Supplementary materials for

"Copas-Like Selection Model to Correct Publication Bias in Systematic Review of Diagnostic Test Studies"

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A: Additional Simulation Studies

We have performed the simulation studies by varying the values of all parameters under the model. Specifically, we have considered combinations of the following settings: the sensitivity and specificity were respectively set to be (0.5, 0.85), (0.8, 0.8) or (0.9, 0.4); the between-study variances were (0.5, 0.5) or (1, 2); the correlation between sensitivity and specificity ρ_B was -0.3 or -0.6; the correlation parameters ρ_1 and ρ_2 were (0.3, 0.3) or (0.2, 0.5); and the non-publishing rate was 15% or 30%. In total, we considered 54 unique simulation settings under different combinations of the parameter values. The simulation results under these settings in Table S1-S7 have the same patterns as those reported in Tables 2-3 in the manuscript. All the results are based on 1000 simulations. Here are some abbreviations for the tables, NP: non-publishing rate; N: sample size; PAR: parameter; TRUE: true parameter value; MEAN: point estimate; SD: empirical standard deviation; SE: model-based standard error; RMSE: root mean squared error; CP: 95% coverage probability.

We have performed simulations with more publication bias. The non-publishing rate was set to be 40% or 50% by letting $(\gamma_0, \gamma_1, \gamma_2)$ equal (-1.0, 0.25, 0.25) or (-1.3, 0.25, 0.25), respectively. Other simulations were similar, as described in the manuscript. We have summarized the results for non-publishing rates ranging from 15% to 50% in Table S8. We made several observations. First, compared to the nave method, the proposed EM-CLM method yielded relatively smaller biases for

the parameters of primary interest β_1 and β_2 (sensitivity and specificity on the logit scale), though the differences were not large. Second, the coverage probabilities obtained from the proposed EM-CLM were close to the nominal level, but those from the naive method were not. When using the naive method without adjusting for publication bias, as the non-publishing rates increase, the deviation from the nominal levels also increases, which would produce misleading results. Third, as non-publishing rates increase, the convergence rates decrease. With a sample size of 200, the convergence rate was 75.4% when the non-publishing rate was 40%, and decreased to 52.9% when the non-publishing rate increased to 50%.

B: Sensitivity Analysis

We have conducted sensitivity studies to evaluate the robustness of the proposed method with respect to violations of model assumptions under two scenarios: (i) violation of the normality assumptions as specified in equations (1); and (ii) violation of the publication process as specified in equation (2).

For Scenario (i), we generated $(\delta_i, \epsilon_{i1}, \epsilon_{i1})$ from the multivariate t distribution with correlation matrix $CM = (1, \rho_1, \rho_2; 1, 0, \rho_2; \rho_2, 0, 1)$, in which the degree of freedom (DF) is chosen to control the degree of violation of the normal distribution assumption. The value for the DF in the simulations was 5 or 10 under the settings of strong and weak violations of the normality assumption. The parameters ρ_1 and ρ_2 in the correlation matrix were (0.3, 0.3). The between-study heterogeneities τ_1 and τ_2 were set to be (0.5, 0.5), and the correlation between sensitivity and specificity ρ_B was -0.4. The results based on 1000 simulations are summarized in Table S9. Under all the simulation settings considered, the performance of the proposed method was reasonably robust to the violations of the normality assumptions. Even in the scenario with a strong violation from normality (DF=5), the standardized biases for sensitivity and specificity were less than 6%.

For Scenario (ii), we introduced the selection process using the Youden index, which is a commonly used univariate measure in diagnostic studies (Youden, 1950). Specifically, we generated $\{N+k\}$ pairs of sensitivity and specificity from the random effects model, then removed k pairs with the lowest

Youden index in order to achieve either 15% or 30% non-publishing rate (Bürkner and Doebler, 2014). Sensitivity and specificity were respectively set to be (0.5, 0.85) or (0.8, 0.8), and the sample size was 50. The between-study heterogeneities τ_1 and τ_2 were set to be (0.5, 0.5), and the correlation between sensitivity and specificity ρ_B was -0.4. The parameters ρ_1 and ρ_2 in the correlation matrix were (0.3, 0.3). The results based on 1000 simulations are summarized in Table S10. Although the way we introduce the publication process is different from the proposed selection model, the estimated results for the parameters of interest (β_1, β_2) remain in a reasonable range. For example, the standardized biases are less than 6% when the non-publishing rate is 15%, and are less than 12% when the non-publishing rate is 30%.

Table S1: Summary statistics when $(\beta_1, \beta_2, \tau_1, \tau_2, \rho_B, \rho_1, \rho_2) = (0, 1.735, 0.5, 0.5, -0.6, 0.3, 0.3)$.

