Web-based Supporting Materials for "Bayesian Hierarchical Model for Multiple Repeated Measures and Survival Data: an application to Parkinson's Disease" by Sheng Luo and Jue Wang

Table 1: Additional simulations results from the reduced model A, reduced model B, and full model for setting I (the terminal event dependent on both the subject-specific and center-specific random effects).

	Reduced Model A				Reduced Model B				Full Model			
	Bias	SE	SD	CP	Bias	SE	SD	CP	Bias	SE	SD	CP
For the first outcome (continuous)												
$a_1 = 3.0$	-0.007	0.051	0.054	0.950	-0.006	0.052	0.057	0.940	-0.002	0.051	0.055	0.935
$b_1 = 1.5$	0.053	0.050	0.050	0.805	-0.002	0.046	0.041	0.975	0.003	0.045	0.043	0.970
$\sigma_\epsilon = 1.0$	0.002	0.018	0.021	0.940	0.006	0.018	0.020	0.920	0.002	0.018	0.019	0.960
For the second outcome (ordinal)												
$a_{22} = 1.0$	0.010	0.062	0.059	0.970	0.007	0.062	0.064	0.965	0.015	0.062	0.064	0.955
$a_{23} = 1.8$	0.017	0.085	0.082	0.945	0.017	0.085	0.085	0.945	0.025	0.085	0.084	0.940
$a_{24} = 2.6$	0.019	0.106	0.106	0.925	0.020	0.107	0.107	0.940	0.021	0.107	0.106	0.935
$a_{25} = 3.3$	0.030	0.126	0.128	0.940	0.026	0.127	0.128	0.945	0.030	0.126	0.132	0.925
$a_{26} = 4.0$	0.036	0.148	0.154	0.940	0.036	0.149	0.157	0.950	0.034	0.148	0.153	0.945
$b_2 = 2.0$	0.075	0.100	0.104	0.885	-0.001	0.095	0.098	0.950	0.021	0.095	0.100	0.915
For the third outcome (ordinal)												
$a_{31} = -2.7$	-0.003	0.076	0.076	0.945	-0.008	0.076	0.078	0.950	-0.009	0.076	0.077	0.965
$a_{32} = -0.6$	0.004	0.048	0.048	0.930	-0.001	0.048	0.051	0.925	-0.002	0.048	0.049	0.935
$a_{33} = 2.0$	0.006	0.068	0.063	0.980	0.003	0.067	0.069	0.955	0.005	0.068	0.066	0.955
$a_{34} = 2.8$	0.015	0.093	0.086	0.975	0.011	0.093	0.086	0.975	0.011	0.093	0.089	0.975
$a_{35} = 5.0$	0.043	0.268	0.284	0.950	0.027	0.266	0.284	0.955	0.053	0.269	0.286	0.945
$a_{36} = 6.0$	0.289	0.646	0.858	0.935	0.223	0.622	0.816	0.945	0.314	0.653	0.870	0.930
$b_3 = 0.4$	0.014	0.026	0.027	0.900	0.001	0.025	0.026	0.940	0.005	0.025	0.026	0.930
For the fourth outcome (ordinal)												
$a_{41} = -1.0$	-0.001	0.055	0.062	0.925	-0.007	0.055	0.063	0.925	-0.011	0.055	0.063	0.915
$a_{42} = -0.1$	0.001	0.051	0.056	0.935	-0.006	0.052	0.058	0.925	-0.008	0.052	0.055	0.925
$a_{43} = 0.5$	0.007	0.052	0.055	0.935	-0.001	0.053	0.058	0.930	-0.003	0.053	0.054	0.935
$a_{44} = 1.0$	0.008	0.056	0.056	0.945	0.005	0.056	0.061	0.925	-0.001	0.056	0.055	0.950
$a_{45} = 1.5$	0.007	0.062	0.062	0.950	0.007	0.062	0.066	0.945	-0.004	0.062	0.056	0.975
$a_{46} = 2.0$	0.013	0.071	0.070	0.950	0.011	0.071	0.072	0.945	-0.002	0.071	0.067	0.960
$a_{47} = 2.4$	0.016	0.081	0.080	0.950	0.019	0.081	0.082	0.940	0.005	0.081	0.078	0.965
$a_{48} = 2.8$	0.025	0.094	0.095	0.950	0.027	0.094	0.097	0.940	0.013	0.093	0.089	0.960
$a_{49} = 3.3$	0.034	0.115	0.115	0.950	0.043	0.115	0.112	0.955	0.027	0.114	0.111	0.950
$b_4 = 0.7$	0.029	0.036	0.037	0.870	0.004	0.034	0.034	0.955	0.008	0.034	0.034	0.960

Table 2: Additional simulations results from reduced model A, reduced model B, and full model for setting II (the terminal event only dependent on the subject-specific random effects).

