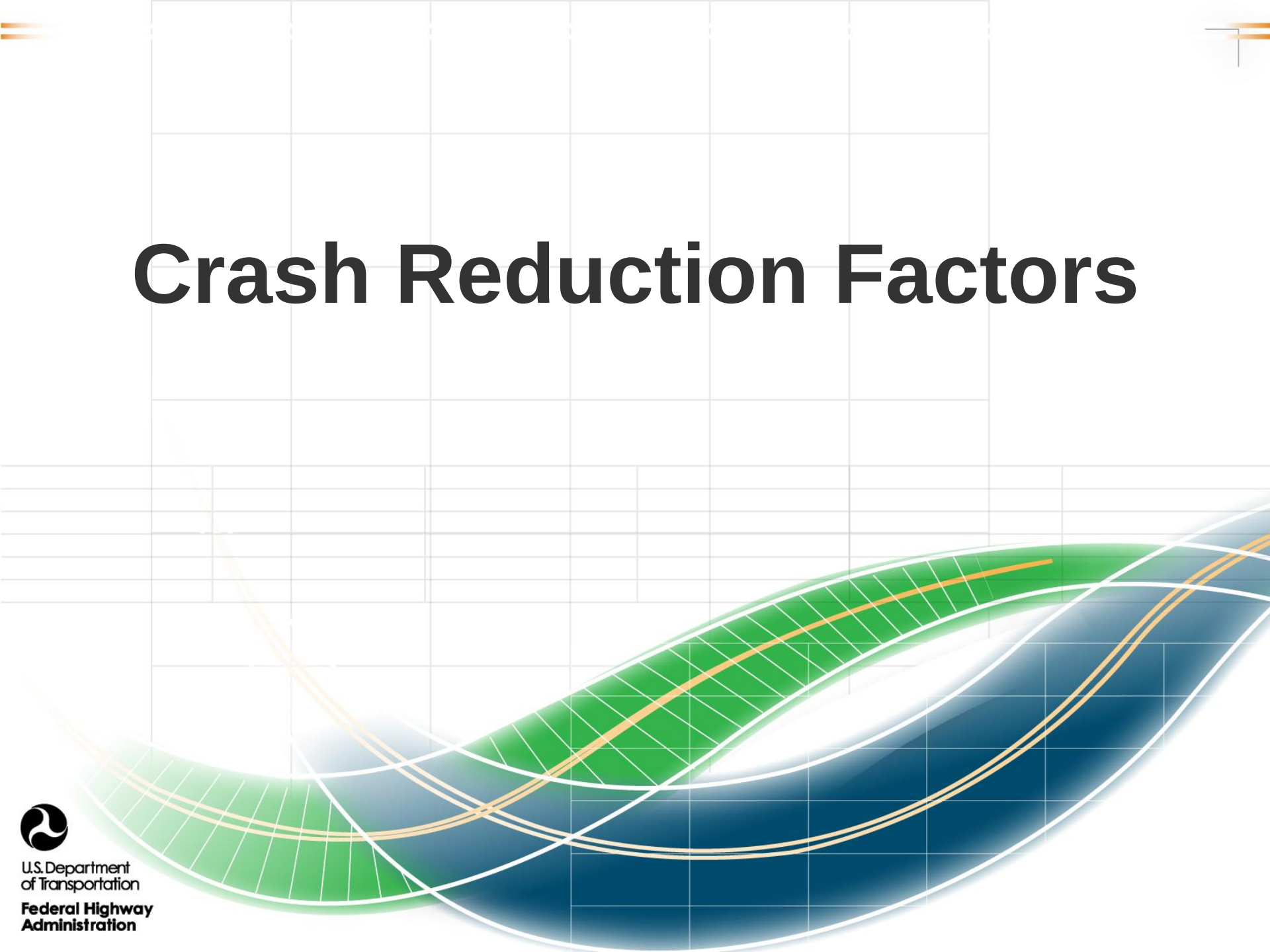
Crash Reduction Factors



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Learning Objectives

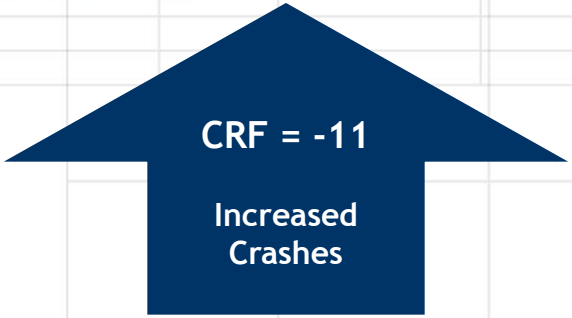
- CRF Background
  - Define CRF
  - Identify Sources of CRFs
  - Differentiate between a CRF, CMF and AMF
  - Describe the use and misuse of CRFs
  - Identify Users of CRFs
  - Calculate the Confidence Interval for a CRF
  - Explain how CRFs are used to estimate the safety effects of highway improvements

What is a Crash Reduction Factor?

A crash reduction factor (CRF) is a number indicating the percent reduction in crashes that would be *expected* after implementing a countermeasure.

