

Simulation results to accompany:

Preacher, K. J., Zhang, Z., & Zyphur, M. J. (submitted). *Alternative methods for assessing mediation in multilevel data: The advantages of multilevel SEM.*

This document reports the results of three simulation studies examining bias, coverage, empirical standard deviation (ESD), root mean squared error (RMSE), convergence, and power for three competing methods of assessing indirect effects in 2-1-1 designs.

The first simulation is the one reported in the paper. A description of the simulation procedure and conditions can be found in the paper. The second simulation reported here uses the same conditions, save that the Within b slope is random across clusters. The third simulation uses the same conditions as the first, save that the Within b slope is set equal to the Between b slope (both are .5).

Simulation 1: Fixed b slopes, unequal in Within and Between models

Table 1

Percentage Relative Bias of the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

J	n_j	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	-60.34	-57.24	-53.27	-49.72	-57.80	-44.61	-31.76	-15.01	-38.16	-15.87	8.02	12.04
50	5	-60.38	-56.87	-53.07	-50.88	-56.84	-45.63	-30.01	-16.76	-19.02	-6.25	10.30	.91
100	5	-59.45	-56.44	-53.55	-49.11	-55.79	-44.08	-30.31	-13.91	-17.45	6.92	4.58	2.60
300	5	-59.66	-57.04	-54.24	-49.98	-57.21	-45.63	-31.07	-15.15	-17.10	6.38	.26	.21
500	5	-59.63	-56.84	-53.44	-49.95	-57.08	-44.82	-29.75	-14.93	-17.02	6.03	1.37	.29
1000	5	-59.41	-56.94	-53.53	-50.23	-57.11	-44.88	-29.96	-15.26	-15.55	3.42	.50	-.17
20	20	-60.07	-58.55	-57.05	-56.51	-50.80	-28.10	-10.34	-5.12	-30.57	9.50	9.53	1.19
50	20	-59.40	-58.27	-57.18	-55.89	-49.48	-26.15	-12.69	-2.47	-19.40	6.65	1.08	2.88
100	20	-59.43	-58.07	-56.96	-57.01	-49.64	-25.82	-12.42	-5.33	-8.92	2.95	.28	-.43
300	20	-59.33	-58.21	-57.35	-56.81	-49.81	-25.75	-12.14	-4.16	3.85	1.11	.12	.58
500	20	-59.34	-58.42	-57.37	-56.86	-49.54	-26.00	-12.29	-4.82	6.07	.23	-.15	-.17
1000	20	-59.32	-58.16	-57.28	-56.80	-49.44	-25.79	-12.13	-4.45	5.32	.18	-.08	.20
20	50	-59.15	-59.00	-58.99	-58.88	-40.40	-14.20	-4.71	-1.26	-2.39	7.88	3.58	1.52
50	50	-59.30	-59.05	-58.09	-59.28	-39.65	-14.80	-3.01	-4.49	6.06	1.65	3.35	-2.36
100	50	-59.32	-59.02	-58.96	-58.81	-39.14	-14.49	-6.44	-2.01	7.70	.23	-.75	.04
300	50	-59.62	-58.98	-58.87	-58.90	-39.43	-14.10	-5.81	-1.94	3.19	.05	-.29	.04
500	50	-59.61	-58.92	-58.59	-58.72	-39.43	-13.82	-5.16	-2.29	1.63	.18	.35	-.34
1000	50	-59.56	-58.96	-58.77	-58.72	-39.50	-13.66	-5.39	-1.77	.47	.39	.09	.18

Note. J : number of clusters; n_j : within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 2

Confidence Interval Coverage for the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

