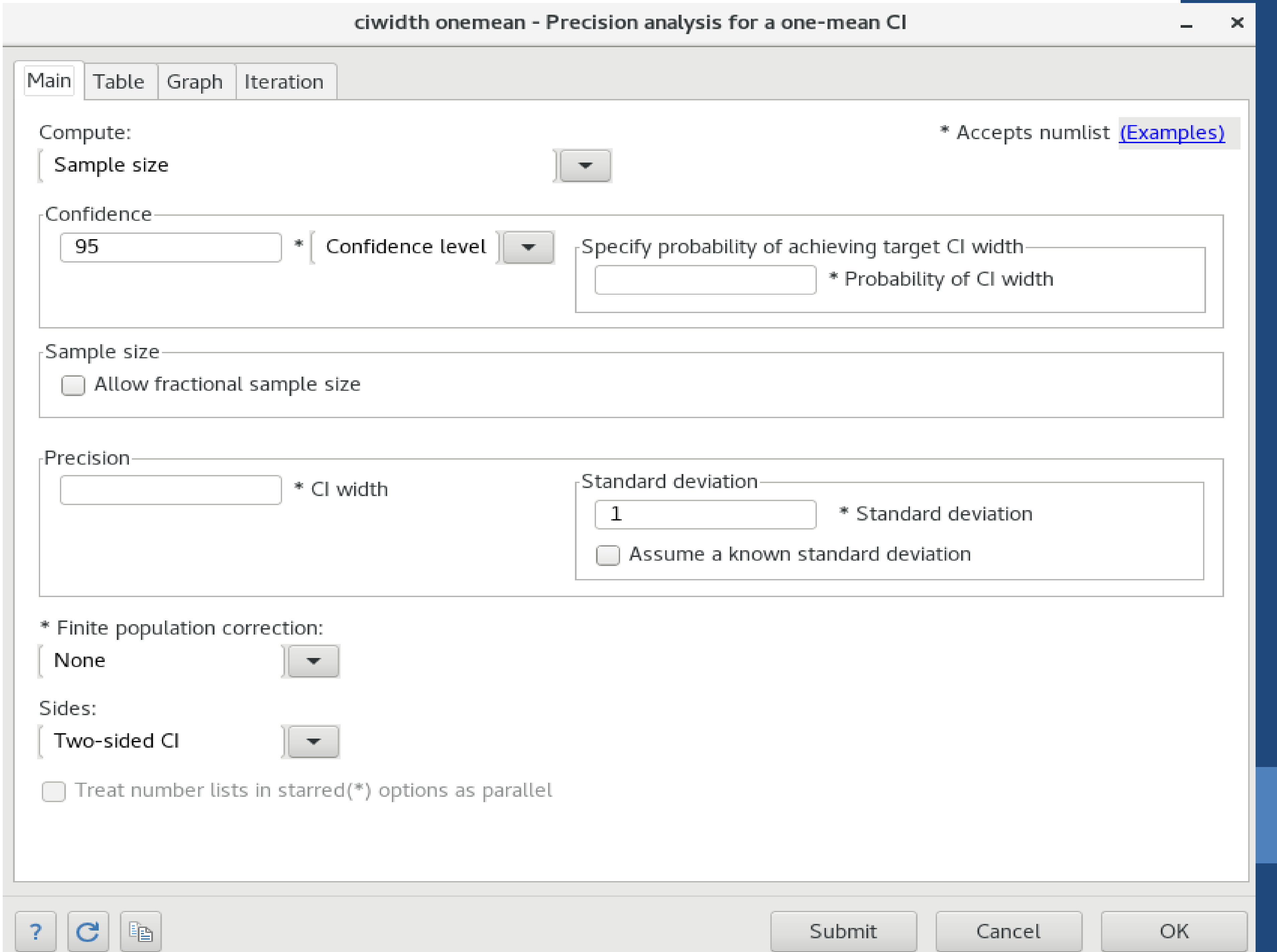
- How long do plug-in air fresheners last?

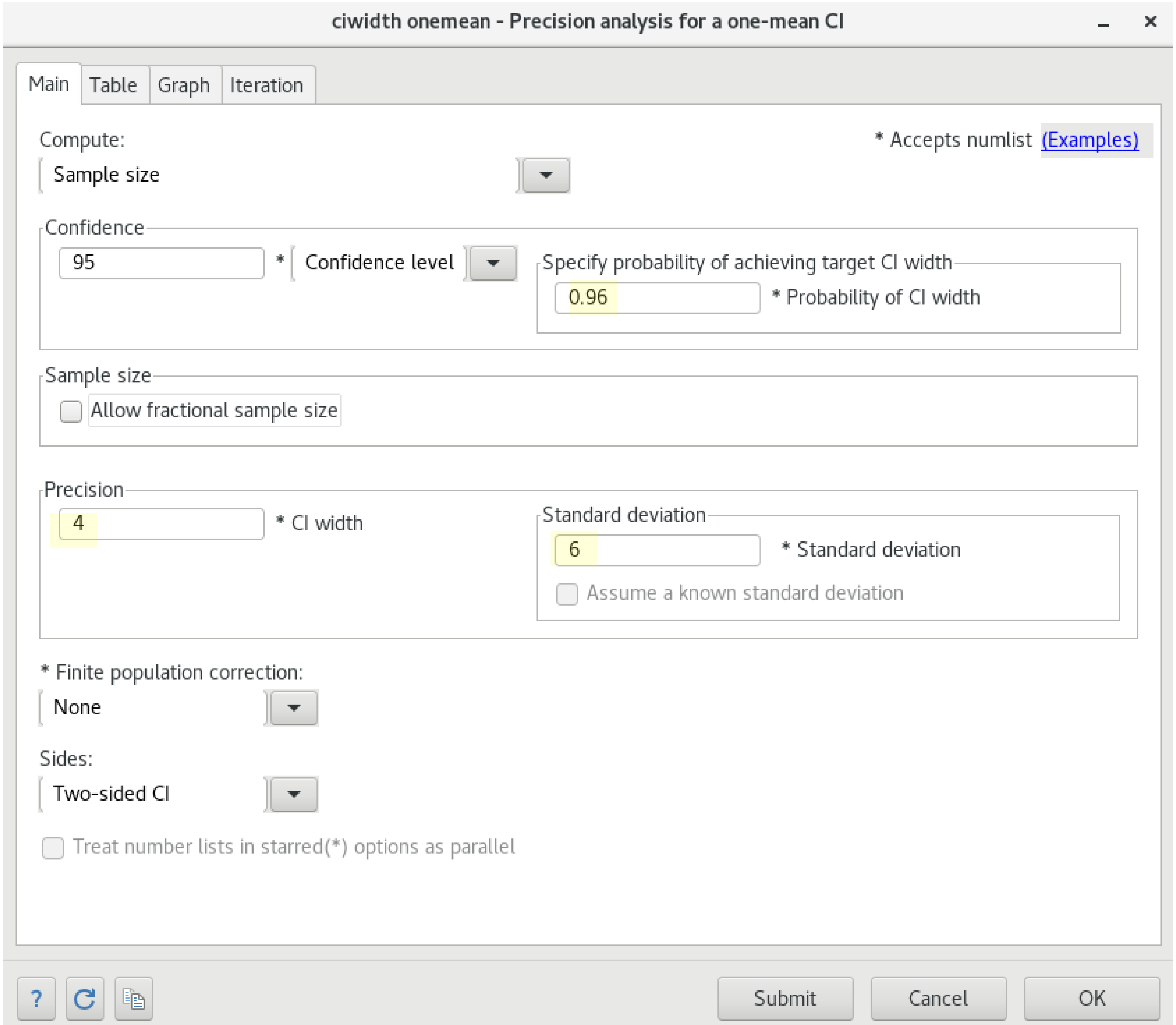


- How many air fresheners would we need to test to obtain a two-sided 95% CI for the mean scent duration with a width no larger than 4 days?