	Reduced Model A				Full Model			
	Bias	SE	SD	CP	Bias	SE	SD	CP
For the first outcome (continuous)								
$a_1 = 3.0$	-0.001	0.051	0.051	0.940	-0.005	0.051	0.055	0.925
$b_1 = 1.5$	0.003	0.046	0.043	0.970	0.006	0.046	0.044	0.955
$\sigma_\epsilon = 1.0$	0.002	0.018	0.018	0.950	0.000	0.018	0.018	0.965
For the second outcome (ordinal)								
$a_{22} = 1.0$	0.010	0.062	0.059	0.975	0.012	0.062	0.062	0.980
$a_{23} = 1.8$	0.021	0.084	0.084	0.940	0.023	0.084	0.084	0.960
$a_{24} = 2.6$	0.031	0.105	0.112	0.920	0.024	0.104	0.107	0.940
$a_{25} = 3.3$	0.036	0.124	0.127	0.935	0.032	0.123	0.122	0.930
$a_{26} = 4.0$	0.044	0.144	0.147	0.955	0.043	0.143	0.146	0.955
$b_2 = 2.0$	0.018	0.093	0.101	0.910	0.018	0.093	0.097	0.940
For the third outcome (ordinal)								
$a_{31} = -2.7$	-0.004	0.075	0.075	0.945	-0.002	0.075	0.074	0.945
$a_{32} = -0.6$	0.003	0.047	0.049	0.945	0.002	0.047	0.047	0.955
$a_{33} = 2.0$	0.003	0.066	0.066	0.965	-0.001	0.065	0.064	0.975
$a_{34} = 2.8$	0.012	0.090	0.089	0.935	-0.000	0.089	0.089	0.935
$a_{35} = 5.0$	0.055	0.259	0.270	0.935	0.059	0.261	0.301	0.920
$a_{36} = 6.0$	0.227	0.480	0.522	0.945	0.238	0.489	0.566	0.920
$b_3 = 0.4$	0.001	0.024	0.024	0.930	0.000	0.024	0.025	0.930
For the fourth outcome (ordinal)								
$a_{41} = -1.0$	-0.006	0.054	0.055	0.935	-0.000	0.054	0.056	0.945
$a_{42} = -0.1$	-0.007	0.051	0.050	0.945	-0.001	0.050	0.055	0.915
$a_{43} = 0.5$	-0.000	0.052	0.050	0.950	0.005	0.051	0.056	0.930
$a_{44} = 1.0$	0.005	0.055	0.054	0.955	0.010	0.055	0.058	0.940
$a_{45} = 1.5$	0.006	0.061	0.060	0.955	0.014	0.060	0.064	0.925
$a_{46} = 2.0$	0.007	0.069	0.063	0.960	0.016	0.069	0.069	0.940
$a_{47} = 2.4$	0.014	0.078	0.074	0.960	0.024	0.078	0.078	0.945
$a_{48} = 2.8$	0.024	0.090	0.090	0.945	0.031	0.090	0.092	0.930
$a_{49} = 3.3$	0.032	0.110	0.107	0.945	0.041	0.110	0.116	0.925
$b_4 = 0.7$	0.007	0.034	0.032	0.950	0.006	0.034	0.032	0.950

Table 3: Additional results of fitting reduced model A, reduced model B, and full model in the DATATOP dataset.

