Multiple Imputation of Missing Data at Level 2: A Comparison of Fully Conditional and Joint Modeling in Multilevel Designs

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Supplemental Online Material

Enclosed in this document are the supplemental materials for our article entitled "Multiple Imputation of Missing Data at Level 2: A Comparison of Fully Conditional and Joint Modeling in Multilevel Designs." Supplement A contains the computer code and M*plus* syntax file used in the empirical example. Supplement B contains an additional simulation study that compares an "empirical Bayes" and a fully Bayesian procedure for FCS-LAT. Supplement C contains an additional simulation study that contrasts the use of least informative and data-dependent priors in JM. Supplement D contains additional tables that include the complete results of Studies 1 and 2.

Supplement A: Computer Code for the Empirical Example

Below, we provide the computer code for the statistical software R (R Core Team, 2016) and the syntax file for the statistical software M*plus* that were used in the empirical example in the main article. The data set comprised the German subsample of the Programme for International Student Assessment (PISA; OECD, 2014). These data are available online free of charge (`https://www.oecd.org/pisa`).

```
# ***
# 0) load packages
#

library(foreign)
library(mice)
library(miceadds)
library(mitml)

# ***
# 1) prepare data
#

# student data set (level 1)
stu.dat <- read.spss("PiSA2012_SPSS_student_DEU.sav", to.data.frame=TRUE)

# school data set (level 2)
sch.dat <- read.spss("PiSA2012_SPSS_school_DEU.sav", to.data.frame=TRUE)

# create combined data sets (level 1 and 2)
ind <- match(stu.dat$SCHOOLID, sch.dat$SCHOOLID)
stu.vars <- c("SCHOOLID","ST04Q01","ESCS","CLSMAN","STUDREL","PV1MATH")
```

```
sch.vars <- c("SC11Q01","SC11Q02")

# combine
dat <- cbind(stu.dat[,stu.vars], sch.dat[ind,sch.vars])

# reformat and rename
dat <- within(dat, SCHOOLID <- as.numeric(SCHOOLID))
colnames(dat) <- c("SCHOOLID","GENDER","ESCS","CLSMAN","STUDREL","PVMATH","NSTU","NCMP")

# fix seed for random number generator(s)
seed <- 1234

# ***
# 2.i) joint modeling (JM)
#

fml <- list( GENDER + ESCS + CLSMAN + STUDREL + PVMATH ~ 1 + (1|SCHOOLID) ,
             NSTU + NCMP ~ 1 )

imp.jm <- mitml::jomoImpute(data=dat, formula=fml, n.burn=5000, n.iter=500, m=20,
                            seed=seed)

# completed data sets
for(i in 1:20){
  out <- within(mitml::mitmlComplete(imp.jm,i),{ GENDER <- as.numeric(GENDER)-1 })
  write.table(out, file=paste0("jm",i,".dat"), row.names=FALSE, col.names=FALSE)
  cat(paste0("jm",i,".dat\n"), file="jm_list.dat", append=TRUE)
}

# ***
# 2.ii) single-level FCS (FCS-SL)
#

predMatrix <- matrix(0, ncol(dat), ncol(dat))
rownames(predMatrix) <- colnames(predMatrix) <- colnames(dat)

predMatrix["ESCS",] <- c(0,1,0,1,1,1,1,1)      # regression (flat file)
predMatrix["CLSMAN",] <- c(0,1,1,0,1,1,1,1)    # regression (flat file)
predMatrix["STUDREL",] <- c(0,1,1,1,0,1,1,1)   # regression (flat file)
predMatrix["NSTU",] <- c(0,1,1,1,1,1,0,1)      # regression (flat file)
predMatrix["NCMP",] <- c(0,1,1,1,1,1,1,0)      # regression (flat file)

impMethod <- c("","","norm","norm","norm","","norm","norm")

imp.fcssl <- mice::mice(data=dat, predictorMatrix=predMatrix, method=impMethod,
                        m=20, maxit=50, seed=seed)

# completed data sets
for(i in 1:20){
  out <- within(mice::complete(imp.fcssl,i),{ GENDER <- as.numeric(GENDER)-1
    NSTU <- mitml::clusterMeans(NSTU,SCHOOLID)
    NCMP <- mitml::clusterMeans(NCMP,SCHOOLID)
  })
```

```
  write.table(out, file=paste0("fcssl",i,".dat"), row.names=FALSE, col.names=FALSE)
  cat(paste0("fcssl",i,".dat\n"), file="fcssl_list.dat", append=TRUE)
}

# ***
# 2.iii) two-level FCS with manifest cluster means (FCS-MAN)
#

predMatrix <- matrix(0, ncol(dat), ncol(dat))
rownames(predMatrix) <- colnames(predMatrix) <- colnames(dat)

predMatrix["ESCS",] <- c(-2,1,0,3,3,3,1,1)      # random intercepts model
predMatrix["CLSMAN",] <- c(-2,1,3,0,3,3,1,1)    # random intercepts model
predMatrix["STUDREL",] <- c(-2,1,3,3,0,3,1,1)   # random intercepts model
predMatrix["NSTU",] <- c(-2,1,1,1,1,1,0,1)      # regression at level 2
predMatrix["NCMP",] <- c(-2,1,1,1,1,1,1,0)      # regression at level 2

impMethod <- c("","","2l.pan","2l.pan","2l.pan","","2lonly.norm","2lonly.norm")

imp.fcsman <- mice::mice(data=dat, predictorMatrix=predMatrix, method=impMethod,
                         m=20, maxit=50, seed=seed)

# completed data sets
for(i in 1:20){
  out <- within(mice::complete(imp.fcsman,i),{ GENDER <- as.numeric(GENDER)-1 })
  write.table(out, file=paste0("fcsman",i,".dat"), row.names=FALSE, col.names=FALSE)
  cat(paste0("fcsman",i,".dat\n"), file="fcsman_list.dat", append=TRUE)
}

# ***
# 2.iv) two-level FCS with manifest and latent cluster means (FCS-LAT)
#

lm.dat <- within(dat, LM.CLSMAN <- LM.STUDREL <- LM.PVMATH <- NA)

predMatrix <- matrix(0, ncol(lm.dat), ncol(lm.dat))
rownames(predMatrix) <- colnames(predMatrix) <- colnames(lm.dat)

predMatrix["LM.CLSMAN",] <- c(-2,1,1,2,0,0,1,1,0,1,1)    # latent group means
predMatrix["LM.STUDREL",] <- c(-2,1,1,0,2,0,1,1,1,0,1)   # latent group means
predMatrix["LM.PVMATH",] <- c(-2,1,1,0,0,2,1,1,1,1,0)    # latent group means
predMatrix["ESCS",] <- c(-2,1,0,1,1,1,1,1,1,1,1)         # random intercepts model
predMatrix["CLSMAN",] <- c(-2,1,3,0,1,1,1,1,0,1,1)       # random intercepts model
predMatrix["STUDREL",] <- c(-2,1,3,1,0,1,1,1,1,0,1)      # random intercepts model
predMatrix["NSTU",] <- c(-2,1,1,0,0,0,0,1,1,1,1)         # regression at level 2
predMatrix["NCMP",] <- c(-2,1,1,0,0,0,1,0,1,1,1)         # regression at level 2

visitSeq <- c(11,4,9,5,10,3,7,8)

impMethod <- c("","","2l.pan","2l.pan","2l.pan","","2lonly.norm","2lonly.norm",
               "2l.latentgroupmean.mcmc","2l.latentgroupmean.mcmc",
               "2l.latentgroupmean.mcmc")
```

```
imp.fcslat <- mice::mice(data=lm.dat, predictorMatrix=predMatrix, method=impMethod,
                         visitSequence=visitSeq, allow.na=TRUE, m=20, maxit=50,
                         seed=seed)

# completed data sets
for(i in 1:20){
  out <- within(mice::complete(imp.fcslat,i),{ GENDER <- as.numeric(GENDER)-1 })
  write.table(out, file=paste0("fcslat",i,".dat"), row.names=FALSE, col.names=FALSE)
  cat(paste0("fcslat",i,".dat\n"), file="fcslat_list.dat", append=TRUE)
}
```