Stata/MP 16.0
Graphics
Statistics
User
Window
Help
Summaries, tables, and tests
Linear models and related
Binary outcomes
Ordinal outcomes
Categorical outcomes
Count outcomes
Fractional outcomes
Generalized linear models
Choice models
Time series
Multivariate time series
Spatial autoregressive models
Longitudinal/panel data
Multilevel mixed-effects models
Survival analysis
Epidemiology and related
Endogenous covariates
Sample-selection models
Treatment effects
SEM (structural equation modeling)
LCA (latent class analysis)
FMM (finite mixture models)
IRT (item response theory)
Multivariate analysis
Survey data analysis
Lasso
Meta-analysis
Multiple imputation
Nonparametric analysis
Exact statistics
Resampling
Power, precision, and sample size
Bayesian analysis


Power, precision, and sample-size analysis
Methods organized by:
Filter methods here
Population parameter
Correlations
Hazard rates
Means
Odds ratio
Proportions
R-squared
Regression slopes
Standard deviations
Survival rates
Variances
Outcome
Hypothesis test
Confidence interval
Sample
CI for one mean
CI for one variance
CI for one standard deviation
CI for a two-means difference
CI for a paired-means difference, specify correlation between paired observations
CI for a paired-means difference, specify the standard deviation of the difference


ciwidth onemean - Precision analysis for a one-mean CI
Main
Table
Graph
Iteration
Compute:
* Accepts numlist
(Examples)
Sample size
Confidence
95
* Confidence level
Specify probability of achieving target CI width
* Probability of CI width
Sample size
Allow fractional sample size
Precision
* CI width
Standard deviation
1
* Standard deviation
Assume a known standard deviation
* Finite population correction:
None
Sides:
Two-sided CI
Treat number lists in starred(*) options as parallel
?
Submit
Cancel
OK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Main
Table
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Compute:
Sample size
* Accepts numlist (Examples)
Confidence
95
* Confidence level
Specify probability of achieving target CI width
0.96
* Probability of CI width
Sample size
Allow fractional sample size
Precision
4
* CI width
Standard deviation
6
* Standard deviation
Assume a known standard deviation
* Finite population correction:
None
Sides:
Two-sided CI
Treat number lists in starred(*) options as parallel
Submit
Cancel
OK

Computing sample size for a population mean

```
. ciwidth onemean, sd(6) probwidth(0.96) width(4)

Performing iteration ...

Estimated sample size for a one-mean CI
Student's t two-sided CI

Study parameters:

        level =     95.00
     Pr_width =    0.9600
        width =    4.0000
           sd =    6.0000

Estimated sample size:

            N =        51
```

Computing CI width for a population mean

How big of an interval width would we expect if we could only afford to sample 30 air fresheners?

Computing CI width for a population mean

```
. ciwidth onemean, sd(6) probwidth(0.96) n(30)

Estimated width for a one-mean CI
Student's t two-sided CI

Study parameters:

        level =     95.00
            N =        30
     Pr_width =    0.9600
           sd =    6.0000

Estimated width:

        width =    5.4945
```

Computing probability of CI width for a population mean

What's the probability that we'll obtain a desired CI width of 4, if we only sample 30 air fresheners?

Computing probability of CI width for a population mean

```
. ciwidth onemean, sd(6) width(4) n(30)

Estimated probability of width for a one-mean CI
Student's t two-sided CI

Study parameters:

        level =     95.00
            N =        30
        width =    4.0000
           sd =    6.0000

Estimated probability of width:

     Pr_width =    0.2285
```

Syntax overview for a one-mean CI

- Estimate sample size
  - `ciwidth onemean, sd(6) probwidth(0.96) width(4)`
- Estimate CI width
  - `ciwidth onemean, sd(6) probwidth(0.96) n(30)`
- Estimate probability of CI width
  - `ciwidth onemean, sd(6) width(4) n(30)`

General syntax for **`ciwidth`**

- Estimate sample size
  - **ciwidth** *method* …, **probwidth() width()** …
- Estimate CI width
  - **ciwidth** *method* …, **probwidth() n()**…
- Estimate probability of CI width
  - **ciwidth** *method* …, **width() n()**…

method:

onemean

onevariance

twomeans

pairedmeans

usermethod

General syntax for **`ciwidth`**

- Estimate sample size
  - **ciwidth** *method* …, **probwidth(*numlist*) width(*numlist*)** [*options*]
- Estimate CI width
  - **ciwidth** *method* …, **probwidth(*numlist*) n(*numlist*)** [*options*]
- Estimate probability of CI width
  - **ciwidth** *method* …, **width(*numlist*) n(*numlist*)** [*options*]

method:

- **onemean**
- **onevariance**
- **twomeans**
- **pairedmeans**
- *usermethod*

options:

- **table**
- **graph**
- **lower**
- **upper**
- …

Finite populations

Infinite vs. finite population

- We've been performing our analyses for a confidence interval for the mean scent duration of all plug-in air fresheners (infinite population).
- But the parameters you are estimating may be for a fixed population. For example, there are only 500 models of the Bugatti Chiron. (finite population).
  - Apply a finite population correction with the `fpc()` option.

Finite population

- Suppose you work for this car manufacturer and you're designing a study to estimate a confidence interval for the maximum speed of this limited edition model.

- What is the largest estimated width for the maximum speed you'll obtain if you only sample 50 out of the 500 cars that were manufactured, assuming a standard deviation of 16 mph?

Compute CI width using a finite population correction

```
. ciwidth onemean, sd(16) probwidth(0.90) n(50) fpc(500)

Estimated width for a one-mean CI
Student's t two-sided CI

Study parameters:

        level =     95.00
            N =        50
     Pr_width =    0.9000
           sd =   16.0000
          fpc =  500.0000

Estimated width:

        width =    9.7078
```

Alternative specification for a finite population correction

```
. ciwidth onemean, sd(16) probwidth(0.90) n(50) fpc(0.10)

Estimated width for a one-mean CI
Student's t two-sided CI

Study parameters:

        level =     95.00
            N =        50
     Pr_width =    0.9000
           sd =   16.0000
          fpc =    0.1000

Estimated width:

        width =    9.7078
```

Finite population correction

```
. ciwidth onemean, sd(16) probwidth(0.90) n(50) fpc(0.10)

Estimated width for a one-mean CI
Student's t two-sided CI

Study parameters:

        level =     95.00
            N =        50
     Pr_width =    0.9000
           sd =   16.0000
          fpc =    0.1000

Estimated width:

        width =    9.7078
```

```
. ciwidth onemean, sd(16) probwidth(0.90) n(50)

Estimated width for a one-mean CI
Student's t two-sided CI

Study parameters:

        level =     95.00
            N =        50
     Pr_width =    0.9000
           sd =   16.0000

Estimated width:

        width =   10.2329
```

Back to infinite populations of air fresheners, and on to one-sided confidence intervals

One-sided confidence intervals

- You may want one-sided confidence intervals if
  - You are certain of the direction of an effect.
    - Examples include toxicity studies and analysis of occurences of adverse drug reaction data(Chow, Shao, Wang, & Lokhnygina, 2017).
  - You are mainly interested in either the lower or upper limit.
    - An example would be product quality and reliability (Meeker, Hahn, & Escobar, 2017).
- In general, use caution with one-sided confidence intervals.
  - There have been cases where the placebo effect is superior to the actual drug effect (Meeker, Hahn, & Escobar, 2017).