				EM-CLM					**Bivariate-LMM**				
NP(%)	N	PAR	TRUE	MEAN	SD	SE	RMSE	CP	MEAN	SD	SE	RMSE	CP
15	15	β_1	0	0.008	0.185	0.178	0.185	0.919	0.029	0.182	0.165	0.184	0.904
		β_2	1.735	1.745	0.181	0.178	0.181	0.931	1.764	0.177	0.165	0.179	0.921
		τ_1	0.5	0.451	0.176	0.160	0.183	0.868	0.446	0.171	0.149	0.179	0.861
		τ_2	0.5	0.454	0.175	0.165	0.181	0.917	0.447	0.175	0.151	0.183	0.908
		ρ_B	-0.6	-0.677	0.341	0.646	0.350	0.962	-0.688	0.338	0.621	0.349	0.973
	50	β_1	0	0.010	0.096	0.098	0.097	0.953	0.031	0.094	0.092	0.099	0.929
		β_2	1.735	1.747	0.096	0.098	0.097	0.937	1.767	0.094	0.092	0.099	0.924
		τ_1	0.5	0.488	0.085	0.086	0.086	0.930	0.485	0.085	0.082	0.086	0.939
		τ_2	0.5	0.488	0.083	0.086	0.084	0.940	0.485	0.082	0.082	0.083	0.929
		ρ_B	-0.6	-0.621	0.213	0.221	0.214	0.925	-0.635	0.206	0.207	0.209	0.913
	200	β_1	0	0.008	0.047	0.049	0.048	0.954	0.029	0.046	0.047	0.054	0.914
		β_2	1.735	1.744	0.048	0.049	0.049	0.940	1.764	0.047	0.047	0.055	0.895
		τ_1	0.5	0.495	0.043	0.043	0.043	0.930	0.493	0.043	0.041	0.044	0.917
		τ_2	0.5	0.495	0.041	0.042	0.041	0.950	0.493	0.041	0.041	0.042	0.941
		ρ_B	-0.6	-0.605	0.105	0.105	0.105	0.931	-0.619	0.101	0.099	0.103	0.918
30	15	β_1	0	0.016	0.189	0.191	0.190	0.897	0.048	0.181	0.163	0.187	0.895
		β_2	1.735	1.745	0.186	0.193	0.186	0.886	1.778	0.174	0.162	0.179	0.897
		τ_1	0.5	0.452	0.171	0.153	0.178	0.840	0.445	0.167	0.145	0.176	0.867
		τ_2	0.5	0.462	0.165	0.153	0.169	0.877	0.452	0.163	0.145	0.170	0.890
		ρ_B	-0.6	-0.662	0.334	0.640	0.340	0.969	-0.683	0.331	0.574	0.341	0.973
	50	β_1	0	0.014	0.097	0.108	0.098	0.944	0.049	0.093	0.091	0.105	0.917
		β_2	1.735	1.746	0.097	0.108	0.098	0.947	1.778	0.091	0.091	0.101	0.917
		τ_1	0.5	0.487	0.084	0.088	0.085	0.929	0.484	0.080	0.079	0.082	0.935
		τ_2	0.5	0.490	0.086	0.088	0.087	0.917	0.485	0.082	0.079	0.083	0.920
		ρ_B	-0.6	-0.607	0.212	0.223	0.212	0.908	-0.623	0.201	0.200	0.202	0.912
	200	β_1	0	0.011	0.050	0.056	0.051	0.943	0.046	0.046	0.046	0.065	0.824
		β_2	1.735	1.748	0.053	0.056	0.055	0.928	1.780	0.048	0.046	0.066	0.813
		τ_1	0.5	0.496	0.043	0.045	0.043	0.934	0.494	0.041	0.039	0.041	0.920
		τ_2	0.5	0.496	0.043	0.045	0.043	0.935	0.494	0.041	0.039	0.041	0.933
		ρ_B	-0.6	-0.605	0.104	0.116	0.104	0.928	-0.617	0.095	0.096	0.097	0.921

Table S2: Summary statistics when $(\beta_1, \beta_2, \tau_1, \tau_2, \rho_B, \rho_1, \rho_2) = (0, 1.735, 0.5, 0.5, -0.3, 0.2, 0.5)$.