Following the imputation, the completed data sets were saved in a series of text files. These files were analyzed with the statistical software M*plus* (L. K. Muthén & Muthén, 2012) using the syntax file given below.

```
TITLE:
Empirical example using data from PISA 2012;
DATA:
FILE = ..._list.dat;   ! replace "..." with prefix for imputation method
TYPE = IMPUTATION;     ! (e.g., "jm_list.dat")

VARIABLE:
NAMES = SCHOOLID GENDER ESCS CLSMAN STUDREL PVMATH NSTU NCMP;
USEVARIABLES = SCHOOLID GENDER ESCS CLSMAN STUDREL PVMATH NSTU NCMP SCHESCS;
BETWEEN = NSTU NCMP SCHESCS;
WITHIN = GENDER ESCS;
CLUSTER = SCHOOLID;

DEFINE:
SCHESCS = CLUSTER_MEAN (ESCS);   ! manifest cluster means for ESCS
CENTER ESCS (GROUPMEAN);         ! cluster mean centering for ESCS
CENTER SCHESCS (GRANDMEAN);      ! grand mean centering for SCHESCH

ANALYSIS:
TYPE = TWOLEVEL;

MODEL:
%within%
PVMATH on GENDER ESCS CLSMAN STUDREL;
%between%
PVMATH on NSTU NCMP SCHESCS CLSMAN STUDREL;
```

