

How to Perform Statistical Testing for Rates and Proportions

This technical assistance document was created by HSAG to assist health plans with statistical testing required for conducting performance improvement projects (PIP). Selected activities from the PIP Summary Form and screen shots from applicable web sites are provided to illustrate the proper techniques required to perform statistical testing and correctly document the results. The websites provided in this document are recommended but not required.

Two Web sites, Graphpad (www.graphpad.com) and Vassar College (www.vassar.edu) are provided to perform statistical testing. Both sites provide three different statistical tests: Pearson's Chi-square test, Yates' Chi-square (correction for continuity) test, and Fisher's exact test. One difference between the two Web site tools is that Graphpad [QuickCalcs](#) requires multiple data entry for the three different statistical tests, while Vassar College's [2x2 Contingency Table](#) allows the user to enter data only once for all three statistical tests.

The Chi-square with Yates continuity correction and the Fisher's exact test are used with numerators and denominators less than 30). The difference between the two tests is that the Fisher's exact test provides the exact p value probability while the Chi-square with the Yates continuity correction is an approximate p value. HSAG recommends that when dealing with small numbers, the Fisher's exact test be used because the p value is the exact probability.

For numerators and denominators larger than 30, all three tests can be used. Please note, for numerators and denominators that are very large, neither of the Web sites provided will calculate the Fisher's exact test due to the required computing power.

If you have large numerators or denominators that won't allow calculation of the Fisher's exact test with either Web site, use the Yates' or Pearson Chi-square test. Either test provides approximately the same p value. This is easy to validate using the Vassar College Web site because the p value from all three statistical tests is presented on one page. This is not possible with the Graphpad Web site; each statistical test must be run separately. With all statistical tests, a two-tailed p value should be calculated.

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Statistical Testing using Graphpad Web Site

When using Graphpad, enter the numerators and denominators from the data table of the PIP Summary Form below. The highlighted cells are where the final results of the statistical testing are entered. The statistical testing below is between the baseline rate of 72.3 percent and the Remeasurement 1 rate of 77.5 percent.

I. Activity IX: Report improvements. Enter results for each study indicator, including benchmarks and statistical testing with complete <i>p</i> values, and statistical significance.						
Quantifiable Measure No. 1: Enter the title of study indicator.						
Time Period Measurement Covers	Baseline Project Indicator Measurement	Numerator	Denominator	Rate or Results	Industry Benchmark	Statistical Test Significance and <i>p</i> value
1/11/2010 – 12/31/2010	<i>Baseline:</i>	402	556	72.3%	85.3%	Not applicable until Remeasurement 1
1/11/2011 – 12/31/2011	Remeasurement 1	455	587	77.5%	87.3%	<i>Fisher's exact test, statistically significant increase, p value=0.0475</i>
	Remeasurement 2					
	Remeasurement 3					
	Remeasurement 4					
<p>Describe any demonstration of meaningful change in performance observed from <i>baseline</i> and each measurement period (e.g., <i>baseline</i> to Remeasurement 1, Remeasurement 1 to Remeasurement 2, or <i>baseline</i> to final remeasurement) for each study indicator.</p> <p style="background-color: yellow;"><i>The 5.2 percentage point increase from the baseline rate of 72.3 percent to the Remeasurement 1 rate of 77.5 percent is statistically significant at the 95 percent confidence level.</i></p>						

GraphPad Instructions

1. Open the GraphPad Web site.

Press and hold down the Control (Ctrl) button on the keyboard while you click this link: [QuickCalcs](#).

Result: The Web page shown in Figure 1 will open in the Web browser without the arrows and text boxes. This page is where you will enter your study indicator data.

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2. Enter the data provided for the measurement periods. (See Figure 2 for an example.)