Interpreting CRFs

Example: Increasing the yellow change interval at signalized intersections is associated with a CRF of 15. This indicates a 15 percent reduction in the expected crash frequency if the yellow change interval is increased.



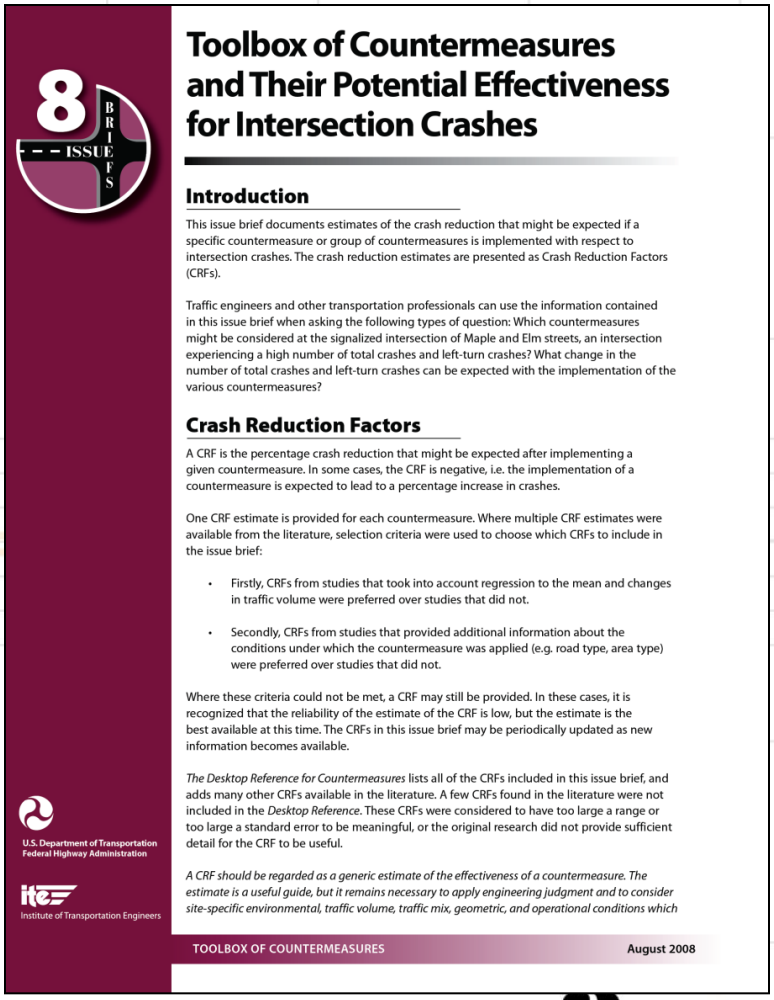
Example: Reducing shoulder width from 6ft to 2ft is associated with a CRF of -11 on two-lane rural roads. This indicates an 11 percent increase in the expected crash frequency if shoulders are reduced.

Example

What CRF indicates a 10 percent reduction in crashes?