J	n_j	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.460	.491	.567	.643	.603	.699	.778	.830	.920	.905	.902	.880
50	5	.168	.255	.357	.486	.492	.621	.754	.857	.929	.908	.914	.910
100	5	.032	.062	.133	.313	.310	.502	.703	.880	.951	.931	.926	.924
300	5	.000	.000	.001	.022	.017	.129	.473	.850	.964	.953	.947	.944
500	5	.000	.000	.000	.002	.001	.031	.335	.799	.967	.956	.943	.939
1000	5	.000	.000	.000	.000	.000	.000	.085	.680	.971	.965	.950	.951
20	20	.124	.191	.340	.496	.652	.774	.831	.863	.920	.888	.863	.880
50	20	.003	.019	.083	.248	.528	.756	.863	.908	.923	.927	.915	.916
100	20	.001	.001	.009	.051	.315	.723	.889	.913	.948	.938	.946	.921
300	20	.001	.000	.000	.000	.025	.457	.848	.922	.956	.957	.947	.933
500	20	.001	.000	.000	.000	.002	.264	.777	.921	.967	.941	.950	.937
1000	20	.001	.000	.000	.000	.000	.064	.686	.918	.965	.951	.946	.942
20	50	.029	.083	.218	.398	.736	.831	.859	.869	.903	.892	.876	.877
50	50	.004	.002	.027	.137	.642	.858	.892	.899	.949	.916	.905	.905
100	50	.003	.000	.001	.019	.468	.840	.900	.927	.952	.936	.920	.938
300	50	.000	.000	.000	.000	.093	.763	.913	.939	.957	.948	.950	.942
500	50	.000	.000	.000	.000	.012	.674	.911	.937	.957	.941	.944	.943
1000	50	.000	.000	.000	.000	.000	.475	.883	.938	.956	.955	.947	.951

Note. J : number of clusters; n_j : within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 3

Empirical Standard Deviation of the Estimate of the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.032	.037	.041	.052	.064	.066	.074	.096	.250	.251	.242	.165
50	5	.019	.020	.023	.029	.033	.037	.041	.054	.169	.170	.114	.070
100	5	.013	.014	.017	.020	.023	.025	.029	.037	.150	.143	.062	.047
300	5	.007	.008	.009	.011	.012	.014	.015	.020	.135	.070	.029	.024
500	5	.006	.006	.007	.009	.010	.011	.012	.016	.144	.049	.023	.020
1000	5	.004	.004	.005	.006	.007	.007	.009	.011	.140	.031	.016	.013
20	20	.016	.021	.027	.037	.053	.058	.075	.093	.181	.151	.110	.103
50	20	.010	.012	.015	.020	.031	.035	.041	.051	.153	.077	.051	.055
100	20	.007	.008	.011	.015	.021	.022	.027	.037	.125	.042	.032	.040
300	20	.004	.005	.006	.009	.012	.013	.015	.021	.101	.022	.018	.023
500	20	.003	.004	.005	.006	.009	.010	.012	.016	.071	.017	.014	.017
1000	20	.003	.003	.003	.005	.006	.007	.009	.011	.047	.012	.010	.012
20	50	.012	.016	.022	.032	.051	.058	.072	.092	.186	.099	.084	.096
50	50	.007	.009	.014	.019	.029	.033	.041	.053	.121	.045	.045	.054
100	50	.006	.007	.010	.013	.021	.023	.028	.036	.082	.029	.030	.036
300	50	.003	.004	.005	.008	.012	.013	.015	.020	.038	.016	.017	.021
500	50	.002	.003	.004	.006	.009	.010	.012	.015	.028	.013	.013	.016
1000	50	.001	.002	.003	.004	.006	.007	.009	.011	.019	.009	.009	.012

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 4

Root Mean Squared Error of the Estimate of the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.069	.068	.067	.072	.086	.079	.081	.096	.253	.251	.242	.165
50	5	.063	.060	.058	.058	.066	.058	.051	.056	.170	.170	.114	.070
100	5	.061	.058	.056	.053	.061	.051	.042	.039	.151	.143	.062	.047
300	5	.060	.057	.055	.051	.058	.048	.035	.024	.136	.070	.028	.024
500	5	.060	.057	.054	.051	.058	.046	.032	.022	.145	.049	.022	.020
1000	5	.059	.057	.054	.051	.057	.046	.032	.020	.141	.032	.014	.014
20	20	.062	.062	.063	.067	.073	.065	.075	.093	.184	.151	.110	.103
50	20	.060	.059	.059	.059	.058	.044	.042	.051	.154	.077	.051	.055
100	20	.060	.058	.058	.059	.054	.035	.030	.037	.125	.042	.032	.040
300	20	.059	.058	.057	.057	.051	.028	.020	.022	.101	.022	.017	.022
500	20	.059	.058	.057	.057	.050	.028	.017	.017	.071	.017	.014	.017
1000	20	.059	.058	.057	.057	.050	.026	.014	.010	.047	.010	.010	.010
20	50	.060	.061	.063	.067	.065	.059	.073	.092	.186	.099	.084	.095
50	50	.060	.060	.060	.062	.049	.036	.041	.053	.122	.045	.045	.054
100	50	.059	.059	.060	.060	.045	.026	.028	.036	.082	.028	.030	.036
300	50	.060	.059	.059	.059	.041	.020	.017	.020	.037	.017	.017	.020
500	50	.060	.059	.059	.059	.040	.017	.014	.014	.028	.014	.014	.014
1000	50	.059	.059	.059	.059	.040	.014	.010	.010	.020	.010	.010	.010

