Data on Obesity from the Muscatine Coronary Risk Factor Study.

Source: Table 10 (page 96) in Woolson and Clarke (1984).
Reference: Woolson, R.F. and Clarke, W.R. (1984). Analysis of categorical incomplete longitudinal data. Journal of the Royal Statistical Society, Series A, 147, 87-99.

Description:
The data are from the Muscatine Coronary Risk Factor (MCRF) study, a longitudinal survey of school-age children in Muscatine, Iowa. The MCRF study had the goal of examining the development and persistence of risk factors for coronary disease in children. In the MCRF study, weight and height measurements of five cohorts of children, initially aged 5-7, 7-9, 9-11, 11-13, and 13-15 years, were obtained biennially from 1977 to 1981. Data were collected on 4856 boys and girls. On the basis of a comparison of their weight to age-gender specific norms, children were classified as obese or not obese.

Variable List:
Gender (0=Male,1=Female), Obesity Status 1977, Obesity Status 1979, Obesity Status 1981, Count in Age Cohort 1, Count in Age Cohort 2, Count in Age Cohort 3, Count in Age Cohort 4, Count in Age Cohort 5.

Note: Obesity Status (1=Obese, 0=Non-Obese, .=Missing).

GEE: Looking at the Overall Trend Across All Children

If we want to answer a **population-level question**—such as,
"How does the probability of obesity change as children grow older?"
—we would use a **GEE model**.

- GEE treats individual differences as a "nuisance" and focuses on the overall trend.
  It gives us the average effect of age on obesity across all children in the study.
- GEE is like looking at the overall pattern of obesity across all children, without worrying about individual differences. It tells us the "big picture" but does not explain why some kids stay obese while others do not.
- **Use GEE if:** We are interested in how obesity trends in the population as a whole change over time.

GLMM: Accounting for Individual Differences

If we are interested in **how each individual child's obesity status changes over time**, we would use a **GLMM**.

- GLMM recognizes that some children have a higher or lower tendency to be obese due to genetics, family environment, or other unmeasured factors.
  These individual variations are accounted for by including a random effect for each child.
- GLMM is like tracking each child individually and recognizing that some children have a higher predisposition to obesity. It models how children differ from each other in their weight trajectories.
- **Use GLMM if:** We are interested in understanding **individual variations** in obesity risk and want to make predictions about a specific child.

```
data obesity_wide;
input Gender OB77 OB79 OB81 CT1 CT2 CT3 CT4 CT5;
datalines;
0 1 1 1   8  20  25  16  15
0 1 1 0   1   7   9  11   6
0 1 0 1   1   9   7   4   0
0 1 0 0   0   8   7  13   8
0 0 1 1   7   8  10   3   7
0 0 1 0   3   8   8   8   2
0 0 0 1   9  15  11   7   4
0 0 0 0  90 150 152 119 101
1 1 1 1   8  21  27  14  15
1 1 1 0   1   6   8   7   6
1 1 0 1   2   6   0   2   0
1 1 0 0   2   2  12   6   6
1 0 1 1   4  19   8   9   3
1 0 1 0   2  13  10   7   5
1 0 0 1   8  14   6   8   9
1 0 0 0  75 154 148 129  91
;
```

Through a series of steps (see sas code) I changed this to individual level data….

```
proc print data=obesity4 (obs=30);
run;
```

Obs	Gender	Cohort	age	year	OB	ID
1	0	6	6	1977	0	1
2	0	6	8	1979	0	1
3	0	6	10	1981	0	1
4	0	6	6	1977	0	2
5	0	6	8	1979	0	2
6	0	6	10	1981	0	2
7	0	6	6	1977	0	3
8	0	6	8	1979	0	3
9	0	6	10	1981	0	3
10	0	6	6	1977	0	4
11	0	6	8	1979	0	4
12	0	6	10	1981	0	4
13	0	6	6	1977	0	5
14	0	6	8	1979	0	5
15	0	6	10	1981	0	5
16	0	6	6	1977	0	6
17	0	6	8	1979	0	6
18	0	6	10	1981	0	6

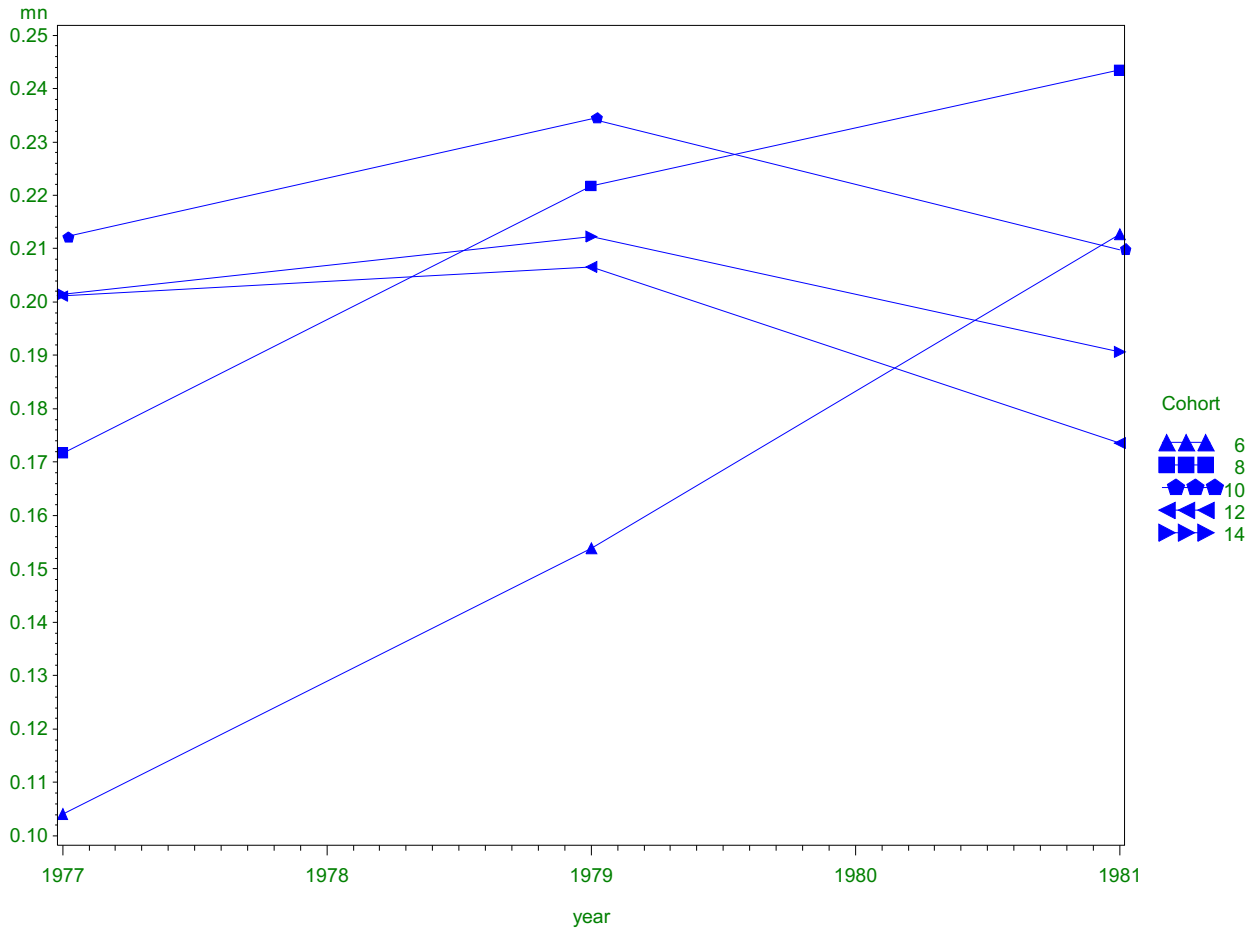
Obs	Gender	Cohort	age	year	OB	ID
19	0	6	6	1977	0	7

```
proc sort data=obesity4;
by Cohort year;
run;

proc means data=obesity4 mean noprint;
by Cohort year;
var OB;
output out=mndat mean=mn N=samp;
run;

proc print data=mndat;
var Cohort year mn samp;
run;
```