	Reduced Model A				Reduced Model B				Full Model			
	Mean	SD	95% CI		Mean	SD	95% CI		Mean	SD	95% CI	
For UPDRS												
a_1	9.047	0.348	8.352	9.708	8.861	0.365	8.157	9.563	9.020	0.385	8.254	9.706
b_1	9.618	0.240	9.109	10.080	9.606	0.241	9.126	10.080	9.644	0.302	9.123	10.300
σ_ϵ	5.277	0.074	5.136	5.424	5.272	0.074	5.132	5.423	5.273	0.076	5.126	5.424
For SEADL												
a_{22}	2.044	0.056	1.934	2.156	2.039	0.057	1.929	2.152	2.045	0.056	1.936	2.157
a_{23}	4.496	0.083	4.337	4.663	4.468	0.083	4.305	4.632	4.498	0.083	4.336	4.664
a_{24}	5.345	0.092	5.169	5.530	5.308	0.093	5.128	5.488	5.346	0.093	5.165	5.531
a_{25}	7.510	0.125	7.269	7.761	7.463	0.126	7.221	7.712	7.509	0.127	7.262	7.761
a_{26}	8.308	0.142	8.034	8.591	8.263	0.143	7.987	8.543	8.306	0.144	8.028	8.590
a_{27}	9.818	0.191	9.452	10.200	9.780	0.194	9.405	10.170	9.815	0.192	9.441	10.190
b_2	1.639	0.052	1.529	1.736	1.613	0.053	1.508	1.715	1.642	0.064	1.521	1.773
For HY												
a_{31}	1.046	0.070	0.906	1.187	1.073	0.073	0.934	1.215	1.049	0.074	0.911	1.194
a_{32}	2.016	0.076	1.868	2.167	2.043	0.078	1.891	2.194	2.019	0.079	1.870	2.174
a_{33}	5.120	0.112	4.902	5.343	5.145	0.113	4.923	5.366	5.122	0.114	4.903	5.348
a_{34}	7.357	0.156	7.056	7.668	7.391	0.156	7.085	7.702	7.360	0.157	7.058	7.674
b_3	1.231	0.044	1.145	1.316	1.230	0.044	1.145	1.318	1.235	0.051	1.139	1.342