CRF = 10

Desktop Reference



8 ISSUE BRIEFS

Toolbox of Countermeasures and Their Potential Effectiveness for Intersection Crashes

Introduction

This issue brief documents estimates of the crash reduction that might be expected if a specific countermeasure or group of countermeasures is implemented with respect to intersection crashes. The crash reduction estimates are presented as Crash Reduction Factors (CRFs).

Traffic engineers and other transportation professionals can use the information contained in this issue brief when asking the following types of question: Which countermeasures might be considered at the signalized intersection of Maple and Elm streets, an intersection experiencing a high number of total crashes and left-turn crashes? What change in the number of total crashes and left-turn crashes can be expected with the implementation of the various countermeasures?

Crash Reduction Factors

A CRF is the percentage crash reduction that might be expected after implementing a given countermeasure. In some cases, the CRF is negative, i.e. the implementation of a countermeasure is expected to lead to a percentage increase in crashes.

One CRF estimate is provided for each countermeasure. Where multiple CRF estimates were available from the literature, selection criteria were used to choose which CRFs to include in the issue brief:

- Firstly, CRFs from studies that took into account regression to the mean and changes in traffic volume were preferred over studies that did not.
- Secondly, CRFs from studies that provided additional information about the conditions under which the countermeasure was applied (e.g. road type, area type) were preferred over studies that did not.

Where these criteria could not be met, a CRF may still be provided. In these cases, it is recognized that the reliability of the estimate of the CRF is low, but the estimate is the best available at this time. The CRFs in this issue brief may be periodically updated as new information becomes available.

The Desktop Reference for Countermeasures lists all of the CRFs included in this issue brief, and adds many other CRFs available in the literature. A few CRFs found in the literature were not included in the *Desktop Reference*. These CRFs were considered to have too large a range or too large a standard error to be meaningful, or the original research did not provide sufficient detail for the CRF to be useful.

A CRF should be regarded as a generic estimate of the effectiveness of a countermeasure. The estimate is a useful guide, but it remains necessary to apply engineering judgment and to consider site-specific environmental, traffic volume, traffic mix, geometric, and operational conditions which

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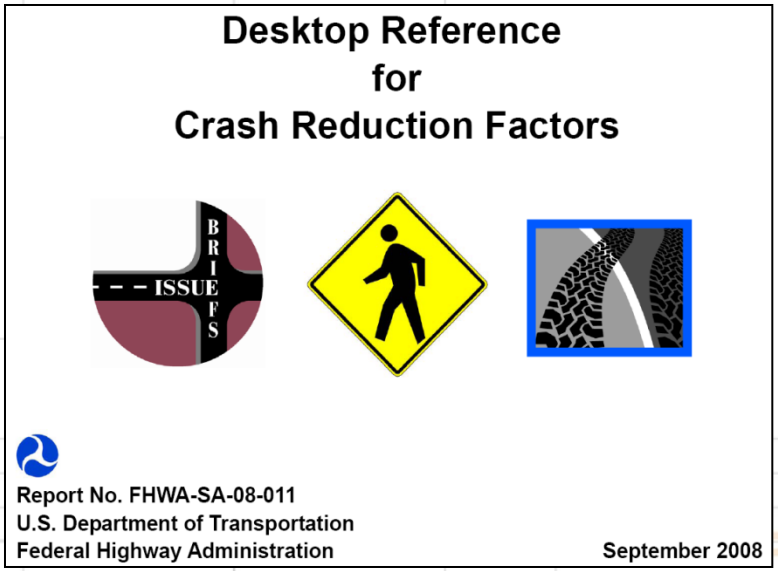
TOOLBOX OF COUNTERMEASURES August 2008



Desktop Reference for Crash Reduction Factors

8 ISSUE BRIEFS

Report No. FHWA-SA-08-011
U.S. Department of Transportation
Federal Highway Administration

September 2008

SAFETY AND OPERATIONS: TEAMING FOR SUCCESS

U.S. Department of Transportation
Federal Highway Administration

CRF Characteristics

point estimate (standard error)[reference]

Example: 42(18)[1]