Field Name	Required Data Input
Group 1	Replace Group 1 with baseline .
Group 2	Replace Group 2 with Remeasurement 1 .
Outcome 1	Replace Outcome 1 with Did get service .
Outcome 2	Replace Outcome 2 with Didn't get service .
First blank field to the right of Baseline (under Did Get Service)	Type the baseline numerator from your table (where 402 is in the example table.)
Second blank field to the right of Baseline (under Didn't Get Service)	From your table, subtract the baseline numerator from the denominator, and type the result. (In the example table, $556 - 402 = 154$. 154 would be our result.)
First blank field to the right of Remeasurement 1 (under Did Get Service)	Type the Remeasurement 1 numerator (where 455 is in the example table.)
Second blank field to the right of Remeasurement 1 (under Did Get Service)	From your table, subtract the Remeasurement 1 numerator from the denominator, and type the result. (In the example table, $587 - 455 = 132$. 132 would be our result.)

3. Click the Calculate button.

Result: The Web page shown in Figure 3 will open and contain your data and results. Figure 3 includes the *p* value and statistical significance between the baseline and Remeasurement 1 rates.

Note: You can also copy the Web page by pressing the Print Screen key on your keyboard. Then, you may paste the screen in your PIP documentation and submit it to support statistical findings. All *p* values are reported to four digits beyond the decimal point.

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Figure 1

The screenshot shows the GraphPad QuickCalcs website interface. The main heading is "QuickCalcs Online Calculators for Scientists". Below this, there are four steps: "1. Select category", "2. Choose calculator", "3. Enter data", and "4. View results". The current step is "3. Enter data", which is titled "Analyze a 2x2 contingency table".

The form includes a section "Enter your data" with the instruction: "Enter the number of subjects actually observed. Don't enter proportions, percentages or means." Below this is a link: "Learn how to create a contingency table." The form itself is a 2x2 table with columns "Outcome 1" and "Outcome 2", and rows "Group 1" and "Group 2".

Annotations in blue boxes with arrows point to the form fields:

- Enter **baseline** instead of Group 1. (points to the Group 1 header)
- Enter **Didn't get service** instead of Outcome 2 (points to the Outcome 2 header)
- Enter **Did get service** instead of Outcome 1. (points to the Outcome 1 header)
- Enter **Remeasurement 1** instead of Group 2. (points to the Group 2 header)

Below the table is a "Which test" section with three radio button options:

- Fisher's exact test (recommended)
- Chi-square with Yates' correction
- Chi-square without Yates' correction

Below that is a section for "A P value can be calculated with either one or two tails. We suggest always using two-tailed (also called two-sided) P values. [Read more about P values.](#)" with two radio button options:

- Two-tailed (recommended)
- One-tailed

At the bottom of the form is a "Calculate" button.

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Figure 2

GraphPad QuickCalcs: Analyze a 2x2 contingency table. - Windows Internet Explorer

http://www.graphpad.com/quickcalcs/contingency1.cfm

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Deltek Time & Expense - T... GraphPad QuickCalcs: ...

GraphPad Software
ANALYZE, GRAPH AND ORGANIZE YOUR DATA

PRIM inStat StatMate Try our free demos

QuickCalcs Online Calculators for Scientists

1. Select category 2. Choose calculator 3. Enter data 4. View results

Analyze a 2x2 contingency table

Enter your data

Enter the number of subjects actually observed. Don't enter proportions, percentages or means.

[Learn how to create a contingency table.](#)

	Did get service	Didn't get service
Baseline		
Remeasurement 1		

Enter 402 (Didn't get service, Baseline)

Enter 154 (Did get service, Baseline)

Enter 132 (Didn't get service, Remeasurement 1)

Enter 455 (Did get service, Remeasurement 1)

Which test

There are three ways to compute a P value from a contingency table. Fisher's test is the best choice as it always gives the exact P value, while the chi-square test only calculates an approximate P value. Only choose chi-square if someone requires you to. The Yates' continuity correction is designed to make the chi-square approximation better. With large sample sizes, the Yates' correction makes little difference. With small sample sizes, chi-square is not accurate, with or without the correction.