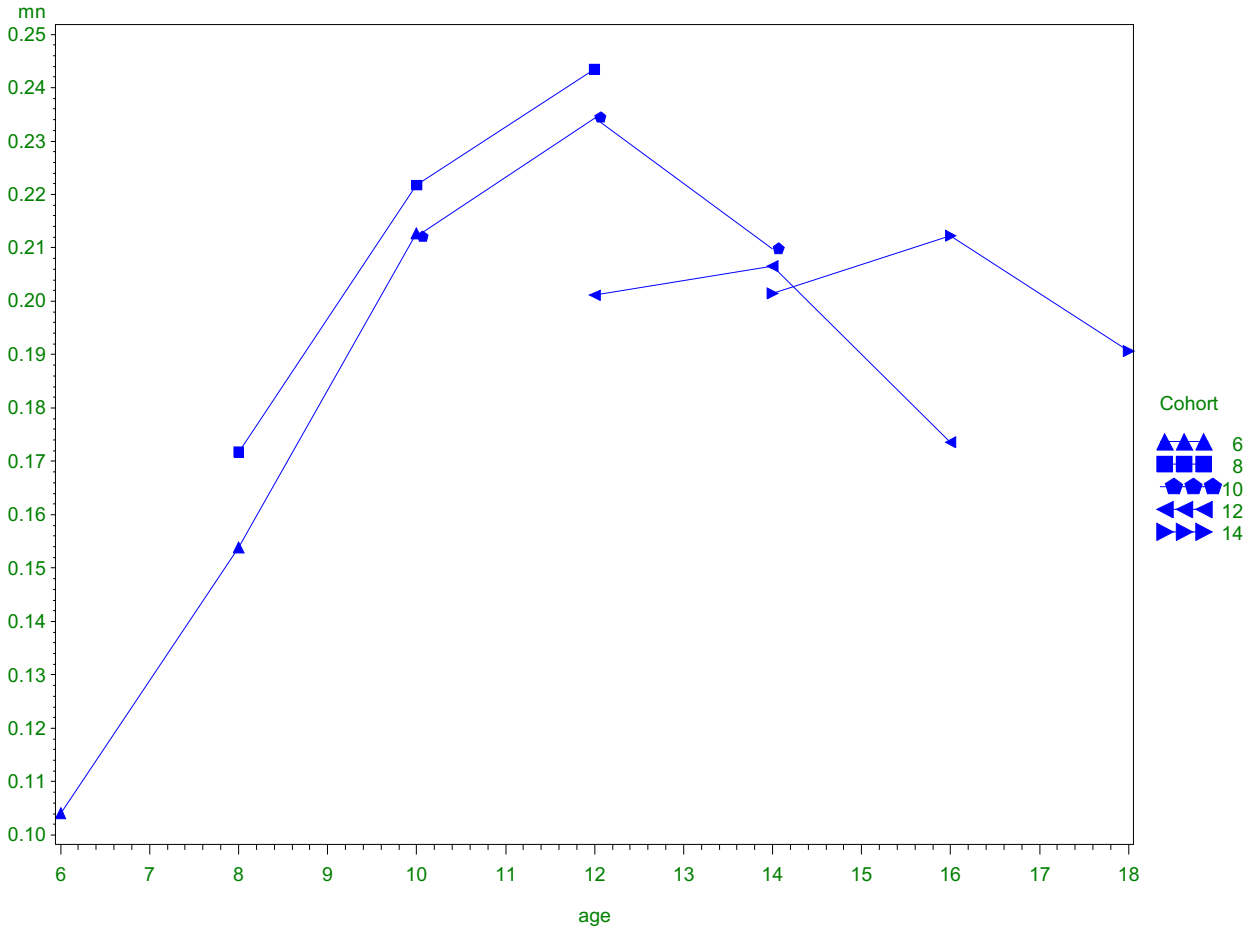
Obs	Cohort	year	mn	samp
1	6	1977	0.10407	221
2	6	1979	0.15385	221
3	6	1981	0.21267	221
4	8	1977	0.17174	460
5	8	1979	0.22174	460
6	8	1981	0.24348	460
7	10	1977	0.21205	448
8	10	1979	0.23438	448
9	10	1981	0.20982	448
10	12	1977	0.20110	363
11	12	1979	0.20661	363
12	12	1981	0.17355	363
13	14	1977	0.20144	278
14	14	1979	0.21223	278
15	14	1981	0.19065	278

```
goptions ftext='Arial' htext=2 gunit=pct ctext=green csymbol=blue;
symbol1 f=marker v='C' i=join h=1.25;
symbol2 f=marker v='U' i=join h=1.25;
symbol3 f=marker v=star i=join h=1.25;
symbol4 f=marker v='A' i=join h=1.25;
symbol5 f=marker v='B' i=join h=1.25;

legend1 position=(right middle)
        label=(position=top)
        across=1;
proc gplot data=mndat;
```