				EM-CLM					**Bivariate-LMM**				
NP(%)	N	PAR	TRUE	MEAN	SD	SE	RMSE	CP	MEAN	SD	SE	RMSE	CP
15	15	β_1	0	0.005	0.190	0.170	0.190	0.889	0.019	0.186	0.164	0.187	0.884
		β_2	1.735	1.748	0.189	0.173	0.189	0.902	1.783	0.184	0.163	0.190	0.890
		τ_1	0.5	0.444	0.178	0.154	0.187	0.893	0.439	0.177	0.151	0.187	0.887
		τ_2	0.5	0.445	0.168	0.155	0.177	0.900	0.435	0.166	0.151	0.178	0.896
		ρ_B	-0.3	-0.458	0.389	0.834	0.420	0.916	-0.469	0.391	0.747	0.426	0.926
	50	β_1	0	0.005	0.097	0.097	0.097	0.936	0.019	0.095	0.093	0.097	0.929
		β_2	1.735	1.750	0.099	0.099	0.100	0.940	1.786	0.096	0.092	0.109	0.904
		τ_1	0.5	0.487	0.085	0.086	0.086	0.940	0.484	0.084	0.083	0.086	0.938
		τ_2	0.5	0.483	0.091	0.086	0.093	0.924	0.475	0.087	0.082	0.091	0.925
		ρ_B	-0.3	-0.331	0.243	0.271	0.245	0.921	-0.344	0.243	0.251	0.247	0.921
	200	β_1	0	0.005	0.048	0.049	0.048	0.952	0.019	0.047	0.047	0.051	0.928
		β_2	1.735	1.751	0.049	0.050	0.052	0.937	1.787	0.047	0.047	0.070	0.797
		τ_1	0.5	0.495	0.044	0.043	0.044	0.938	0.493	0.043	0.041	0.044	0.938
		τ_2	0.5	0.493	0.043	0.044	0.044	0.940	0.487	0.041	0.041	0.043	0.935
		ρ_B	-0.3	-0.300	0.125	0.129	0.125	0.935	-0.318	0.120	0.122	0.121	0.932
30	15	β_1	0	0.013	0.185	0.189	0.185	0.899	0.034	0.178	0.161	0.181	0.900
		β_2	1.735	1.763	0.195	0.187	0.197	0.872	1.819	0.179	0.161	0.198	0.854
		τ_1	0.5	0.447	0.174	0.156	0.182	0.889	0.441	0.174	0.147	0.184	0.895
		τ_2	0.5	0.448	0.166	0.154	0.174	0.880	0.439	0.159	0.147	0.170	0.888
		ρ_B	-0.3	-0.439	0.372	0.806	0.397	0.914	-0.447	0.377	0.715	0.405	0.934
	50	β_1	0	0.010	0.099	0.108	0.100	0.945	0.033	0.094	0.092	0.100	0.920
		β_2	1.735	1.758	0.105	0.107	0.107	0.920	1.817	0.095	0.091	0.125	0.828
		τ_1	0.5	0.487	0.083	0.092	0.084	0.930	0.484	0.081	0.081	0.083	0.934
		τ_2	0.5	0.485	0.091	0.084	0.092	0.903	0.477	0.082	0.079	0.085	0.918
		ρ_B	-0.3	-0.327	0.231	0.273	0.233	0.924	-0.338	0.231	0.241	0.234	0.914
	200	β_1	0	0.008	0.051	0.054	0.052	0.947	0.032	0.047	0.046	0.057	0.898
		β_2	1.735	1.758	0.053	0.056	0.058	0.908	1.818	0.047	0.046	0.095	0.567
		τ_1	0.5	0.496	0.043	0.045	0.043	0.939	0.494	0.041	0.040	0.041	0.937
		τ_2	0.5	0.494	0.044	0.044	0.044	0.933	0.489	0.040	0.040	0.041	0.938
		ρ_B	-0.3	-0.304	0.124	0.136	0.124	0.940	-0.320	0.117	0.117	0.119	0.942

Table S3: Summary statistics when $(\beta_1, \beta_2, \tau_1, \tau_2, \rho_B, \rho_1, \rho_2) = (0, 1.735, 1, 2, -0.3, 0.2, 0.5)$.