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 5

Successful Convergence Rates 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	1.000	1.000	1.000	1.000	.931	.970	.997	1.000	.999	1.000	.999	1.000
50	5	1.000	1.000	1.000	1.000	.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000
100	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
300	5	1.000	1.000	1.000	1.000	.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
500	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1000	5	1.000	1.000	1.000	1.000	.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
20	20	1.000	1.000	1.000	1.000	.954	.997	1.000	1.000	1.000	1.000	1.000	1.000
50	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
100	20	.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.999	1.000	1.000	1.000
300	20	1.000	1.000	1.000	1.000	.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
500	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1000	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
20	50	1.000	1.000	1.000	1.000	.978	1.000	1.000	1.000	.999	1.000	1.000	1.000
50	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
100	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
300	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
500	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1000	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconfined multilevel modeling; MSEM: multilevel structural equation modeling.

Table 6

Rejection Rates (Power) for the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.184	.189	.190	.140	.087	.098	.102	.107	.035	.035	.049	.071
50	5	.622	.603	.558	.421	.225	.282	.365	.326	.037	.082	.146	.257
100	5	.965	.948	.897	.793	.504	.683	.777	.739	.065	.141	.466	.678
300	5	1.000	1.000	1.000	.998	.957	.995	1.000	.998	.066	.394	.983	.998
500	5	1.000	1.000	1.000	1.000	.998	1.000	1.000	1.000	.083	.687	1.000	1.000
1000	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.091	.953	1.000	1.000
20	20	.786	.673	.477	.315	.201	.268	.242	.159	.069	.162	.196	.147
50	20	.997	.967	.848	.634	.449	.675	.660	.497	.133	.414	.580	.484
100	20	1.000	1.000	.988	.864	.720	.959	.975	.830	.166	.808	.945	.825
300	20	1.000	1.000	1.000	.999	.993	1.000	1.000	.999	.240	.999	1.000	.999
500	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.386	1.000	1.000	1.000
1000	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.738	1.000	1.000	1.000
20	50	.955	.817	.587	.391	.331	.382	.287	.194	.155	.305	.262	.188
50	50	1.000	.993	.901	.637	.613	.844	.752	.489	.225	.751	.725	.482
100	50	1.000	1.000	.989	.887	.860	.992	.983	.854	.392	.970	.980	.853
300	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.828	1.000	1.000	1.000
500	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.979	1.000	1.000	1.000
1000	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconfined multilevel modeling; MSEM: multilevel structural equation modeling.

Simulation 2: Random b slopes, unequal in Within and Between models

Table 1

Percentage Relative Bias of the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