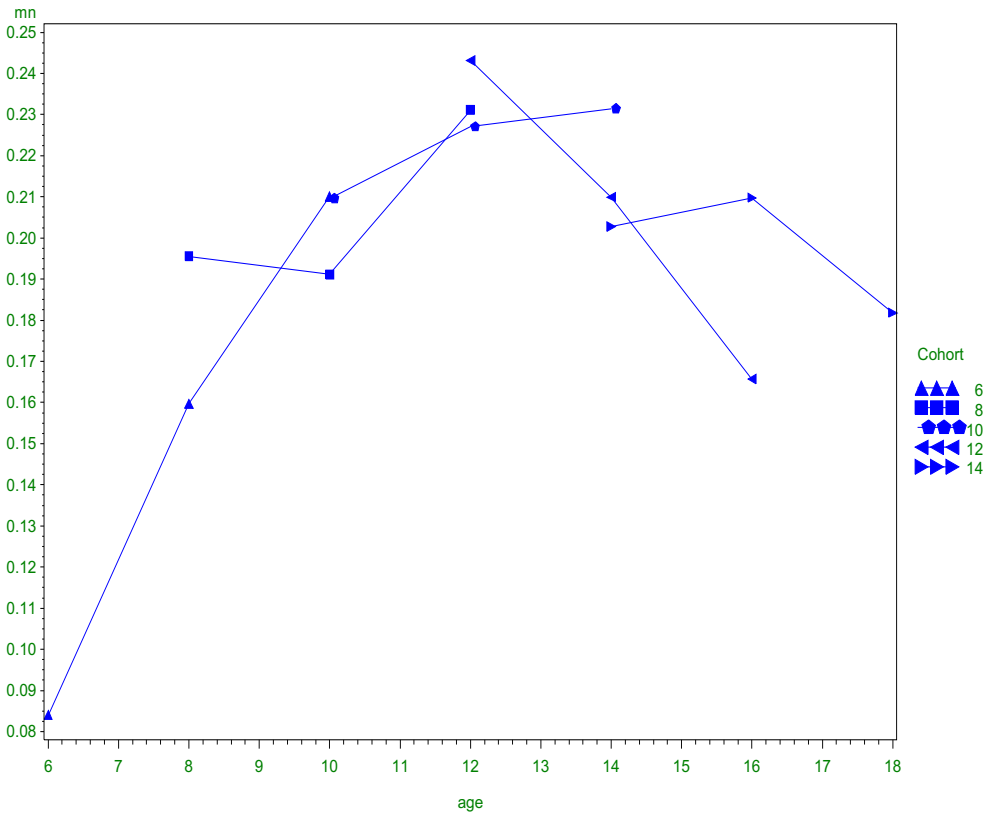
```
plot mn*year=Cohort/ legend=legend1;
run;
quit;
```

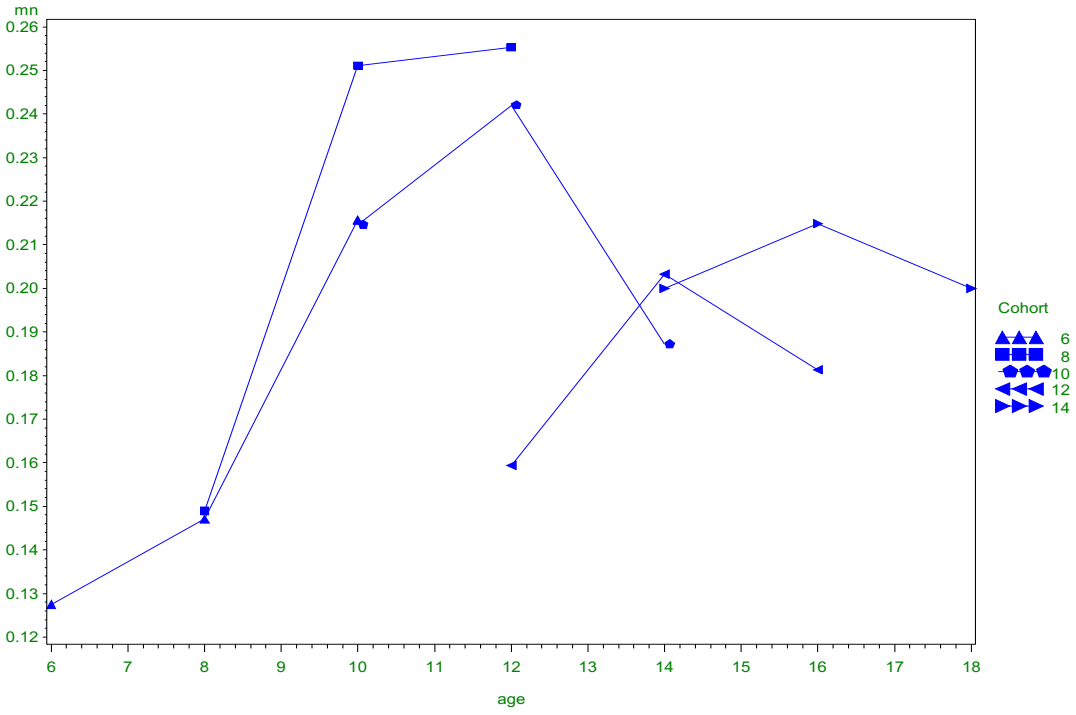



```
proc sort data=obesity4;
by cohort age;
run;

proc means data=obesity4 mean noprint;
by cohort age;
var OB;
output out=mndat2 mean=mn N=samp;
run;

proc gplot data=mndat2;
plot mn*age=Cohort/ legend=legend1;
run;
quit;
```



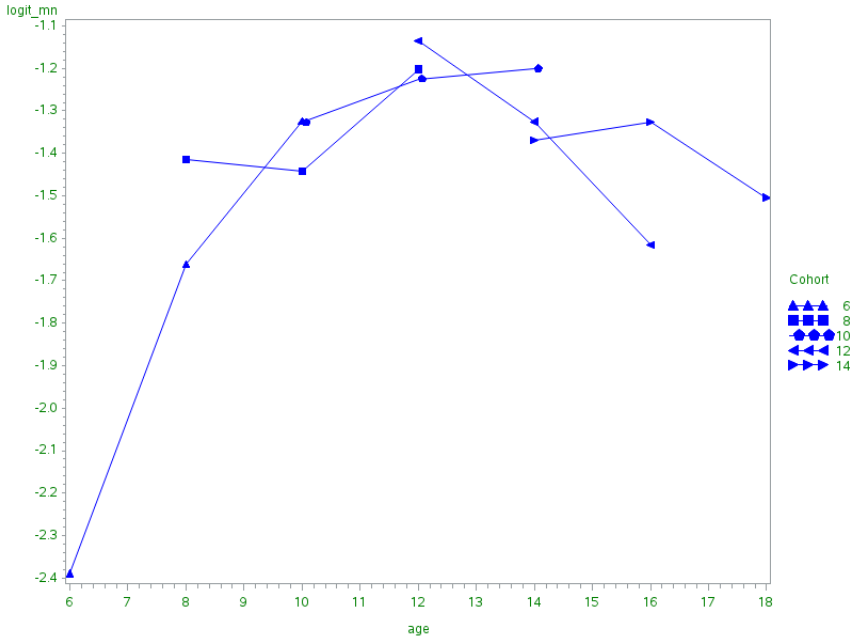

```
proc sort data=obesity4;
by cohort age gender;
run;

proc means data=obesity4 mean noprint;
by cohort age gender;
var OB;
output out=mndat4 mean=mn N=samp;
run;

proc gplot data=mndat4;
where gender = 0;
plot mn*age=Cohort/ legend=legend1;
run;
quit;
proc gplot data=mndat4;
where gender = 1;
plot mn*age=Cohort/ legend=legend1;
run;
quit;
```