Point Estimate

Countermeasure(s)	Crash Severity	Area Type	All Crashes	Pedestrian
Convert two-way to all-way STOP control	All	Urban		39[5]
Improve lighting at intersection	Fatal			78(87)[1]
	Injury			**42**(18)[1]

42(18)[1]

Standard Error

Countermeasure(s)	Crash Severity	Area Type	All Crashes	Pedestrian
Convert two-way to all-way STOP control	All	Urban		39[5]
Improve lighting at intersection	Fatal			78(87)[1]
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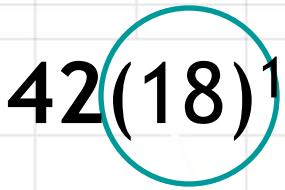

Reference

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42(18)[1]

Reference

References

1 Agent, K. R., Stamatiadis, N., and Jones, S., "Development of Accident Reduction Factors." KTC-96-13, Kentucky Transportation Cabinet, (1996)

2 Al-Masaeid, H. R. and Sinha, H., "Analysis of Accident Reduction Potentials of Pavement Marking." Journal of Transportation Engineering, ASCE, (1994) pp. 723-736.

3 Antonucci, N. D., Hardy, K. K., Slack, K. L., Pfefer, R., and Neuman, T. R., "NCHRP Report 500 Volume 12: A Guide for Addressing Collisions at Signalized Intersections." Washington, D.C., Transportation Research Board, National Research Council, (2004)

4 Bahar, G., Mollett, C., Persaud, B., Lyon, C., Smiley, A., Smahel, T., and McGee, H., "NCHRP Report 518: Safety Evaluation of Permanent Raised Pavement Markers." Washington, D.C., Transportation Research Board, National Research Council, (2004)

5 Bahar, G., Parkhill, M., Hauer, E., Council, F., Persaud, B., Zegeer, C., Elvik, R., Smiley, A., and Scott, B. "Prepare Parts I and II of a Highway Safety Manual: Knowledge Base for Part II". Unpublished material from NCHRP Project 17-27. (May 2007)

6 Bonneson, J., Zimmerman, K., and Fitzpatrick, K., "Roadway Safety Design Synthesis." Texas Transportation Institute for Texas DOT, (2005)

http://safety.fhwa.dot.gov/tools/crf/

Example

The CRF for flattening a crest vertical curve is given as:

$$20(19)^{17}$$

- Point Estimate = 20
- Standard Error = 19
- Reference = 17

CRF Categories

- Crash Severity
- Site Condition
- Crash Type

CRF Category: Crash Severity

Countermeasure(s)	Crash Severity	Control	Area Type	Configuration	All Crashes	Left-turn Crashes	Rt-angle Crashes	Rear-end Crashes	Sideswipe Crashes	Other Crashes	Major/Minor Daily Traffic Volume (vehicles/day)
SIGNAL HARDWARE COUNTERMEASURES											
Install signals	All	No Signal			33[16]	38[26]				j 50[26]	
	All	No Signal			38[9]		74[9]	22[9]		c 22[9]	<5,000/lane (Total)
	All	No Signal			20[9]		43[9]	20[9]		c 20[9]	>5,000/lane (Total)
	All	No Signal	Rural		15[26]						
	Fatal	No Signal			38[26]						
	Fatal/Injury	Stop	Urban	3-Leg	14(32)[21]		34(45)[21]	-50(51)[21]			11,750-42,000 / 900-4,000
	Fatal/Injury	Stop	Urban	4-Leg	23(22)[21]		**67**(20)[21]	-38(39)[21]			12,650-22,400 / 2,400-3,625
	PDO	No Signal			-15[26]						

CRF Category: Site Condition

Countermeasure(s)	Crash Severity	Control	Area Type	Configuration	All Crashes	Left-turn Crashes	Rt-angle Crashes	Rear-end Crashes	Sideswipe Crashes	Other Crashes	Major/Minor Daily Traffic Volume (vehicles/day)
SIGNAL HARDWARE COUNTERMEASURES											
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	PDO	No Signal			-15[26]						

CRF Category: Crash Type

Countermeasure(s)	Crash Severity	Control	Area Type	Configuration	All Crashes	Left-turn Crashes	Rt-angle Crashes	Rear-end Crashes	Sideswipe Crashes	Other Crashes	Major/Minor Daily Traffic Volume (vehicles/day)
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	Fatal/Injury	Stop	Urban	4-Leg	23(22)[21]		**67**(20)[21]	-38(39)[21]			12,650-22,400 / 2,400-3,625
	PDO	No Signal			-15[26]						

Example

Identify the CRF for this scenario:

Estimate the reduction in right angle crashes if a traffic signal is installed at a rural, unsignalized intersection with total entering volume of 8,000 vehicles per day per lane.