J	n_j	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	-59.99	-58.57	-56.70	-55.07	-57.33	-43.94	-28.50	-14.68	-40.11	-23.93	2.97	4.01
50	5	-60.02	-58.61	-56.87	-55.22	-56.16	-44.26	-29.39	-14.50	-26.77	-9.32	5.33	2.25
100	5	-59.61	-58.31	-56.78	-55.21	-56.13	-44.05	-28.99	-13.94	-22.62	-.12	5.99	2.42
300	5	-59.95	-58.73	-57.24	-55.59	-56.72	-44.70	-29.66	-14.55	-19.11	6.26	2.00	.87
500	5	-59.90	-58.79	-57.33	-55.72	-56.90	-44.85	-29.81	-14.77	-19.87	4.86	1.18	.52
1000	5	-59.78	-58.78	-57.36	-55.79	-56.95	-44.97	-29.97	-14.98	-17.66	2.13	.37	.10
20	20	-59.04	-57.85	-56.89	-56.25	-49.58	-23.89	-9.28	-1.24	-28.07	11.93	8.23	4.73
50	20	-59.53	-58.47	-57.67	-57.17	-50.33	-25.80	-11.51	-3.85	-24.01	4.67	2.05	1.27
100	20	-59.75	-58.82	-58.07	-57.61	-50.26	-26.14	-12.22	-4.76	-14.48	2.10	.57	.18
300	20	-59.75	-58.86	-58.09	-57.61	-49.72	-25.89	-12.12	-4.69	1.80	.52	.12	.02
500	20	-59.75	-58.87	-58.13	-57.68	-49.55	-25.72	-12.05	-4.73	6.21	.52	.10	-.08
1000	20	-59.74	-58.85	-58.10	-57.65	-49.33	-25.51	-11.86	-4.57	6.27	.67	.30	.11
20	50	-59.77	-59.25	-59.24	-59.50	-40.54	-16.21	-8.83	-6.57	-14.11	2.93	-1.69	-3.96
50	50	-59.90	-59.20	-58.93	-58.90	-39.93	-14.43	-6.24	-2.99	3.99	1.44	-.15	-.83
100	50	-59.88	-59.19	-58.90	-58.83	-39.79	-14.77	-6.57	-3.23	7.90	-.07	-.80	-1.15
300	50	-59.83	-59.07	-58.70	-58.53	-39.81	-14.41	-5.99	-2.44	2.34	-.38	-.47	-.49
500	50	-59.73	-58.95	-58.58	-58.41	-39.61	-14.12	-5.70	-2.18	.93	-.24	-.24	-.24
1000	50	-59.76	-58.97	-58.61	-58.46	-39.60	-14.08	-5.67	-2.17	.15	-.16	-.14	-.17

Note. J : number of clusters; n_j : within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 2

Confidence Interval Coverage for the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

J	n_j	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.737	.687	.648	.643	.638	.718	.782	.835	.983	.967	.933	.895
50	5	.243	.259	.310	.401	.514	.651	.784	.878	.965	.935	.928	.913
100	5	.039	.054	.091	.179	.336	.516	.721	.872	.971	.957	.933	.928
300	5	.000	.000	.000	.003	.032	.161	.526	.848	.974	.959	.945	.938
500	5	.000	.000	.000	.000	.001	.034	.354	.814	.974	.960	.950	.948
1000	5	.000	.000	.000	.000	.000	.001	.102	.711	.972	.956	.946	.951
20	20	.324	.296	.386	.516	.682	.778	.828	.853	.947	.913	.874	.873
50	20	.005	.023	.105	.252	.547	.779	.868	.896	.938	.937	.911	.915
100	20	.000	.000	.004	.047	.344	.735	.886	.921	.945	.946	.937	.938
300	20	.000	.000	.000	.001	.035	.491	.852	.922	.970	.947	.939	.940
500	20	.000	.000	.000	.000	.004	.313	.801	.923	.955	.942	.942	.947
1000	20	.000	.000	.000	.000	.000	.084	.706	.918	.965	.948	.950	.953
20	50	.094	.131	.269	.440	.751	.837	.852	.864	.944	.895	.878	.875
50	50	.000	.004	.043	.172	.665	.854	.887	.899	.949	.927	.908	.909
100	50	.000	.000	.002	.024	.502	.845	.900	.920	.956	.941	.930	.926
300	50	.000	.000	.000	.000	.112	.758	.897	.928	.956	.938	.938	.937
500	50	.000	.000	.000	.000	.023	.688	.905	.936	.946	.946	.944	.942
1000	50	.000	.000	.000	.000	.001	.489	.877	.930	.945	.947	.942	.945

Note. J : number of clusters; n_j : within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 3