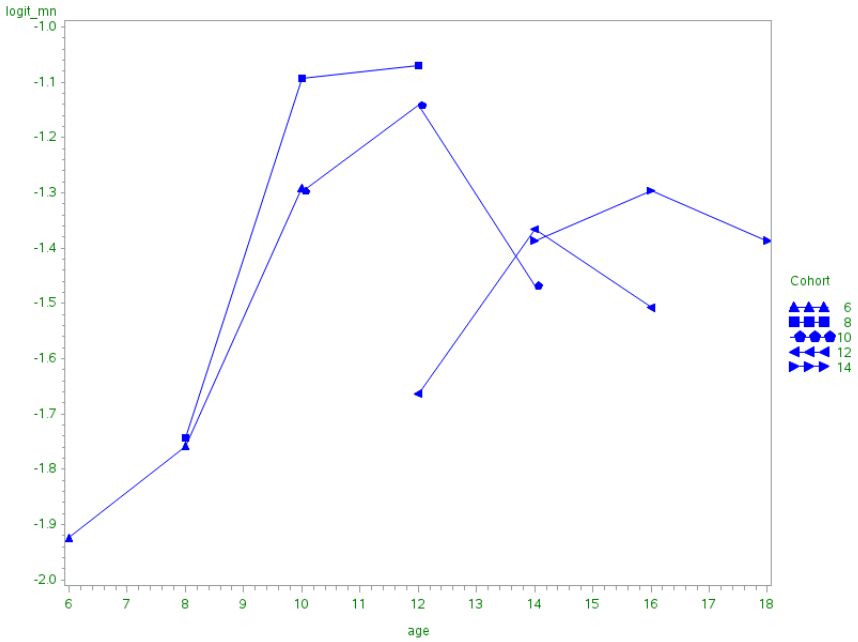



```
data mn_logit;
set mndat4;
logit_mn = log(mn/(1-mn));
run;

proc gplot data=mn_logit;
where gender = 0;
```

```
plot logit_mn*age=Cohort/ legend=legend1;
run;
quit;
```




```
proc gplot data=mn_logit;
where gender = 1;
plot logit_mn*age=Cohort/ legend=legend1;
run;
quit;
```




```
proc genmod data=obesity4 DESCENDING;
class ID gender (param=ref);
model OB = gender age age*age gender*age gender*age*age/d=bin link=logit;
repeated subject=ID/type=exch corrw modelse covb ;
output out=full_mod pred=pred;
run;
quit;
```

Model Information	
Data Set	WORK.OBESITY4
Distribution	Binomial
Link Function	Logit
Dependent Variable	OB

Number of Observations Read	5310
Number of Observations Used	5310
Number of Events	1070
Number of Trials	5310

Class Level Information		
Class	**Value**	**Design Variables**
Gender	**0**	1
	1	0

Response Profile		
Ordered Value	**OB**	**Total Frequency**
1	1	1070
2	0	4240

PROC GENMOD is modeling the probability that OB='1'.

Parameter Information		
Parameter	**Effect**	**Gender**
Prm1	Intercept	
Prm2	Gender	0
Prm3	age	
Prm4	age*age	
Prm5	age*Gender	0
Prm6	age*age*Gender	0

Algorithm converged.

GEE Model Information	
Correlation Structure	Exchangeable
Subject Effect	ID (1770 levels)
Number of Clusters	1770
Correlation Matrix Dimension	3
Maximum Cluster Size	3
Minimum Cluster Size	3

Covariance Matrix (Model-Based)						
	Prm1	Prm2	Prm3	Prm4	Prm5	Prm6
Prm1	0.38017	-0.38017	-0.06001	0.002293	0.06001	-0.002293
Prm2	-0.38017	0.73490	0.06001	-0.002293	-0.11645	0.004468
Prm3	-0.06001	0.06001	0.009921	-0.000392	-0.009921	0.0003919
Prm4	0.002293	-0.002293	-0.000392	0.0000160	0.0003919	-0.000016
Prm5	0.06001	-0.11645	-0.009921	0.0003919	0.01934	-0.000767
Prm6	-0.002293	0.004468	0.0003919	-0.000016	-0.000767	0.0000314

Covariance Matrix (Empirical)						
	Prm1	Prm2	Prm3	Prm4	Prm5	Prm6
Prm1	0.42984	-0.42984	-0.06884	0.002656	0.06884	-0.002656
Prm2	-0.42984	0.79942	0.06884	-0.002656	-0.12879	0.005008
Prm3	-0.06884	0.06884	0.01152	-0.000458	-0.01152	0.0004585
Prm4	0.002656	-0.002656	-0.000458	0.0000188	0.0004585	-0.000019
Prm5	0.06884	-0.12879	-0.01152	0.0004585	0.02174	-0.000874
Prm6	-0.002656	0.005008	0.0004585	-0.000019	-0.000874	0.0000362

Algorithm converged.

Working Correlation Matrix			
	Col1	Col2	Col3
Row1	1.0000	0.5452	0.5452
Row2	0.5452	1.0000	0.5452
Row3	0.5452	0.5452	1.0000

Exchangeable Working Correlation	
Correlation	0.5452275473

GEE Fit Criteria	
QIC	5329.8048
QICu	5326.1063

Analysis Of GEE Parameter Estimates							
Empirical Standard Error Estimates							
Parameter		Estimate	Standard Error	95% Confidence Limits		Z	Pr > |Z|
Intercept		-3.7998	0.6556	-5.0847	-2.5148	-5.80	<.0001
Gender	0	-0.1091	0.8941	-1.8615	1.6433	-0.12	0.9029
age		0.3803	0.1073	0.1699	0.5906	3.54	0.0004
age*age		-0.0141	0.0043	-0.0226	-0.0056	-3.25	0.0012
age*Gender	0	0.0421	0.1474	-0.2469	0.3311	0.29	0.7751
age*age*Gender	0	-0.0026	0.0060	-0.0143	0.0092	-0.42	0.6712

Analysis Of GEE Parameter Estimates							
Model-Based Standard Error Estimates							
Parameter		Estimate	Standard Error	95% Confidence Limits		Z	Pr > |Z|
Intercept		-3.7998	0.6166	-5.0082	-2.5913	-6.16	<.0001
Gender	0	-0.1091	0.8573	-1.7893	1.5711	-0.13	0.8987
age		0.3803	0.0996	0.1850	0.5755	3.82	0.0001
age*age		-0.0141	0.0040	-0.0219	-0.0062	-3.52	0.0004
age*Gender	0	0.0421	0.1391	-0.2304	0.3147	0.30	0.7620
age*age*Gender	0	-0.0026	0.0056	-0.0135	0.0084	-0.46	0.6486
Scale		1.0000	.	.	.	.	.

Note: The scale parameter was held fixed.