Lower 95% confidence interval

```
. ciwidth onemean, sd(6) probwidth(0.96) n(30) lower

Estimated width for a one-mean CI
Student's t lower CI

Study parameters:

        level =     95.00
            N =        30
     Pr_width =    0.9600
           sd =    6.0000

Estimated width:

        width =    2.2823
```

Two-sided 90% confidence level

```
. ciwidth onemean, sd(6) probwidth(0.96) n(30) level(90)

Estimated width for a one-mean CI
Student's t two-sided CI

Study parameters:

        level =     90.00
            N =        30
     Pr_width =    0.9600
           sd =    6.0000

Estimated width:

        width =    4.5647
```

Sensitivity analysis

- Precision and sample-size analysis is centered on a prospective study, and we are obtaining estimates based on values that are truly unknown
  - Estimates may come from historical data or pilot studies
- Sensitivity analysis is used to investigate the effect of varying study parameters on CI precision, probability of CI width, sample size, and other components of a study.
  - In Stata, you can perform sensitivity analysis with tables and graphs.

Computing probability of CI width for a population mean

```
. ciwidth onemean, sd(6) width(4) n(30)

Estimated probability of width for a one-mean CI
Student's t two-sided CI

Study parameters:

        level =     95.00
            N =        30
        width =    4.0000
           sd =    6.0000

Estimated probability of width:

     Pr_width =    0.2285
```

Probability of CI width for a range of standard deviations

```
. ciwidth onemean, sd(6 7 8 9) width(4) n(45)

Estimated probability of width for a one-mean CI
Student's t two-sided CI
```

level	N	Pr_width	width	sd
95	45	.8599	4	6
95	45	.3476	4	7
95	45	.06042	4	8
95	45	.00627	4	9

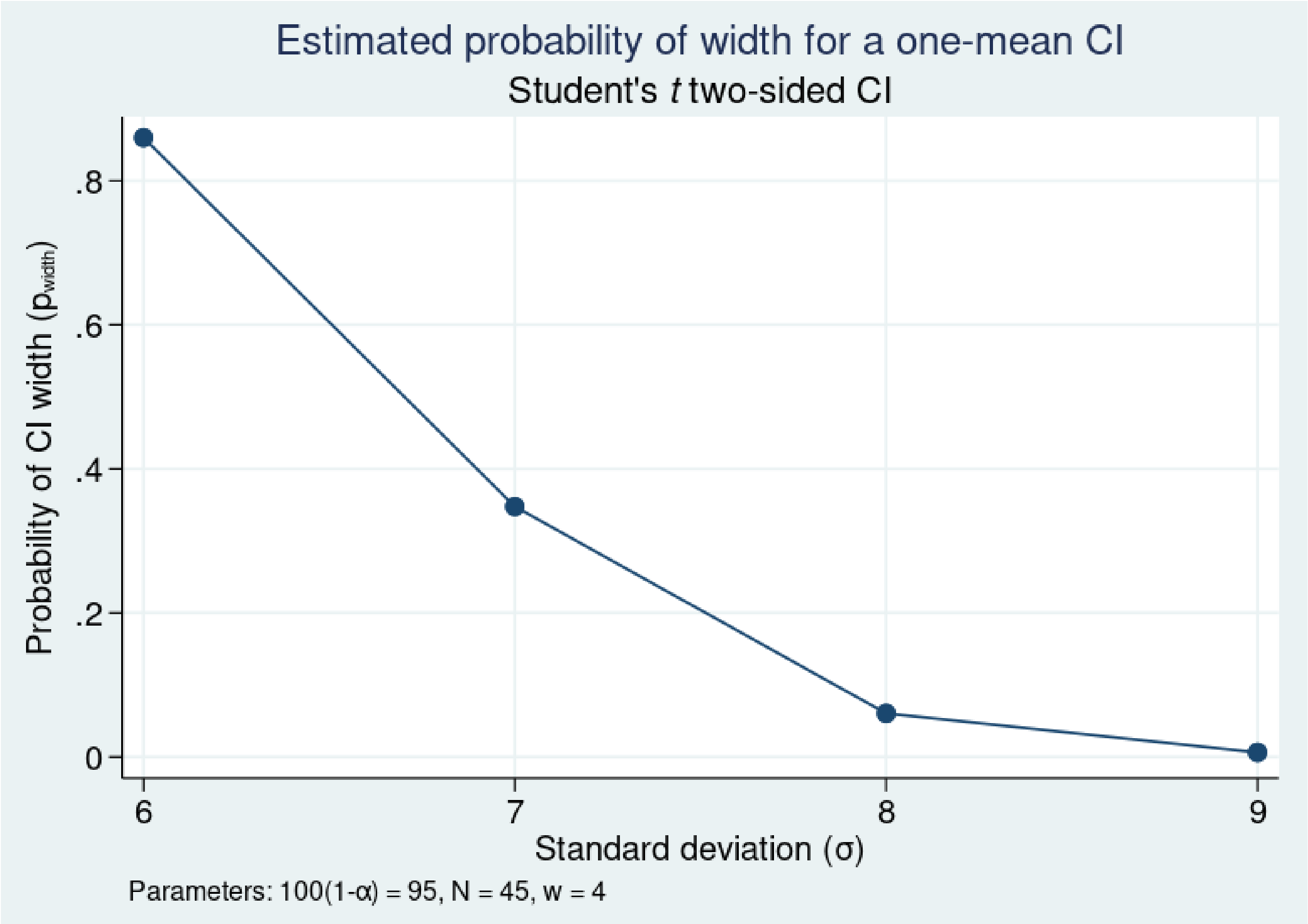
Table and graph for sensitivity analysis

```
. ciwidth onemean, sd(6 7 8 9) width(4) n(45) table graph
```

<output omitted>

Sensitivity analysis graph

```
. ciwidth onemean, sd(6 7 8 9) width(4) n(45) graph
```



Probability of CI width for ranges of multiple parameters

```
. ciwidth onemean, sd(6 7 8 9) width(4) n(45(10)65)

Estimated probability of width for a one-mean CI
Student's t two-sided CI
```

level	N	Pr_width	width	sd
95	45	.8599	4	6
95	45	.3476	4	7
95	45	.06042	4	8
95	45	.00627	4	9
95	55	.9918	4	6
95	55	.7419	4	7
95	55	.2336	4	8
95	55	.03245	4	9
95	65	.9999	4	6
95	65	.9599	4	7
95	65	.5635	4	8
95	65	.1295	4	9

Tables for sensitivity analysis

```
. ciwidth onemean, sd(6 7 8 9) width(4) n(45(10)65) table(, separator(4))

Estimated probability of width for a one-mean CI
Student's t two-sided CI
```

level	N	Pr_width	width	sd
95	45	.8599	4	6
95	45	.3476	4	7
95	45	.06042	4	8
95	45	.00627	4	9
95	55	.9918	4	6
95	55	.7419	4	7
95	55	.2336	4	8
95	55	.03245	4	9
95	65	.9999	4	6
95	65	.9599	4	7
95	65	.5635	4	8
95	65	.1295	4	9

Reordering table columns

```
. ciwidth onemean, sd(6 7 8 9) width(4) n(45(10)65) table(N sd Pr_width width, separator(4))

Estimated probability of width for a one-mean CI
Student's t two-sided CI
```