Table 1

Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y with z ($\hat{\sigma}_{yz}$) and the Regression Coefficients of y on z and z on y ($\hat{\beta}_{yz}$ and $\hat{\beta}_{zy}$) for Small ICC of y ($\rho_{Iy} = .10$) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)			Rel. RMSE			Coverage (%)		
	FCS-MAN	FCS-LAT (EB)	FCS-LAT (FB)	FCS-MAN	FCS-LAT (EB)	FCS-LAT (FB)	FCS-MAN	FCS-LAT (EB)	FCS-LAT (FB)
Covariance y with z ($\hat{\sigma}_{yz}$)									
$J = 30$	0.9	5.0	−3.7	0.789	0.809	0.743	93.8	93.4	94.1
$J = 50$	−0.3	3.6	−1.6	0.584	0.604	0.565	94.5	93.9	95.0
$J = 100$	0.1	3.0	0.3	0.419	0.426	0.406	94.3	93.8	94.7
Regression $y \sim z$ ($\hat{\beta}_{yz}$)									
$J = 30$	−4.7	−1.2	−7.5	0.707	0.726	0.688	91.5	90.1	93.6
$J = 50$	−3.0	0.1	−4.0	0.532	0.544	0.519	92.4	91.7	94.4
$J = 100$	−1.5	0.8	−1.4	0.382	0.389	0.376	93.4	92.7	94.3
Regression $z \sim y$ ($\hat{\beta}_{zy}$)									
$J = 30$	−10.2	−6.7	−10.8	0.957	0.989	0.968	92.8	93.3	94.5
$J = 50$	−4.3	−0.9	−4.3	0.791	0.793	0.795	94.0	94.0	95.0
$J = 100$	−1.3	1.4	−1.1	0.601	0.596	0.582	93.9	94.0	94.5

Note. J = number of clusters; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means (empirical Bayes); FCS-LAT = two-level FCS with latent cluster means (fully Bayesian).

Supplement B: Fully Bayesian Procedure for FCS-LAT

As an alternative to using an "empirical Bayes" procedure during the generation of plausible values of latent cluster means, a fully Bayesian procedure may be used that draws the model parameters from their posterior distributions. The resulting procedure is "Bayesianly proper" in the sense of Rubin (1987) and may improve efficiency and coverage properties in smaller samples. In the following simulation study, we evaluated the differences between the empirical Bayes and the fully Bayesian procedure for the generation of latent cluster means. Both procedures were implemented using the R package `miceadds` (Robitzsch, Grund, & Henke, 2017). The simulated conditions were similar to those in Study 1 in the main article and were intended to match the conditions displayed in Figure 2

and Table 2 with smaller samples ($n = 5$, $J = 30, 50, 100$).

The results of this simulation are provided in Table 1. When FCS-LAT was based on an empirical Bayes procedure (EB), we observed coverage rates for the regression coefficient of y on z ($\hat{\beta}_{yz}$) below the nominal value of 95% in very small samples ($J \leq 50$). On the other hand, when FCS-LAT was based on a fully Bayesian procedure (FB), the coverage rates were nearly optimal for all parameters and even in very small samples. In addition, FCS-LAT (FB) yielded lower values for the RMSE than FCS-MAN or FCS-LAT (EB) in these conditions, indicating that the parameters were estimated with greater accuracy overall. By contrast, the results for the bias were usually best under FCS-LAT (EB), whereas the bias under FCS-LAT (FB) was slightly higher for the two regression coefficients ($\hat{\beta}_{yz}$ and $\hat{\beta}_{zy}$).

Supplement C: Data-Dependent Priors in JM

Even though the use of data-dependent priors (DDPs) is not without criticism (e.g., see Gelman et al., 2014), it has been recommended that DDPs be used to mitigate problems in the estimation of multilevel models in smaller samples (e.g., Grund, Lüdtke, & Robitzsch, 2016; McNeish, 2016). In the following simulation study, we explored the effects of using DDPs for MI of missing data at Level 2 using JM. In order to specify DDPs, we estimated the covariance matrix of the variables at Level 1 ($\hat{\boldsymbol{\Sigma}}_1$) and Level 2 ($\hat{\boldsymbol{\Sigma}}_2$) from the complete data using the formulae provided by B. O. Muthén (1994). To ensure that these matrices were positive-definite, the variances were constrained to be larger than zero, and the covariances were constrained in such a way that they implied a correlation between -1 and 1. Using these estimates, we set the scale matrices of the inverse-Wishart priors to $\mathbf{S}_1 = \nu_1 \hat{\boldsymbol{\Sigma}}_1$ for the covariance matrix at Level 1 and $\mathbf{S}_2 = \nu_2 \hat{\boldsymbol{\Sigma}}_2$ for the covariance matrix at Level 2, where the degrees of freedom ν_1 and ν_2 were set to match the dimensions of $\hat{\boldsymbol{\Sigma}}_1$ and $\hat{\boldsymbol{\Sigma}}_2$, respectively (i.e., largest possible dispersion; see Schafer & Yucel, 2002). The remaining parameters of the simulation were a subset of the conditions in Study 1 ($n = 5$; $J = 30, 50, 100, 200, 500,$

