STAT 697L FINAL EXAM – FALL 2010

Please attach your SAS code wherever necessary. It is presumed you will do your own work. You are encouraged to work in study groups, however, the final write-up must be in your own words, not copied.

Read the paper titled **Models for Longitudinal Data: A Generalized Estimating Equation Approach** by Scott L. Zeger; Kung-Yee Liang; Paul S. Albert, *Biometrics*, 1988, page1049-1060. Answer the following questions:

1. What is longitudinal data?
2. In a short paragraph, summarize the differences between a population averaged (PA) model and a subject specific (SS) model.
3. Reproduce Figure 1 using equation (2.2). Create a new figure that is the same as Figure 1 but with the identity link instead of the logit link. Do you still observe the attenuation of effect of covariates as in Figure 1? In (2.2), you need to perform numerical integration. The simplest numerical integration one can do is to approximate $\int f(x)\,dx$ by $\sum_{i=1}^{n} f(x_i)\nabla x$ where $x_i, i=1,\cdots,n$ is an equally spaced partition of the integral range with the space being ∇x. In equation (2.2), the integral range is best set as (-3, 3) because b is distributed as $N(0,\sigma^2)$.
4. Derive (2.4) from (2.3). The two equations show that with the identity link, the mean in the PA model, the marginal mean, is same as the fixed effects in the SS model. Therefore, no attenuation has occurred.
5. Reproduce Figure 2 which is based on the cumulative Gaussian approximation to the logistic function mentioned in line -19 of page 1054. Compare Figure 2 and Figure 1 and comment on the performance of the approximation.
6. Reproduce Table 1 and Table 3 using the GENMOD procedure and the NLMIXED procedure (or GLIMMIX which you have to download yourself). Note that you might not able to reproduce Table 3 exactly as the NLMIXED or GLIMMIX perform maximum likelihood based analysis, as opposed to the GEE approach for the SS model in the paper.

Harvard Study of Air Pollution and Health data:

ID	Y10	Y9	Y8	Y7	mat.smoke	count
1	0	0	0	0	0	237
2	1	0	0	0	0	10
3	0	1	0	0	0	15
4	1	1	0	0	0	4
5	0	0	1	0	0	16
6	1	0	1	0	0	2
7	0	1	1	0	0	7
8	1	1	1	0	0	3
9	0	0	0	1	0	24
10	1	0	0	1	0	3
11	0	1	0	1	0	3
12	1	1	0	1	0	2
13	0	0	1	1	0	6
14	1	0	1	1	0	2
15	0	1	1	1	0	5
16	1	1	1	1	0	11
17	0	0	0	0	1	118
18	1	0	0	0	1	6
19	0	1	0	0	1	8
20	1	1	0	0	1	2
21	0	0	1	0	1	11
22	1	0	1	0	1	1
23	0	1	1	0	1	6
24	1	1	1	0	1	4
25	0	0	0	1	1	7
26	1	0	0	1	1	3
27	0	1	0	1	1	3
28	1	1	0	1	1	1
29	0	0	1	1	1	4
30	1	0	1	1	1	2
31	0	1	1	1	1	4
32	1	1	1	1	1	7