N	sd	Pr_width	width
45	6	.8599	4
45	7	.3476	4
45	8	.06042	4
45	9	.00627	4
55	6	.9918	4
55	7	.7419	4
55	8	.2336	4
55	9	.03245	4
65	6	.9999	4
65	7	.9599	4
65	8	.5635	4
65	9	.1295	4

Modifying column labels and widths

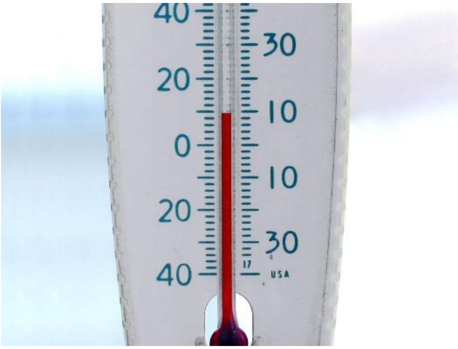
```
. ciwidth onemean, sd(6 7 8 9) width(4) n(45(10)65) table(N sd:"S.D." Pr_width:"Pr(CI width)"
>  width:"CI width", widths(. 14 16 12) separator(4))

Estimated probability of width for a one-mean CI
Student's t two-sided CI
```

N	S.D.	Pr(CI width)	CI width
45	6	.8599	4
45	7	.3476	4
45	8	.06042	4
45	9	.00627	4
55	6	.9918	4
55	7	.7419	4
55	8	.2336	4
55	9	.03245	4
65	6	.9999	4
65	7	.9599	4
65	8	.5635	4
65	9	.1295	4

ciwidth

- We computed the following for the CI for a population mean
  - Sample size
  - Confidence-interval width
  - Probability of confidence-interval width
- We created a graph and tables for sensitivity analysis
- We can perform precision and sample-size analysis for CIs for any of the following
  - A population mean
  - A population variance
  - A difference between two independent means
  - A difference between paired means

Precision analysis for a population variance



Computing probability of CI width for a population variance

```
. ciwidth onevariance 9, width(6) n(100)
```

Computing probability of CI width for a population variance

```
. ciwidth onevariance 9, width(6) n(100)

Estimated probability of width for a one-variance CI
Chi-squared two-sided CI

Study parameters:

        level =     95.00
            N =       100
        width =    6.0000
            v =    9.0000

Estimated probability of width:

     Pr_width =    0.8572
```

Computing sample size for a population standard deviation

```
. ciwidth onevariance 3, probwidth(0.96) width(2) sd

Performing iteration ...

Estimated sample size for a one-standard-deviation CI
Chi-squared two-sided CI

Study parameters:

        level =     95.00
     Pr_width =    0.9600
        width =    2.0000
            s =    3.0000

Estimated sample size:

            N =        31
```

Sensitivity analysis for a population standard deviation

```
. ciwidth onevariance (3 4 5 6), probwidth(0.96) width(2) sd

Performing iteration ...

Estimated sample size for a one-standard-deviation CI
Chi-squared two-sided CI
```

level	N	Pr_width	width	s
95	31	.96	2	3
95	48	.96	2	4
95	68	.96	2	5
95	93	.96	2	6

Paired samples

Paired-means for bad (LDL) cholesterol levels

	$\text{Cholesterol}_{\text{Before}}$ (mg/dL)	$\text{Cholesterol}_{\text{After}}$ (mg/dL)	Difference
	167	140	-27
	149	138	-11
	192	194	2
	200	180	-20
	162	162	0
	52	41	67.25
	…	…	…
Mean	**129.58**	**111.96**	**-17.62**
S.D.	52.27	42.15	6.47

CI for a paired-means difference

```
. ciwidth pairedmeans, width(6) probwidth(0.98) sddiff(18)
```

CI for a paired-means difference

```
. ciwidth pairedmeans, width(6) probwidth(0.98) sddiff(18)

Performing iteration ...

Estimated sample size for a paired-means-difference CI
Student's t two-sided CI

Study parameters:

        level =   95.0000
     Pr_width =    0.9800
        width =    6.0000
         sd_d =   18.0000

Estimated sample size:

            N =       174
```

Fractional sample sizes

```
. ciwidth pairedmeans, width(6) probwidth(0.98) sddiff(18) nfractional

Performing iteration ...

Estimated sample size for a paired-means-difference CI
Student's t two-sided CI

Study parameters:

        level =   95.0000
     Pr_width =    0.9800
        width =    6.0000
         sd_d =   18.0000

Estimated sample size:

            N =  173.0371
```

Sample-size determination using the correlation

```
. ciwidth pairedmeans, width(6) probwidth(0.98) sd1(16) sd2(23) corr(0.78)

Performing iteration ...

Estimated sample size for a paired-means-difference CI
Student's t two-sided CI

Study parameters:

        level =   95.0000             sd1 =   16.0000
     Pr_width =    0.9800             sd2 =   23.0000
        width =    6.0000            corr =    0.7800
         sd_d =   14.5231

Estimated sample size:

            N =       119
```

CI for a difference of two means

- Let's consider the cholesterol example, but instead randomly sample individuals who take cholesterol medication and individuals who don't
    - Two independent samples

