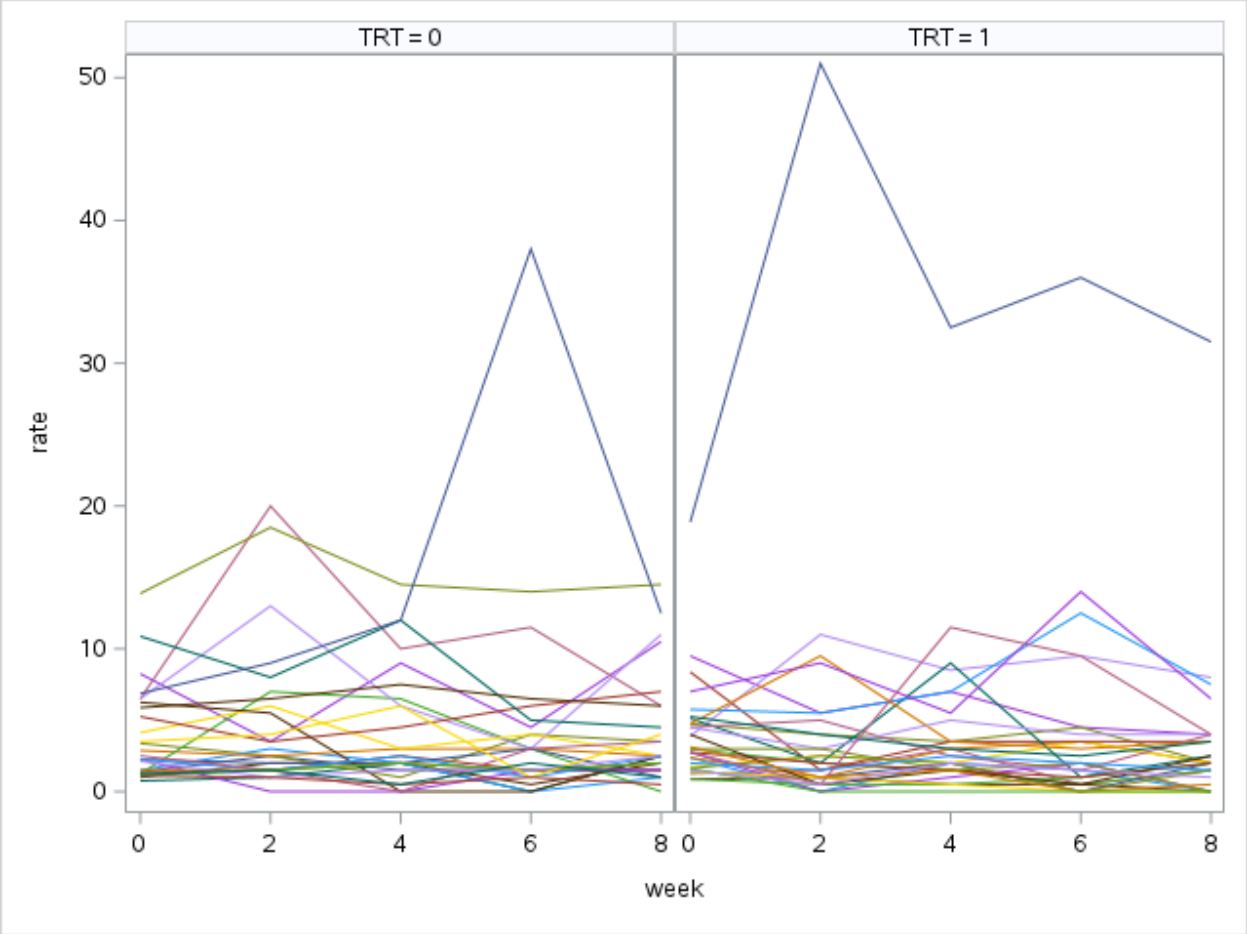
```
data epileptic_w;
input ID TRT Age C0 C1 C2 C3 C4;
datalines;
           1      0       31       11       5      3      3      3
           2      0       30       11       3      5      3      3
……..
          59      1       37       12       1      4      3      2
              ;
              run;

data epileptic;
set epileptic_w;
  array AC(1:5) C0-C4;
  array Aweek(1:5) (0 2 4 6 8);
  do i=1 to 5;
   Count = AC[i];
   week = Aweek[i];
   L_per = log(2);
   if i eq 1 then L_per=log(8);
   output;
  end;
  drop C0-C4 Aweek1 - Aweek5 i;
run;

data epileptic;
set epileptic;
  rate = Count/exp(L_per);
  l_count = log(Count+1);
  l_rate = log((Count+1)/exp(L_per));
run;

proc print data=epileptic (obs=10);
run;
```

