Chapter 394

GEE Tests for the TAD of Two Groups in a Repeated Measures Design (Count Outcome)

Introduction

This module calculates the power for testing the time-averaged difference (TAD) between two event rates from correlated **count** data that are analyzed using the GEE method. Such data occur in two design types: clustered and longitudinal.

GEE is different from MM in that it does not require the full specification of the joint distribution of the repeated measurements, as long as the marginal mean model is correctly specified. Estimation consistency is achieved even if the correlation matrix is incorrect. Also, the correlation matrix of the responses is specified directly, rather than using an intermediate, random effects model as is the case in MM. For clustered designs, GEE often uses a *compound symmetric* (CS) correlation structure. For longitudinal data, an *autoregressive* (AR(1)) correlation structure is often used.

Time-averaged difference analysis is often used when the outcome to be measured varies with time. For example, suppose that you want to compare two treatment groups based on the means of a certain count outcome such as the number of seizures in a 48-hour period. It is known that the number of seizures depends on several factors such as amount of sleep, excitement level, mood, exercise, etc. If only a single measurement is taken from each patient, then the comparison of mean values from the two groups may be invalid because of the large degree of variation within patients. The precision of the experiment is increased by taking multiple measurements from subjects in each treatment group and comparing the time-averaged difference between the two groups. Care must be taken in the analysis because of the correlation that is introduced when several measurements are taken from the same individual. The correlation structure may take on several forms depending on the nature of the experiment and the subjects involved.

Missing Values

This procedure allows you to specify various patterns of incomplete (or missing) data. Subjects may miss some appointments but attend others. This phenomenon of incomplete data can be accounted for in the sample size calculation which can greatly reduce the overall sample size from that calculated by just omitting subjects with incomplete observations.

Technical Details

Theory and Notation

Technical details are given in Ahn, Heo, and Zhang (2015), chapter 4, section 4.8.1, pages 130-132.

Suppose we have n_1 subjects in group 1 (treatment) and n_2 subjects in group 2 (control) for a total of N subjects, each measured on M occasions at times t_j (j = 1, ..., M). For convenience, we normalize these time points to the proportion of total time so that t_1 = 0 and t_m = 1. Let y_{kij} be the count response of subject i in group k at time t_j. The count is modeled by the Poisson distribution

$$f(y_{kij}) = \frac{e^{-\mu_{kij}}\mu_{kij}^{y_{kij}}}{y_{kij}!}$$

For a particular group, the mean of y_{ij} is modeled by

$$\log(\mu_{ij}) = \beta_1 + \beta_2 r_i$$

where

y_{ij} is the j^{th} count from subject i during time period j.

μ_{ij} is expectation of y_{ij},

r_i is the subject treatment indicator with 0 for control and 1 for treatment,

β_1 is the regression coefficient giving time-average response of the control group,

β_2 is the regression coefficient gives the TAD between treatment and control on the log scale,

In this procedure, the primary interest is on β_2.

This log model is reparametrized as

$$\log(\mu_{ij}) = b_1 + b_2(r_i - \bar{r})$$

where

$$b_1 = \beta_1 + \bar{r}\beta_2$$

$$b_2 = \beta_2$$

The vector of covariates is given by $x_{ij} = (1, r_i - \bar{r})'$.

GEE is used to estimate and test hypotheses about $\boldsymbol{b}$ with $\hat{\boldsymbol{b}}$.

Correlation Patterns

In a longitudinal design with *N* subjects, each measured *m* times, observations from a single subject are correlated, and a pattern of those correlations through time needs to be specified. Several choices are available.

Compound Symmetry

A compound symmetry correlation model assumes that all correlations are equal. That is

$$[\rho_{jj'}] = \begin{bmatrix} 1 & \rho & \rho & \rho & \cdots & \rho \\ \rho & 1 & \rho & \rho & \cdots & \rho \\ \rho & \rho & 1 & \rho & \cdots & \rho \\ \rho & \rho & \rho & 1 & \cdots & \rho \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \rho & \rho & \rho & \rho & \cdots & 1 \end{bmatrix}_{M\times M}$$

where ρ is the baseline correlation.

Banded(1)

A Banded(1) (banded order 1) correlation model assumes that correlations for observations one time period apart are equal to ρ, and correlations for measurements greater than one time period apart are equal to zero. That is

$$[\rho_{jj'}] = \begin{bmatrix} 1 & \rho & 0 & 0 & \cdots & 0 \\ \rho & 1 & \rho & 0 & \cdots & 0 \\ 0 & \rho & 1 & \rho & \cdots & 0 \\ 0 & 0 & \rho & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & 0 & \cdots & 1 \end{bmatrix}_{M\times M}$$

where ρ is the baseline correlation.

Banded(2)

A Banded(2) (banded order 2) correlation model assumes that correlations for observations one time period or two periods apart are equal to ρ, and correlations for measurements greater than one time period apart are equal to zero. That is

$$[\rho_{jj'}] = \begin{bmatrix} 1 & \rho & \rho & 0 & \cdots & 0 \\ \rho & 1 & \rho & \rho & \cdots & 0 \\ \rho & \rho & 1 & \rho & \cdots & 0 \\ 0 & \rho & \rho & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & 0 & \cdots & 1 \end{bmatrix}_{M\times M}$$

where ρ is the baseline correlation.

AR1 (Traditional)

This version of AR1 (autoregressive order 1) correlation model assumes that correlations *t* time periods apart are equal to ρ^t. That is

$$[\rho_{jj'}] = \begin{bmatrix} 1 & \rho & \rho^2 & \rho^3 & \cdots & \rho^{M-1} \\ \rho & 1 & \rho & \rho^2 & \cdots & \rho^{M-2} \\ \rho^2 & \rho & 1 & \rho & \cdots & \rho^{M-3} \\ \rho^3 & \rho^2 & \rho & 1 & \cdots & \rho^{M-4} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \rho^{M-1} & \rho^{M-2} & \rho^{M-3} & \rho^{M-4} & \cdots & 1 \end{bmatrix}_{M\times M}$$

where ρ is the baseline correlation.

AR1 (Proportional)

This version of AR1 (autoregressive order 1) correlation model is described in the book by Ahn et al. (2015). It assumes that correlations $|t_j - t_k|$ time periods apart are equal to $\rho^{|t_j - t_k|}$. That is

$$[\rho_{jk}] = \left[\rho^{|t_j - t_k|}\right]_{M\times M}$$

where ρ is the baseline correlation. Note that in this pattern, the value of ρ is shown in the final column since in this case $t_j = 0$ and $t_k = 1$, so $|t_j - t_k| = 1$.

Damped Exponential

A damped exponential is an extension of the AR(1) correlation model in which the exponents are raised to the power *Dexp* (θ = *Dexp* in the diagram below). This causes the resulting correlations to be reduced (dampened). Here is an example

$$[\rho_{jj'}] = \begin{bmatrix} 1 & \rho & \rho^{2^\theta} & \rho^{3^\theta} & \cdots & \rho^{(M-1)^\theta} \\ \rho & 1 & \rho & \rho^{2^\theta} & \cdots & \rho^{(M-2)^\theta} \\ \rho^{2^\theta} & \rho & 1 & \rho & \cdots & \rho^{(M-3)^\theta} \\ \rho^{3^\theta} & \rho^{2^\theta} & \rho & 1 & \cdots & \rho^{(M-4)^\theta} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ \rho^{(M-1)^\theta} & \rho^{(M-2)^\theta} & \rho^{(M-3)^\theta} & \rho^{(M-4)^\theta} & \cdots & 1 \end{bmatrix}_{M\times M}$$

where ρ is the baseline correlation.

Damped Exponential (Proportional)

This version of the damped exponential correlation model is described in the book by Ahn et al. (2015). It assumes that correlations $|t_j - t_k|$ time periods apart are equal to $\rho^{|t_j-t_k|^{\theta}}$. That is

$$[\rho_{jk}] = \left[\rho^{|t_j-t_k|^{\theta}}\right]_{M\times M}$$

where ρ is the baseline correlation. Note that in this pattern, the value of $\rho^{|t_j-t_k|^{\theta}}$ turns up in the final column since in this case t_j = 0 and t_k = 1, so $|t_j - t_k|$ = 1.