- **Example GEE interpretation:**
  "On average, the odds of obesity for males were 10% lower (0.1 = 1- 0.90 where 0.9=exp(-0.11)) than the odds of obesity for females when age was zero.

```
proc sort data=full_mod;
by cohort age gender;
run;

data full2;
set full_mod;
by cohort age gender;
drop_var = 0;
if first.gender then drop_var = 1;
if drop_var = 1;
drop drop_var OB;
run;
```

Obs	Gender	Cohort	age	year	ID	pred
1	0	6	6	1977	1	0.12207
2	1	6	6	1977	2692	0.11665
3	0	6	8	1979	1	0.16888
4	1	6	8	1979	2692	0.16004
5	0	6	10	1981	1	0.20634
6	1	6	10	1981	2692	0.19722
7	0	8	8	1977	271	0.16888
8	1	8	8	1977	2917	0.16004
9	0	8	10	1979	271	0.20634
10	1	8	10	1979	2917	0.19722
11	0	8	12	1981	271	0.22554

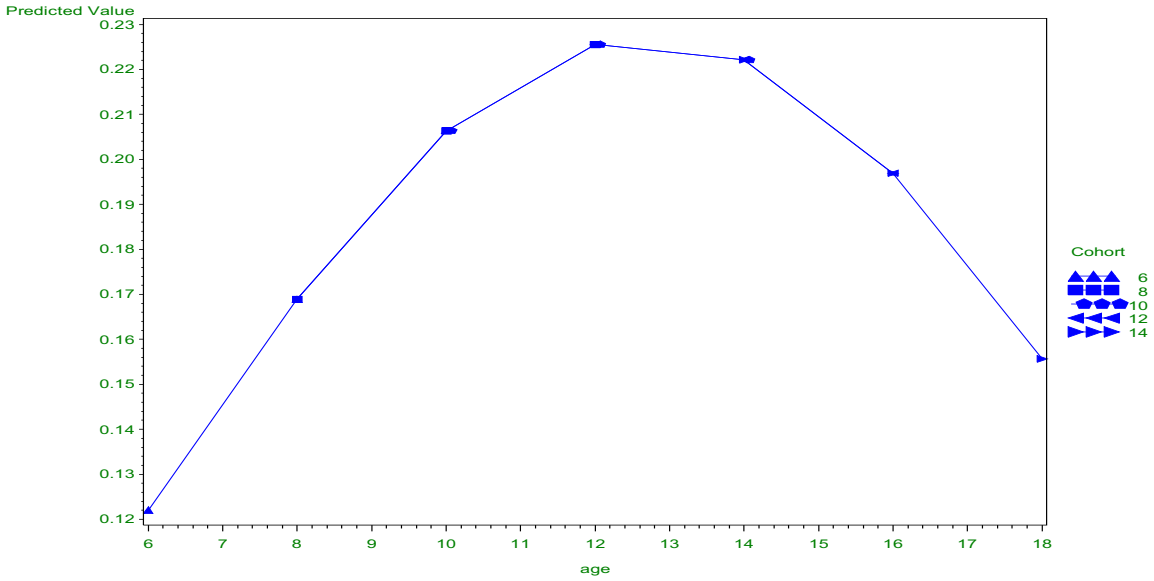
Obs	Gender	Cohort	age	year	ID	pred
12	1	8	12	1981	2917	0.22061
13	0	10	10	1977	721	0.20634
14	1	10	10	1977	3379	0.19722
15	0	10	12	1979	721	0.22554
16	1	10	12	1979	3379	0.22061
17	0	10	14	1981	721	0.22215
18	1	10	14	1981	3379	0.22565
19	0	12	12	1977	1177	0.22554
20	1	12	12	1977	3823	0.22061
21	0	12	14	1979	1177	0.22215
22	1	12	14	1979	3823	0.22565
23	0	12	16	1981	1177	0.19692
24	1	12	16	1981	3823	0.21140

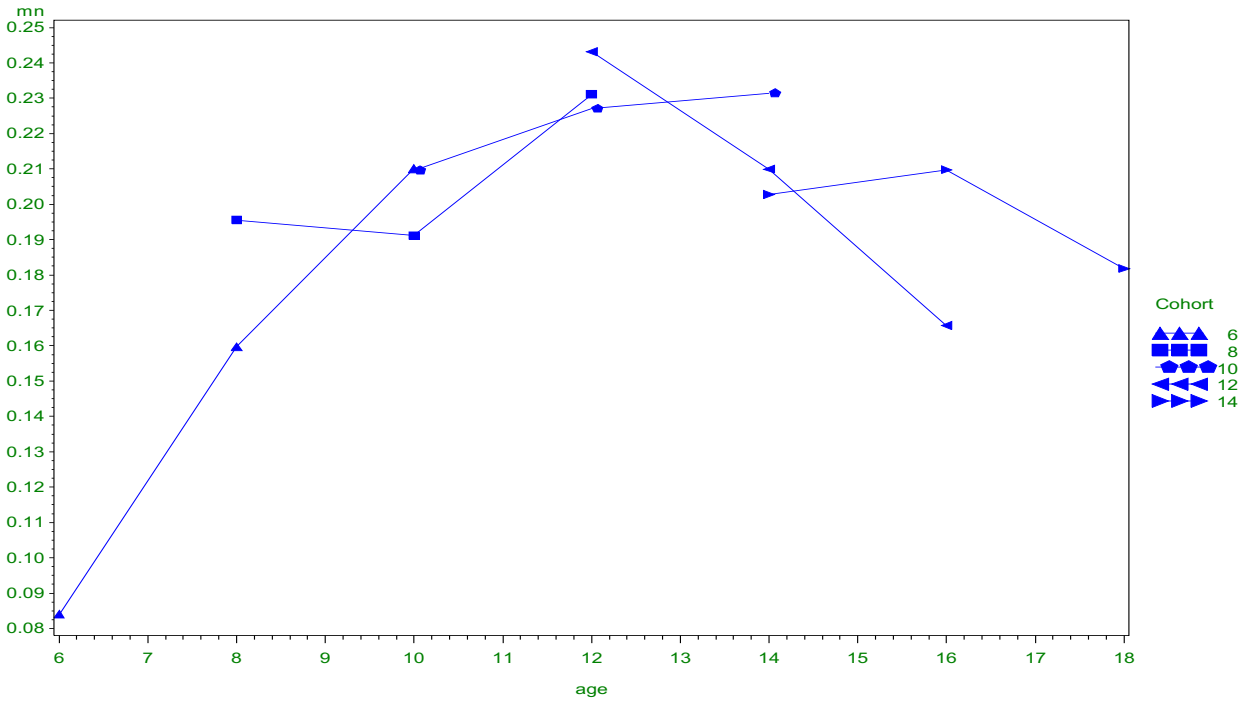
```
proc print data=full2;
run;
data merg_dat;
merge full2 mndat4;
by cohort age gender;
drop _TYPE_ _FREQ_;
run;
proc print data=merg_dat;
run;
```