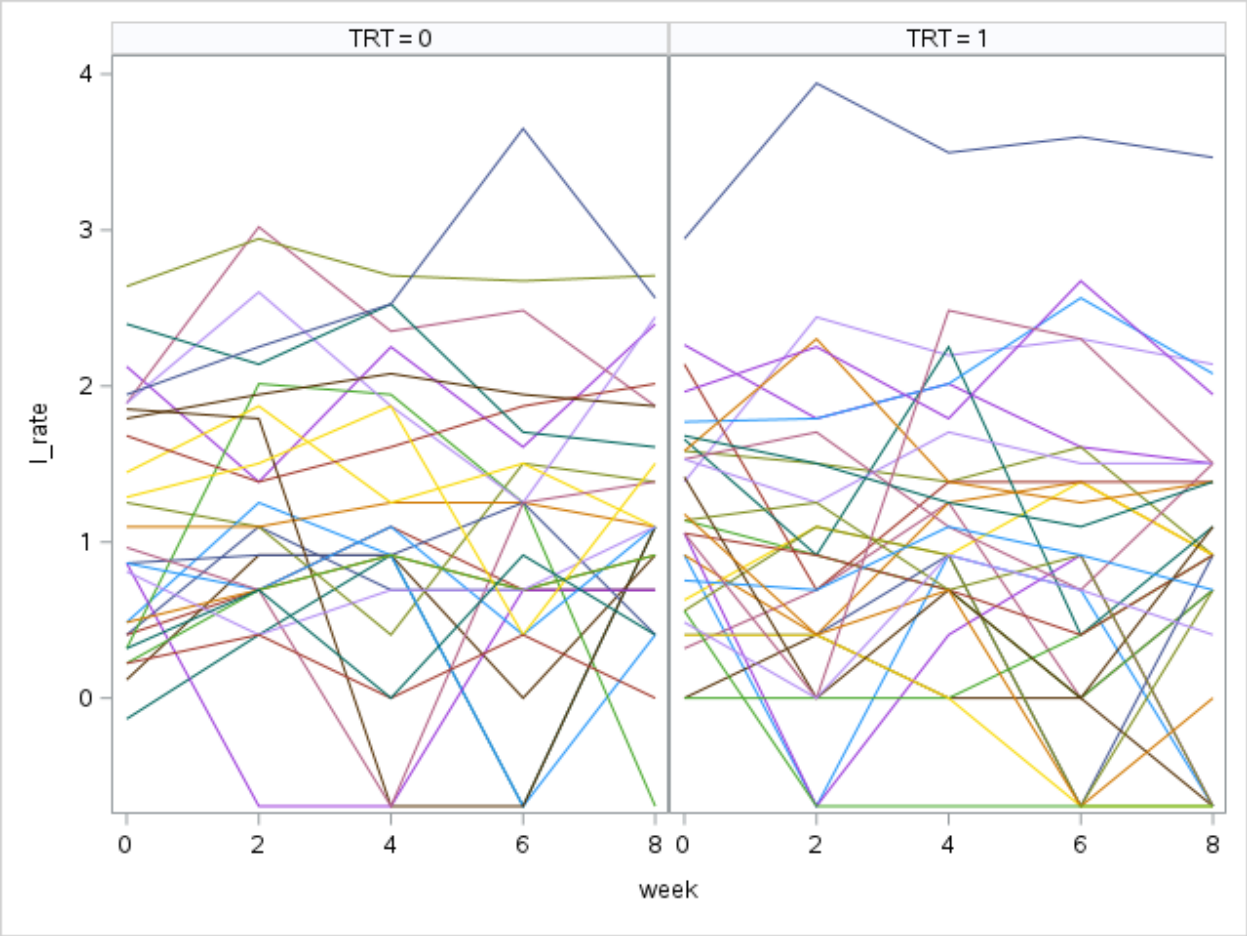
Obs	ID	TRT	Age	Count	week	L_per	rate	l_count	l_rate
1	1	0	31	11	0	2.07944	1.375	2.48491	0.40547
2	1	0	31	5	2	0.69315	2.500	1.79176	1.09861
3	1	0	31	3	4	0.69315	1.500	1.38629	0.69315
4	1	0	31	3	6	0.69315	1.500	1.38629	0.69315
5	1	0	31	3	8	0.69315	1.500	1.38629	0.69315
6	2	0	30	11	0	2.07944	1.375	2.48491	0.40547
7	2	0	30	3	2	0.69315	1.500	1.38629	0.69315
8	2	0	30	5	4	0.69315	2.500	1.79176	1.09861
9	2	0	30	3	6	0.69315	1.500	1.38629	0.69315
10	2	0	30	3	8	0.69315	1.500	1.38629	0.69315

```
Proc SGpanel data = epileptic;
PanelBy TRT / columns=2;
```

