

Supplementary Material for “Modeling Disease Progression in the Presence of an Outcome-dependent Visiting Process with Application to Cystic Fibrosis Clinical Data”

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1. Table S1 Parameter Estimations of Joint Model with Random Slope (Slope_JM) and Intercept (Int_JM)
2. Table S2 Parameter Estimations of LME Model with GP and Adjusted by Number of Visits within a year
3. Table S3 Percentage of Replications Selected as the Best-Performing Model Under Outcome-Dependent Visiting Process
4. Table S4 Percentage of Replications Selected as the Best-Performing Model Under Outcome-Independent Visiting Process
5. Table S5 Simulation Result from $M = 50$ Replications for Data with Longitudinal Responses Dependent ($\gamma = -2$) on Sparse Visits
6. Table S6 Simulation Result from $M = 50$ Replications for Data with Longitudinal Responses Independent ($\gamma = 0$) on Sparse Visits
7. Figure S1 Trace Plot of Parameter Posterior from Monte Carlo Sampling
8. Figure S2 Residual Diagnostic of the Joint Model with GP of CF Application

Table S1 Parameter Estimation of Joint Model with Random Slope (Slope_JM) and Intercept (Int_JM)

Parameter	Estimation (95% HPD)	
	Slope_JM	Int_JM
LME with GP Submodel (Lung Function)		
α_0 , Intercept	102.46 (96.85, 107.95)	92.2 (86.3, 97.83)
α_1 , Age	-0.41 (-0.88, 0.14)	-0.59 (-0.09, -1.00)
α_2 , Gender (Male)	-0.66 (-4.96, 3.82)	-0.9 (-5.21, 3.65)
α_3 , CF-related diabetes mellitus	-4.26 (-9.58, 0.83)	-8.22 (-13.58, -2.67)
α_4 , Methicillin-resistant Staphylococcus aureus	-0.84 (-1.8, 0.15)	0.14 (-1.43, 1.67)
α_5 , Pseudomonas aeruginosa	-1.94 (-3.25, -0.51)	-2.72 (-4.03, -1.41)
α_6 , Medicaid insurance	-3.74 (-7.95, 0.67)	0.58 (-4.14, 5.49)
$\sigma_{b_0}^2$, Variance of intercept	23.86 (20.78, 27.35)	17.86 (15.98, 19.94)
$\sigma_{b_1}^2$, Variance of slope	2.00 (1.74, 2.31)	---
σ^2 , Variance of residual	7.16 (6.99, 7.33)	7.48 (7.30, 7.66)
γ , Association	-1.66 (-2.00, 0.50)	-1.19 (-3.53, -1.05)
Survival Submodel (Log Hazard Ratio for Visiting Process)		
β_0 , Intercept	1.80 (1.47, 2.12)	1.40 (1.12, 1.66)
β_1 , Age at previous visit	0.08 (0.06, 0.10)	0.11 (0.09, 0.12)
β_2 , Gender (Male)	-0.22 (-0.43, -0.01)	-0.23 (-0.45, -0.03)
β_3 , CF-related diabetes mellitus	0.09 (-0.17, 0.34)	0.06 (-0.19, 0.3)
β_4 , Methicillin-resistant Staphylococcus aureus	-0.04 (-0.17, 0.08)	0.04 (-0.02, 0.1)
β_5 , Pseudomonas aeruginosa	-0.25 (-0.37, -0.13)	-0.06 (-0.11, -0.01)
β_6 , Medicaid insurance	0.24 (0.02, 0.46)	0.24 (0.02, 0.47)
κ , Weibull shape	1.89 (1.84, 1.94)	1.89 (1.84, 1.94)
σ_{μ}^2 , Variance of u_i	0.66 (0.57, 0.76)	0.68 (0.59, 0.78)

Table S2 Parameter Estimations of LME Model with GP and adjusted by number of visits within a year