Empirical Standard Deviation of the Estimate of the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.034	.036	.040	.047	.060	.064	.075	.095	.228	.213	.174	.132
50	5	.020	.021	.023	.026	.034	.036	.042	.053	.150	.124	.086	.067
100	5	.014	.014	.016	.018	.023	.025	.029	.037	.119	.097	.058	.047
300	5	.008	.008	.009	.010	.013	.014	.017	.021	.099	.061	.031	.026
500	5	.006	.006	.007	.008	.010	.011	.012	.016	.089	.046	.022	.019
1000	5	.004	.004	.005	.006	.007	.008	.009	.011	.096	.031	.016	.014
20	20	.018	.022	.028	.036	.055	.062	.074	.095	.167	.138	.102	.103
50	20	.011	.013	.016	.021	.032	.035	.041	.053	.125	.066	.050	.056
100	20	.008	.009	.011	.014	.022	.023	.027	.035	.109	.040	.032	.037
300	20	.004	.005	.006	.008	.012	.013	.016	.020	.080	.022	.019	.022
500	20	.003	.004	.005	.007	.010	.011	.013	.016	.066	.017	.015	.017
1000	20	.002	.003	.003	.004	.007	.007	.009	.011	.046	.012	.010	.012
20	50	.014	.017	.024	.033	.052	.056	.068	.089	.139	.082	.074	.091
50	50	.008	.011	.014	.020	.031	.034	.041	.053	.106	.043	.043	.053
100	50	.006	.007	.010	.014	.022	.023	.028	.036	.074	.029	.030	.037
300	50	.003	.004	.006	.008	.012	.014	.016	.021	.038	.017	.017	.021
500	50	.003	.003	.004	.006	.010	.010	.013	.016	.028	.013	.013	.016
1000	50	.002	.002	.003	.004	.007	.007	.009	.011	.019	.009	.009	.012

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 4

Root Mean Squared Error of the Estimate of the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.069	.069	.069	.073	.083	.078	.080	.096	.232	.214	.173	.132
50	5	.063	.062	.061	.061	.066	.057	.051	.055	.153	.124	.086	.067
100	5	.061	.060	.059	.058	.061	.051	.041	.040	.122	.096	.058	.047
300	5	.061	.059	.058	.057	.058	.047	.035	.026	.101	.062	.030	.026
500	5	.060	.059	.057	.057	.057	.046	.032	.022	.092	.046	.022	.020
1000	5	.060	.059	.057	.056	.057	.046	.032	.017	.097	.030	.014	.014
20	20	.062	.062	.063	.067	.074	.066	.075	.095	.169	.138	.102	.102
50	20	.061	.060	.060	.061	.060	.044	.042	.053	.128	.066	.050	.056
100	20	.060	.059	.059	.059	.055	.035	.030	.035	.110	.040	.032	.036
300	20	.060	.059	.058	.058	.051	.028	.020	.020	.080	.022	.020	.022
500	20	.060	.059	.058	.058	.051	.028	.017	.017	.066	.017	.014	.017
1000	20	.060	.059	.058	.057	.050	.026	.014	.010	.047	.010	.010	.010
20	50	.062	.062	.064	.068	.066	.057	.069	.089	.140	.081	.074	.091
50	50	.061	.060	.061	.062	.051	.036	.041	.053	.106	.042	.044	.053
100	50	.060	.060	.060	.060	.045	.028	.028	.036	.074	.028	.030	.037
300	50	.060	.059	.059	.059	.041	.020	.017	.020	.039	.017	.017	.020
500	50	.060	.059	.059	.058	.041	.017	.014	.017	.028	.014	.014	.017
1000	50	.060	.059	.058	.058	.040	.017	.010	.010	.020	.010	.010	.010

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 5

Successful Convergence Rates 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	1.000	1.000	1.000	1.000	.667	.694	.714	.714	.998	.999	1.000	1.000
50	5	1.000	1.000	1.000	1.000	.968	.968	.968	.974	1.000	1.000	1.000	1.000
100	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
300	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
500	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1000	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.999	1.000	1.000	1.000
20	20	1.000	1.000	1.000	1.000	.901	.976	.984	.985	1.000	1.000	1.000	1.000
50	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
100	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
300	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
500	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1000	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
20	50	1.000	1.000	1.000	1.000	.979	.999	.999	.999	1.000	1.000	1.000	1.000
50	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
100	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
300	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
500	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1000	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconfined multilevel modeling; MSEM: multilevel structural equation modeling.