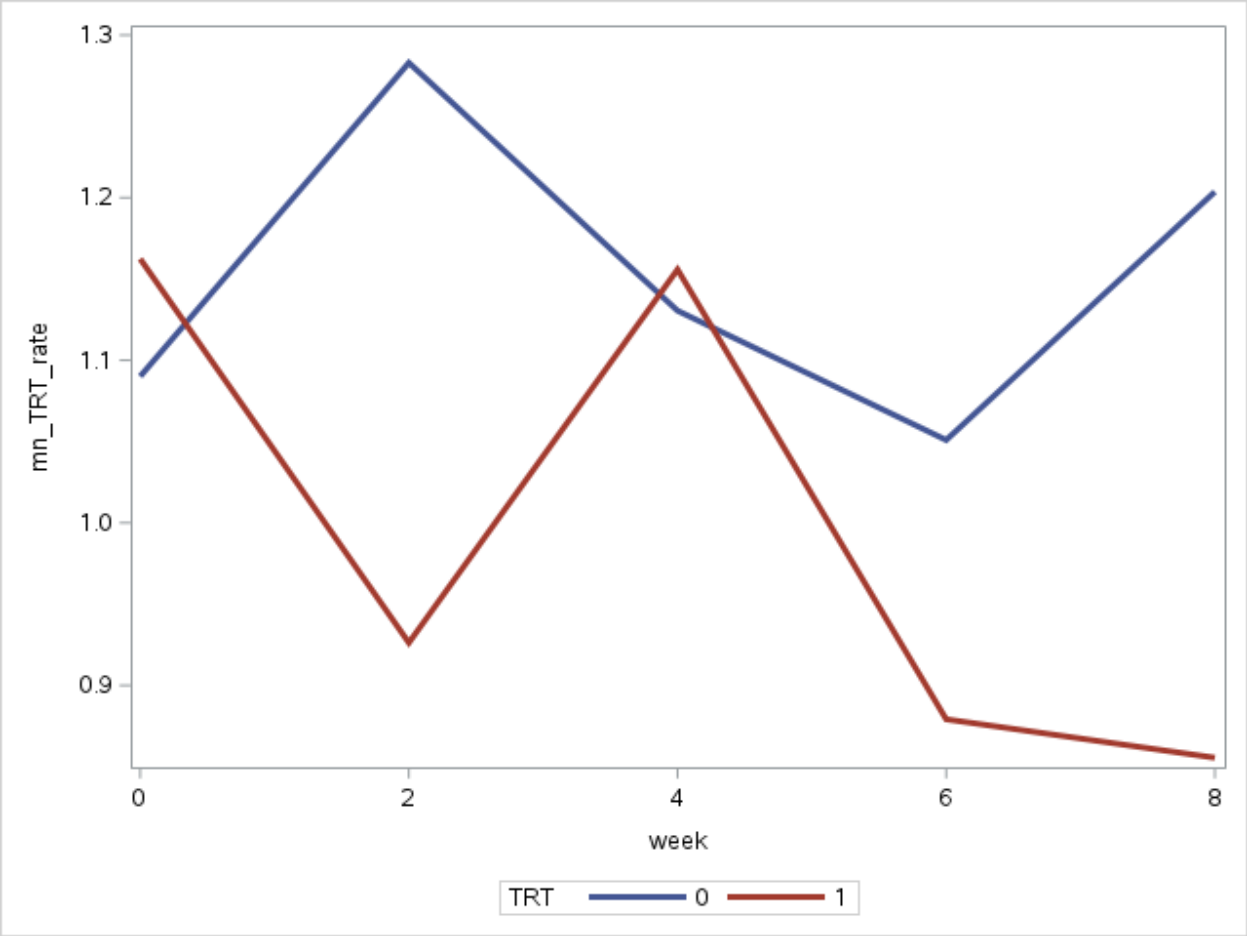
```
series y=rate x=week / group =ID LineAttrs= (pattern=1 );
run;
quit;
```




```
Proc SGpanel data = epileptic;
PanelBy TRT / columns=2;
series y=l_rate x=week / group =ID LineAttrs= (pattern=1 );
run;
quit;
```




```
proc sort data=epileptic;
by TRT week;

*Calculate the mean by week;
proc means mean data=epileptic noprint;
by TRT week;
var l_rate;
output out = MN_TRT_dat mean = mn_TRT_rate;
run;

*First, let's look at the mean by TRT group;
Proc SGplot data = MN_TRT_dat;
series x=week y=mn_TRT_rate / group =TRT LineAttrs= (pattern=1
thickness=3);
run;
```