Parameter	Estimation (95% HPD)
α_0 , Intercept	102.16 (95.7, 108.44)
α_1 , Age	-0.83 (-1.22, -0.44)
α_2 , Gender (Male)	1.62 (-2.48, 5.89)
α_3 , CF-related diabetes mellitus	-9.17 (-14.28, -4.05)
α_4 , Methicillin-resistant Staphylococcus aureus	-1.04 (-1.87, -0.19)
α_5 , Pseudomonas aeruginosa	-1.36 (-2.13, -0.6)
α_6 , Medicaid insurance	-2.77 (-6.96, 1.55)
α_7 , Num. of Visit/year	-0.12 (-0.62, 0.4)
α_8 , Age*Num. of Visit/year	0.01 (-0.02, 0.04)
ϕ^2 , GP marginal variance	5.41 (4.76, 6.23)
ρ , GP length scale	1.09 (0.82, 1.41)
σ^2 , Variance of residual	6.75 (6.56, 6.94)

Table S3 Percentage of Replications Selected as the Best-Performing Model Under Outcome-Dependent Visiting Process

Model	LPML	DIC	WAIC	RMSE	MAD
<u>Random intercept</u>					
Int_null	0	0	0	0	0
Int_nvisit	0	0	0	0	0
Int_JM	0	0	0	0	0
<u>Random intercept and slope</u>					
Slope_null	0	0	0	0	0
Slope_nvisit	0	0	0	0	0
Slope_JM	0	0	0	0	0
<u>Random intercept and GP</u>					
GP_null	0	0	0	0	0
GP_nvisit	0	0	0	0	0
GP_JM	100	100	100	100	100

See Table 4 for parameter estimates and Section 4.2 for model abbreviations and descriptions.

Abbreviations: DIC = deviance information criterion; LPML = log-pseudo marginal likelihood; MAD = mean absolute deviation; RMSE = root mean square error; SD = standard deviation; WAIC = Watanabe-Akaike information criterion.

Table S4 Percentage of Replications Selected as the Best-Performing Model Under Outcome-Independent Visiting Process

Model	LPML	DIC	WAIC	RMSE	MAD
<u>Random intercept</u>					
Int_null	0	0	0	0	0
Int_nvisit	0	0	0	0	0
Int_JM	0	0	0	0	0
<u>Random intercept and slope</u>					
Slope_null	0	0	0	0	0
Slope_nvisit	0	0	0	0	0
Slope_JM	0	0	0	0	0
<u>Random intercept and GP</u>					
GP_null	26	24	26	26	26
GP_nvisit	32	32	32	54	50
GP_JM	42	44	42	20	24

See Table 5 for parameter estimates and Section 4.2 for model abbreviations and descriptions.

Abbreviations: DIC = deviance information criterion; LPML = log-pseudo marginal likelihood; MAD = mean absolute deviation; RMSE = root mean square error; SD = standard deviation; WAIC = Watanabe-Akaike information criterion.

Table S5 Simulation Result from $M = 50$ Replications for Data with Longitudinal Responses Dependent ($\gamma = -2$) on Sparse Visits

a. Parameter Estimation

True Model	Intercept			Age			Gender			Association		
	C_{95}	$\alpha_0 = 85$ Bias(SD)	RMSE	C_{95}	$\alpha_1 = -0.5$ Bias(SD)	RMSE	C_{95}	$\alpha_2 = 1$ Bias(SD)	RMSE	C_{95}	$\gamma = -2$ Bias(SD)	RMSE
<u>Random intercept</u>												
Int_null	0	9.65 (1.69)	10.06	0	1.36 (0.43)	1.37	38	2.99 (1.22)	3.33	---	---	---
Int_nvisit	76	2.80 (1.43)	3.45	0	0.75 (0.45)	0.78	46	2.82 (1.20)	3.17	---	---	---
Int_JM	82	1.39 (1.14)	1.89	90	0.11 (0.25)	0.13	98	0.56 (0.70)	0.74	92	0.6 (1.17)	1.48
<u>Random intercept and slope</u>												
Slope_null	36	4.40 (1.30)	4.71	0	0.91 (0.35)	0.92	48	2.09 (1.00)	2.31	---	---	---
Slope_nvisit	94	1.82 (1.19)	2.30	0	0.70 (0.35)	0.72	50	2.05 (0.99)	2.27	---	---	---
Slope_JM	84	1.26 (0.96)	1.56	94	0.11 (0.24)	0.12	96	0.52 (0.64)	0.66	94	0.31 (0.50)	0.40
<u>Random intercept and GP</u>												
GP_null	36	5.06 (1.43)	5.44	0	1.08 (0.37)	1.09	38	2.99 (1.21)	3.32	---	---	---
GP_nvisit	80	2.63 (1.35)	3.19	0	0.86 (0.39)	0.88	42	2.89 (1.21)	3.23	---	---	---
GP_JM	88	1.88 (1.98)	4.31	90	0.12 (0.25)	0.13	98	0.49 (0.64)	0.64	96	0.31 (0.53)	0.42