				EM-CLM					**Bivariate-LMM**				
NP(%)	N	PAR	TRUE	MEAN	SD	SE	RMSE	CP	MEAN	SD	SE	RMSE	CP
15	15	β_1	0	0.012	0.306	0.281	0.306	0.913	0.029	0.301	0.272	0.302	0.906
		β_2	1.735	1.740	0.562	0.532	0.562	0.914	1.791	0.552	0.513	0.555	0.913
		τ_1	1	0.928	0.235	0.218	0.246	0.870	0.925	0.235	0.216	0.247	0.873
		τ_2	2	1.914	0.383	0.380	0.393	0.900	1.912	0.379	0.377	0.389	0.906
		ρ_B	-0.3	-0.330	0.250	0.281	0.252	0.904	-0.333	0.250	0.269	0.252	0.902
	50	β_1	0	0.008	0.161	0.160	0.161	0.934	0.027	0.159	0.155	0.161	0.932
		β_2	1.735	1.753	0.297	0.300	0.298	0.954	1.807	0.294	0.289	0.303	0.943
		τ_1	1	0.981	0.123	0.124	0.124	0.936	0.979	0.122	0.122	0.124	0.933
		τ_2	2	1.978	0.215	0.219	0.216	0.935	1.973	0.211	0.211	0.213	0.933
		ρ_B	-0.3	-0.301	0.155	0.154	0.155	0.934	-0.304	0.153	0.149	0.153	0.939
	200	β_1	0	0.006	0.080	0.081	0.080	0.953	0.026	0.079	0.078	0.083	0.926
		β_2	1.735	1.755	0.147	0.150	0.148	0.948	1.809	0.146	0.145	0.164	0.917
		τ_1	1	0.993	0.065	0.063	0.065	0.935	0.992	0.064	0.061	0.064	0.934
		τ_2	2	1.991	0.107	0.111	0.107	0.946	1.987	0.105	0.106	0.106	0.949
		ρ_B	-0.3	-0.297	0.078	0.078	0.078	0.948	-0.301	0.076	0.075	0.076	0.946
30	15	β_1	0	0.020	0.302	0.324	0.303	0.911	0.047	0.293	0.272	0.297	0.901
		β_2	1.735	1.774	0.575	0.626	0.576	0.922	1.852	0.550	0.510	0.562	0.912
		τ_1	1	0.933	0.232	0.234	0.241	0.877	0.931	0.234	0.214	0.244	0.892
		τ_2	2	1.904	0.389	0.402	0.401	0.879	1.906	0.383	0.374	0.394	0.891
		ρ_B	-0.3	-0.322	0.242	0.307	0.243	0.898	-0.325	0.242	0.268	0.243	0.908
	50	β_1	0	0.014	0.164	0.181	0.165	0.951	0.044	0.159	0.154	0.165	0.936
		β_2	1.735	1.764	0.311	0.338	0.312	0.952	1.848	0.297	0.288	0.318	0.930
		τ_1	1	0.978	0.121	0.135	0.123	0.933	0.977	0.118	0.120	0.120	0.930
		τ_2	2	1.971	0.217	0.235	0.219	0.918	1.968	0.209	0.210	0.211	0.930
		ρ_B	-0.3	-0.300	0.153	0.168	0.153	0.939	-0.303	0.148	0.148	0.148	0.942
	200	β_1	0	0.009	0.082	0.091	0.082	0.965	0.042	0.079	0.078	0.089	0.913
		β_2	1.735	1.764	0.153	0.173	0.156	0.951	1.851	0.146	0.145	0.186	0.865
		τ_1	1	0.994	0.064	0.069	0.064	0.952	0.992	0.062	0.060	0.063	0.938
		τ_2	2	1.992	0.106	0.124	0.106	0.962	1.989	0.102	0.106	0.103	0.956
		ρ_B	-0.3	-0.299	0.079	0.087	0.079	0.951	-0.303	0.075	0.074	0.075	0.942

Table S4: Summary statistics when $(\beta_1, \beta_2, \tau_1, \tau_2, \rho_B, \rho_1, \rho_2) = (1.386, 1.386, 2, -0.3, 0.3, 0.3)$.

				EM-CLM					**Bivariate-LMM**				
NP(%)	N	PAR	TRUE	MEAN	SD	SE	RMSE	CP	MEAN	SD	SE	RMSE	CP
15	15	β_1	1.386	1.397	0.301	0.289	0.301	0.914	1.425	0.297	0.274	0.300	0.903
		β_2	1.386	1.404	0.548	0.535	0.548	0.926	1.433	0.540	0.514	0.542	0.918
		τ_1	1	0.934	0.242	0.225	0.251	0.888	0.930	0.240	0.217	0.250	0.889
		τ_2	2	1.918	0.389	0.384	0.398	0.896	1.916	0.387	0.377	0.396	0.898
		ρ_B	-0.3	-0.335	0.254	0.282	0.256	0.880	-0.338	0.255	0.268	0.258	0.884
	50	β_1	1.386	1.399	0.162	0.161	0.163	0.942	1.429	0.159	0.155	0.165	0.927
		β_2	1.386	1.404	0.300	0.299	0.301	0.937	1.435	0.296	0.289	0.300	0.926
		τ_1	1	0.981	0.122	0.125	0.123	0.939	0.979	0.121	0.122	0.123	0.937
		τ_2	2	1.979	0.209	0.217	0.210	0.944	1.976	0.207	0.211	0.208	0.942
		ρ_B	-0.3	-0.308	0.155	0.154	0.155	0.926	-0.311	0.154	0.148	0.154	0.922
	200	β_1	1.386	1.396	0.080	0.081	0.081	0.944	1.427	0.078	0.078	0.088	0.919
		β_2	1.386	1.400	0.150	0.150	0.151	0.945	1.432	0.148	0.146	0.155	0.932
		τ_1	1	0.993	0.064	0.063	0.064	0.934	0.990	0.063	0.061	0.064	0.931
		τ_2	2	1.993	0.106	0.109	0.106	0.948	1.991	0.105	0.106	0.105	0.940
		ρ_B	-0.3	-0.298	0.077	0.078	0.077	0.955	-0.302	0.076	0.075	0.076	0.947
30	15	β_1	1.386	1.406	0.306	0.312	0.307	0.911	1.450	0.296	0.271	0.303	0.899
		β_2	1.386	1.398	0.558	0.628	0.558	0.918	1.445	0.540	0.513	0.543	0.916
		τ_1	1	0.930	0.236	0.225	0.246	0.868	0.927	0.234	0.213	0.245	0.884
		τ_2	2	1.916	0.396	0.419	0.405	0.882	1.916	0.386	0.376	0.395	0.906
		ρ_B	-0.3	-0.334	0.245	0.299	0.247	0.883	-0.336	0.247	0.276	0.250	0.891
	50	β_1	1.386	1.405	0.163	0.182	0.164	0.947	1.452	0.155	0.154	0.168	0.932
		β_2	1.386	1.396	0.302	0.350	0.302	0.950	1.447	0.289	0.289	0.295	0.942
		τ_1	1	0.978	0.124	0.135	0.126	0.922	0.976	0.119	0.120	0.121	0.930
		τ_2	2	1.978	0.217	0.247	0.218	0.943	1.975	0.210	0.211	0.211	0.937
		ρ_B	-0.3	-0.301	0.153	0.175	0.153	0.927	-0.303	0.149	0.147	0.149	0.939
	200	β_1	1.386	1.401	0.084	0.091	0.085	0.946	1.449	0.079	0.078	0.101	0.871
		β_2	1.386	1.402	0.162	0.170	0.163	0.952	1.454	0.154	0.145	0.168	0.904
		τ_1	1	0.993	0.065	0.069	0.065	0.935	0.991	0.063	0.060	0.064	0.929
		τ_2	2	1.993	0.110	0.124	0.110	0.965	1.992	0.106	0.106	0.106	0.947
		ρ_B	-0.3	-0.298	0.077	0.087	0.077	0.954	-0.301	0.073	0.074	0.073	0.950