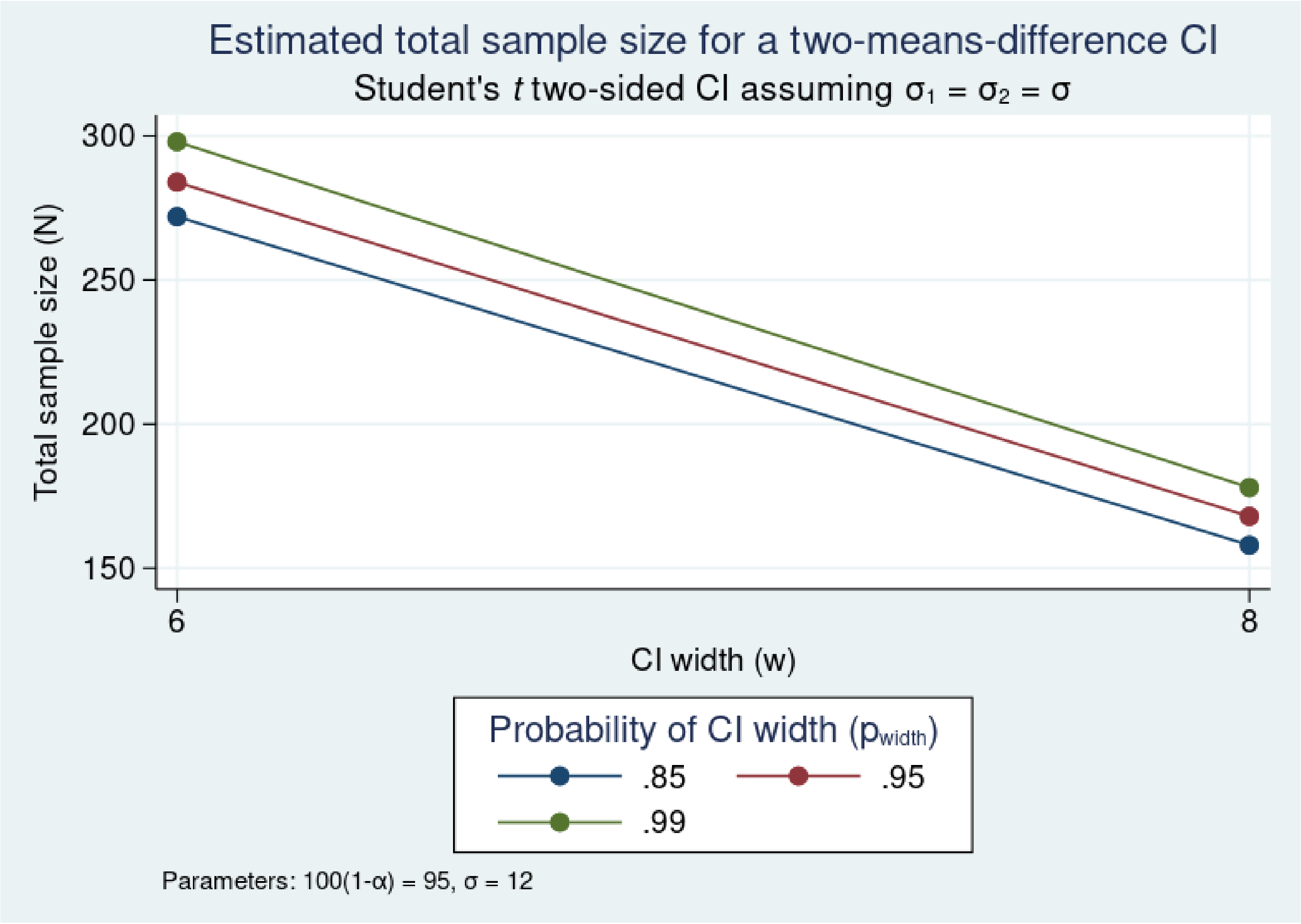
- Group sizes may differ

CI for a difference of two means

```
. ciwidth twomeans, width(6) probwidth(0.99) sd(12)

Performing iteration ...

Estimated sample sizes for a two-means-difference CI
Student's t two-sided CI assuming sd1 = sd2 = sd

Study parameters:

        level =     95.00
     Pr_width =    0.9900
        width =    6.0000
           sd =   12.0000

Estimated sample sizes:

            N =       298
  N per group =       149
```

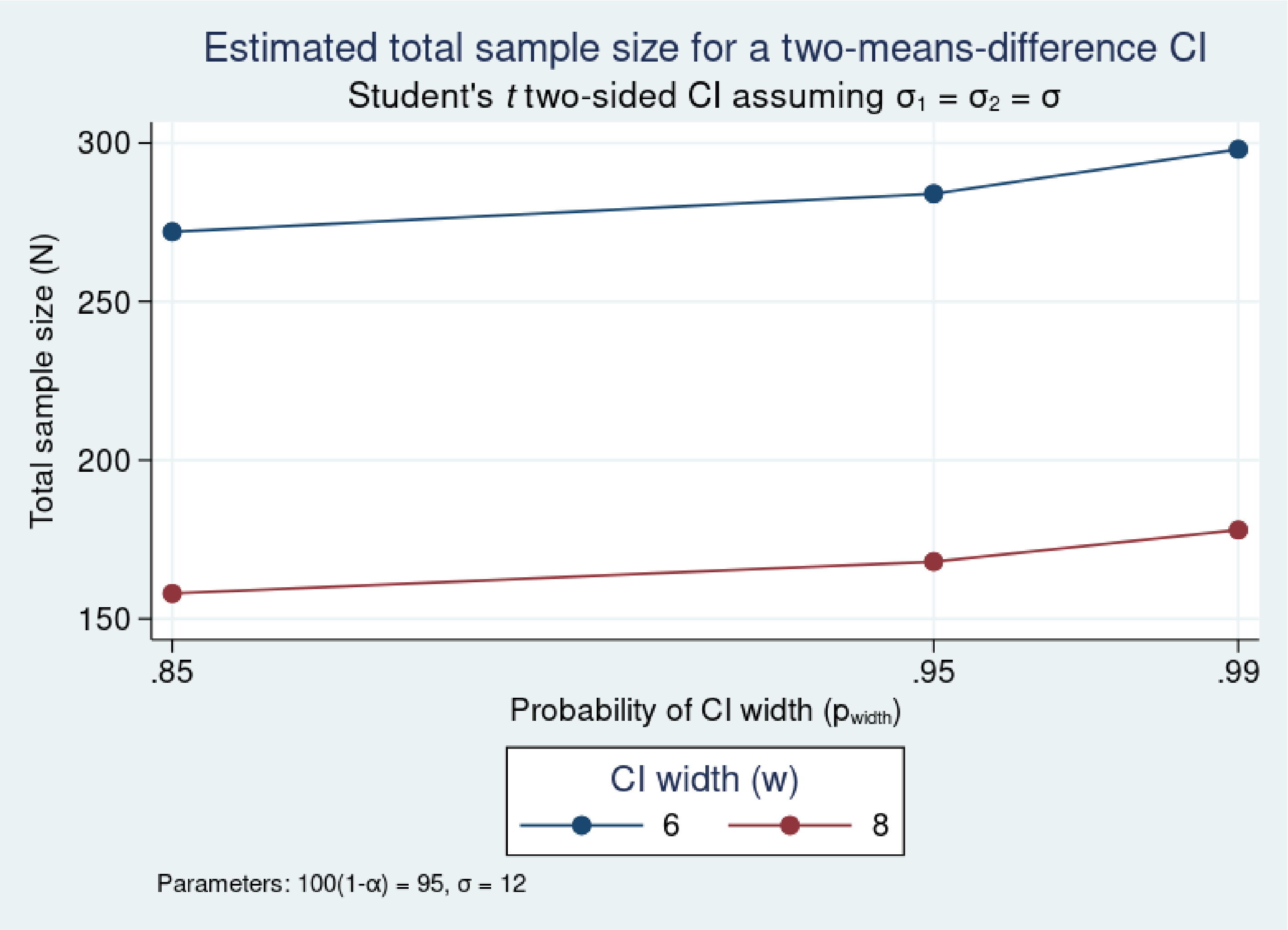
Graphs for sensitivity analysis

```
. ciwidth twomeans, width(6 8) probwidth(0.85 0.95 0.99) sd(12) graph
```