Linear Exponential Decay

A linear exponential decay correlation model is one in which the exponent of the correlation decays according to a linear equation from 1 at the *Base Time Proportion* to a final value, *Emax*. The resulting pattern looks similar to the damped exponential. Note that the exponents are applied to the absolute difference between the Measurement Time Proportions. This method allows you to easily construct comparable correlation matrices of different dimensions. Otherwise, differences in the resulting power would be more strongly due to differences in the correlation matrices.

Here is an example. Suppose *M* is 6, *ρ* = 0.5, *Emax* = 3, the *Base Time Proportion* is 0.20, and the Measurement Time Proportions are (0, 0.2, 0.4, 0.6, 0.8, 1). The following correlation matrix would be obtained

$$[\rho_{jj'}] = \begin{bmatrix} 1 & 0.5 & 0.3536 & 0.25 & 0.1768 & 0.125 \\ 0.5 & 1 & 0.5 & 0.3536 & 0.25 & 0.1768 \\ 0.3536 & 0.5 & 1 & 0.5 & 0.3536 & 0.25 \\ 0.25 & 0.3536 & 0.5 & 1 & 0.5 & 0.3536 \\ 0.1768 & 0.25 & 0.3536 & 0.5 & 0.3536 & 0.5 \\ 0.125 & 0.1768 & 0.25 & 0.3536 & 0.5 & 1 \end{bmatrix}_{M\times M}$$

Note that in the top row, the correlation is 0.5 for the second (0.2 - 0) time point and 0.125 (0.5^3) at the last (1 - 0) time points. The correlations are obtained by raising 0.5 to the appropriate exponent. The linear equation from 1 to 3 results in the exponents 1, 1.5, 2, 2.5, 3 correspondent to the time proportions 0, 0.2, 0.4, 0.6, 0.8, and 1.

As a further example, note that the correlation for the 0.4 time point is, $0.5^{1.5} = 0.35355339 \approx 0.3536$.

This method allows you to compare various values of *M* while keeping the correlation matrix similar. To see what we mean, consider what the correlation matrix looks like when *M* is reduced to 4 and the measurement time proportions are set to (0, 0.2, 0.6, 1). It becomes

$$[\rho_{jj'}] = \begin{bmatrix} 1 & 0.5 & 0.25 & 0.125 \\ 0.5 & 1 & 0.5 & 0.25 \\ 0.25 & 0.5 & 1 & 0.5 \\ 0.125 & 0.25 & 0.5 & 1 \end{bmatrix}_{M\times M}$$

Note that the correlation at a measurement time difference of 0.6 is equal to 0.25 in both matrices.

Missing Data Patterns

The problem of missing data occurs for several reasons. In longitudinal studies in which a subject is measured multiple times, missing data becomes more complicated to model because it is possible that a subject is measured only some of the time. In fact, it is probably more common for data to be incomplete than complete. The approach of omitting subjects with incomplete data during the planning phase is very inaccurate. Certainly, subjects with partial measurements are included in the analysis. This procedure provides several missing data patterns to choose from so that your sample size calculations are more realistic.

In the presentation to following, we denote the percent of subjects with a missing response at time point t_j as κ_j. The proportion non-missing at a particular time point is $\phi_j = 1 - \kappa_j$. We will refer to ϕ_j as the *marginal observant probability* at time t_j and $\phi_{jj'}$ as a *joint observant probability* at times t_j and $t_{j'}$.

Pairwise Missing Pattern

The program provides three options for how the pairwise (joint) observant probabilities $\phi_{jj'}$ are calculated. These are

Independent (Ind): $\phi_{jj'} = \phi_j \phi_{j'}, \phi_{jj} = \phi_j$

Monotonic (Mon): $\phi_{jj'} = \phi_k \text{ where } k = \max(j, j')$

Mixture: $\phi_{jj'} = W(\text{Ind}) + (1 - W)(\text{Mon})$ for weighting factor W.

Missing Input Type

The are several ways in which the missing value pattern can be specified. Each missing value pattern is a list of missing proportions at each of the M time points. Each value in the list must be non-negative and less than 1. Possible input choices are

- **Constant = 0**

  All missing proportions are set to 0. That is, there are no missing values.

- **Constant**

  All missing proportions are set to constant value.

- **Piecewise Constant on Spreadsheet**

  A set of missing proportions are defined for several time intervals using the spreadsheet. One column contains the missing proportions for the interval, going down the rows. Another column defines the corresponding upper limit of time proportion of the interval. The lower limit is implied by the limit given immediately above. The program assumes that the first-time interval starts at 0 percent.

- **Linear (Steady Change)**

  The missing proportions fall along a straight-line between 0 and 1 elapsed time. Only the first and last proportions are entered.

- **Piecewise Linear on Spreadsheet**

  The missing proportions fall along a set of connected straight-lines that are defined by two columns on the spreadsheet.

- **List**

  Enter a list of M missing proportions, one for each time point.

- **Multiple Lists on Spreadsheet**

  Select multiple columns containing vertical lists of missing proportions. Each column contains a set of missing proportions in rows, one for each time point.

- **Pairwise Observed Proportions on Spreadsheet**

  Enter an $M \times M$ matrix of observant probabilities by selecting M columns. These observant probabilities are the proportion of the responses for both the row and column time points that are observed.

Sample Size Calculations

The details of the calculation of sample size and power is given in Ahn, Heo, and Zhang (2015), Chapter 4. These are summarized here.

As explained above, GEE is used to estimate the regression coefficients $\boldsymbol{b}$ with $\hat{\boldsymbol{b}}$. The significance of b_4, the coefficient associated with the difference between the control and treatment slopes, is tested using a Wald statistic from which the following sample size formula is derived

$$n = \frac{\sigma_2^2\left(z_{1-\frac{\alpha}{h}} + z_{1-\gamma}\right)^2}{\beta_2^2}$$

where

h = 1 (one-sided test) or 2 (two-sided test)

γ = 1 – power

α = significance level

$\beta_2 = \text{TAD between treatment and control on the log scale}$

$$\sigma_2^2 = \frac{\bar{\mu}\sum_{j=1}^{M}\sum_{j'=1}^{M}\phi_{jj'}\rho_{jj'}}{\left(\sum_{j=1}^{M}\phi_j\right)^2\sigma_r^2\mu_2\mu_1}$$

$$\sigma_r^2 = \bar{r}(1-\bar{r})$$

$$\bar{\mu} = (1-\bar{r})\mu_2 + \bar{r}\mu_1$$

$$\mu_1 = \exp(\beta_1 + \beta_2)$$

$$\mu_2 = \exp(\beta_1)$$

$\phi_j = 1 - \kappa_j, \text{where } \kappa_j = \text{proportion missing at the } j^{\text{th}} \text{ time point}$

$\rho_{jj'}$ is the corresponding element from within-subject correlation matrix

$\phi_{jj'}$ is the joint observant probability of observing both y_{ij} and $y_{ij'}$ for every subject *i*

Three possible choices are available to calculate $\phi_{jj'}$. These are

Independent: $\phi_{jj'} = \phi_j \phi_{j'}, \phi_{jj} = \phi_j$

Monotonic: $\phi_{jj'} = \phi_k$ where $k = \max(j, j')$

Mixture: $\phi_{jj'} = W(\text{Independent}) + (1 - W)(\text{Monotonic})$ for weighting factor *W*.

The above formula is easily rearranged to obtain a formula for power.

Example 1 – Determining Sample Size

Researchers are planning a study of the impact of a new drug on seizure counts in an epilepsy trial with rats as subjects. They want to determine if the administration of the new drug will significantly reduce the average seizure count below the rate achieved by the standard drug. Their experimental protocol calls for the administration of the drugs at the beginning of each of four 24-hour periods. They want to be able to detect a reduction of 1.0 in the average seizure count. They want a sensitivity analysis by considering a range of differences from 0.5 to 1.5.

Similar studies have found an average of 6.2 seizures per time period. These studies also showed an autocorrelation between adjacent measurements on the same animal of 0.7, so they want to try values of 0.6, 0.7, and 0.8. The researchers assume that first-order autocorrelation adequately represents the autocorrelation pattern. The two-sided test will be conducted at the 0.05 significance level and at 90% power. They are planning on dividing the subjects equally between the treatment and control groups.

The researchers anticipate that the missing pattern across time will begin at 0% missing and increase steadily to 10% at the fourth measurement. They assume that the pairwise missing is *independent*.

What are the sample size requirements for this study?