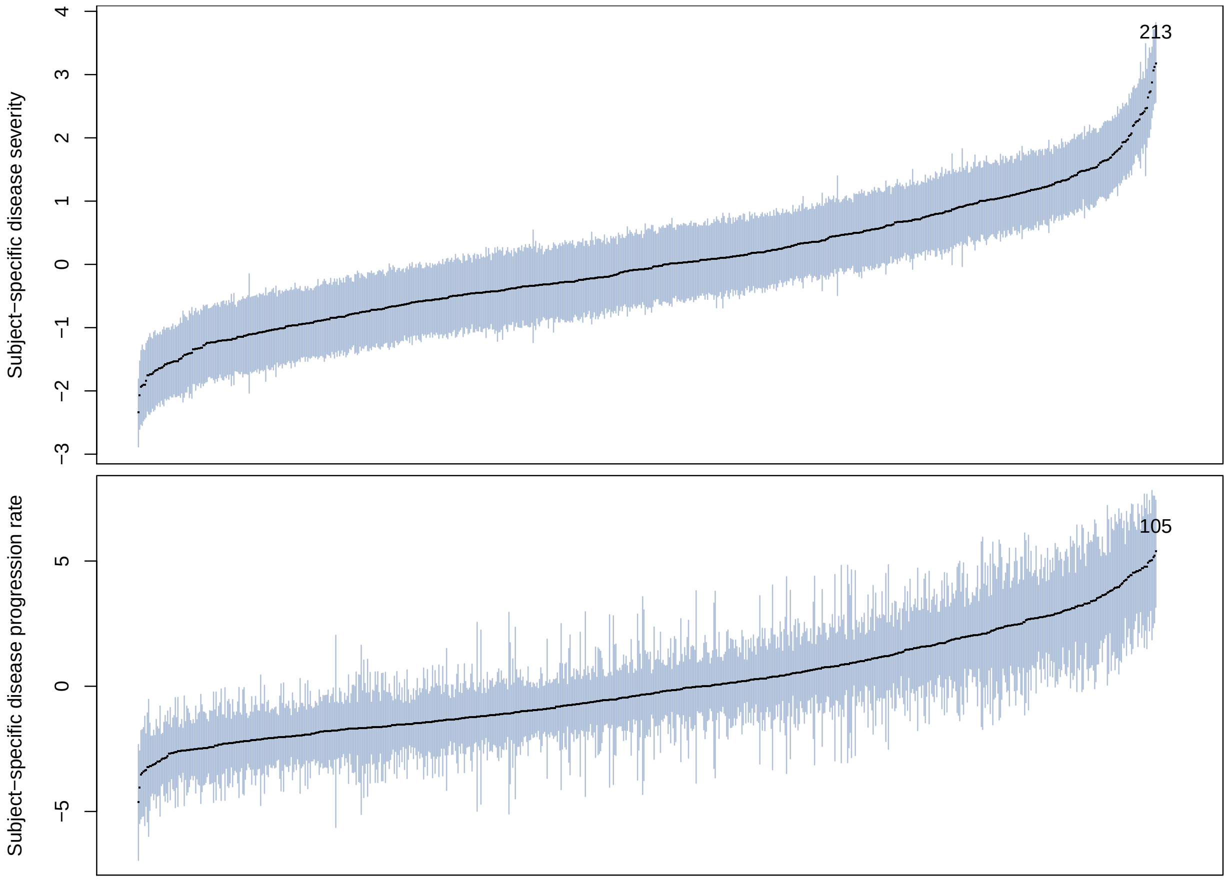

Figure 1: The ranking of the subject-specific disease severity u_{hi0} (upper panel) and the disease progression rate u_{hi1} (lower panel) with point estimates and 95% CIs. The numbers in the figures are patients' ID.

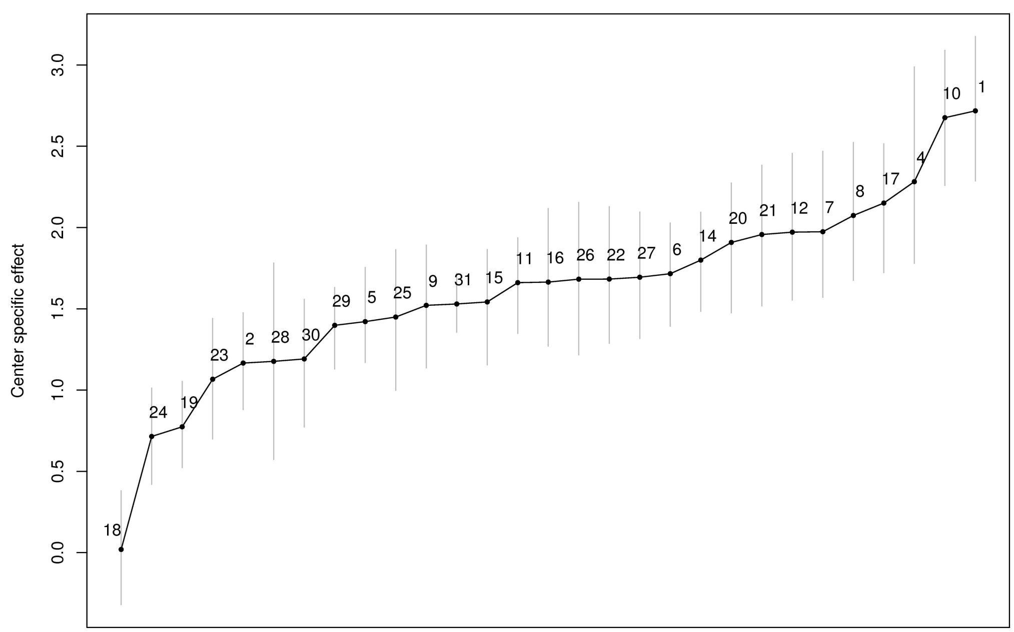

Figure 2: The ranking of the center-specific random effects v_h with point estimates and 95% CIs. The number in the figure is a center's ID.