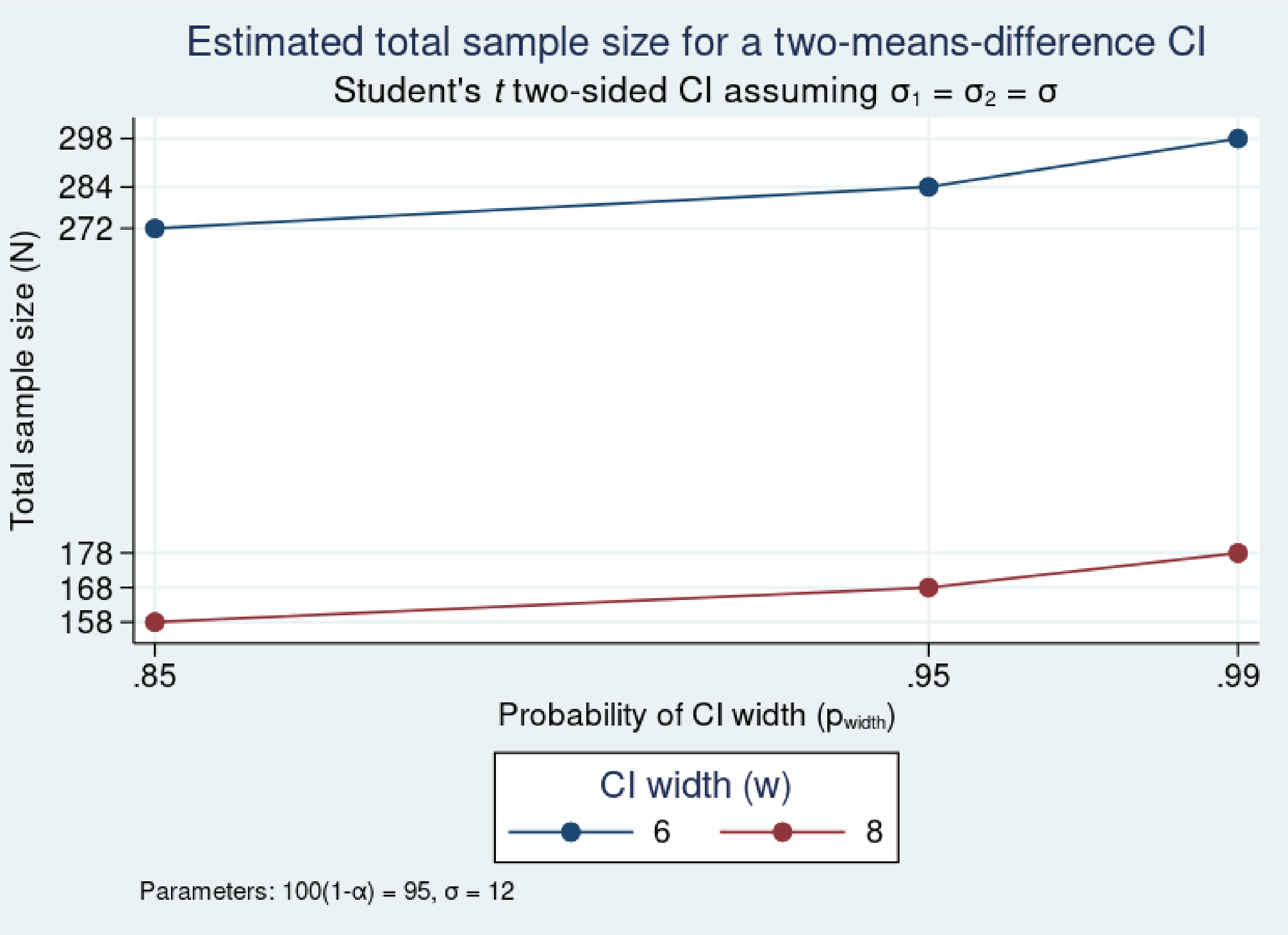
Define the x axis

```
. ciwidth twomeans, width(6 8) probwidth(0.85 0.95 0.99) sd(12)
>  graph(xdimension(Pr_width))
```



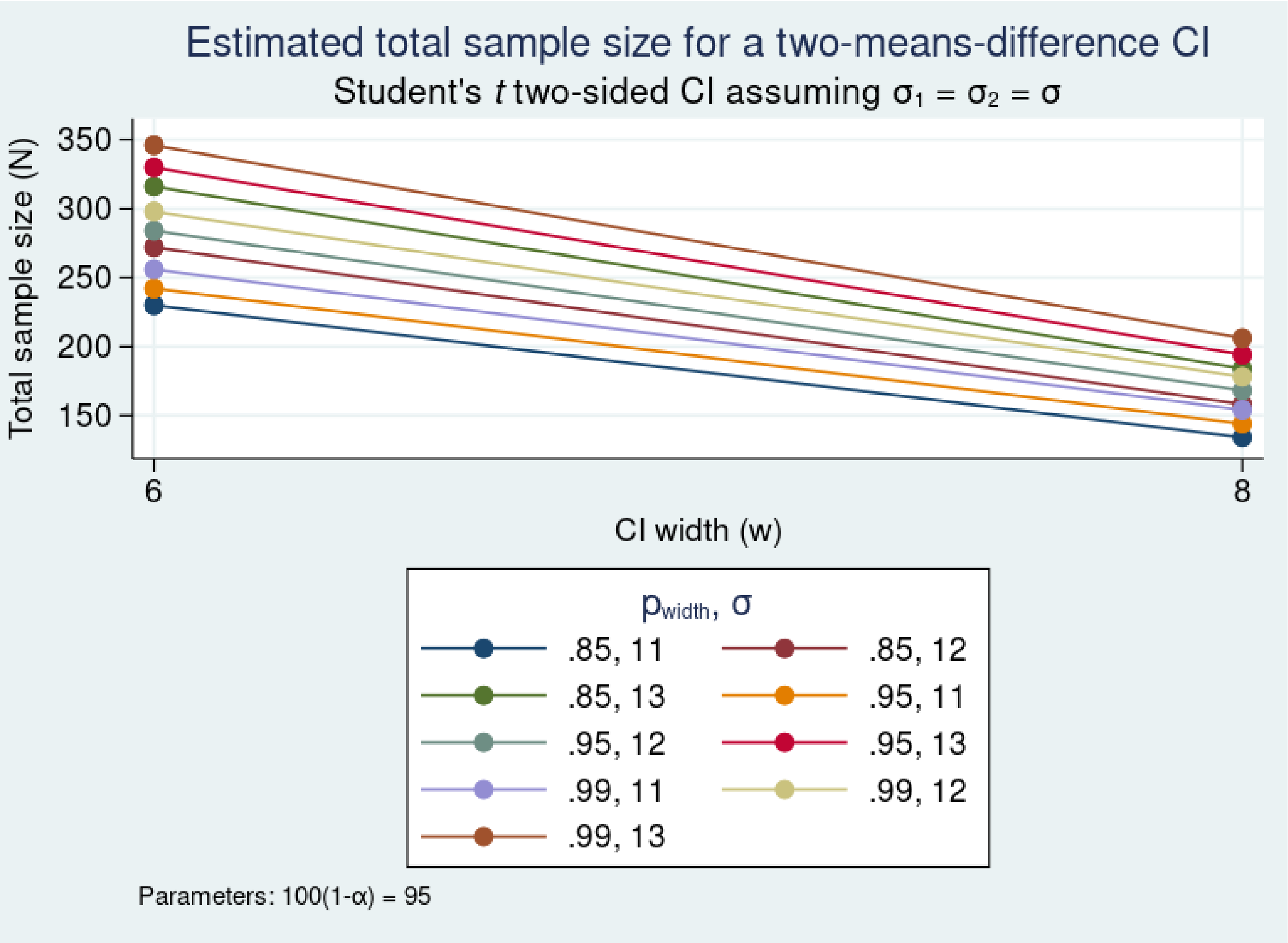
Label distinct values on the y axis

```
. ciwidth twomeans, width(6 8) probwidth(0.85 0.95 0.99) sd(12)
>  graph(xdimension(Pr_width) yvalues)
```