Obs	Gender	Cohort	age	year	ID	pred	mn	samp
1	0	5	5	1977	1	0.11152	0.08403	119
2	1	5	5	1977	2692	0.11831	0.12745	102
3	0	5	6	1979	1	0.14432	0.15966	119
4	1	5	6	1979	2692	0.14612	0.14706	102
5	0	5	7	1981	1	0.17615	0.21008	119
6	1	5	7	1981	2692	0.17275	0.21569	102
7	0	7	7	1977	271	0.17615	0.19556	225
8	1	7	7	1977	2917	0.17275	0.14894	235
9	0	7	8	1979	271	0.20366	0.19111	225
10	1	7	8	1979	2917	0.19603	0.25106	235
11	0	7	9	1981	271	0.22397	0.23111	225

Obs	Gender	Cohort	age	year	ID	pred	mn	samp
12	1	7	9	1981	2917	0.21409	0.25532	235
13	0	9	9	1977	721	0.22397	0.20961	229
14	1	9	9	1977	3379	0.21409	0.21461	219
15	0	9	10	1979	721	0.23507	0.22707	229
16	1	9	10	1979	3379	0.22555	0.24201	219
17	0	9	11	1981	721	0.23590	0.23144	229
18	1	9	11	1981	3379	0.22953	0.18721	219
19	0	11	11	1977	1177	0.23590	0.24309	181
20	1	11	11	1977	3823	0.22953	0.15934	182
21	0	11	12	1979	1177	0.22638	0.20994	181

```
proc gplot data=merg_dat;
where gender = 0;
plot (pred mn)*age=Cohort/legend=legend1;
run;
quit;
```






```
proc genmod data=obesity4 DESCENDING;
class ID gender cohort (param=ref);
model OB = cohort gender age age*age gender*age gender*age*age/d=bin link=logit type3;
repeated subject=ID/type=exch corrw modelse covb ;
output out=full_mod pred=pred;
run;
quit;
```

Model Information	
Data Set	WORK.OBESITY4
Distribution	Binomial
Link Function	Logit
Dependent Variable	OB

Number of Observations Read	5310
Number of Observations Used	5310
Number of Events	1070
Number of Trials	5310

Class Level Information					
Class	Value	Design Variables			
Gender	0	1			
	1	-1			
Cohort	6	1	0	0	0
	8	0	1	0	0
	10	0	0	1	0
	12	0	0	0	1
	14	0	0	0	0

Response Profile		
Ordered Value	OB	Total Frequency
1	1	1070
2	0	4240

PROC GENMOD is modeling the probability that OB='1'.

Parameter Information			
Parameter	Effect	Gender	Cohort
Prm1	Intercept		
Prm2	Cohort		6
Prm3	Cohort		8
Prm4	Cohort		10
Prm5	Cohort		12
Prm6	Gender	0	
Prm7	age		
Prm8	age*age		
Prm9	age*Gender	0	
Prm10	age*age*Gender	0	

Algorithm converged.

GEE Model Information	
Correlation Structure	Exchangeable
Subject Effect	ID (1770 levels)
Number of Clusters	1770
Correlation Matrix Dimension	3
Maximum Cluster Size	3
Minimum Cluster Size	3

Covariance Matrix (Model-Based)										
	Prm1	Prm2	Prm3	Prm4	Prm5	Prm6	Prm7	Prm8	Prm9	Prm10
Prm1	0.21167	-0.03564	-0.02176	-0.01320	-0.01117	-0.005258	-0.02999	0.001105	0.0007406	-0.000024
Prm2	-0.03564	0.04838	0.02316	0.02075	0.01824	-0.001339	0.001028	0.0000158	0.0001674	-5.538E-6
Prm3	-0.02176	0.02316	0.03104	0.02038	0.01826	-0.000295	-0.000891	0.0000811	0.0000749	-3.396E-6
Prm4	-0.01320	0.02075	0.02038	0.02853	0.01784	-0.000506	-0.001792	0.0001035	0.0000836	-3.379E-6
Prm5	-0.01117	0.01824	0.01826	0.01784	0.02921	-0.000503	-0.001494	0.0000764	0.0000899	-3.424E-6
Prm6	-0.005258	-0.001339	-0.000295	-0.000506	-0.000503	0.18236	0.0008185	-0.000028	-0.02895	0.001113
Prm7	-0.02999	0.001028	-0.000891	-0.001792	-0.001494	0.0008185	0.005125	-0.000203	-0.000119	3.942E-6
Prm8	0.001105	0.0000158	0.0000811	0.0001035	0.0000764	-0.000028	-0.000203	8.3829E-6	4.0271E-6	-1.285E-7
Prm9	0.0007406	0.0001674	0.0000749	0.0000836	0.0000899	-0.02895	-0.000119	4.0271E-6	0.004818	-0.000191
Prm10	-0.000024	-5.538E-6	-3.396E-6	-3.379E-6	-3.424E-6	0.001113	3.942E-6	-1.285E-7	-0.000191	7.8547E-6

Covariance Matrix (Empirical)										
	Prm1	Prm2	Prm3	Prm4	Prm5	Prm6	Prm7	Prm8	Prm9	Prm10
Prm1	0.23049	-0.03967	-0.02268	-0.01248	-0.01178	-0.01235	-0.03326	0.001242	0.001851	-0.000062
Prm2	-0.03967	0.05100	0.02459	0.02147	0.01856	-0.004847	0.001347	0.0000106	0.0007051	-0.000026
Prm3	-0.02268	0.02459	0.03202	0.02116	0.01865	0.0008781	-0.001050	0.0000936	-0.000117	2.5958E-6
Prm4	-0.01248	0.02147	0.02116	0.02946	0.01818	-0.001844	-0.002084	0.0001175	0.0002943	-0.000012
Prm5	-0.01178	0.01856	0.01865	0.01818	0.02905	-0.002783	-0.001447	0.0000739	0.0005728	-0.000026
Prm6	-0.01235	-0.004847	0.0008781	-0.001844	-0.002783	0.19680	0.002018	-0.000069	-0.03181	0.001241
Prm7	-0.03326	0.001347	-0.001050	-0.002084	-0.001447	0.002018	0.005777	-0.000232	-0.000302	0.0000102
Prm8	0.001242	0.0000106	0.0000936	0.0001175	0.0000739	-0.000069	-0.000232	9.7048E-6	9.8683E-6	-3.09E-7
Prm9	0.001851	0.0007051	-0.000117	0.0002943	0.0005728	-0.03181	-0.000302	9.8683E-6	0.005390	-0.000217
Prm10	-0.000062	-0.000026	2.5958E-6	-0.000012	-0.000026	0.001241	0.0000102	-3.09E-7	-0.000217	9.0429E-6

Algorithm converged.