Table 6

Rejection Rates (Power) for the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.060	.079	.116	.127	.073	.091	.098	.100	.001	.008	.026	.067
50	5	.486	.497	.486	.396	.184	.266	.326	.317	.019	.047	.124	.237
100	5	.946	.937	.900	.787	.479	.657	.771	.731	.031	.119	.457	.670
300	5	1.000	1.000	1.000	.998	.950	.997	1.000	.997	.047	.426	.984	.997
500	5	1.000	1.000	1.000	1.000	.997	1.000	1.000	1.000	.071	.694	1.000	1.000
1000	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.087	.950	1.000	1.000
20	20	.517	.508	.376	.261	.194	.269	.230	.161	.029	.125	.177	.146
50	20	.993	.971	.845	.587	.386	.642	.639	.454	.091	.424	.567	.439
100	20	1.000	1.000	.988	.880	.663	.946	.967	.842	.126	.790	.955	.843
300	20	1.000	1.000	1.000	1.000	.987	1.000	1.000	.999	.235	.998	1.000	.999
500	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.400	1.000	1.000	1.000
1000	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.747	1.000	1.000	1.000
20	50	.866	.754	.490	.293	.300	.348	.246	.139	.116	.282	.232	.140
50	50	.999	.995	.876	.610	.563	.809	.725	.473	.210	.752	.719	.482
100	50	1.000	1.000	.993	.883	.834	.984	.980	.853	.344	.973	.982	.856
300	50	1.000	1.000	1.000	1.000	.999	1.000	1.000	1.000	.840	1.000	1.000	1.000
500	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.970	1.000	1.000	1.000
1000	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconfined multilevel modeling; MSEM: multilevel structural equation modeling.

Simulation 3: Fixed b slopes, equal in Within and Between models

Table 1

Percentage Relative Bias of the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

J	n_j	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	-2.25	-.01	2.12	.01	-.13	1.52	.77	.64	4.19	8.44	-5.50	1.60
50	5	.85	1.35	.10	-1.69	1.12	1.50	1.27	-1.50	9.22	1.32	4.66	-1.30
100	5	.42	.37	-.25	-.69	.33	.80	.01	-.78	2.99	3.55	.46	-.76
300	5	-.07	.36	-.07	.84	.64	.29	.05	.95	8.69	.67	.24	1.00
500	5	-.83	-.08	-1.00	.07	-.47	.06	-.88	-.03	-.37	.62	-.80	-.06
1000	5	.09	.08	.06	.05	.18	.14	.10	.06	2.25	.21	.13	.07
20	20	.45	-1.43	-.54	-.08	.71	-.22	-1.77	-.10	1.68	2.03	-3.36	-.08
50	20	.45	.97	-.11	.40	-.14	1.40	-.89	.82	.90	2.76	-1.01	.87
100	20	.37	.01	-.64	-.13	-.25	.00	-1.01	-.68	-3.32	-.01	-1.20	-.74
300	20	.08	.31	-.01	.73	-.34	-.03	.23	1.25	-3.85	-.36	.27	1.30
500	20	.01	-.39	.27	-.64	-.07	-.31	.32	-.51	.18	-.22	.34	-.50
1000	20	-.06	-.07	-.08	-.09	-.13	-.11	-.09	-.07	-.51	-.16	-.09	-.07
20	50	-.10	.37	1.30	.64	-.68	.53	2.75	.06	2.61	.65	2.99	.05
50	50	-.06	.20	-1.59	.21	-.83	.34	-1.71	.50	-6.28	.32	-1.75	.51
100	50	.12	.26	.07	-1.18	.49	.80	.08	-.62	.70	1.00	.08	-.60
300	50	.23	-.21	.31	-.20	.07	-.20	.79	-.05	-.58	-.20	.84	-.05
500	50	.04	.12	.09	.29	.01	-.07	.32	.10	-.08	-.13	.35	.09
1000	50	-.06	-.04	-.02	.02	-.14	-.19	-.18	-.14	-.34	-.23	-.19	-.14

Note. J : number of clusters; n_j : within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 2

Confidence Interval Coverage for the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