Setup

If the procedure window is not already open, use the PASS Home window to open it. The parameters for this example are listed below and are stored in the **Example 1** settings file. To load these settings to the procedure window, click **Open Example Settings File** in the Help Center or File menu.

Design Tab

Solve For	**Sample Size**
Alternative Hypothesis	**Two-Sided**
Power	**0.90**
Alpha	**0.05**
R (Group 1 Allocation %)	**50**
Measurement Time Input Type	**Equally Spaced Measurement Times**
M (Number of Measurements)	**4**
μ1 Input Type	**Difference (μ1 - μ2)**
Difference (μ1 - μ2)	**-0.5 -1 -1.5**
μ2 (Group 2 Event Rate)	**6.2**
Pattern of ρ's Across Time	**AR1 (Traditional)**
ρ (Base Correlation)	**0.6 0.7 0.8**
Missing Input Type	**Linear (Steady Change)**
Pairwise Missing Pattern	**Independent (Ind)**
First Missing Proportion (Ind)	**0**
Last Missing Proportion (Ind)	**0.10**

Output

Click the Calculate button to perform the calculations and generate the following output.

Numeric Reports

Numeric Results for the Test of Time-Averaged Differences in Count Data using GEE

Solve For:	Sample Size
Measurement Times:	Equally spaced
Correlation:	AR1: ρ(j,k) = ρ^|j-k|
Missing Pattern:	Range of missing proportions
Observant Proportions:	Assume independence
μ1, μ2:	Event rates of group 1 (treatment) and group 2 (control)

Power	Total Sample Size N	Group 1 Allocation Percent R	Number of Measurement Times M	Event Rate μ1	Event Rate μ2	Event Rate Difference	Base Correlation ρ	First Row of Correlation Matrix	Missing Data Proportions	Measurement Times	Alpha
0.9000	62	50	4	4.7	6.2	-1.5	0.6	ρ1(1)	0.05	Ms1(1)	T(1)
0.9008	71	50	4	4.7	6.2	-1.5	0.7	ρ2(1)	0.05	Ms1(1)	T(1)
0.9013	81	50	4	4.7	6.2	-1.5	0.8	ρ3(1)	0.05	Ms1(1)	T(1)
0.9013	146	50	4	5.2	6.2	-1.0	0.6	ρ1(1)	0.05	Ms1(1)	T(1)
0.9001	166	50	4	5.2	6.2	-1.0	0.7	ρ2(1)	0.05	Ms1(1)	T(1)
0.9015	190	50	4	5.2	6.2	-1.0	0.8	ρ3(1)	0.05	Ms1(1)	T(1)
0.9002	606	50	4	5.7	6.2	-0.5	0.6	ρ1(1)	0.05	Ms1(1)	T(1)
0.9002	692	50	4	5.7	6.2	-0.5	0.7	ρ2(1)	0.05	Ms1(1)	T(1)
0.9001	788	50	4	5.7	6.2	-0.5	0.8	ρ3(1)	0.05	Ms1(1)	T(1)

Item	Values
ρ1(1)	1, 0.6, 0.36, 0.216
ρ2(1)	1, 0.7, 0.49, 0.343
ρ3(1)	1, 0.8, 0.64, 0.512
Ms1(1)	0, 0.03, 0.07, 0.1
T(1)	0, 0.33, 0.67, 1

Power	The probability of rejecting a false null hypothesis when the alternative hypothesis is true.
N	The total number of subjects in the study.
R	The treatment group allocation proportion. It is the proportion of subjects that are in the treatment group.
M	The number of time points at which each subject is measured.
Difference	The difference between the treatment and control event rates. Difference = μ1 - μ2.
μk	The event rate of group k (1 = treatment, 2 = control).
ρ	The base correlation between two responses on the same subject. It may be transformed based on the correlation pattern.
First Row of Correlation Matrix	Presents the top row of the correlation matrix.
Missing Data Proportions	Gives the name of the set containing the missing data proportions across time.
Measurement Times	Gives the name of the set containing the measurement time proportions. These measurement times represent the proportion of the total study time that has elapsed just before the measurement.
Alpha	The probability of rejecting a true null hypothesis.

Summary Statements

A two-group repeated measures design (with a count response and with 4 measurements for each subject) will be used to test whether there is a group difference in time-averaged response. The comparison will be made using a two-sided Wald test using GEE methods, with a Type I error rate (α) of 0.05. The (repeated) measurements of each subject will be made at the following 4 times, expressed as proportions of the total study time: 0, 0.33, 0.67, 1. Missing values are assumed to occur completely at random (MCAR). The missing value proportions will be combined to form the pairwise observant probabilities using an independent pairwise missing pattern. The anticipated proportions missing at each measurement time are 0, 0.03, 0.07, 0.1. The first row of the autocorrelation matrix of the responses within a subject is assumed to be 1, 0.6, 0.36, 0.216, with subsequent rows following the same pattern (AR1: ρ(j,k) = ρ^|j-k|). To detect time-averaged group event rates of 4.7 (μ1) and 6.2 (μ2) (difference of -1.5) with 90% power, the total number of needed subjects is 62 (with 50% of the subjects in the treatment group (Group 1)).

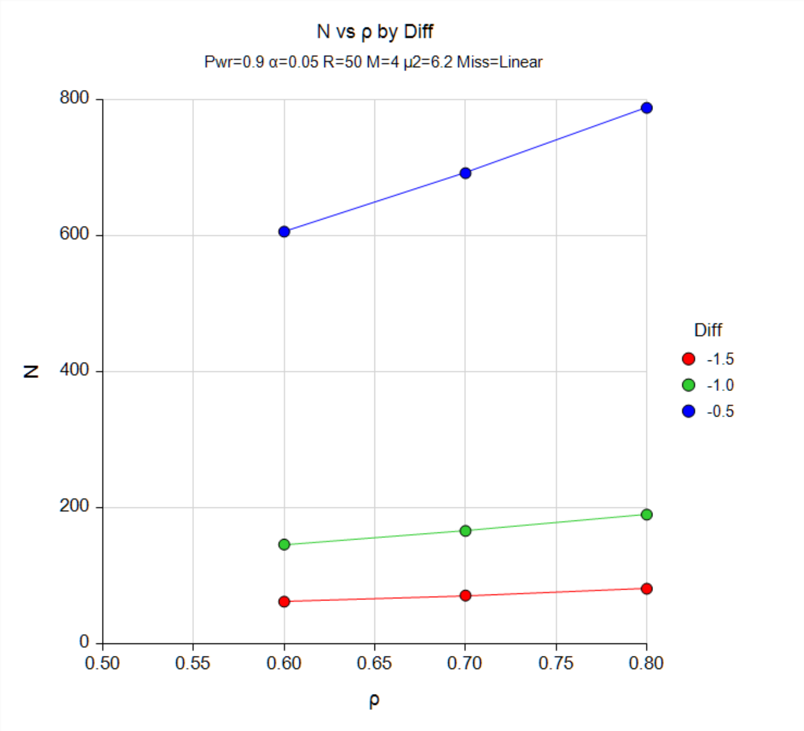
References

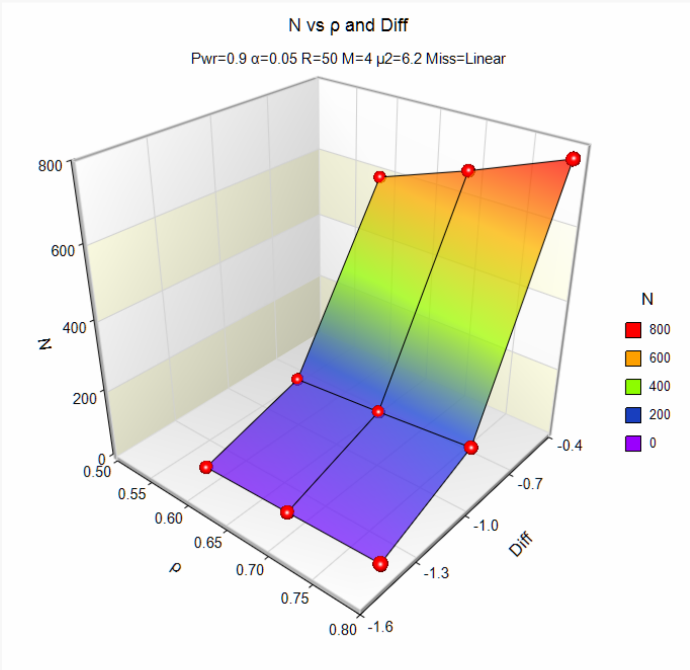
Ahn, C., Heo, M., and Zhang, S. 2015. Sample Size Calculations for Clustered and Longitudinal Outcomes in Clinical Research. CRC Press. New York.