1.3
1.2
1.1
1.0
0.9
mn_TRT_rate
0
2
4
6
8
week
TRT
0
1

```
proc glimmix data=epileptic;
class ID trt (ref='0');
model Count = week trt week*trt/d=poisson link=log offset=L_per solution;
random intercept week/subject=ID type=UN G;
run;
quit;
```

Model Information	
Data Set	WORK.EPILEPTIC
Response Variable	Count
Response Distribution	Poisson
Link Function	Log
Variance Function	Default
Offset Variable	L_per
Variance Matrix Blocked By	ID
Estimation Technique	Residual PL
Degrees of Freedom Method	Containment

Class Level Information		
Class	**Levels**	**Values**
ID	59	1 2 3 4 5 ……. 59
TRT	2	1 0

Number of Observations Read	295
Number of Observations Used	295

Dimensions	
G-side Cov. Parameters	3
Columns in X	6
Columns in Z per Subject	2
Subjects (Blocks in V)	59
Max Obs per Subject	5

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	3
Lower Boundaries	2
Upper Boundaries	0
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	**Restarts**	**Subiterations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	**5**	715.90199832	2.00000000	0.141681
1	**0**	**6**	790.0318566	0.25874549	0.00005
2	**0**	**5**	799.18843282	0.00762797	0.000969
18	**0**	**1**	799.46552535	0.00000026	0.000155
19	**0**	**1**	799.46552774	0.00000463	0.001866

Did not converge.

```
proc glimmix data=epileptic method=quad(QPOINTS=5);
class ID trt (ref='0');
model Count = week trt week*trt/d=poisson link=log offset=L_per solution;
random intercept week/subject=ID type=UN G;
run;
quit;
```

Model Information	
Data Set	WORK.EPILEPTIC
Response Variable	Count
Response Distribution	Poisson
Link Function	Log
Variance Function	Default
Offset Variable	L_per
Variance Matrix Blocked By	ID
Estimation Technique	Maximum Likelihood

Model Information	
Likelihood Approximation	Gauss-Hermite Quadrature
Degrees of Freedom Method	Containment

Class Level Information		
Class	**Levels**	**Values**
ID	59	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59
TRT	2	1 0

Number of Observations Read	295
Number of Observations Used	295

Dimensions	
G-side Cov. Parameters	3
Columns in X	6
Columns in Z per Subject	2
Subjects (Blocks in V)	59
Max Obs per Subject	5

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	7
Lower Boundaries	2
Upper Boundaries	0
Fixed Effects	Not Profiled
Starting From	GLM estimates
Quadrature Points	5

Iteration History					
Iteration	**Restarts**	**Evaluations**	**Objective Function**	**Change**	**Max Gradient**
0	**0**	4	1935.877681	.	1360.217
1	**0**	5	1934.0660428	1.81163821	1278.973
2	**0**	5	1931.4844275	2.58161522	1243.717
3	**0**	5	1929.8241138	1.66031377	1179.902
4	**0**	5	1920.0003502	9.82376352	491.0731
5	**0**	3	1913.8175124	6.18283779	1285.27
6	**0**	3	1912.8773189	0.94019352	674.922
7	**0**	4	1910.8501449	2.02717403	497.4587
8	**0**	5	1910.4180459	0.43209903	192.8727
9	**0**	2	1909.983809	0.43423687	54.65148
10	**0**	3	1909.915481	0.06832802	45.72635
11	**0**	3	1909.8969513	0.01852967	26.35039
12	**0**	3	1909.8935545	0.00339679	4.640038
13	**0**	3	1909.8931368	0.00041772	6.534372
14	**0**	3	1909.8930695	0.00006733	0.209633
15	**0**	3	1909.8930693	0.00000021	0.00327

Convergence criterion (GCONV=1E-8) satisfied.

Fit Statistics	
-2 Log Likelihood	1909.89
AIC (smaller is better)	1923.89
AICC (smaller is better)	1924.28
BIC (smaller is better)	1938.44
CAIC (smaller is better)	1945.44
HQIC (smaller is better)	1929.57

Fit Statistics for Conditional Distribution	
-2 log L(Count | r. effects)	1562.24
Pearson Chi-Square	472.31
Pearson Chi-Square / DF	1.60

Estimated G Matrix			
Effect	**Row**	**Col1**	**Col2**
Intercept	**1**	0.5277	0.01120
week	**2**	0.01120	0.005059

Covariance Parameter Estimates			
Cov Parm	**Subject**	**Estimate**	**Standard Error**
UN(1,1)	ID	0.5277	0.1045
UN(2,1)	ID	0.01120	0.008762
UN(2,2)	ID	0.005059	0.001461

Solutions for Fixed Effects						
Effect	**TRT**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept		1.1039	0.1428	57	7.73	<.0001
week		-0.01133	0.01692	57	-0.67	0.5057
TRT	1	0.01755	0.1966	177	0.09	0.9290
TRT	0	0	.	.	.	.
week*TRT	1	-0.04675	0.02350	177	-1.99	0.0482
week*TRT	0	0	.	.	.	.