BUGS code for fitting full model (8) with piecewise-constant baseline hazard function.

```
model {
  for (i in 1:obs) { # obs: number of total observations
    Y.conti[i] ~ dnorm(mu.conti[i], tau.conti)
    # K.ordi: number of ordinal variables. K=2 in DATATOP study
    for (k in 1:K.ordi) { Y.ordi[i, k] ~ dcat(prob.y[i, k, 1:n.ordi[k]]) }
    # construct the means for the continuous variables
    mu.conti[i] <- a.conti + b.conti * theta[i]
  }
  # construct the probability vector for the ordinal variables
  for (i in 1:obs) {
    for (k in 1:K.ordi) {
      for (l in 1:(n.ordi[k]-1)) { logit(psi[i, k, l]) <- a.ordi[k, l] - b.ordi[k]*theta[i] }
      psi[i, k, n.ordi[k]] <- 1
      prob.y[i, k, 1] <- psi[i, k, 1]
      for (l in 2:n.ordi[k]) { prob.y[i, k, l] <- psi[i, k, l] - psi[i, k, l-1]}
    }
  }
  # construct random effects
  for (i in 1:H) { v[i] ~ dnorm(0, tau.v) } # H: number of centers
  for (i in 1:N) { U[i, 1:2] ~ dmnorm(zero[], pr.U[,]) } # N: total number of individuals. N=800 in DATATOP study
  # construct the variance-covariance matrix
  pr.U[1:2, 1:2] <- inverse(Sigma.U[,])
  Sigma.U[1, 1] <- 1
  Sigma.U[1, 2] <- rho*sig
  Sigma.U[2, 1] <- Sigma.U[1, 2]
  Sigma.U[2, 2] <- sig*sig
  # construct theta[i], the latent variable of subject i at time j
  for (i in 1:obs) {
    theta[i] <- beta0*treat[i] + U[subject[i], 1] + v[center.obs[i]] + (beta1[1] + beta1[2]*treat[i] + U[subject[i], 2])*t[i]
  }
  # construct survival part
  for (i in 1:N) {
    zeros[i] <- 0
    phi[i] <- -log(L[i])
    zeros[i] ~ dpois(phi[i])
    # k is the number of time interval for baseline step function
    for (k in 1:3) {
      h0[i,k] <- inprod(g[k],I0[i,k])
      gt[i,k] <- inprod(g[k],dt1[i,k])
    }
    L[i] <- pow(h[i],event[i])*S[i]/1.0E+08  # event=1 for event; 0 for censored
    h[i] <- exp(gam*treat.pts[i] + nu0*U[i, 1] + nu1*U[i,2] + nu2*v[center.pts[i]])*sum(h0[i,])
    S[i] <- exp(-exp(gam*treat.pts[i] + nu0*U[i, 1] + nu1*U[i,2] + nu2*v[center.pts[i]])*sum(gt[i,]))
  }
  # prior for piecewise constants
  for (k in 1:3) {  g[k] ~dunif(0,20) }
  # prior for regression coefficients
  beta0 ~ dnorm(0, 0.01)
  for (i in 1:2) { beta1[i] ~ dnorm(0, 0.01) }
  # prior for survival coefficients
  gam ~ dnorm(0, 0.01)
  nu0 ~ dnorm(0, 0.01)
  nu1 ~ dnorm(0, 0.01)
  nu2 ~ dnorm(0, 0.01)
  # prior for variances of random effects
  rho ~ dunif(-1, 1)
```

```
  sig ~ dgamma(0.01, 0.01)
  tau.v ~ dgamma(0.01, 0.01)
  sd.v <- 1/sqrt(tau.v)
  # prior for continuous variable's parameters
  b.conti ~ dunif(0, 30)
  a.conti ~ dnorm(0, 0.005)
  tau.conti ~ dgamma(0.01, 0.01)
  sd.conti <- 1/sqrt(tau.conti)
  # prior for ordinal variables' parameters
  b.ordi[1] ~ dunif(0, 30)
  a.ordi[1, 1] <- 0
  for (l in 2:(n.ordi[1]-1)) { a.ordi[1, l] <- a.ordi[1, l-1] + delta[1, l-1] }
  for (i in 1:(n.ordi[1]-2)) {delta[1, i] ~ dnorm(0, 0.01)I(0,) }
  for (k in 2:K.ordi) {
    b.ordi[k] ~ dunif(0, 30)
    a.ordi[k, 1] ~ dnorm(0, 0.01)
    for (l in 2:(n.ordi[k]-1)) { a.ordi[k, l] <- a.ordi[k, l-1] + delta[k, l-1]}
    for (i in 1:(n.ordi[k]-2)) { delta[k, i] ~ dnorm(0, 0.01)I(0,) }
  }
}
```