This report gives the sample size for each value of the other parameters. The definition of each parameter is shown in the Report Definitions section.

Plots Section

Plots





These charts show the relationship between sample size, Difference (μ1 – μ2), and ρ when the other parameters in the design are held constant.

Autocorrelation Matrices

Autocorrelation Matrix for Report Row 1

Time	T(0)	T(0.33)	T(0.67)	T(1)
T(0)	1.000	0.60	0.36	0.216
T(0.33)	0.600	1.00	0.60	0.360
T(0.67)	0.360	0.60	1.00	0.600
T(1)	0.216	0.36	0.60	1.000

Autocorrelation Matrix for Report Row 2

Time	T(0)	T(0.33)	T(0.67)	T(1)
T(0)	1.000	0.70	0.49	0.343
T(0.33)	0.700	1.00	0.70	0.490
T(0.67)	0.490	0.70	1.00	0.700
T(1)	0.343	0.49	0.70	1.000

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(More Reports Follow)

These reports show the autocorrelation matrix for the indicated row of the report.

Example 2 – Finding the Power

Continuing with Example 1, the researchers want to determine the power corresponding to sample sizes ranging from 50 to 250 for the main cases of the other parameters.

Setup

If the procedure window is not already open, use the PASS Home window to open it. The parameters for this example are listed below and are stored in the **Example 2** settings file. To load these settings to the procedure window, click **Open Example Settings File** in the Help Center or File menu.

Design Tab

Solve For	**Power**
Alternative Hypothesis	**Two-Sided**
Alpha	**0.05**
N (Subjects)	**50 to 250 by 50**
R (Group 1 Allocation %)	**50**
Measurement Time Input Type	**Equally Spaced Measurement Times**
M (Number of Measurements)	**4**
μ1 Input Type	**Difference (μ1 - μ2)**
Difference (μ1 - μ2)	**-1**
μ2 (Group 2 Event Rate)	**6.2**
Pattern of ρ's Across Time	**AR1 (Traditional)**
ρ (Base Correlation)	**0.7**
Missing Input Type	**Linear (Steady Change)**
Pairwise Missing Pattern	**Independent (Ind)**
First Missing Proportion (Ind)	**0**
Last Missing Proportion (Ind)	**0.10**

Output

Click the Calculate button to perform the calculations and generate the following output.

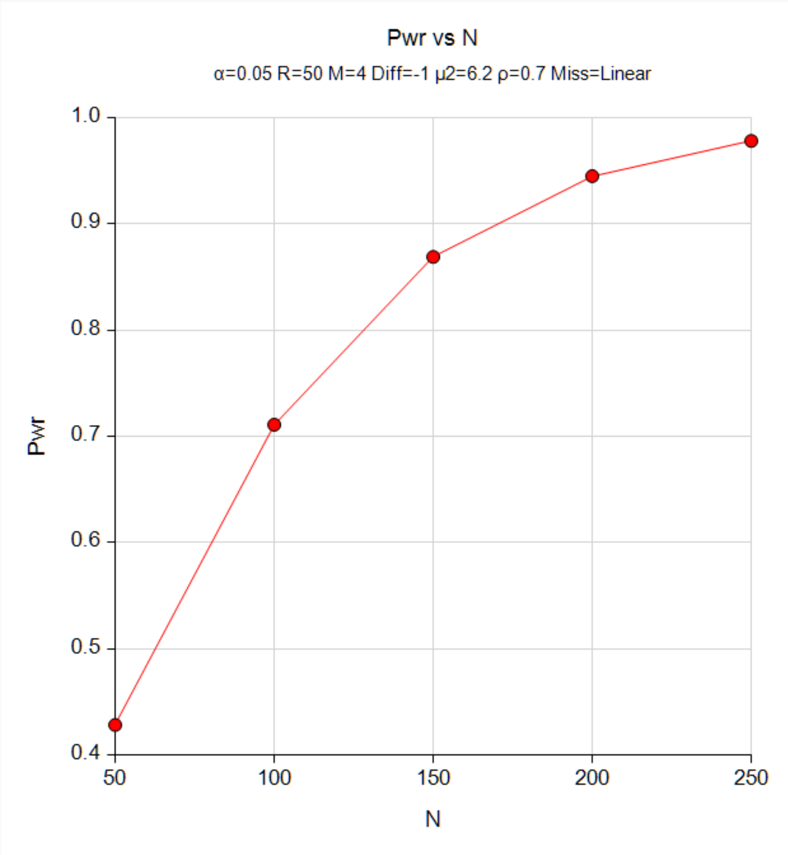
Numeric Results for the Test of Time-Averaged Differences in Count Data using GEE

Solve For:	Power
Measurement Times:	Equally spaced
Correlation:	AR1: ρ(j,k) = ρ^|j-k|
Missing Pattern:	Range of missing proportions
Observant Proportions:	Assume independence
μ1, μ2:	Event rates of group 1 (treatment) and group 2 (control)

Power	Total Sample Size N	Group 1 Allocation Percent R	Number of Measurement Times M	Event Rate μ1	Event Rate μ2	Event Rate Difference	Base Correlation ρ	First Row of Correlation Matrix	Missing Data Proportions	Measurement Times	Alpha
0.4283	50	50	4	5.2	6.2	-1	0.7	ρ1(1)	0.05	Ms1(1)	T(1)
0.7110	100	50	4	5.2	6.2	-1	0.7	ρ1(1)	0.05	Ms1(1)	T(1)
0.8690	150	50	4	5.2	6.2	-1	0.7	ρ1(1)	0.05	Ms1(1)	T(1)
0.9450	200	50	4	5.2	6.2	-1	0.7	ρ1(1)	0.05	Ms1(1)	T(1)
0.9782	250	50	4	5.2	6.2	-1	0.7	ρ1(1)	0.05	Ms1(1)	T(1)

Item	Values
ρ1(1)	1, 0.7, 0.49, 0.343
Ms1(1)	0, 0.03, 0.07, 0.1
T(1)	0, 0.33, 0.67, 1

Plots



These results show that an N between 150 and 200 is needed to guarantee that 90% power is reached.

Example 3 – Impact of the Number of Repeated Measurements

Continuing with Examples 1 and 2, the researchers want to study the impact on the sample size of changing the number of measurements made on each individual. Their experimental protocol calls for 4. They want to see the impact of taking 6 or even 8 measurements.

Setup

If the procedure window is not already open, use the PASS Home window to open it. The parameters for this example are listed below and are stored in the **Example 3** settings file. To load these settings to the procedure window, click **Open Example Settings File** in the Help Center or File menu.

Design Tab

Solve For	**Power**
Alternative Hypothesis	**Two-Sided**
Alpha:	**0.05**
N (Subjects)	**50 to 250 by 50**
R (Group 1 Allocation %)	**50**
Measurement Time Input Type	**Equally Spaced Measurement Times**
M (Number of Measurements)	**4 6 8**
μ1 Input Type	**Difference (μ1 - μ2)**
Difference (μ1 - μ2)	**-1**
μ2 (Group 2 Event Rate)	**6.2**
Pattern of ρ's Across Time	**AR1 (Traditional)**
ρ (Base Correlation)	**0.7**
Missing Input Type	**Linear (Steady Change)**
Pairwise Missing Pattern	**Independent (Ind)**
First Missing Proportion (Ind)	**0**
Last Missing Proportion (Ind)	**0.10**

Output

Click the Calculate button to perform the calculations and generate the following output.