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
week	1	57	8.09	0.0062
TRT	1	177	0.01	0.9290
week*TRT	1	177	3.96	0.0482

```
proc glimmix data=epileptic method=quad(QPOINTS=20);
class ID trt (ref='0');
model Count = week trt week*trt/d=poisson link=log offset=L_per solution;
random intercept week/subject=ID type=UN G;
run;
quit;
```

Solutions for Fixed Effects						
Effect	**TRT**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept		1.1039	0.1428	57	7.73	<.0001
week		-0.01133	0.01692	57	-0.67	0.5058
TRT	1	0.01755	0.1966	177	0.09	0.9290
TRT	0	0	.	.	.	.
week*TRT	1	-0.04675	0.02351	177	-1.99	0.0482
week*TRT	0	0	.	.	.	.

```
proc glimmix data=epileptic method=quad(QPOINTS=50);
class ID trt (ref='0');
model Count = week trt week*trt/d=poisson link=log offset=L_per solution;
random intercept week/subject=ID type=UN G;
run;
quit;
```

Solutions for Fixed Effects						
Effect	**TRT**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept		1.1039	0.1428	57	7.73	<.0001
week		-0.01133	0.01692	57	-0.67	0.5058
TRT	1	0.01755	0.1966	177	0.09	0.9290
TRT	0	0	.	.	.	.
week*TRT	1	-0.04675	0.02351	177	-1.99	0.0482
week*TRT	0	0	.	.	.	.

The negative binomial model is an alternative to the Poisson model. The interpretation is similar, and it allow for overdispersion. In the negative binomial model $\text{var}(Y)=\mu+k\mu^2$

```
proc glimmix data=epileptic method=quad(QPOINTS=20);
class ID trt (ref='0');
model Count = week trt week*trt/d=negbin link=log offset=L_per solution;
random intercept week/subject=ID type=UN G;
run;
quit;
```

The SAS System

The GLIMMIX Procedure

Model Information

Data Set	WORK.EPILEPTIC
Response Variable	Count
Response Distribution	Negative Binomial
Link Function	Log
Variance Function	Default
Offset Variable	L_per
Variance Matrix Blocked By	ID
Estimation Technique	Maximum Likelihood
Likelihood Approximation	Gauss-Hermite Quadrature
Degrees of Freedom Method	Containment

Class Level Information

Class	Levels	Values
ID	59	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59
TRT	2	1 0

Number of Observations Read	295
Number of Observations Used	295

Dimensions

G-side Cov. Parameters	3
R-side Cov. Parameters	1

Dimensions

Columns in X	6
Columns in Z per Subject	2
Subjects (Blocks in V)	59
Max Obs per Subject	5

Optimization Information

Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	8
Lower Boundaries	3
Upper Boundaries	0
Fixed Effects	Not Profiled
Starting From	GLM estimates
Quadrature Points	20

Iteration History

Iteration	Restarts	Evaluations	Objective Function	Change	Max Gradient
0	**0**	4	1864.9791757	.	1322.935
1	**0**	5	1863.4623877	1.51678805	1357.649
61	**0**	3	1773.992202	0.00000511	1021.949

Convergence criterion (GCONV=1E-8) satisfied.

Fit Statistics

-2 Log Likelihood	1773.99
AIC (smaller is better)	1789.99
AICC (smaller is better)	1790.50
BIC (smaller is better)	1806.61
CAIC (smaller is better)	1814.61
HQIC (smaller is better)	1796.48

Fit Statistics for Conditional Distribution

-2 log L(Count | r. effects)	1570.51
Pearson Chi-Square	227.57

Fit Statistics for Conditional Distribution

Pearson Chi-Square / DF	0.77

Estimated G Matrix

Effect	Row	Col1	Col2
Intercept	**1**	0.5610	0.04230
week	**2**	0.04230	0.003190

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error
UN(1,1)	**ID**	0.5610	0.1585
UN(2,1)	**ID**	0.04230	0.01823
UN(2,2)	**ID**	0.003190	0.003409
Scale		**0.1407**	**0.02871**

Solutions for Fixed Effects

Effect	TRT	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept		1.1728	0.1586	57	7.40	<.0001
week		-0.02103	0.01921	57	-1.09	0.2782
TRT	**1**	-0.01187	0.2179	177	-0.05	0.9566
TRT	**0**	0	.	.	.	.
week*TRT	**1**	-0.04466	0.02665	177	-1.68	0.0955
week*TRT	**0**	0	.	.	.	.