J	n_j	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.909	.888	.914	.885	.872	.862	.893	.872	.933	.921	.918	.896
50	5	.934	.937	.932	.934	.918	.910	.915	.910	.949	.937	.930	.901
100	5	.934	.943	.943	.955	.924	.927	.930	.939	.955	.958	.939	.932
300	5	.949	.933	.957	.945	.945	.937	.939	.948	.972	.975	.943	.945
500	5	.948	.939	.947	.951	.942	.946	.938	.951	.977	.979	.938	.945
1000	5	.942	.943	.941	.942	.943	.941	.942	.946	.974	.960	.951	.943
20	20	.916	.897	.899	.879	.872	.855	.867	.882	.938	.895	.868	.878
50	20	.934	.919	.927	.927	.921	.918	.914	.924	.937	.934	.911	.922
100	20	.942	.941	.939	.929	.930	.928	.927	.915	.946	.936	.924	.916
300	20	.950	.947	.943	.947	.947	.950	.943	.952	.983	.947	.943	.951
500	20	.945	.961	.951	.960	.950	.945	.945	.948	.976	.945	.943	.947
1000	20	.947	.943	.945	.945	.947	.943	.947	.949	.974	.951	.948	.950
20	50	.895	.871	.897	.881	.875	.868	.864	.860	.915	.888	.871	.859
50	50	.930	.924	.941	.923	.913	.909	.924	.920	.942	.919	.924	.921
100	50	.938	.939	.944	.930	.925	.937	.939	.934	.960	.937	.937	.934
300	50	.944	.945	.942	.953	.941	.961	.936	.950	.964	.957	.934	.950
500	50	.937	.939	.933	.937	.955	.936	.939	.947	.957	.938	.937	.946
1000	50	.950	.951	.952	.952	.950	.951	.951	.951	.954	.954	.950	.951

Note. J : number of clusters; n_j : within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 3

Empirical Standard Deviation of the Estimate of the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.060	.066	.072	.095	.075	.079	.086	.108	.233	.238	.225	.145
50	5	.034	.038	.043	.053	.042	.047	.051	.060	.145	.155	.109	.069
100	5	.025	.026	.030	.034	.031	.032	.034	.038	.127	.120	.058	.042
300	5	.014	.016	.017	.021	.017	.018	.019	.023	.114	.073	.028	.025
500	5	.010	.012	.013	.016	.013	.014	.015	.017	.117	.042	.021	.019
1000	5	.007	.008	.009	.011	.009	.010	.011	.012	.133	.027	.014	.013
20	20	.030	.043	.057	.080	.054	.065	.076	.098	.168	.146	.103	.103
50	20	.019	.025	.033	.046	.032	.037	.041	.054	.150	.071	.046	.055
100	20	.013	.017	.024	.034	.022	.025	.029	.039	.141	.039	.033	.040
300	20	.007	.009	.013	.018	.012	.014	.017	.020	.107	.020	.019	.021
500	20	.006	.007	.010	.014	.010	.010	.013	.016	.073	.016	.014	.016
1000	20	.004	.005	.007	.010	.007	.008	.009	.012	.038	.011	.010	.012
20	50	.023	.037	.052	.079	.050	.061	.076	.095	.183	.096	.084	.096
50	50	.013	.021	.029	.045	.029	.034	.039	.053	.154	.043	.041	.053
100	50	.009	.015	.022	.031	.020	.023	.028	.036	.077	.028	.029	.036
300	50	.005	.008	.012	.017	.011	.012	.016	.020	.034	.015	.017	.020
500	50	.004	.007	.010	.014	.009	.010	.013	.016	.024	.012	.013	.016
1000	50	.003	.004	.007	.010	.006	.007	.009	.011	.017	.008	.009	.011