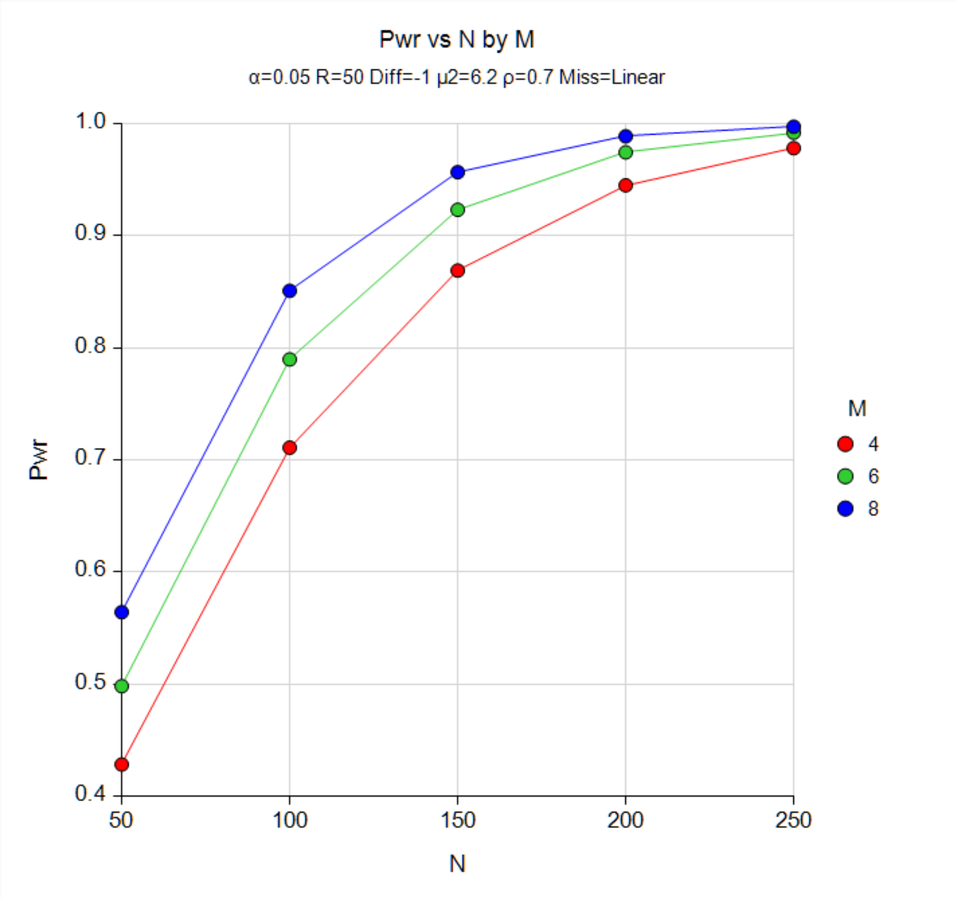
Numeric Results for the Test of Time-Averaged Differences in Count Data using GEE

Solve For:	Power
Measurement Times:	Equally spaced
Correlation:	AR1: ρ(j,k) = ρ^|j-k|
Missing Pattern:	Range of missing proportions
Observant Proportions:	Assume independence
μ1, μ2:	Event rates of group 1 (treatment) and group 2 (control)

Power	Total Sample Size N	Group 1 Allocation Percent R	Number of Measurement Times M	Event Rate μ1	Event Rate μ2	Event Rate Difference	Base Correlation ρ	First Row of Correlation Matrix	Missing Data Proportions	Measurement Times	Alpha
0.4283	50	50	4	5.2	6.2	-1	0.7	ρ1(1)	0.05	Ms1(1)	T(1)
0.4982	50	50	6	5.2	6.2	-1	0.7	ρ1(2)	0.05	Ms1(2)	T(2)
0.5642	50	50	8	5.2	6.2	-1	0.7	ρ1(3)	0.05	Ms1(3)	T(3)
0.7110	100	50	4	5.2	6.2	-1	0.7	ρ1(1)	0.05	Ms1(1)	T(1)
0.7897	100	50	6	5.2	6.2	-1	0.7	ρ1(2)	0.05	Ms1(2)	T(2)
0.8509	100	50	8	5.2	6.2	-1	0.7	ρ1(3)	0.05	Ms1(3)	T(3)
0.8690	150	50	4	5.2	6.2	-1	0.7	ρ1(1)	0.05	Ms1(1)	T(1)
0.9232	150	50	6	5.2	6.2	-1	0.7	ρ1(2)	0.05	Ms1(2)	T(2)
0.9568	150	50	8	5.2	6.2	-1	0.7	ρ1(3)	0.05	Ms1(3)	T(3)
0.9450	200	50	4	5.2	6.2	-1	0.7	ρ1(1)	0.05	Ms1(1)	T(1)
0.9745	200	50	6	5.2	6.2	-1	0.7	ρ1(2)	0.05	Ms1(2)	T(2)
0.9888	200	50	8	5.2	6.2	-1	0.7	ρ1(3)	0.05	Ms1(3)	T(3)
0.9782	250	50	4	5.2	6.2	-1	0.7	ρ1(1)	0.05	Ms1(1)	T(1)
0.9921	250	50	6	5.2	6.2	-1	0.7	ρ1(2)	0.05	Ms1(2)	T(2)
0.9973	250	50	8	5.2	6.2	-1	0.7	ρ1(3)	0.05	Ms1(3)	T(3)

Item	Values
ρ1(1)	1, 0.7, 0.49, 0.343
ρ1(2)	1, 0.7, 0.49, 0.343, 0.24, 0.168
ρ1(3)	1, 0.7, 0.49, 0.343, 0.24, 0.168, 0.118, 0.082
Ms1(1)	0, 0.03, 0.07, 0.1
Ms1(2)	0, 0.02, 0.04, 0.06, 0.08, 0.1
Ms1(3)	0, 0.01, 0.03, 0.04, 0.06, 0.07, 0.09, 0.1
T(1)	0, 0.33, 0.67, 1
T(2)	0, 0.2, 0.4, 0.6, 0.8, 1
T(3)	0, 0.14, 0.29, 0.43, 0.57, 0.71, 0.86, 1

Plots



Note that increasing the number of measurements has had the result of increasing power.

Example 4 – Validation of Sample Size Calculation using Hand Calculations

Ahn, Heo, and Zhang (2015) do not present a numerical example for this procedure. We will calculate a result by hand using their formulas and compare this with the program output to validate this procedure.

The sample size formula is

$$n = \frac{\sigma_2^2 \left(z_{1-\frac{\alpha}{h}} + z_{1-\gamma}\right)^2}{\beta_2^2}$$

where

$$\sigma_2^2 = \frac{\bar{\mu} \sum_{j=1}^{m} \sum_{j'=1}^{m} \phi_{jj'}\, \rho_{jj'}}{\left(\sum_{j=1}^{m} \phi_j\right)^2 \sigma_r^2 \mu_1 \mu_2}$$

$$\sigma_r^2 = \bar{r}(1-\bar{r})$$

$$\bar{\mu} = \bar{r}\mu_1 + (1-\bar{r})\mu_2$$

Using m = 3, μ1 = 2, μ2 = 1, compound symmetry, ρ = 0.6, constant missing = 0.1, α = 0.05, and power = 0.9, we obtain

$$\bar{\mu} = 1.5$$

$$\sum_{j=1}^{m} \phi_j = 2.7$$

$$\sum_{j=1}^{m} \sum_{j'=1}^{m} \phi_{jj'}\, \rho_{jj'} = 5.94$$

$$\sigma_2^2 = \frac{(1.5)(5.94)}{(2.7)^2 (0.25)2} = 2.4444$$

$$n = \text{ceiling}\left(\frac{2.4444(1.96 + 1.28155)^2}{0.69314^2}\right) = \text{ceiling}(53.46) = 54.$$

Setup

If the procedure window is not already open, use the PASS Home window to open it. The parameters for this example are listed below and are stored in the **Example 4** settings file. To load these settings to the procedure window, click **Open Example Settings File** in the Help Center or File menu.

Design Tab

Solve For .... **Sample Size**
Alternative Hypothesis .... **Two-Sided**
Power.. **0.90**
Alpha.. **0.05**
R (Group 1 Allocation %) **50**
Measurement Time Input Type .... **Equally Spaced Measurement Times**
M (Number of Measurements) **3**
μ1 Input Type................................... **μ1 (Group 1 Event Rate)**
μ1 (Group 1 Event Rate)....................... **2**
μ2 (Group 2 Event Rate)....................... **1**
Pattern of ρ's Across Time .... **Compound Symmetry (All ρ's Equal)**
ρ (Base Correlation)............................ **0.6**
Missing Input Type.............................. **Constant**
Constant Missing Proportion **0.10**

Output

Click the Calculate button to perform the calculations and generate the following output.