Table S5: Summary statistics when $(\beta_1, \beta_2, \tau_1, \tau_2, \rho_B, \rho_1, \rho_2) = (1.386, 1.386, 1, 2, -0.3, 0.2, 0.5)$.

				EM-CLM					**Bivariate-LMM**				
NP(%)	N	PAR	TRUE	MEAN	SD	SE	RMSE	CP	MEAN	SD	SE	RMSE	CP
15	15	β_1	1.386	1.398	0.306	0.281	0.306	0.913	1.416	0.301	0.272	0.302	0.906
		β_2	1.386	1.392	0.562	0.532	0.562	0.914	1.443	0.552	0.513	0.555	0.913
		τ_1	1	0.928	0.235	0.218	0.246	0.870	0.925	0.235	0.216	0.247	0.874
		τ_2	2	1.914	0.383	0.380	0.393	0.900	1.912	0.379	0.377	0.389	0.906
		ρ_B	-0.3	-0.330	0.250	0.281	0.252	0.904	-0.333	0.250	0.269	0.252	0.902
	50	β_1	1.386	1.395	0.161	0.160	0.161	0.934	1.414	0.159	0.155	0.161	0.932
		β_2	1.386	1.405	0.297	0.300	0.298	0.954	1.459	0.294	0.289	0.303	0.943
		τ_1	1	0.981	0.123	0.124	0.124	0.936	0.979	0.122	0.122	0.124	0.933
		τ_2	2	1.978	0.215	0.219	0.216	0.935	1.973	0.211	0.211	0.213	0.933
		ρ_B	-0.3	-0.301	0.155	0.154	0.155	0.934	-0.304	0.153	0.149	0.153	0.939
	200	β_1	1.386	1.392	0.080	0.081	0.080	0.953	1.412	0.079	0.078	0.083	0.926
		β_2	1.386	1.407	0.147	0.150	0.148	0.948	1.461	0.146	0.145	0.164	0.917
		τ_1	1	0.993	0.065	0.063	0.065	0.935	0.992	0.064	0.061	0.064	0.934
		τ_2	2	1.991	0.107	0.111	0.107	0.946	1.987	0.105	0.106	0.106	0.949
		ρ_B	-0.3	-0.297	0.078	0.078	0.078	0.948	-0.301	0.076	0.075	0.076	0.946
30	15	β_1	1.386	1.406	0.302	0.324	0.303	0.911	1.434	0.293	0.272	0.297	0.901
		β_2	1.386	1.426	0.575	0.626	0.576	0.922	1.504	0.550	0.510	0.563	0.912
		τ_1	1	0.933	0.232	0.234	0.241	0.877	0.931	0.234	0.214	0.244	0.893
		τ_2	2	1.904	0.389	0.402	0.401	0.879	1.906	0.383	0.374	0.394	0.891
		ρ_B	-0.3	-0.322	0.242	0.307	0.243	0.898	-0.325	0.242	0.268	0.243	0.908
	50	β_1	1.386	1.400	0.164	0.181	0.165	0.951	1.431	0.159	0.154	0.165	0.936
		β_2	1.386	1.415	0.311	0.338	0.312	0.952	1.500	0.297	0.288	0.318	0.930
		τ_1	1	0.978	0.121	0.135	0.123	0.933	0.977	0.118	0.120	0.120	0.930
		τ_2	2	1.971	0.217	0.235	0.219	0.918	1.968	0.209	0.210	0.211	0.930
		ρ_B	-0.3	-0.300	0.153	0.168	0.153	0.939	-0.303	0.148	0.148	0.148	0.942
	200	β_1	1.386	1.396	0.082	0.091	0.083	0.965	1.428	0.079	0.078	0.089	0.913
		β_2	1.386	1.415	0.153	0.173	0.156	0.951	1.502	0.146	0.145	0.186	0.865
		τ_1	1	0.994	0.064	0.069	0.064	0.952	0.992	0.062	0.060	0.063	0.938
		τ_2	2	1.992	0.106	0.124	0.106	0.962	1.989	0.102	0.106	0.103	0.956
		ρ_B	-0.3	-0.299	0.079	0.087	0.079	0.951	-0.303	0.075	0.074	0.075	0.942