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 4

Root Mean Squared Error of the Estimate of the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.060	.066	.072	.095	.075	.079	.085	.108	.233	.238	.225	.145
50	5	.035	.039	.044	.053	.042	.047	.051	.060	.145	.155	.109	.069
100	5	.024	.026	.030	.035	.030	.032	.035	.039	.127	.120	.058	.042
300	5	.014	.014	.017	.020	.017	.017	.020	.022	.114	.073	.028	.024
500	5	.010	.010	.014	.017	.014	.014	.014	.017	.117	.041	.022	.020
1000	5	.010	.010	.010	.010	.010	.010	.010	.014	.133	.026	.014	.014
20	20	.030	.042	.057	.081	.055	.065	.075	.097	.168	.146	.102	.103
50	20	.017	.024	.033	.047	.032	.037	.041	.054	.150	.071	.046	.056
100	20	.014	.017	.024	.033	.022	.024	.030	.039	.141	.039	.033	.040
300	20	.010	.010	.014	.017	.010	.014	.017	.020	.107	.020	.017	.020
500	20	.000	.000	.010	.014	.010	.010	.014	.014	.073	.014	.014	.017
1000	20	.000	.000	.010	.010	.000	.010	.010	.010	.037	.010	.010	.010
20	50	.022	.036	.052	.079	.050	.061	.076	.094	.182	.096	.084	.096
50	50	.014	.022	.030	.045	.028	.035	.039	.053	.154	.042	.041	.053
100	50	.010	.014	.022	.032	.020	.022	.028	.036	.077	.028	.030	.036
300	50	.000	.010	.014	.017	.010	.014	.017	.020	.035	.014	.017	.020
500	50	.000	.000	.010	.014	.010	.010	.014	.017	.024	.010	.014	.017
1000	50	.000	.000	.000	.010	.000	.000	.010	.010	.017	.010	.010	.010

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 5

Successful Convergence Rates 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	1.000	1.000	1.000	1.000	.919	.983	.996	1.000	.999	1.000	.998	1.000
50	5	1.000	1.000	1.000	1.000	.997	.999	1.000	1.000	.999	1.000	1.000	1.000
100	5	.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.997	1.000	1.000
300	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.998	1.000	1.000	1.000
500	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1000	5	.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
20	20	.999	1.000	1.000	1.000	.959	1.000	1.000	1.000	1.000	1.000	1.000	1.000
50	20	1.000	1.000	1.000	1.000	.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000
100	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
300	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
500	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1000	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
20	50	1.000	1.000	1.000	1.000	.982	1.000	1.000	1.000	1.000	1.000	1.000	1.000
50	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
100	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
300	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
500	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1000	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.

Table 6

Rejection Rates (Power) for the Between Indirect Effect in 2-1-1 Models for CMM, UMM, and MSEM Strategies

<i>J</i>	<i>n_j</i>	CMM				UMM				MSEM			
		$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$	$\rho = .05$	$\rho = .10$	$\rho = .20$	$\rho = .40$
20	5	.450	.451	.392	.315	.280	.271	.198	.172	.046	.055	.057	.095
50	5	.870	.796	.706	.534	.759	.680	.573	.420	.094	.123	.194	.290
100	5	.982	.971	.920	.802	.974	.961	.904	.771	.110	.206	.512	.684
300	5	1.000	1.000	1.000	.999	1.000	1.000	1.000	.998	.164	.543	.984	.998
500	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.189	.758	.999	1.000
1000	5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.205	.946	1.000	1.000
20	20	.878	.745	.566	.382	.567	.431	.278	.171	.109	.175	.184	.145
50	20	.998	.980	.868	.622	.957	.910	.760	.472	.178	.480	.608	.445
100	20	1.000	1.000	.982	.862	.998	.998	.976	.836	.206	.821	.934	.823
300	20	1.000	1.000	1.000	.998	1.000	1.000	1.000	.998	.362	.999	1.000	.998
500	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.504	1.000	1.000	1.000
1000	20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.794	1.000	1.000	1.000
20	50	.966	.849	.632	.410	.655	.500	.309	.176	.207	.329	.273	.162
50	50	1.000	.994	.895	.661	.961	.936	.770	.528	.272	.770	.717	.513
100	50	1.000	1.000	.994	.897	1.000	.999	.987	.862	.470	.970	.980	.855
300	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.857	1.000	1.000	1.000
500	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.971	1.000	1.000	1.000
1000	50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.999	1.000	1.000	1.000

Note. *J*: number of clusters; *n_j*: within-cluster sample size; ρ : population intraclass correlation; CMM: conflated multilevel modeling; UMM: unconflated multilevel modeling; MSEM: multilevel structural equation modeling.