Numeric Results for the Test of Time-Averaged Differences in Count Data using GEE

Solve For: Sample Size
Measurement Times: Equally spaced
Correlation: Compound symmetry (all ρ's equal)
Missing Pattern: Constant (All missing proportions are equal)
μ1, μ2: Event rates of group 1 (treatment) and group 2 (control)

Power	Total Sample Size N	Group 1 Allocation Percent R	Number of Measurement Times M	Event Rate μ1	Event Rate μ2	Event Rate Difference	Base Correlation ρ	First Row of Correlation Matrix	Missing Data Proportion	Measurement Times	Alpha
0.9028	54	50	3	2	1	1	0.6	ρ1(1)	0.05	0.1	T(1)

Item	Values
ρ1(1)	1, 0.6, 0.6
T(1)	0, 0.5, 1

The sample size is 54, which matches Ahn, Heo, and Zhang (2015) exactly.

Example 5 – Impact of Measurement-Time Distribution

This example will investigate the impact of measurement time on power by comparing studies that are evenly spaced with those that take more measurements at the beginning, near the middle, and at the end.

In this example the basic parameters are μ1 = 5.2, and μ2 = 6.2, the significance level is 0.05, the sample size ranges from 50 to 250, and R is 50%. The correlation pattern will be Linear Exponential Decay with a base correlation of 0.4, Base Time Proportion of 0.20, and Emax set to 4. The missing input type will be set to Linear from 0 to 10% and the pairwise missing assumption will be independent. The measurement times for five scenarios are given in the following table.

Table of Measurement Times in Proportion of Total Study Time

Tm1	Tm2	Tm3	Tm4	Tm5
0	0	0	0	0
0.20	0.60	0.10	0.10	0.45
0.40	0.70	0.20	0.20	0.50
0.60	0.80	0.30	0.80	0.55
0.80	0.90	0.40	0.90	0.60
1.00	1.00	1.00	1.00	1.00

Note that the measurements in Tm1 are evenly spaced, those in Tm2 are loaded near the end, those of Tm3 occur at the beginning, those of Tm4 occur only at the beginning and the end, and those of Tm5 occur mostly near the middle.

Setup

If the procedure window is not already open, use the PASS Home window to open it. The parameters for this example are listed below and are stored in the **Example 5** settings file. To load these settings to the procedure window, click **Open Example Settings File** in the Help Center or File menu.

Design Tab

Solve For .... **Power**
Alternative Hypothesis .... **Two-Sided**
Alpha.. **0.05**
N (Subjects) .... **50 to 250 by 50**
R (Group 1 Allocation %) **50**
Measurement Time Input Type .... **Columns of Measurement Time Proportions**
Column(s) of Time Proportions **Tm1-Tm5**
μ1 Input Type.. **μ1 (Group 1 Event Rate)**
μ1 (Group 1 Event Rate)............................... **5.2**
μ2 (Group 2 Event Rate)............................... **6.2**
Pattern of ρ’s Across Time............................ **Linear Exponential Decay**
ρ (Base Correlation)...................................... **0.4**
Base Time Proportion **0.2**
Emax (Max Decay Exponent) **4**
Missing Input Type.. **Linear (Steady Change)**

Pairwise Missing Pattern................................**Independent (Ind)**
First Missing Proportion (Ind).........................**0**
Last Missing Proportion (Ind).........................**0.10**

Input Spreadsheet Data

Row	Tm1	Tm2	Tm3	Tm4	Tm5
1	0.0	0.0	0.0	0.0	0.00
2	0.2	0.6	0.1	0.1	0.45
3	0.4	0.7	0.2	0.2	0.50
4	0.6	0.8	0.3	0.8	0.55
5	0.8	0.9	0.4	0.9	0.60
6	1.0	1.0	1.0	1.0	1.00

Output

Click the Calculate button to perform the calculations and generate the following output.

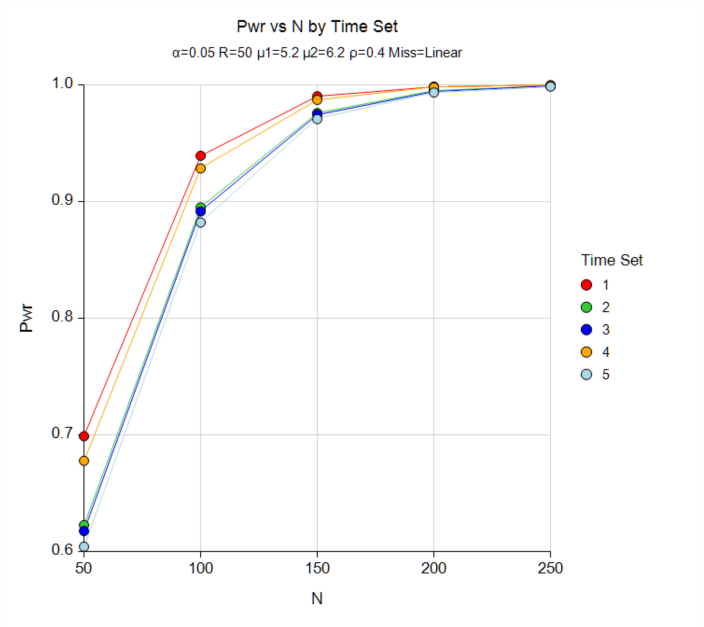
Numeric Results for the Test of Time-Averaged Differences in Count Data using GEE

Solve For: Power
Measurement Times: Lists in spreadsheet columns: {TM1-TM5}
Correlation: Linear exponential decay, with Emax = 4 and Base Time Prop = 0.2
Missing Pattern: Range of missing proportions
Observant Proportions: Assume independence
μ1, μ2: Event rates of group 1 (treatment) and group 2 (control)

Power	Total Sample Size N	Group 1 Allocation Percent R	Number of Measurement Times M	Event Rate μ1	μ2	Difference	Base Correlation ρ	First Row of Correlation Matrix	Missing Data Proportions	Measurement Times	Alpha
0.6989	50	50	6	5.2	6.2	-1	0.4	ρ1(Tm1)	0.05	Ms1(Tm1)	Tm1(1)
0.6228	50	50	6	5.2	6.2	-1	0.4	ρ1(Tm2)	0.05	Ms1(Tm2)	Tm2(2)
0.6177	50	50	6	5.2	6.2	-1	0.4	ρ1(Tm3)	0.05	Ms1(Tm3)	Tm3(3)
0.6779	50	50	6	5.2	6.2	-1	0.4	ρ1(Tm4)	0.05	Ms1(Tm4)	Tm4(4)
0.6043	50	50	6	5.2	6.2	-1	0.4	ρ1(Tm5)	0.05	Ms1(Tm5)	Tm5(5)
0.9393	100	50	6	5.2	6.2	-1	0.4	ρ1(Tm1)	0.05	Ms1(Tm1)	Tm1(1)
0.8951	100	50	6	5.2	6.2	-1	0.4	ρ1(Tm2)	0.05	Ms1(Tm2)	Tm2(2)
0.8916	100	50	6	5.2	6.2	-1	0.4	ρ1(Tm3)	0.05	Ms1(Tm3)	Tm3(3)
0.9285	100	50	6	5.2	6.2	-1	0.4	ρ1(Tm4)	0.05	Ms1(Tm4)	Tm4(4)
0.8821	100	50	6	5.2	6.2	-1	0.4	ρ1(Tm5)	0.05	Ms1(Tm5)	Tm5(5)
0.9903	150	50	6	5.2	6.2	-1	0.4	ρ1(Tm1)	0.05	Ms1(Tm1)	Tm1(1)
0.9759	150	50	6	5.2	6.2	-1	0.4	ρ1(Tm2)	0.05	Ms1(Tm2)	Tm2(2)
0.9746	150	50	6	5.2	6.2	-1	0.4	ρ1(Tm3)	0.05	Ms1(Tm3)	Tm3(3)
0.9873	150	50	6	5.2	6.2	-1	0.4	ρ1(Tm4)	0.05	Ms1(Tm4)	Tm4(4)
0.9708	150	50	6	5.2	6.2	-1	0.4	ρ1(Tm5)	0.05	Ms1(Tm5)	Tm5(5)
0.9987	200	50	6	5.2	6.2	-1	0.4	ρ1(Tm1)	0.05	Ms1(Tm1)	Tm1(1)
0.9951	200	50	6	5.2	6.2	-1	0.4	ρ1(Tm2)	0.05	Ms1(Tm2)	Tm2(2)
0.9947	200	50	6	5.2	6.2	-1	0.4	ρ1(Tm3)	0.05	Ms1(Tm3)	Tm3(3)
0.9980	200	50	6	5.2	6.2	-1	0.4	ρ1(Tm4)	0.05	Ms1(Tm4)	Tm4(4)
0.9936	200	50	6	5.2	6.2	-1	0.4	ρ1(Tm5)	0.05	Ms1(Tm5)	Tm5(5)
0.9998	250	50	6	5.2	6.2	-1	0.4	ρ1(Tm1)	0.05	Ms1(Tm1)	Tm1(1)
0.9991	250	50	6	5.2	6.2	-1	0.4	ρ1(Tm2)	0.05	Ms1(Tm2)	Tm2(2)
0.9990	250	50	6	5.2	6.2	-1	0.4	ρ1(Tm3)	0.05	Ms1(Tm3)	Tm3(3)
0.9997	250	50	6	5.2	6.2	-1	0.4	ρ1(Tm4)	0.05	Ms1(Tm4)	Tm4(4)
0.9987	250	50	6	5.2	6.2	-1	0.4	ρ1(Tm5)	0.05	Ms1(Tm5)	Tm5(5)