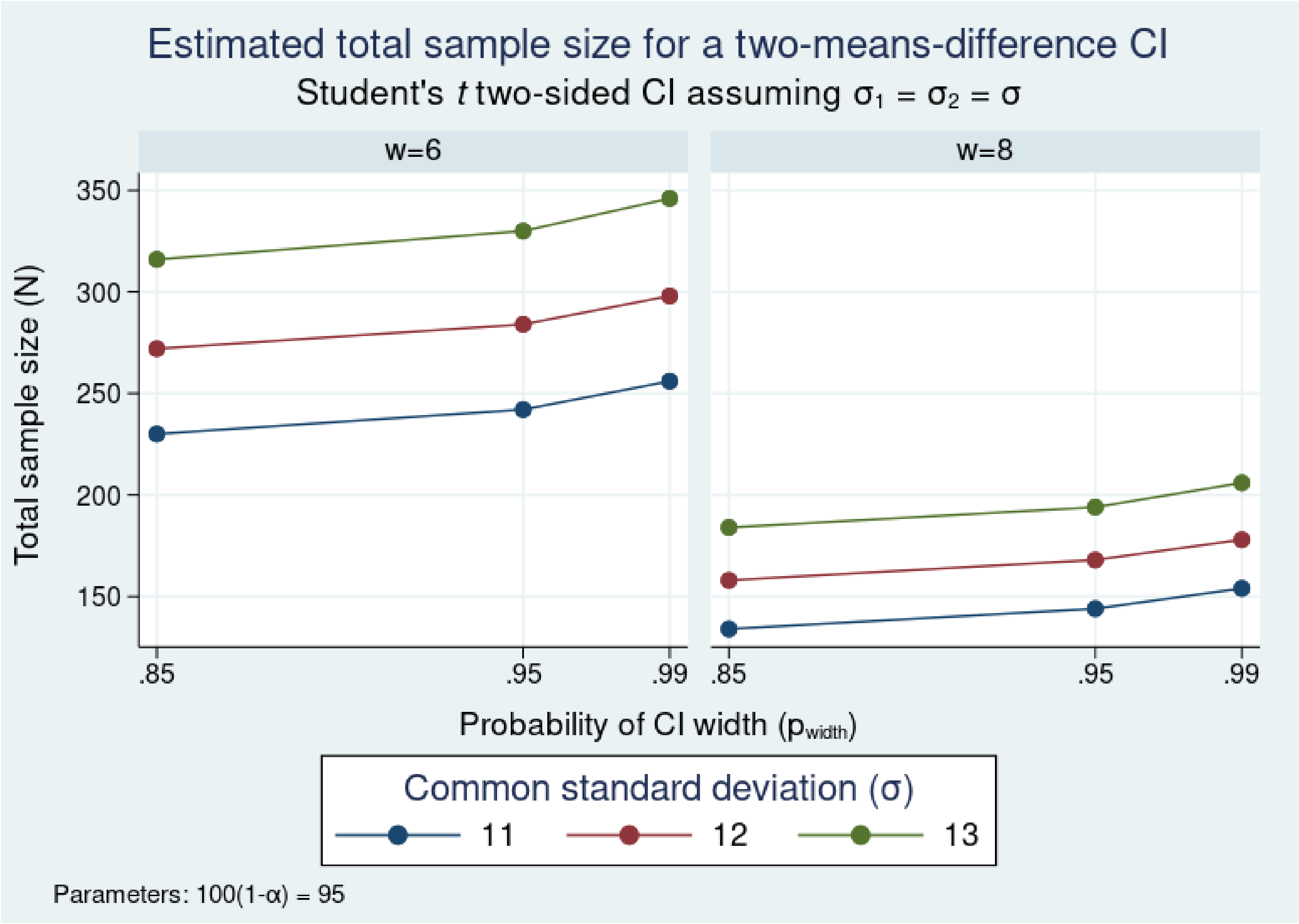
Specifying multiple values for multiple parameters

```
. ciwidth twomeans, width(6 8) probwidth(0.85 0.95 0.99)
>  sd(11 12 13) graph
```



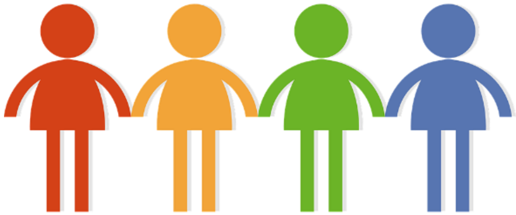
Create subgraphs for values of width

```
. ciwidth twomeans, width(6 8) probwidth(0.85 0.95 0.99)
> sd(11 12 13) graph(bydimension(width) legend(rows(1)))
```



Unbalanced sample sizes

Experimental group
(Medication)



Control group
(No medication)

Unbalanced sample sizes

```
. ciwidth twomeans, width(6) sd(12) nratio(0.5) probwidth(0.99)

Performing iteration ...

Estimated sample sizes for a two-means-difference CI
Student's t two-sided CI assuming sd1 = sd2 = sd

Study parameters:

        level =     95.00
     Pr_width =    0.9900
        width =    6.0000
           sd =   12.0000
        N2/N1 =    0.5000

Estimated sample sizes:

            N =       333
           N1 =       222
           N2 =       111
```

Unbalanced sample sizes

```
. ciwidth twomeans, width(6) sd(12) nratio(0.5) probwidth(0.98)

Performing iteration ...

Estimated sample sizes for a two-means-difference CI
Student's t two-sided CI assuming sd1 = sd2 = sd

Study parameters:

        level =     95.00
     Pr_width =    0.9800
        width =    6.0000
           sd =   12.0000
        N2/N1 =    0.5000

Estimated sample sizes:

            N =       326
           N1 =       217
           N2 =       109
        N2/N1 =    0.5023
```

Unbalanced sample sizes

```
. ciwidth twomeans, width(6) sd(12) n1(218) n2(109)

Estimated probability of width for a two-means-difference CI
Student's t two-sided CI assuming sd1 = sd2 = sd

Study parameters:

        level =     95.00
            N =       327
           N1 =       218
           N2 =       109
        N2/N1 =    0.5000
        width =    6.0000
           sd =   12.0000

Estimated probability of width:

     Pr_width =    0.9830
```

Unbalanced sample sizes

```
. ciwidth twomeans, width(6) sd(12) n1(217) n2(108)

Estimated probability of width for a two-means-difference CI
Student's t two-sided CI assuming sd1 = sd2 = sd

Study parameters:

        level =     95.00
            N =       325
           N1 =       217
           N2 =       108
        N2/N1 =    0.4977
        width =    6.0000
           sd =   12.0000

Estimated probability of width:

     Pr_width =    0.9778
```

Compute one sample size given another

```
. ciwidth twomeans, width(10) sd(12) n2(60) compute(n1) probwidth(0.98)
```

Compute one sample size given another

```
. ciwidth twomeans, width(10) sd(12) n2(60) compute(n1) probwidth(0.98)

Performing iteration ...

Estimated sample sizes for a two-means-difference CI
Student's t two-sided CI assuming sd1 = sd2 = sd

Study parameters:

        level =     95.00
     Pr_width =    0.9800
        width =   10.0000
           sd =   12.0000
           N2 =        60

Estimated sample sizes:

            N =       117
           N1 =        57
```

Known standard deviations

```
. ciwidth twomeans, width(10) sd(12) n2(60) compute(n1) knownsds

Estimated sample sizes for a two-means-difference CI
Normal two-sided CI assuming sd1 = sd2 = sd

Study parameters:

        level =     95.00
        width =   10.0000
           sd =   12.0000
           N2 =        60

Estimated sample sizes:

            N =        96
           N1 =        36
```

Do you have another method in mind?

Adding your own method to **`ciwidth`**

Adding your own methods to **`ciwidth`** is easy. Suppose you want to add a method called **`mymethod`** to **`ciwidth`**. Simply

1. write an r-class program called **`ciwidth_cmd_mymethod`** that computes sample size, probability of CI width, or CI width and follows **`ciwidth`**'s convention for naming common options and storing results; and

2. place the program where Stata can find it.

You are done. You can now use **`mymethod`** within **`ciwidth`** like any other official **`ciwidth`** method.