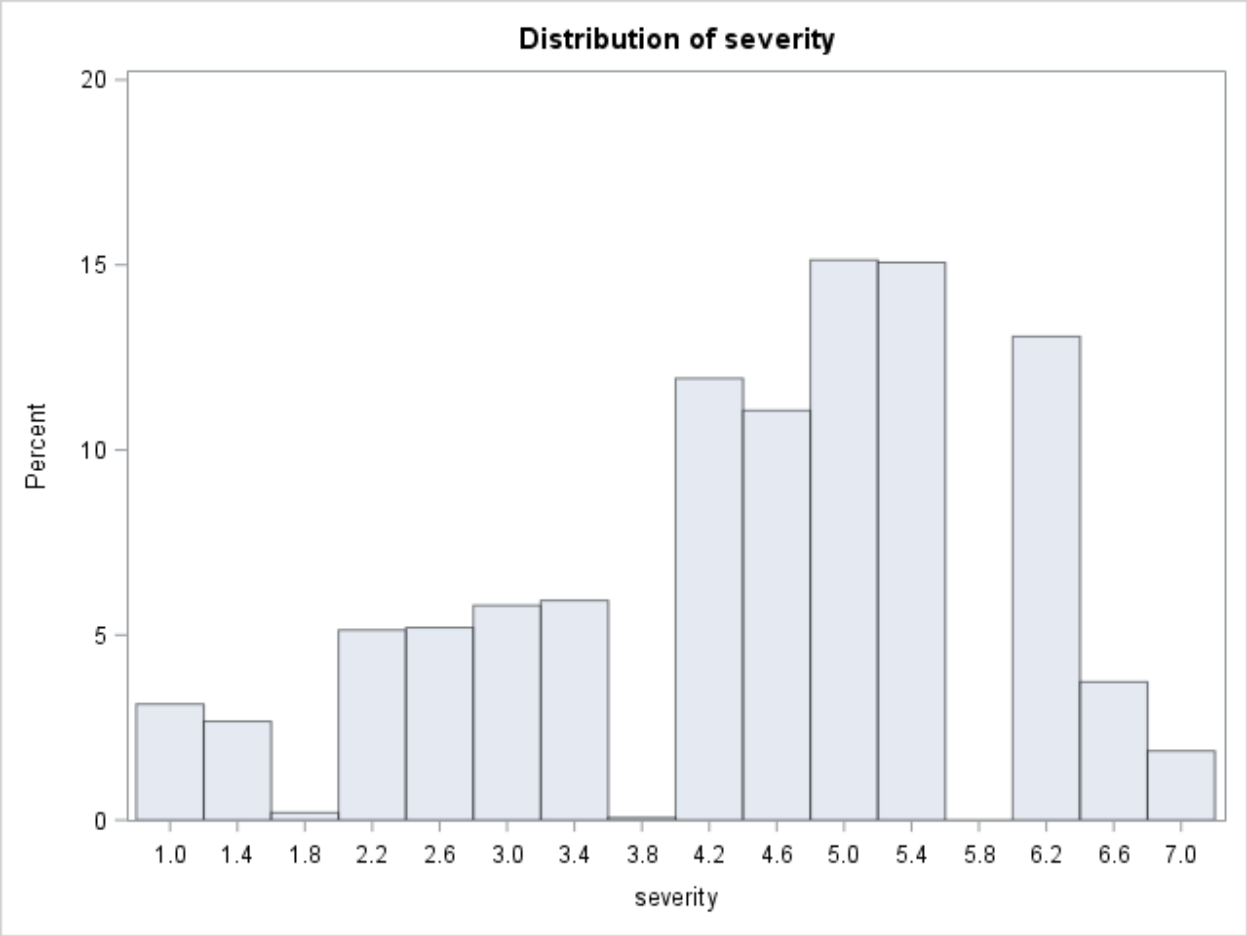
Type III Tests of Fixed Effects

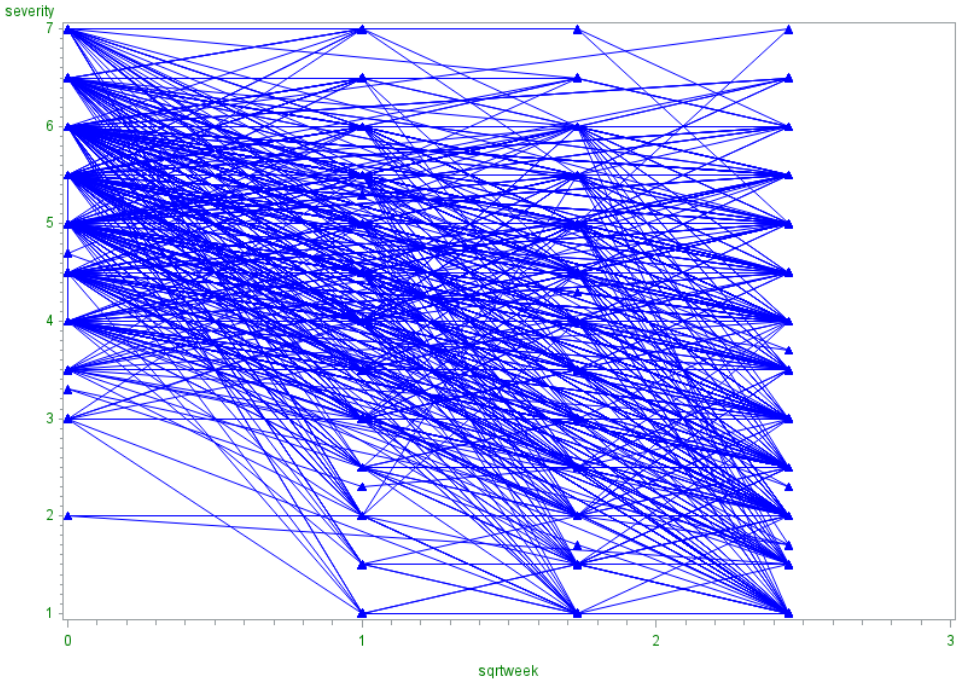
Effect	Num DF	Den DF	F Value	Pr > F
week	1	57	9.50	0.0032
TRT	1	177	0.00	0.9566
week*TRT	1	177	2.81	0.0955

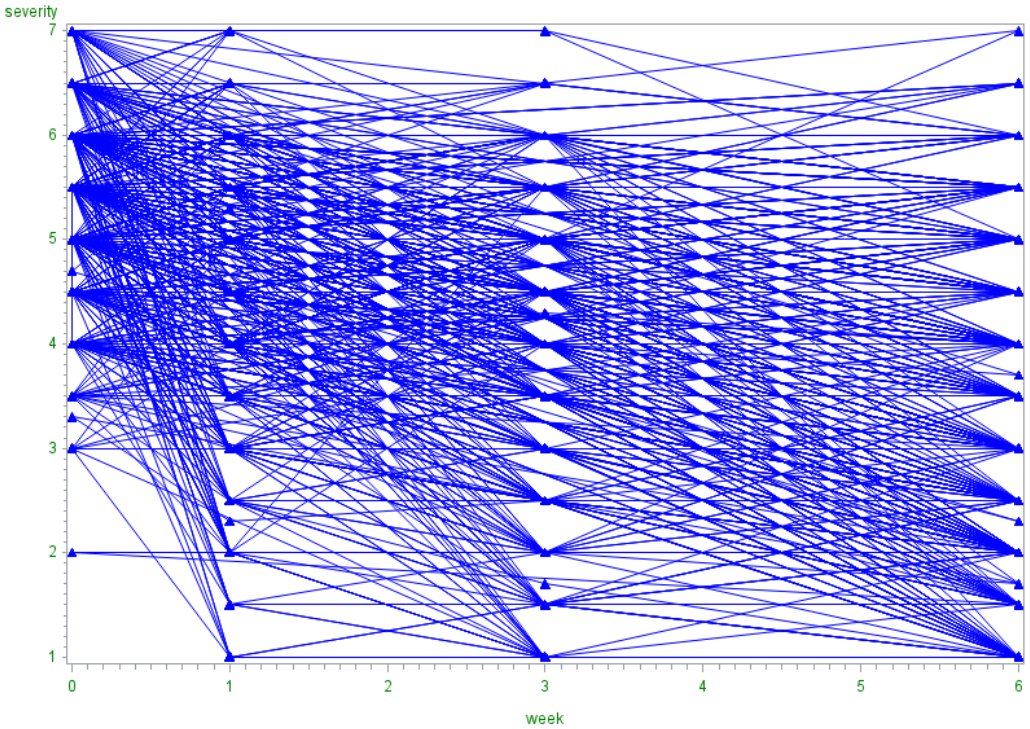
```
*Example - Schizophrenia

Data analyzed by Hedeker and Gibbons (1997). A randomized trial for
schizophrenia.  The trial contained
312 patients received drug therapy and 101 received placebo.  The
measurements were taken at weeks 0, 1, 3, 6,
but some subjects have missing data due to dropout.  The outcome of interest
is severity of illness (1 = normal, ... , 7 = extremely ill);

data schizo;
input ID Group week severity;
sqrtweek = week**(0.5);
r_severity = round(severity);
datalines;
1103 1 0 5.5
1103 1 1 3.0
1103 1 3 2.5
1103 1 6 4.0
.....
9316 0 0 5.5
9316 0 1 6.0
9316 0 3 6.5
9316 0 6 6.0
run;

proc freq data=schizo;
tables group*week;
run;
```