Item	Values
ρ1(Tm1)	1, 0.4, 0.201, 0.101, 0.051, 0.026
ρ1(Tm2)	1, 0.101, 0.072, 0.051, 0.036, 0.026
ρ1(Tm3)	1, 0.564, 0.4, 0.284, 0.201, 0.026
ρ1(Tm4)	1, 0.564, 0.4, 0.051, 0.036, 0.026
ρ1(Tm5)	1, 0.169, 0.143, 0.12, 0.101, 0.026
Ms1(Tm1)	0, 0.02, 0.04, 0.06, 0.08, 0.1
Ms1(Tm2)	0, 0.06, 0.07, 0.08, 0.09, 0.1
Ms1(Tm3)	0, 0.01, 0.02, 0.03, 0.04, 0.1
Ms1(Tm4)	0, 0.01, 0.02, 0.08, 0.09, 0.1
Ms1(Tm5)	0, 0.05, 0.05, 0.06, 0.06, 0.1
Tm1(1)	0, 0.2, 0.4, 0.6, 0.8, 1
Tm2(2)	0, 0.6, 0.7, 0.8, 0.9, 1
Tm3(3)	0, 0.1, 0.2, 0.3, 0.4, 1
Tm4(4)	0, 0.1, 0.2, 0.8, 0.9, 1
Tm5(5)	0, 0.45, 0.5, 0.55, 0.6, 1

Plots



The legend, *Time Set*, gives the sequence number of the measurement columns. Thus, 1.0 is Tm1, 2.0 is Tm2, and so on.

The pattern Tm1 consistently produces the highest power across all sample sizes. Remember that Tm1 is the equally spaced scenario.

Patterns Tm2, Tm3, and Tm5 are nearly tied for achieving the lowest powers. Tm3 put most of the measurements at the beginning of the study. Tm5 put most of the measurements during the middle of the study.

Rearranging the Axes

You will note that the Time Column Id comes out on the horizontal axis by default. We changed the horizontal axis variable to N by setting the X (Horizontal) Axis dropdown on the plots tab to N (Sample Size).

Example 6 – Entering a Correlation Matrix

This example will show how a correlation matrix can be loaded directly.

In this example the basic parameters are μ1 = 5.2, and μ2 = 6.2, the significance level is 0.05, the sample size ranges from 50 to 250, and R is 50%. A correlation matrix (shown below) is available from a previous study and will be loaded and used. The missing input type will be set to Linear from 0 to 10% and the pairwise missing assumption will be independent. The measurement times for five scenarios are given in the following table.

Table of Correlations

C1	C2	C3	C4
1.0000	0.7000	0.4900	0.3430
0.7000	1.0000	0.7000	0.4900
0.4900	0.7000	1.0000	0.7000
0.3430	0.4900	0.7000	1.0000

Setup

If the procedure window is not already open, use the PASS Home window to open it. The parameters for this example are listed below and are stored in the **Example 6** settings file. To load these settings to the procedure window, click **Open Example Settings File** in the Help Center or File menu.

Design Tab

Solve For .... **Power**
Alternative Hypothesis .... **Two-Sided**
Alpha... **0.05**
N (Subjects) .... **50 to 250 by 50**
R (Group 1 Allocation %) **50**
Measurement Time Input Type .... **Equally Spaced Measurement Times**
M (Number of Measurements) **4**
μ1 Input Type.. **μ1 (Group 1 Event Rate)**
μ1 (Group 1 Event Rate)............................... **5.2**
μ2 (Group 2 Event Rate)............................... **6.2**
Pattern of ρ's Across Time............................ **Matrix on Spreadsheet**
Columns Containing the ρjk's **C1-C4**
Missing Input Type.. **Linear (Steady Change)**
Pairwise Missing Pattern............................... **Independent (Ind)**
First Missing Proportion (Ind)......................... **0**
Last Missing Proportion (Ind)......................... **0.10**

Input Spreadsheet Data

Row	C1	C2	C3	C4
1	1.000	0.70	0.49	0.343
2	0.700	1.00	0.70	0.490
3	0.490	0.70	1.00	0.700
4	0.343	0.49	0.70	1.000

Output

Click the Calculate button to perform the calculations and generate the following output.

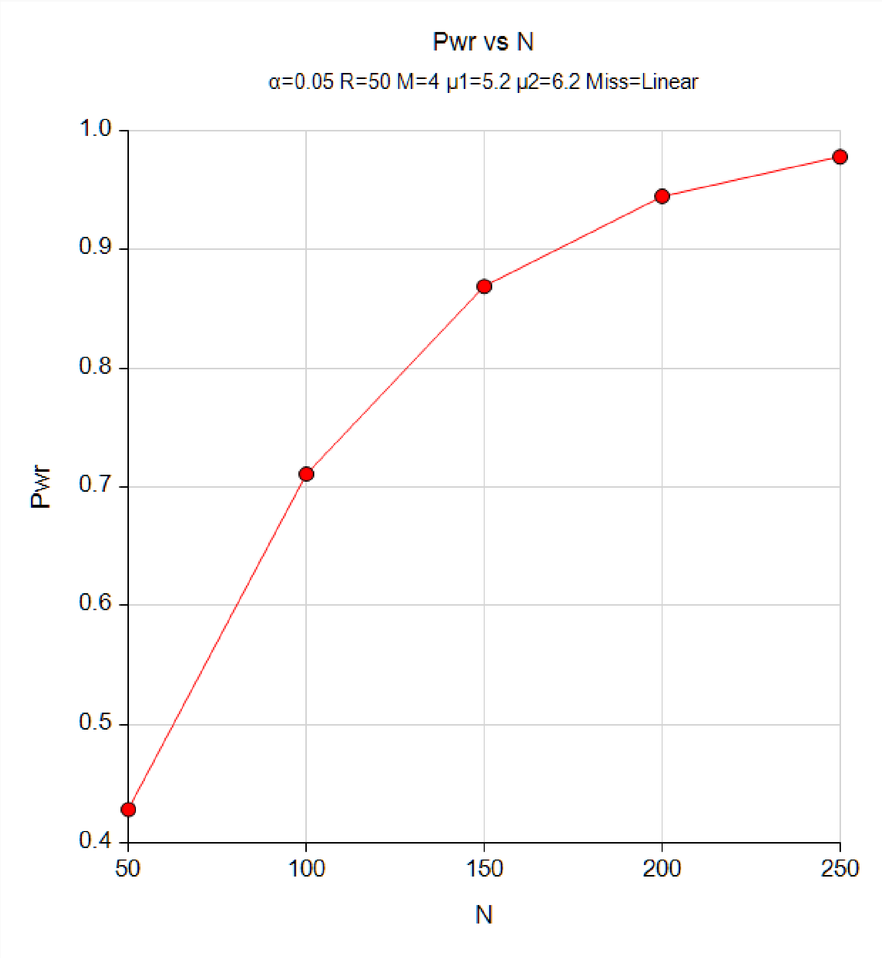
Numeric Results for the Test of Time-Averaged Differences in Count Data using GEE

Solve For: Power
Measurement Times: Equally spaced
Correlation: Matrix stored on spreadsheet in columns C1-C4
Missing Pattern: Range of missing proportions
Observant Proportions: Assume independence
μ1, μ2: Event rates of group 1 (treatment) and group 2 (control)