Table S6: Summary statistics when $(\beta_1, \beta_2, \tau_1, \tau_2, \rho_B, \rho_1, \rho_2) = (2.197, -0.405, 2, -0.3, 0.3, 0.3)$.

				EM-CLM					**Bivariate-LMM**				
NP(%)	N	PAR	TRUE	MEAN	SD	SE	RMSE	CP	MEAN	SD	SE	RMSE	CP
15	15	β_1	2.197	2.208	0.301	0.289	0.301	0.914	2.236	0.297	0.274	0.300	0.903
		β_2	-0.405	-0.387	0.548	0.535	0.548	0.926	-0.359	0.540	0.514	0.542	0.918
		τ_1	1	0.934	0.242	0.225	0.251	0.887	0.930	0.240	0.216	0.250	0.888
		τ_2	2	1.918	0.389	0.384	0.398	0.896	1.916	0.387	0.377	0.396	0.898
		ρ_B	-0.3	-0.335	0.254	0.282	0.256	0.880	-0.338	0.255	0.268	0.258	0.884
	50	β_1	2.197	2.210	0.162	0.161	0.163	0.942	2.240	0.159	0.155	0.165	0.927
		β_2	-0.405	-0.388	0.300	0.299	0.300	0.937	-0.357	0.296	0.289	0.300	0.926
		τ_1	1	0.981	0.122	0.125	0.123	0.939	0.979	0.121	0.122	0.123	0.937
		τ_2	2	1.979	0.209	0.217	0.210	0.944	1.976	0.207	0.211	0.208	0.942
		ρ_B	-0.3	-0.308	0.155	0.154	0.155	0.926	-0.311	0.154	0.148	0.154	0.922
	200	β_1	2.197	2.207	0.080	0.081	0.081	0.944	2.237	0.078	0.078	0.088	0.919
		β_2	-0.405	-0.392	0.150	0.150	0.151	0.945	-0.360	0.148	0.146	0.155	0.932
		τ_1	1	0.993	0.064	0.063	0.064	0.934	0.990	0.063	0.061	0.064	0.931
		τ_2	2	1.993	0.106	0.109	0.106	0.948	1.991	0.105	0.106	0.105	0.940
		ρ_B	-0.3	-0.298	0.077	0.078	0.077	0.955	-0.302	0.076	0.075	0.076	0.947
30	15	β_1	2.197	2.217	0.306	0.312	0.307	0.911	2.261	0.296	0.271	0.303	0.899
		β_2	-0.405	-0.394	0.558	0.628	0.558	0.918	-0.347	0.540	0.513	0.543	0.916
		τ_1	1	0.930	0.236	0.225	0.246	0.868	0.927	0.234	0.213	0.245	0.884
		τ_2	2	1.916	0.396	0.419	0.405	0.882	1.916	0.386	0.376	0.395	0.906
		ρ_B	-0.3	-0.334	0.245	0.299	0.247	0.883	-0.336	0.247	0.276	0.250	0.891
	50	β_1	2.197	2.216	0.163	0.182	0.164	0.947	2.263	0.155	0.154	0.168	0.932
		β_2	-0.405	-0.396	0.302	0.350	0.302	0.950	-0.345	0.289	0.289	0.295	0.942
		τ_1	1	0.978	0.124	0.135	0.126	0.922	0.976	0.119	0.120	0.121	0.930
		τ_2	2	1.978	0.217	0.247	0.218	0.943	1.975	0.210	0.211	0.211	0.937
		ρ_B	-0.3	-0.301	0.153	0.175	0.153	0.927	-0.303	0.149	0.147	0.149	0.939
	200	β_1	2.197	2.212	0.084	0.091	0.085	0.946	2.260	0.079	0.078	0.101	0.871
		β_2	-0.405	-0.390	0.162	0.170	0.163	0.952	-0.338	0.154	0.145	0.168	0.904
		τ_1	1	0.993	0.065	0.069	0.065	0.935	0.991	0.063	0.060	0.064	0.929
		τ_2	2	1.993	0.110	0.124	0.110	0.965	1.992	0.106	0.106	0.106	0.947
		ρ_B	-0.3	-0.298	0.077	0.087	0.077	0.954	-0.301	0.073	0.074	0.073	0.950

Table S7: Summary statistics when $(\beta_1, \beta_2, \tau_1, \tau_2, \rho_B, \rho_1, \rho_2) = (2.197, -0.405, 1, 2, -0.3, 0.2, 0.5)$.