Example

Identify the CRF for this scenario:

Estimate the expected reduction in all fatal crashes if a traffic signal is installed at an unsignalized intersection.

Example

Identify the CRF for this scenario:

Estimate the expected reduction in total crashes if a traffic signal is installed at a rural, unsignalized intersection.

Terminology

- Crash Modification Factor
- CMF Relationship to CRF

$$CMF = 1 – (CRF/100)$$

- Accident Modification Factor

Example

What is the corresponding CMF for a CRF = 25?

$$CMF = 1 – (25/100) = 1 – 0.25 = 0.75$$

Example

How many crashes would be expected after installing larger STOP signs if the expected crashes without treatment equals 10 crashes per year and the CMF for installing larger STOP signs is 0.81.

Expected crashes after installing larger STOP signs =
0.81*10 crashes per year =
8.1 crashes per year.

Use and Misuse of CRFs

- Combining CRFs
- Site Conditions
- Crash Type & Crash Severity

Example

A CRF of 13 was used to estimate the reduction in run-off-road crashes for rural two-lane road with a daily traffic volume of 6,000 vehicles per day.

Proper Use

Example

A CRF of 16 was used to estimate the reduction in total injury crashes for a rural, multi-lane, divided road.

Misuse

Example

A CRF of 13 was used to estimate the reduction in run-off-road injury crashes for a rural freeway.

Misuse

CRF Users

- Highway Safety Engineer
- Traffic Engineer
- Highway Designers
- Transportation Planners
- Transportation Researchers
- Managers

CRF Resources

- Desktop Reference & Issue Briefs
- Highway Safety Manual
- SafetyAnalyst
- Interactive Highway Safety Design Model
- TRIS

Example

What is the most appropriate CRF to estimate the reduction in pedestrian-related crashes when considering the installation of pedestrian countdown signals?

25

Confidence Interval

Confidence Interval =

CRF Cumulative Probability * Standard Error

CRF

$$\text{Confidence Interval} = \text{CRF} \pm \text{Cumulative Probability} * \text{Standard Error}$$

Countermeasure(s)	Crash Severity	Area Type	All Crashes	Pedestrian
Convert two-way to all-way STOP control	All	Urban		39[5]
Improve lighting at intersection	Fatal			78(87)[1]
	Injury			**42**(18)[1]

42(18)[1]

Cumulative Probability

$$\text{Confidence Interval} = \text{CRF} \pm \text{Cumulative Probability} * \text{Standard Error}$$

Confidence Interval	Cumulative Probability
90 percent	1.645
95 percent	1.960
99 percent	2.576

Standard Error

$$\text{Confidence Interval} = \text{CRF} \pm \text{Cumulative Probability} * \text{Standard Error}$$

Countermeasure(s)	Crash Severity	Area Type	All Crashes	Pedestrian
Convert two-way to all-way STOP control	All	Urban		39[5]
Improve lighting at intersection	Fatal			78(87)[1]
	Injury			**42**(18)[1]

42 (18)[1]

Example

The CRF for improving intersection lighting for pedestrian-related crashes is **42**(18)[1] as provided in the Pedestrian Issue Brief.

Calculate the 95 percent confidence interval.

The 95 percent confidence interval:

= 42 ± [1.960 * 18]

= 42 ± 35.28

= (6.72, 77.28)

Summary

- Definition
- CRF Characteristics
- CRF Categories
- Terminology
- Use and Misuse of CRFs
- CRF Users
- Resources
- Confidence Interval

Questions?

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