Power	Total Sample Size N	Group 1 Allocation Percent R	Number of Measurement Times M	Event Rate μ1	Event Rate μ2	Event Rate Difference	Base Correlation ρ	First Row of Correlation Matrix	Missing Data Proportions	Measurement Times	Alpha
0.4283	50	50	4	5.2	6.2	-1	N/A	ρ1(1)	0.05	Ms1(1)	T(1)
0.7110	100	50	4	5.2	6.2	-1	N/A	ρ1(1)	0.05	Ms1(1)	T(1)
0.8690	150	50	4	5.2	6.2	-1	N/A	ρ1(1)	0.05	Ms1(1)	T(1)
0.9450	200	50	4	5.2	6.2	-1	N/A	ρ1(1)	0.05	Ms1(1)	T(1)
0.9782	250	50	4	5.2	6.2	-1	N/A	ρ1(1)	0.05	Ms1(1)	T(1)

Item	Values
ρ1(1)	1, 0.7, 0.49, 0.343
Ms1(1)	0, 0.03, 0.07, 0.1
T(1)	0, 0.33, 0.67, 1

Plots



Autocorrelation Matrix for Report Row 1

Time	T(0)	T(0.33)	T(0.67)	T(1)
T(0)	1.000	0.70	0.49	0.343
T(0.33)	0.700	1.00	0.70	0.490
T(0.67)	0.490	0.70	1.00	0.700
T(1)	0.343	0.49	0.70	1.000

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(More Reports Follow)

The standard reports are displayed.

Example 7 – Entering an Observant Probabilities Matrix

This example will show how an observant probabilities matrix can be loaded directly.

In this example the basic parameters are P1 = 0.75, and P2 = 0.55. The significance level is 0.05, the sample size ranges from 50 to 300, and R is 50%. The correlation pattern will be Linear Exponential Decay with a base correlation of 0.8, Base Time Proportion of 0.1, and Emax set to 4. The missing input type will be set to Matrix of Pairwise Missing.

In this example the basic parameters are μ1 = 5.2, and μ2 = 6.2, the significance level is 0.05, the sample size ranges from 50 to 250, and R is 50%. The correlation pattern will be Linear Exponential Decay with a base correlation of 0.8, Base Time Proportion of 0.1, and Emax set to 4. The missing input type will be set to Matrix of Pairwise Missing.

Table of Observant Probabilities

Row	C1	C2	C3	C4
1	1.00	0.90	0.80	0.70
2	0.90	0.90	0.72	0.63
3	0.80	0.72	0.80	0.56
4	0.70	0.63	0.56	0.70

This table gives the pairwise observant probabilities. That is, each entry gives the probability of obtaining a response for both the row and column time points. For example, 0.63 is the probability of observing both the second response and the fourth response.

Setup

If the procedure window is not already open, use the PASS Home window to open it. The parameters for this example are listed below and are stored in the **Example 7** settings file. To load these settings to the procedure window, click **Open Example Settings File** in the Help Center or File menu.

Design Tab

Solve For .... **Power**
Alternative Hypothesis .... **Two-Sided**
Alpha.. **0.05**
N (Subjects) .... **50 to 250 by 50**
R (Group 1 Allocation %) **50**
Measurement Time Input Type .... **Equally Spaced Measurement Times**
M (Number of Measurements) **4**
μ1 Input Type.. **μ1 (Group 1 Event Rate)**
μ1 (Group 1 Event Rate)............................... **5.2**
μ2 (Group 2 Event Rate)............................... **6.2**
Pattern of ρ's Across Time............................ **Linear Exponential Decay**
ρ (Base Correlation)...................................... **0.8**
Base Time Proportion **0.1**
Emax (Max Decay Exponent) **4**
Missing Input Type.. **Pairwise Observed Proportions on Spreadsheet**
Columns of Pairwise Observed...................... **C1-C4**

Input Spreadsheet Data

Row	C1	C2	C3	C4
1	1.0	0.90	0.80	0.70
2	0.9	0.90	0.72	0.63
3	0.8	0.72	0.80	0.56
4	0.7	0.63	0.56	0.70

Output

Click the Calculate button to perform the calculations and generate the following output.

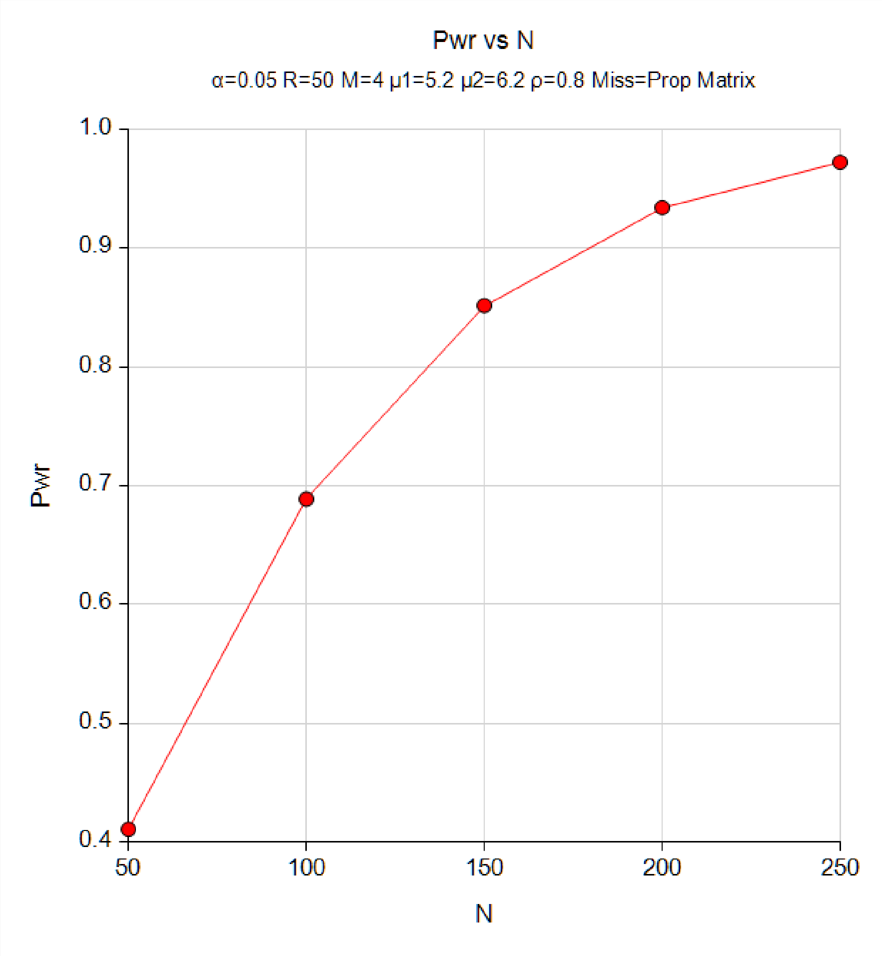
Numeric Results for the Test of Time-Averaged Differences in Count Data using GEE

Solve For: Power
Measurement Times: Equally spaced
Correlation: Linear exponential decay, with Emax = 4 and Base Time Prop = 0.1
Missing Pattern: N/A. Matrix of observant probabilities entered in columns C1-C4.
μ1, μ2: Event rates of group 1 (treatment) and group 2 (control)

	Total Sample Size	Group 1 Allocation Percent	Number of Measurement Times	Event Rate			Base Correlation	First Row of Correlation	Missing Data	Measurement	
Power	N	R	M	μ1	μ2	Difference	ρ	Matrix	Proportions	Times	Alpha
0.4107	50	50	4	5.2	6.2	-1	0.8	ρ1(1)	0.05	N/A	T(1)
0.6889	100	50	4	5.2	6.2	-1	0.8	ρ1(1)	0.05	N/A	T(1)
0.8517	150	50	4	5.2	6.2	-1	0.8	ρ1(1)	0.05	N/A	T(1)
0.9343	200	50	4	5.2	6.2	-1	0.8	ρ1(1)	0.05	N/A	T(1)
0.9724	250	50	4	5.2	6.2	-1	0.8	ρ1(1)	0.05	N/A	T(1)

Item	Values
ρ1(1)	1, 0.673, 0.525, 0.41
T(1)	0, 0.33, 0.67, 1

Plots



The standard reports are displayed.