Table of Group by week					
Group	week				
Frequency Percent Row Pct Col Pct	0	1	3	6	Total
0	101 6.11 25.00 24.46	101 6.11 25.00 24.46	101 6.11 25.00 24.46	101 6.11 25.00 24.46	404 24.46
1	312 18.89 25.00 75.54	312 18.89 25.00 75.54	312 18.89 25.00 75.54	312 18.89 25.00 75.54	1248 75.54
Total	413 25.00	413 25.00	413 25.00	413 25.00	1652 100.00

```
proc univariate data=schizo;
var severity;
histogram;
run;
```


Distribution of severity
Percent
20
15
10
5
0
1.0
1.4
1.8
2.2
2.6
3.0
3.4
3.8
4.2
4.6
5.0
5.4
5.8
6.2
6.6
7.0
severity


severity
7
6
5
4
3
2
1
0
1
2
3
sqrtweek


severity
7
6
5
4
3
2
1
0
1
2
3
4
5
6
week

```
proc glimmix data=schizo method=RMPL;
class ID Group (ref="0");
model r_severity = Group sqrtweek Group*sqrtweek/solution link=cumlogit
dist=multinomial;
random intercept/subject=ID type=UN G;
run;
```

Model Information	
Data Set	WORK.SCHIZO
Response Variable	r_severity
Response Distribution	Multinomial (ordered)
Link Function	Cumulative Logit
Variance Function	Default
Variance Matrix Blocked By	ID
Estimation Technique	Residual MPL
Degrees of Freedom Method	Containment

Class Level Information		
Class	**Levels**	**Values**
ID	413	1103 1104 1105 ……..9316
Group	2	1 0

Number of Observations Read	1652
Number of Observations Used	1500

Response Profile		
Ordered Value	**r_severity**	**Total Frequency**
1	1	47
2	2	120
3	3	166
4	4	268
5	5	394
6	6	421

Response Profile		
Ordered Value	r_severity	Total Frequency
7	7	84
The GLIMMIX procedure is modeling the probabilities of levels of r_severity having lower Ordered Values in the Response Profile table.		

Dimensions	
G-side Cov. Parameters	1
Columns in X	11
Columns in Z per Subject	1
Subjects (Blocks in V)	413
Max Obs per Subject	4

Optimization Information	
Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	1
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Profiled
Starting From	Data

Iteration History					
Iteration	Restarts	Subiterations	Objective Function	Change	Max Gradient
0	0	4	28161.4378	2.00000000	0.00019
1	0	5	31754.375232	1.21312762	0.001151
2	0	3	32373.253267	0.08405759	0.000602
3	0	2	32383.501727	0.00164673	7.522E-8
4	0	2	32383.492634	0.00015664	1.132E-9
5	0	1	32383.476423	0.00000453	4.411E-6
6	0	0	32383.475503	0.00000045	5.13E-6
7	0	0	32383.475457	0.00000002	5.602E-6
8	0	0	32383.475454	0.00000000	5.633E-6

Convergence criterion (PCONV=1.11022E-8) satisfied.

Fit Statistics	
-2 Res Log Pseudo-Likelihood	32383.48

Estimated G Matrix		
Effect	**Row**	**Col1**
Intercept	**1**	1.0920

Covariance Parameter Estimates			
Cov Parm	**Subject**	**Estimate**	**Standard Error**
UN(1,1)	ID	1.0920	0.1399

Solutions for Fixed Effects							
Effect	**r_severity**	**Group**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	1		-5.3218	0.2523	411	-21.09	<.0001
Intercept	2		-3.8528	0.2188	411	-17.61	<.0001
Intercept	3		-2.8738	0.2090	411	-13.75	<.0001
Intercept	4		-1.7987	0.2015	411	-8.93	<.0001
Intercept	5		-0.4393	0.1951	411	-2.25	0.0249
Intercept	6		1.9550	0.2127	411	9.19	<.0001
Group		1	-0.01599	0.2220	1080	-0.07	0.9426
Group		0	0	.	.	.	.
sqrtweek			0.4862	0.1138	1080	4.27	<.0001
sqrtweek*Group		1	0.8172	0.1299	1080	6.29	<.0001
sqrtweek*Group		0	0	.	.	.	.

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Group	1	1080	0.01	0.9426
sqrtweek	1	1080	176.53	<.0001
sqrtweek*Group	1	1080	39.60	<.0001