				EM-CLM					**Bivariate-LMM**				
NP(%)	N	PAR	TRUE	MEAN	SD	SE	RMSE	CP	MEAN	SD	SE	RMSE	CP
15	15	β_1	2.197	2.209	0.306	0.281	0.306	0.913	2.226	0.301	0.272	0.302	0.906
		β_2	-0.405	-0.400	0.562	0.532	0.562	0.914	-0.349	0.552	0.513	0.555	0.913
		τ_1	1	0.928	0.235	0.218	0.246	0.870	0.925	0.235	0.216	0.247	0.873
		τ_2	2	1.914	0.383	0.380	0.393	0.900	1.912	0.379	0.377	0.389	0.906
		ρ_B	-0.3	-0.330	0.250	0.281	0.252	0.904	-0.333	0.250	0.269	0.252	0.902
	50	β_1	2.197	2.206	0.161	0.160	0.161	0.934	2.225	0.159	0.155	0.161	0.932
		β_2	-0.405	-0.387	0.297	0.300	0.298	0.954	-0.333	0.294	0.289	0.303	0.943
		τ_1	1	0.981	0.123	0.124	0.124	0.936	0.979	0.122	0.122	0.124	0.933
		τ_2	2	1.978	0.215	0.219	0.216	0.935	1.973	0.211	0.211	0.213	0.933
		ρ_B	-0.3	-0.301	0.155	0.154	0.155	0.934	-0.304	0.153	0.149	0.153	0.939
	200	β_1	2.197	2.203	0.080	0.081	0.080	0.953	2.223	0.079	0.078	0.083	0.926
		β_2	-0.405	-0.385	0.147	0.150	0.148	0.948	-0.331	0.146	0.145	0.164	0.917
		τ_1	1	0.993	0.065	0.063	0.065	0.935	0.992	0.064	0.061	0.064	0.934
		τ_2	2	1.991	0.107	0.111	0.107	0.946	1.987	0.105	0.106	0.106	0.949
		ρ_B	-0.3	-0.297	0.078	0.078	0.078	0.948	-0.301	0.076	0.075	0.076	0.946
30	15	β_1	2.197	2.217	0.302	0.324	0.303	0.911	2.244	0.293	0.272	0.297	0.901
		β_2	-0.405	-0.366	0.575	0.626	0.576	0.922	-0.288	0.550	0.510	0.562	0.912
		τ_1	1	0.933	0.232	0.234	0.241	0.877	0.931	0.234	0.214	0.244	0.892
		τ_2	2	1.904	0.389	0.402	0.401	0.879	1.906	0.383	0.374	0.394	0.891
		ρ_B	-0.3	-0.322	0.242	0.307	0.243	0.898	-0.325	0.242	0.268	0.243	0.908
	50	β_1	2.197	2.211	0.164	0.181	0.165	0.951	2.241	0.159	0.154	0.165	0.936
		β_2	-0.405	-0.376	0.311	0.338	0.312	0.952	-0.292	0.297	0.288	0.318	0.930
		τ_1	1	0.978	0.121	0.135	0.123	0.933	0.977	0.118	0.120	0.120	0.930
		τ_2	2	1.971	0.217	0.235	0.219	0.918	1.968	0.209	0.210	0.211	0.930
		ρ_B	-0.3	-0.300	0.153	0.168	0.153	0.939	-0.303	0.148	0.148	0.148	0.942
	200	β_1	2.197	2.207	0.082	0.091	0.083	0.965	2.239	0.079	0.078	0.089	0.913
		β_2	-0.405	-0.376	0.153	0.173	0.156	0.951	-0.289	0.146	0.145	0.186	0.865
		τ_1	1	0.994	0.064	0.069	0.064	0.952	0.992	0.062	0.060	0.063	0.938
		τ_2	2	1.992	0.106	0.124	0.106	0.962	1.989	0.102	0.106	0.103	0.956
		ρ_B	-0.3	-0.299	0.079	0.087	0.079	0.951	-0.303	0.075	0.074	0.075	0.942

Table S8: Summary statistics for simulations with different non-publishing rates, and parameters are set as $(\beta_1, \beta_2, \tau_1, \tau_2, \rho_B, \rho_1, \rho_2) = (0, 1.735, 0.5, 0.5, -0.3, 0.3, 0.3)$.