b. Percentage of Being the Best Performed Model

Model	LPML	DIC	WAIC	RMSE	MAD
<u>Random intercept</u>					
Int_null	0	0	0	0	0
Int_nvisit	0	0	0	0	0
Int_JM	0	0	0	0	0
<u>Random intercept and slope</u>					
Slope_null	0	0	0	0	0
Slope_nvisit	0	0	0	0	0
Slope_JM	0	0	0	0	0
<u>Random intercept and GP</u>					
GP_null	0	0	0	0	0
GP_nvisit	0	0	0	0	0
GP_JM	100	100	100	100	100

Table S6 Simulation Result from $M = 50$ Replications for Data with Longitudinal Responses Independent ($\gamma = 0$) on Sparse Visits

a. Parameter Estimation

True Model	Intercept			Age			Gender			Association		
	C_{95}	$\alpha_0 = 85$ Bias(SD)	RMSE	C_{95}	$\alpha_1 = -0.5$ Bias(SD)	RMSE	C_{95}	$\alpha_2 = 1$ Bias(SD)	RMSE	C_{95}	$\gamma = 0$ Bias(SD)	RMSE
<u>Random intercept</u>												
Int_null	94	0.49 (0.64)	0.64	92	0.03 (0.15)	0.03	100	0.19 (0.36)	0.23	---	---	---
Int_nvisit	82	1.43 (1.03)	1.77	82	0.08 (0.24)	0.10	100	0.19 (0.36)	0.23	---	---	---
Int_JM	94	0.57 (0.65)	0.71	92	0.05 (0.19)	0.06	100	0.23 (0.44)	0.30	92	0.12 (0.47)	0.25
<u>Random intercept and slope</u>												
Slope_null	94	0.49 (0.64)	0.64	92	0.03 (0.15)	0.03	100	0.20 (0.36)	0.24	---	---	---
Slope_nvisit	82	1.48 (1.04)	1.83	82	0.08 (0.24)	0.10	100	0.21 (0.36)	0.24	---	---	---
Slope_JM	94	0.57 (0.65)	0.70	94	0.04 (0.18)	0.05	100	0.23 (0.42)	0.29	92	0.10 (0.42)	0.20
<u>Random intercept and GP</u>												
GP_null	92	0.47 (0.62)	0.60	92	0.02 (0.14)	0.03	100	0.18 (0.37)	0.23	---	---	---
GP_nvisit	82	1.3 (0.97)	1.59	88	0.07 (0.23)	0.09	100	0.18 (0.36)	0.22	---	---	---
GP_JM	94	0.51 (0.61)	0.63	96	0.04 (0.16)	0.05	100	0.21 (0.37)	0.25	98	0.08 (0.3)	0.12

b. Percentage of Being the Best Performed Model

Model	LPML	DIC	WAIC	RMSE	MAD
<u>Random intercept</u>					
Int_null	0	0	0	0	0
Int_nvisit	0	0	0	0	0
Int_JM	0	0	0	0	0
<u>Random intercept and slope</u>					
Slope_null	0	0	0	0	0
Slope_nvisit	0	0	0	0	0
Slope_JM	0	0	0	0	0
<u>Random intercept and GP</u>					
GP_null	38	38	32	34	32
GP_nvisit	34	32	36	32	40
GP_JM	28	30	32	34	28