- Fisher's exact test (recommended)
- Chi-square with Yates' correction
- Chi-square without Yates' correction

A P value can be calculated with either one or two tails. We suggest always using two-tailed (also called two-sided) P values. [Read more about P values.](#)

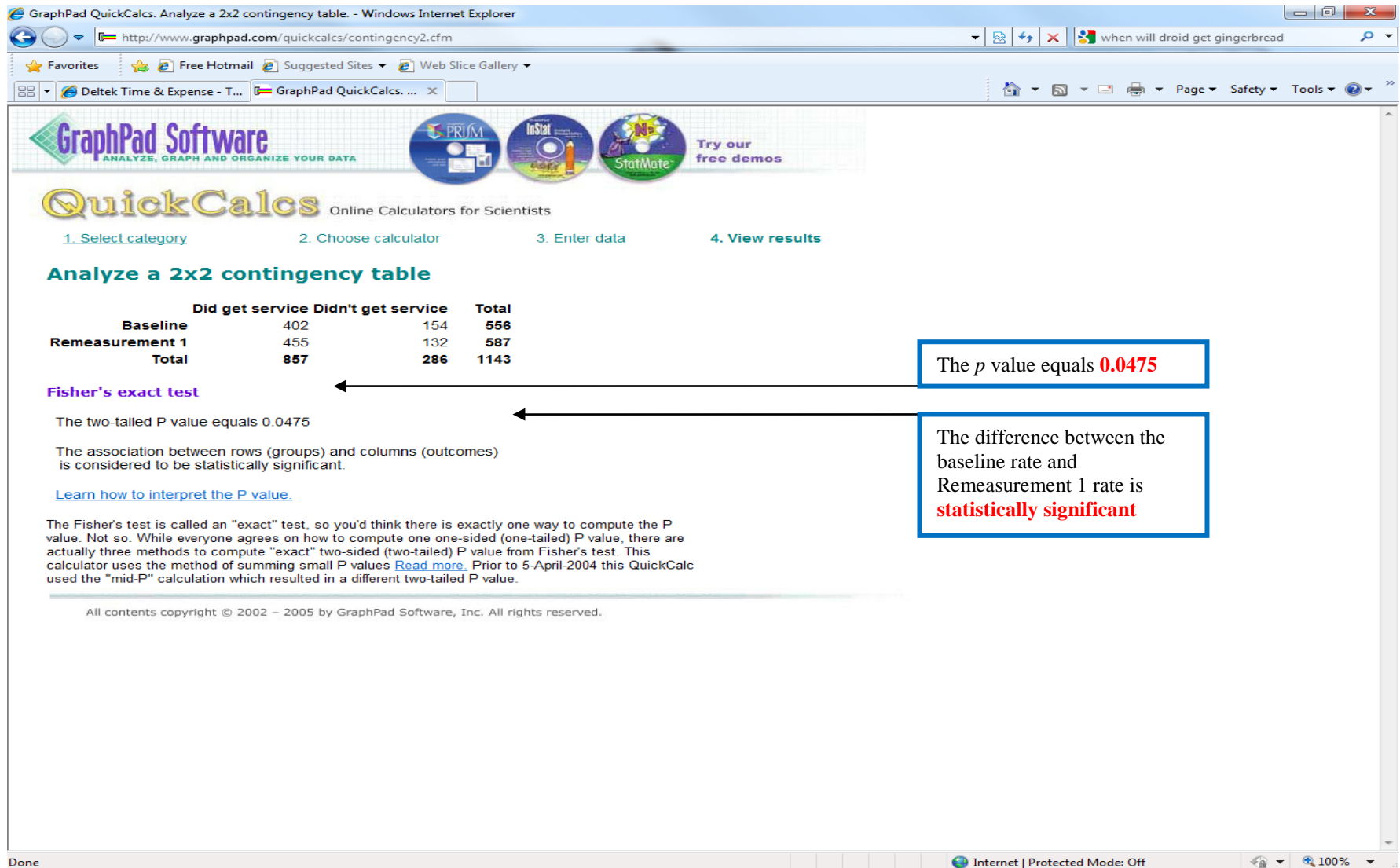
- Two-tailed (recommended)
- One-tailed

Calculate

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Figure 3



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Statistical Testing Using Vassar College Web Site

To conduct statistical testing using the Vassar College Web site, start with the numerators and denominators entered in the data table of the PIP Summary Form below. The highlighted cells are where the final results of the statistical testing will be entered. The statistical testing below is between the baseline rate of 3 percent and the Remeasurement 1 rate of 77.5 percent.