Working Correlation Matrix			
	Col1	Col2	Col3
Row1	1.0000	0.5446	0.5446
Row2	0.5446	1.0000	0.5446
Row3	0.5446	0.5446	1.0000

Exchangeable Working Correlation	
Correlation	0.5446473868

GEE Fit Criteria	
QIC	5338.9232
QICu	5328.0878

Analysis Of GEE Parameter Estimates							
Empirical Standard Error Estimates							
Parameter		Estimate	Standard Error	95% Confidence Limits		Z	Pr > |Z|
Intercept		-3.9598	0.4801	-4.9008	-3.0188	-8.25	<.0001
Cohort	6	0.0382	0.2258	-0.4044	0.4808	0.17	0.8657
Cohort	8	0.1436	0.1789	-0.2071	0.4943	0.80	0.4223
Cohort	10	0.0367	0.1716	-0.2997	0.3730	0.21	0.8309
Cohort	12	-0.1257	0.1704	-0.4598	0.2083	-0.74	0.4608
Gender	0	-0.0525	0.4436	-0.9219	0.8170	-0.12	0.9059
age		0.4065	0.0760	0.2575	0.5555	5.35	<.0001
age*age		-0.0152	0.0031	-0.0213	-0.0091	-4.89	<.0001
age*Gender	0	0.0210	0.0734	-0.1229	0.1649	0.29	0.7745
age*age*Gender	0	-0.0013	0.0030	-0.0072	0.0046	-0.43	0.6691

Analysis Of GEE Parameter Estimates							
Model-Based Standard Error Estimates							
Parameter		Estimate	Standard Error	95% Confidence Limits		Z	Pr > |Z|
Intercept		-3.9598	0.4601	-4.8615	-3.0581	-8.61	<.0001
Cohort	6	0.0382	0.2199	-0.3929	0.4693	0.17	0.8621
Cohort	8	0.1436	0.1762	-0.2017	0.4889	0.81	0.4151
Cohort	10	0.0367	0.1689	-0.2944	0.3677	0.22	0.8282
Cohort	12	-0.1257	0.1709	-0.4607	0.2093	-0.74	0.4620
Gender	0	-0.0525	0.4270	-0.8894	0.7845	-0.12	0.9022
age		0.4065	0.0716	0.2662	0.5468	5.68	<.0001
age*age		-0.0152	0.0029	-0.0209	-0.0096	-5.26	<.0001
age*Gender	0	0.0210	0.0694	-0.1150	0.1571	0.30	0.7619
age*age*Gender	0	-0.0013	0.0028	-0.0068	0.0042	-0.46	0.6465
Scale		1.0000	.	.	.	.	.

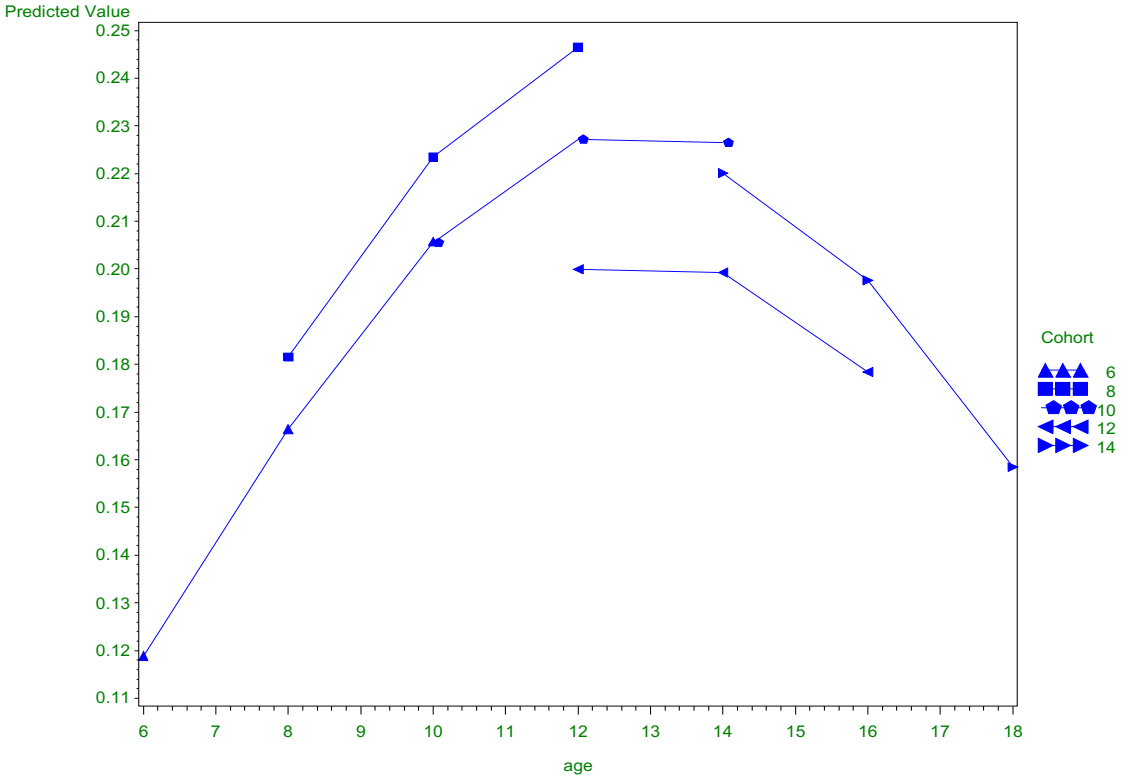
Note: The scale parameter was held fixed.

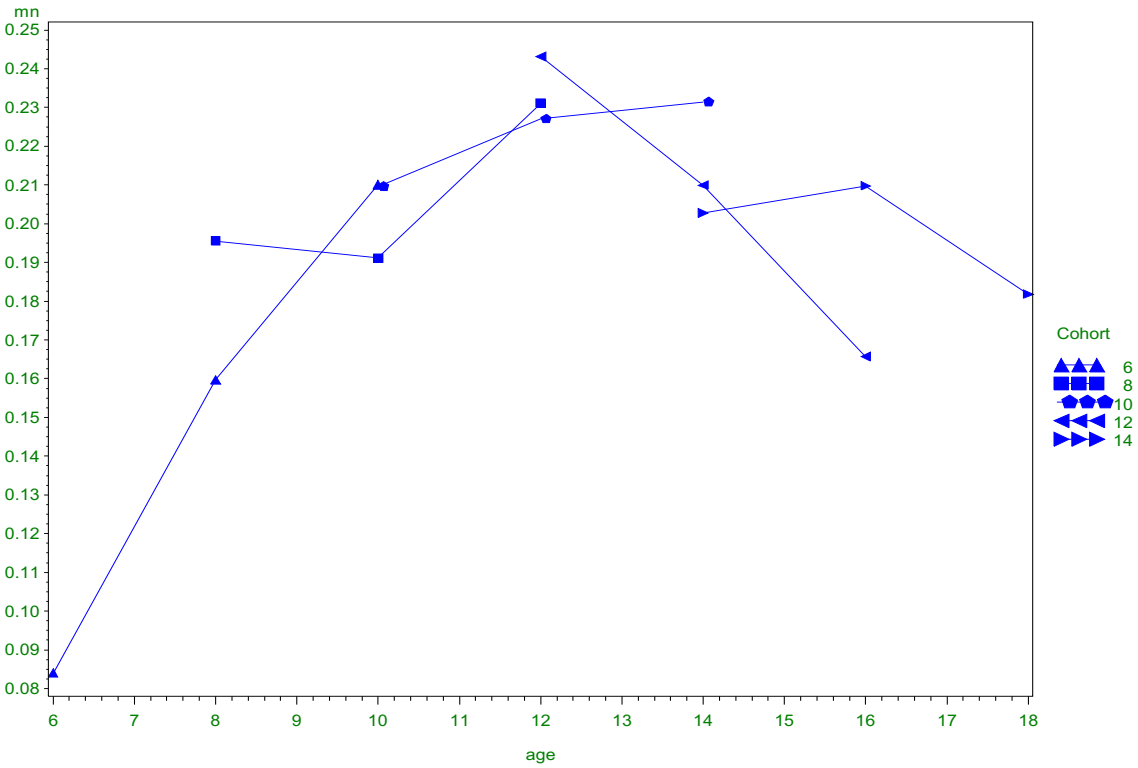
Score Statistics For Joint Tests For GEE			
Source	DF	Chi-Square	Pr > ChiSq
Cohort	4	3.13	0.5355
Gender	1	0.01	0.9054
age	1	28.86	<.0001
age*age	1	24.53	<.0001
age*Gender	1	0.08	0.7744
age*age*Gender	1	0.18	0.6702