			EM-CLM					**Bivariate-LMM**				
NP(%)	PAR	TRUE	MEAN	SD	SE	RMSE	CP	MEAN	SD	SE	RMSE	CP
15	β_1	0	0.008	0.048	0.050	0.049	0.955	0.031	0.046	0.047	0.055	0.903
	β_2	1.735	1.744	0.049	0.049	0.050	0.940	1.766	0.048	0.047	0.057	0.889
	τ_1	0.5	0.495	0.044	0.044	0.044	0.929	0.492	0.043	0.041	0.044	0.921
	τ_2	0.5	0.495	0.042	0.043	0.042	0.945	0.493	0.041	0.041	0.042	0.943
	ρ_B	-0.3	-0.303	0.124	0.127	0.124	0.943	-0.316	0.120	0.121	0.121	0.938
30	β_1	0	0.012	0.051	0.054	0.052	0.936	0.049	0.047	0.046	0.068	0.810
	β_2	1.735	1.749	0.053	0.055	0.055	0.928	1.784	0.049	0.046	0.069	0.794
	τ_1	0.5	0.496	0.044	0.045	0.044	0.936	0.493	0.042	0.040	0.043	0.930
	τ_2	0.5	0.496	0.043	0.045	0.043	0.936	0.494	0.042	0.040	0.042	0.928
	ρ_B	-0.3	-0.304	0.122	0.136	0.122	0.949	-0.315	0.114	0.117	0.115	0.948
40	β_1	0.000	0.015	0.054	0.061	0.056	0.919	0.063	0.047	0.046	0.079	0.716
	β_2	1.735	1.751	0.054	0.063	0.056	0.925	1.796	0.047	0.046	0.077	0.715
	τ_1	0.500	0.496	0.045	0.046	0.045	0.922	0.494	0.041	0.039	0.041	0.935
	τ_2	0.500	0.496	0.043	0.046	0.043	0.932	0.494	0.040	0.039	0.040	0.933
	ρ_B	-0.300	-0.304	0.125	0.140	0.125	0.940	-0.313	0.112	0.115	0.113	0.944
50	β_1	0.000	0.016	0.057	0.085	0.059	0.904	0.072	0.046	0.045	0.085	0.626
	β_2	1.735	1.754	0.058	0.080	0.061	0.881	1.805	0.047	0.045	0.084	0.643
	τ_1	0.500	0.497	0.045	0.053	0.045	0.919	0.495	0.039	0.038	0.039	0.936
	τ_2	0.500	0.496	0.043	0.052	0.043	0.917	0.495	0.039	0.038	0.039	0.944
	ρ_B	-0.300	-0.303	0.125	0.154	0.125	0.921	-0.308	0.106	0.113	0.106	0.954

Table S9: Sensitivity analysis with respect to violation of the normality assumption.

DF	NP(%)	PAR	TRUE	MEAN	SD	RMSE
5	15	β_1	0	0.019	0.115	0.117
		β_2	1.735	1.735	0.118	0.118
		τ_1	0.5	0.573	0.147	0.164
		τ_2	0.5	0.578	0.160	0.178
		ρ_B	-0.4	-0.346	0.250	0.256
	30	β_1	0	0.012	0.140	0.141
		β_2	1.735	1.723	0.189	0.189
		τ_1	0.5	0.587	0.167	0.188
		τ_2	0.5	0.588	0.174	0.195
		ρ_B	-0.4	-0.339	0.242	0.250
10	15	β_1	0	0.013	0.101	0.102
		β_2	1.735	1.742	0.101	0.101
		τ_1	0.5	0.514	0.092	0.093
		τ_2	0.5	0.516	0.098	0.099
		ρ_B	-0.4	-0.396	0.237	0.237
	30	β_1	0	0.013	0.106	0.107
		β_2	1.735	1.745	0.102	0.102
		τ_1	0.5	0.518	0.104	0.106
		τ_2	0.5	0.521	0.101	0.103
		ρ_B	-0.4	-0.391	0.231	0.231

Table S10: Sensitivity analysis with respect to violation of the publication process assumption.

NP(%)	PAR	TRUE	MEAN	SD	RMSE
15	β_1	0	0.105	0.089	0.138
	β_2	1.735	1.792	0.095	0.111
	τ_1	0.5	0.420	0.077	0.111
	τ_2	0.5	0.456	0.086	0.097
	ρ_B	-0.4	-0.667	0.224	0.349
30	β_1	0	0.228	0.083	0.243
	β_2	1.735	1.813	0.092	0.121
	τ_1	0.5	0.361	0.070	0.156
	τ_2	0.5	0.447	0.079	0.095
	ρ_B	-0.4	-0.803	0.187	0.444
15	β_1	1.386	1.464	0.089	0.118
	β_2	1.386	1.469	0.091	0.123
	τ_1	0.5	0.430	0.077	0.104
	τ_2	0.5	0.429	0.080	0.107
	ρ_B	-0.4	-0.642	0.236	0.338
30	β_1	1.386	1.542	0.083	0.177
	β_2	1.386	1.546	0.086	0.182
	τ_1	0.5	0.392	0.070	0.129
	τ_2	0.5	0.395	0.072	0.127
	ρ_B	-0.4	-0.800	0.192	0.444

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