Figure S1 Trace Plot of Parameter Posterior from Monte Carlo Sampling

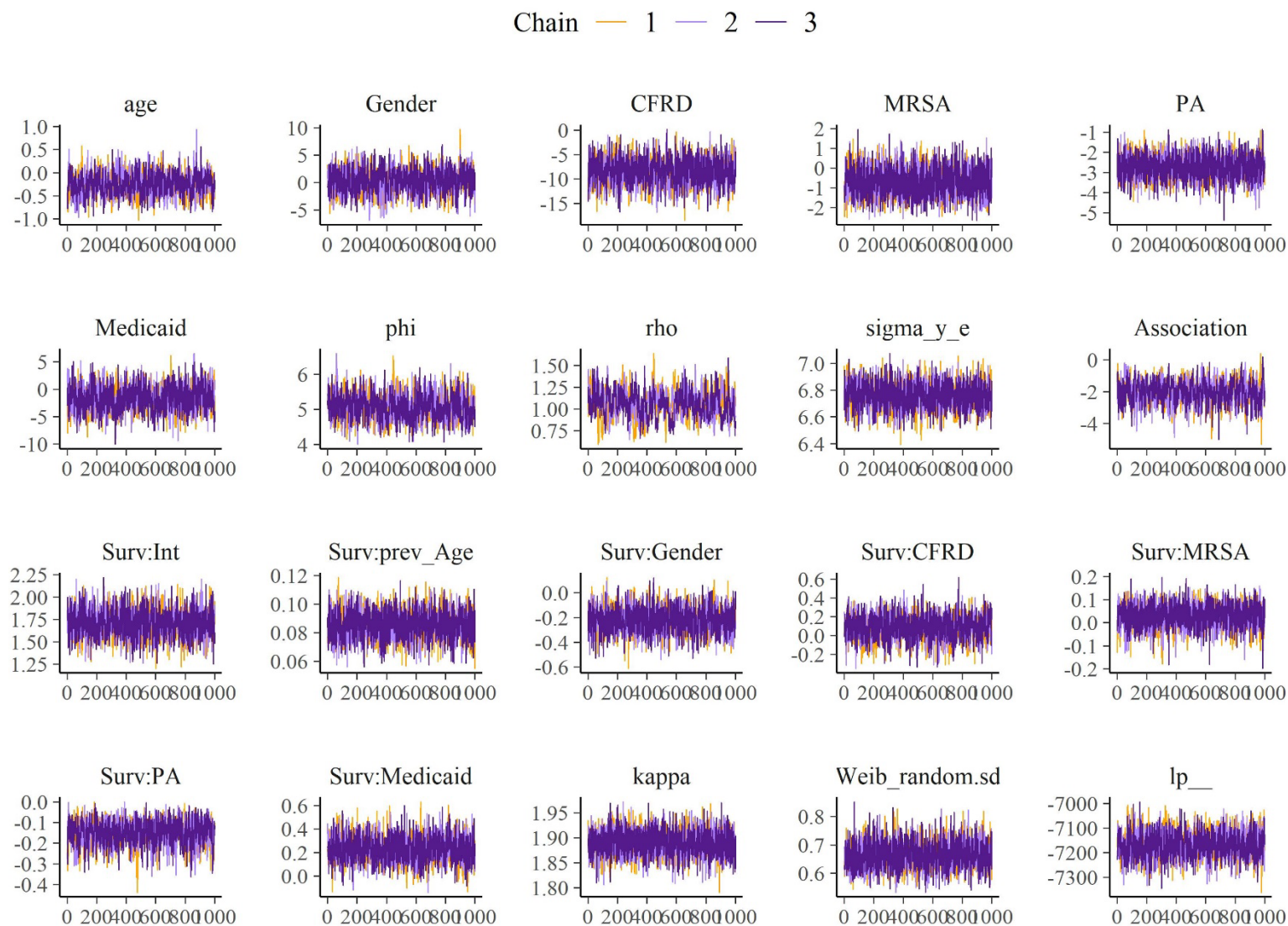


Figure S2 Residual Diagnostic of the Joint Model with GP of CF Application