I. Activity IX: Report improvements. Enter results for each study indicator, including benchmarks and statistical testing with complete <i>p</i> values, and statistical significance.						
Quantifiable Measure No. 1: Enter the title of study indicator.						
Time Period Measurement Covers	Baseline Project Indicator Measurement	Numerator	Denominator	Rate or Results	Industry Benchmark	Statistical Test Significance and <i>p</i> value
1/11/2010 – 12/31/2010	Baseline:	301	455	66.2%	85.3%	Not applicable until Remeasurement 1
1/11/2011 – 12/31/2011	Remeasurement 1	326	427	76.3%	87.3%	<i>Fisher's exact Test, statistically significant increase, p value=0.0010</i>
	Remeasurement 2					
	Remeasurement 3					
	Remeasurement 4					
Describe any demonstration of meaningful change in performance observed from <i>baseline</i> and each measurement period (e.g., <i>baseline</i> to Remeasurement 1, Remeasurement 1 to Remeasurement 2, or <i>baseline</i> to final remeasurement) for each study indicator.						
<i>The 5.2 percentage point increase from the baseline rate of 66.2 percent to the Remeasurement 1 rate of 76.3 percent is statistically significant at the 95 percent confidence level.</i>						

Vassar College Site Instructions

1. Open the Vassar College Web site.

Press and hold down the Control (Ctrl) button on the keyboard while you click this link: [Vassar College](#)

Result: The Web page shown in Figure 4 will open in the Web browser without the arrows and text boxes. This page is where you will enter your study indicator data.

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- Enter the data provided for the measurement periods. (See Figure 4 for an example.)

In Figure 4, there are 4 fields under the X heading, to the right of the Y heading that are ready for input. They appear in a 2x2 box that looks something like this:

		X	
		0	1
Y	1	Field A	Field B
	0	Field C	Field D

Field Name	Required Data Input
A	Type the baseline numerator from your table (where 301 is in the example table.) Note: This number indicates the number of members who did get service.
B	From your table, subtract the baseline numerator from the denominator, and type the result. (In the example table, $556 - 402 = 154$. 154 would be our result.) Note: This number indicates the number of members who did not get service.
C	Type the Remeasurement 1 numerator (where 326 is in the example table.) Note: This number indicates the number of members who did get service.
D	From your table, subtract the Remeasurement 1 numerator from the denominator, and type the result. (In the example table, $427 - 326 = 101$. 101 would be our result.) Note: This number indicates the number of members who did not get service.

- Click the Calculate button.

Result: The Web page shown in Figure 5 will open and contain your data and results. Figure 5 includes the *p* value and statistical significance between the baseline and Remeasurement 1 rates.

Note: You can also copy the Web page by pressing the Print Screen key on your keyboard. Then, you may paste the screen into your PIP documentation and submit it to support statistical findings. All *p* values are reported to four digits beyond the decimal point.

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Figure 4

For a 2x2 Contingency Table:

- Phi Coefficient of Association
- Chi-Square Test of Association
- Fisher Exact Probability Test

For a table of frequency data cross-classified according to two categorical variables, X and Y, each of which has two levels or subcategories, this page will

- calculate the Phi coefficient of association;
- perform a chi-square test of association, if the sample size is not too small; and
- perform the Fisher exact probability test, if the sample size is not too large. [Although the Fisher test is traditionally used with relatively small samples, the programming for this page will handle fairly large samples, up to about $n=1000$, depending on how the frequencies are arrayed within the four cells.]