Program for computing CI width

```
program ciwidth_cmd_mymean, rclass
version 16.0
```

Program for computing CI width

```
program ciwidth_cmd_mymean, rclass
version 16.0
syntax, n(integer) [ Level(cilevel) Stddev(real 1) * ]
```

Program for computing CI width

```
program ciwidth_cmd_mymean, rclass
version 16.0
syntax, n(integer) [ Level(cilevel) Stddev(real 1) * ]
tempname width
scalar `width' = 2*invnormal(1/2+`level'/200)*`stddev'/sqrt(`n')
```

Program for computing CI width

```
program ciwidth_cmd_mymean, rclass
version 16.0
syntax, n(integer) [ Level(cilevel) Stddev(real 1) * ]
tempname width
scalar `width' = 2*invnormal(1/2+`level'/200)*`stddev'/sqrt(`n')
return scalar level = `level'
return scalar N = `n'
return scalar width = `width'
return scalar stddev = `stddev'
end
```

Program for computing CI width

File Edit View Language Project Tools

ciwidth_cmd_mymean.ado

```
program ciwidth_cmd_mymean, rclass
version 16.0
syntax, n(integer) [ Level(cilevel) Stddev(real 1) * ]
tempname width
scalar `width' = 2*invnormal(1/2+`level'/200)*`stddev'/sqrt(`n')
return scalar level = `level'
return scalar N = `n'
return scalar width = `width'
return scalar stddev = `stddev'
end
```

ciwidth mymean : compute CI width

```
. ciwidth mymean, level(95) n(10) stddev(0.25)

Estimated width
Two-sided CI
```

level	N	width
95	**10**	**.3099**

ciwidth onemean : compute CI width

```
. ciwidth onemean, level(95) n(10) sd(0.25) knownsd

Estimated width for a one-mean CI
Normal two-sided CI

Study parameters:

        level =     95.00
            N =        10
           sd =    0.2500

Estimated width:

        width =    0.3099
```

Naming conventions for stored results

```
. return list

scalars:
                r(level) =  95
                r(alpha) =  .05
                r(width) =  .3098975161522807
                    r(N) =  10
             r(onesided) =  0
                   r(sd) =  .25
              r(knownsd) =  1

macros:
               r(method) : "onemean"
                 r(type) : "ci"
```

```
return scalar level = `level'
return scalar N = `n'
return scalar width = `width'
```

ciwidth mymean : Specifying multiple values

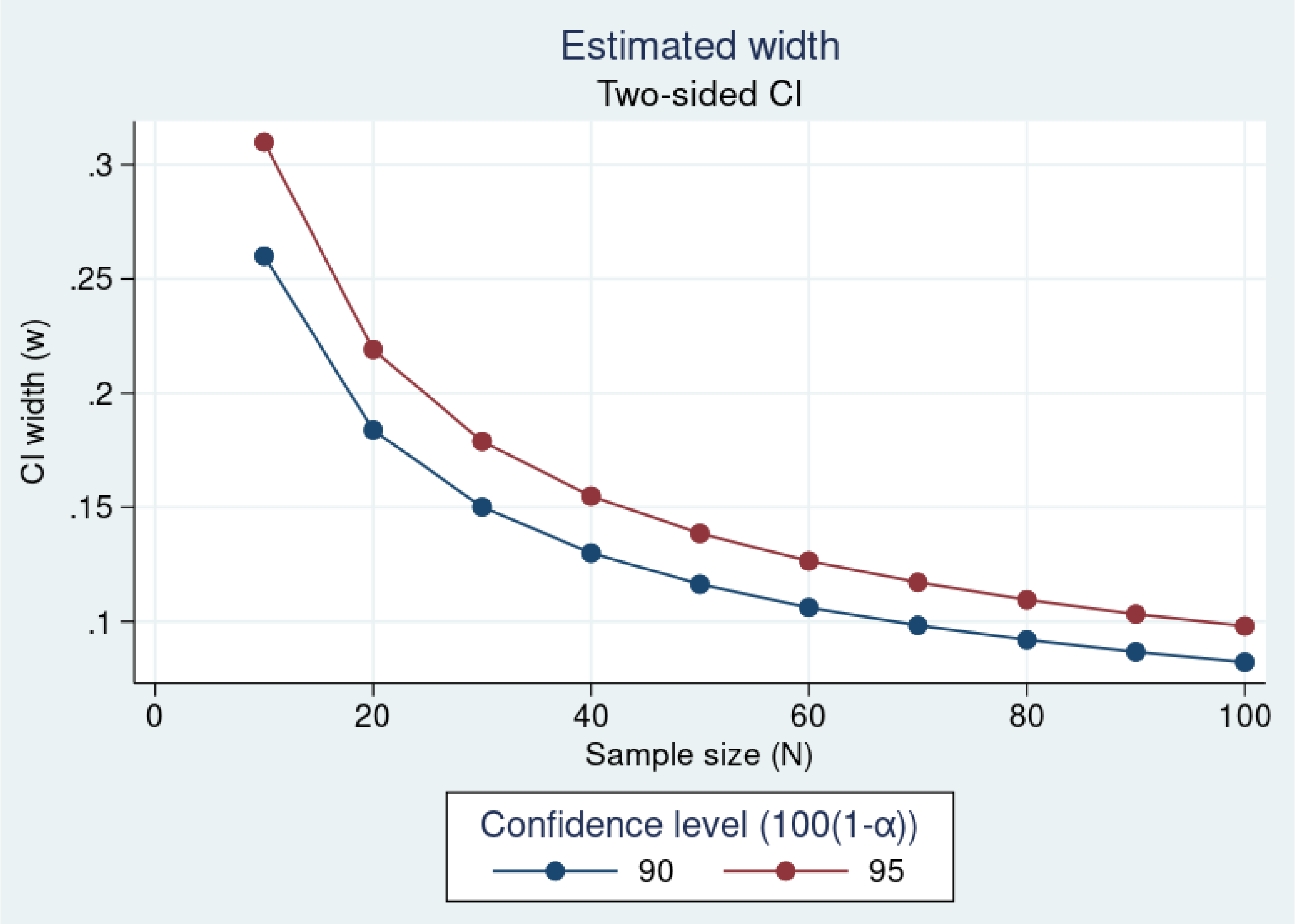
We can also compute results for multiple sample sizes and confidence levels without any additional effort on our part:

```
. ciwidth mymean, level(90 95) n(10 20) stddev(0.25) table(,separator(2))

Estimated width
Two-sided CI
```

level	N	width
90	10	.2601
90	20	.1839
95	10	.3099
95	20	.2191

`ciwidth mymean` : Automatic graphs

```
. ciwidth mymean, level(90 95) n(10(10)100) stddev(0.25) graph
```



Customizing your `ciwidth` command

- Add method-specific options and set them up to allow multiple values
- Tables
  - Change column labels, formats, and widths to modify the look and contents for the table created by default
- Graphs
  - Change the default column labels
  - Use different symbols to label the results

Summary

- Perform precision and sample-size analysis for CIs for
  - A population mean
  - A population variance
  - A difference between two independent means
  - A difference between paired means
- Compute
  - Sample size, CI width, and probability of CI width
- Perform sensitivity analysis graphically and with a table
- Implement your own method, and easily create tables and graphs as if it were an official **`ciwidth`** command

References

- Dixon, W. J., and F. J. Massey, Jr. 1983. *Introduction to Statistical Analysis*. 4th ed. New York: McGraw–Hill.

- Chow, Shein-Chung, J. Shao, H. Wang, and Y. Lokhnygina. 2017. Sample Size Calculations in Clinical Research. 3rd ed. Boca Raton: Taylor & Francis.

- Meeker, W. Q., G. J. Hahn, and L. A. Escobar. 2017. *Statistical Intervals: A Guide for Practitioners and Researchers*. 2nd ed. Hoboken, NJ: Wiley.

Thank you !!