Note: Under full-rank parameterizations, Type 3 effect tests are replaced by joint tests. The joint test for an effect is a test that all the parameters associated with that effect are zero. Such joint tests might not be equivalent to Type 3 effect tests under GLM parameterization.

```
proc sort data=full_mod;
by cohort age gender;
run;

data full2;
set full_mod;
by cohort age gender;
drop_var = 0;
if first.gender then drop_var = 1;
if drop_var = 1;
drop drop_var OB;
run;

data merg_dat;
merge full2 mndat4;
by cohort age gender;
drop _TYPE_ _FREQ_;
run;

proc gplot data=merg_dat;
where gender = 0;
plot (pred mn)*age=Cohort/legend=legend1;
run;
```

```
quit;
```


Predicted Value
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
6
7
8
9
10
11
12
13
14
15
16
17
18
age
Cohort
6
8
10
12
14


mn
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
6
7
8
9
10
11
12
13
14
15
16
17
18
age
Cohort
6
8
10
12
14

```
proc genmod data=obesity4 DESCENDING;
class ID gender (param=ref);
model OB = gender age age*age/d=bin link=logit type3;
repeated subject=ID/type=exch corrw modelse covb ;
run;
quit;
```

Model Information	
Data Set	WORK.OBESITY4
Distribution	Binomial
Link Function	Logit
Dependent Variable	OB

Number of Observations Read	5310
Number of Observations Used	5310
Number of Events	1070
Number of Trials	5310

Class Level Information		
Class	**Value**	**Design Variables**
Gender	**0**	1
	1	0

Response Profile		
Ordered Value	**OB**	**Total Frequency**
1	1	1070
2	0	4240

PROC GENMOD is modeling the probability that OB='1'.

Parameter Information		
Parameter	**Effect**	**Gender**
Prm1	Intercept	
Prm2	Gender	0
Prm3	age	
Prm4	age*age	

Algorithm converged.

GEE Model Information	
Correlation Structure	Exchangeable
Subject Effect	ID (1770 levels)
Number of Clusters	1770
Correlation Matrix Dimension	3
Maximum Cluster Size	3
Minimum Cluster Size	3

Covariance Matrix (Model-Based)				
	Prm1	Prm2	Prm3	Prm4
Prm1	0.18629	-0.005137	-0.02911	0.001117
Prm2	-0.005137	0.009760	0.0000303	-1.173E-6
Prm3	-0.02911	0.0000303	0.004833	-0.000192
Prm4	0.001117	-1.173E-6	-0.000192	7.8518E-6

Covariance Matrix (Empirical)				
	Prm1	Prm2	Prm3	Prm4
Prm1	0.20108	-0.004622	-0.03203	0.001246
Prm2	-0.004622	0.009802	-0.000047	1.1928E-6
Prm3	-0.03203	-0.000047	0.005413	-0.000218
Prm4	0.001246	1.1928E-6	-0.000218	9.0233E-6

Algorithm converged.

Working Correlation Matrix			
	Col1	Col2	Col3
Row1	1.0000	0.5448	0.5448
Row2	0.5448	1.0000	0.5448
Row3	0.5448	0.5448	1.0000

Exchangeable Working Correlation	
Correlation	0.5447884924

GEE Fit Criteria	
QIC	5325.5632
QICu	5321.5477

Analysis Of GEE Parameter Estimates							
Empirical Standard Error Estimates							
Parameter		Estimate	Standard Error	95% Confidence Limits		Z	Pr > |Z|
Intercept		-3.8571	0.4484	-4.7360	-2.9782	-8.60	<.0001
Gender	0	0.0065	0.0990	-0.1876	0.2005	0.07	0.9478
age		0.4014	0.0736	0.2572	0.5456	5.46	<.0001
age*age		-0.0154	0.0030	-0.0212	-0.0095	-5.11	<.0001

Analysis Of GEE Parameter Estimates							
Model-Based Standard Error Estimates							
Parameter		Estimate	Standard Error	95% Confidence Limits		Z	Pr > |Z|
Intercept		-3.8571	0.4316	-4.7031	-3.0112	-8.94	<.0001
Gender	0	0.0065	0.0988	-0.1872	0.2001	0.07	0.9477
age		0.4014	0.0695	0.2651	0.5377	5.77	<.0001
age*age		-0.0154	0.0028	-0.0208	-0.0099	-5.48	<.0001
Scale		1.0000	.	.	.	.	.

Note: The scale parameter was held fixed.

Score Statistics For Type 3 GEE Analysis			
Source	**DF**	**Chi-Square**	**Pr > ChiSq**
Gender	1	0.00	0.9478
age	1	33.80	<.0001
age*age	1	29.30	<.0001

- **Example GEE interpretation of Gender:**
  "On average, the odds of obesity for males were 0.6% higher (0.006 = 1.006 - 1 where 1.006=exp(0.0065)) than the odds of obesity for females, after controlling for age."

- **Example GEE interpretation of Age:**
  *"On average, the odds of obesity increase by **15.0% higher** for kids who are 9 versus 8 (0.150 = 1.150 - 1 where 1.150=exp(0.4014 - 0.0154 *(9^2 – 8^2)), after controlling for gender."*
- *"On average, the odds of obesity increase by **1.7% higher** for kids who are 13 versus 12 (0.017 = 1.017 - 1 where 1.017=exp(0.4014 - 0.0154 *(13^2 – 12^2)), after controlling for gender."*
- *"On average, the odds of obesity increase by **10.1% lower** for kids who are 17 versus 16 (0.101 = 1 – 0.8987 where 0.8987=exp(0.4014 - 0.0154 *(17^2 – 16^2)), after controlling for gender."*

- **Example GLMM interpretation:**
  *"As a child ages from 8 to 9, their odds of **obesity increase by 15.0%,** after controlling for gender."*