For intermediate values of n , the chi-square and Fisher tests will both be performed.

To proceed, enter the values of X_0Y_1 , X_1Y_1 , etc., into the designated cells. When all four cell values have been entered, click the «Calculate» button. To perform a new analysis with a new set of data, click the «Reset» button.

The logic and computational details of the Chi-Square and Fisher tests are described in Chapter 8 and Subchapter 8a, respectively, of [Concepts and Applications](#). A briefer account of the Fisher test will be found toward the bottom of this page.

Data Entry

		X		Totals	Expected Cell Frequencies per Null Hypothesis	
Y	1					
	0					
Totals						

Buttons: Calculate, Reset

Phi	Chi-Square	
	Yates	Pearson
P		

Chi-square is calculated only if all expected cell frequencies are equal to or greater than 5. The Yates value is corrected for continuity; the Pearson value is not. Both probability estimates are non-directional.

Fisher Exact Probability Test:

P one-tailed two-tailed

[Home](#) Click this link **only** if you did not arrive here via the VassarStats main page.

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Figure 5

2x2 Contingency Table - Windows Internet Explorer

http://faculty.vassar.edu/lowry/tab2x2.html

For a 2x2 Contingency Table:

- Phi Coefficient of Association
- Chi-Square Test of Association
- Fisher Exact Probability Test

For a table of frequency data cross-classified according to two categorical variables, X and Y, each of which has two levels or subcategories, this page will

- calculate the Phi coefficient of association;
- perform a chi-square test of association, if the sample size is not too small; and
- perform the Fisher exact probability test, if the sample size is not too large. [Although the Fisher test is traditionally used with relatively small samples, the programming for this page will handle fairly large samples, up to about n=1000, depending on how the frequencies are arrayed within the four cells.]

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To proceed, enter the values of X_0Y_1 , X_1Y_1 , etc., into the designated cells. When all four cell values have been entered, click the «Calculate» button. To perform a new analysis with a new set of data, click the «Reset» button.

The logic and computational details of the Chi-Square and Fisher tests are described in Chapter 8 and Subchapter 8a, respectively, of [Concepts and Applications](#). A briefer account of the Fisher test will be found toward the bottom of this page.

Data Entry

		X		Totals	Expected Cell Frequencies per Null Hypothesis	
		0	1			
Y	1	301	154	455	323.45	131.55
	0	326	101	427	303.55	123.45
Totals		627	255	882		

Calculate Reset

		Chi-Square	
		Yates	Pearson
Phi	+0.11	10.64	11.13
P	0.001107	0.000849	

Chi-square is calculated only if all expected cell frequencies are equal to or greater than 5. The Yates value is corrected for continuity; the Pearson value is not. Both probability estimates are non-directional.

Fisher Exact Probability Test:

P	one-tailed	0.0005349637910449755
	two-tailed	0.0010555813944801127

Home Click this link **only** if you did not arrive here via the VassarStats main page.

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The p value equals **0.0011**

The p value equals **0.0008**

The p value equals **0.0010**

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Unlike Graphpad, the Vassar College Web site doesn't include the interpretation of the p value. As such, the interpretation of the p value is as follows:

- ◆ If the p value is less than or equal to 0.05, then the difference between rates is statistically significant.
- ◆ If the p value is greater than 0.05, then the difference is not statistically significant.

This interpretation assumes that the statistical testing is conducted at the 95 percent confidence level. It is HSAG's PIP Review Team's recommendation that statistical testing be conducted at the 95 percent confidence level.

For the above example shown in Figure 5, all p values displayed by the Vassar College Web site are less than or equal to 0.05 indicating that there is a statistically significant difference between the 66.2 percent baseline rate and the 76.3 percent Remeasurement 1 rate.

Questions

For questions pertaining to the information presented in this document, please contact Jenny Montano at 602.801.6851 to schedule a technical assistance call.