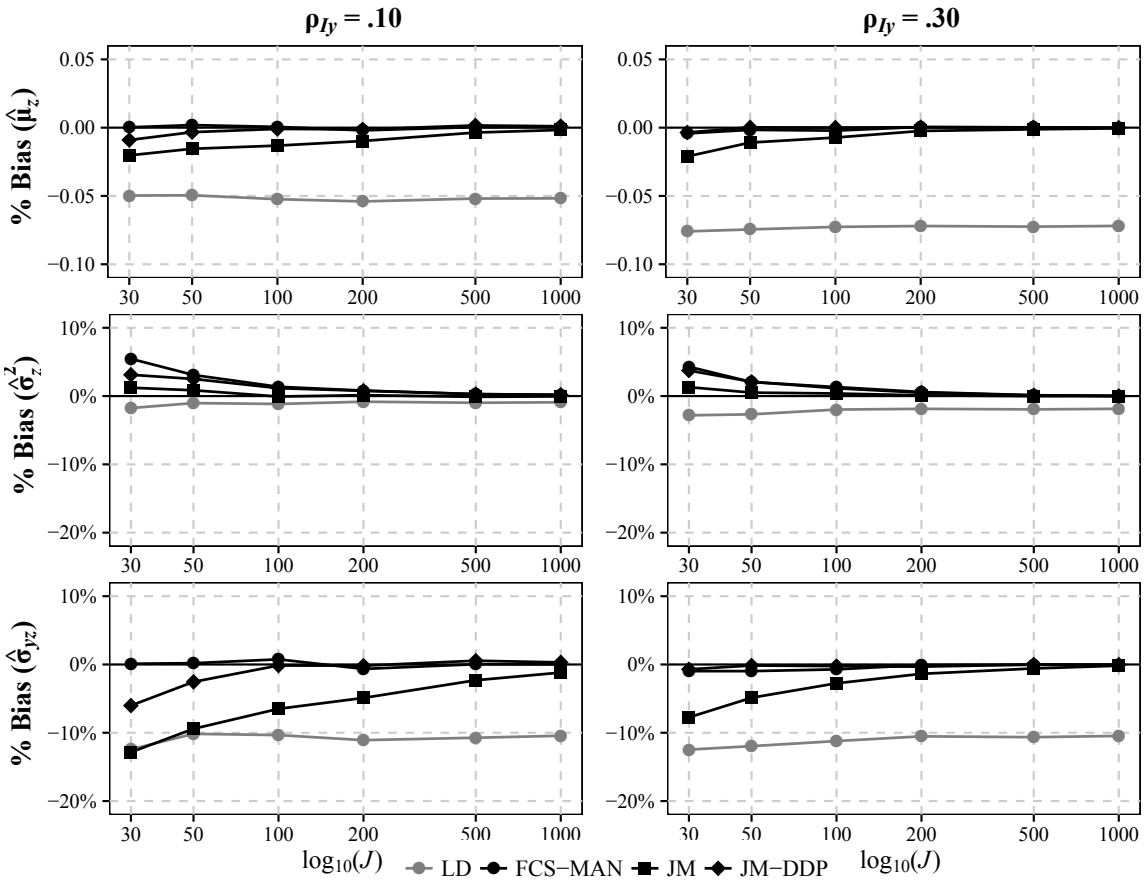

Figure 1. Estimated bias for the mean and the variance of z ($\hat{\mu}_z$ and $\hat{\sigma}^2_z$) and the covariance of y with z ($\hat{\sigma}_{yz}$) for varying numbers of clusters (J) and ICCs of y (ρ_{I_y}) and 20% missing data (MAR, $\lambda = 0.5$). LD = listwise deletion; FCS-MAN = two-level FCS with manifest group means; JM = joint modeling with least-informative priors; JM-DDP = joint modeling with data-dependent priors.

1000; $\rho_{I_y} = .10, .30$; $\lambda = 0.5$; 20% missing data).

The results for the bias in the mean and variance of z ($\hat{\mu}_z$ and $\hat{\sigma}^2_z$), and the covariance of y with z ($\hat{\sigma}_{yz}$) are presented in Figure 1. As in the main study, all procedures provided essentially unbiased estimates of the mean and variance of z. However, to provide unbiased estimates of the covariance of y with z, JM required slightly larger samples than FCS-MAN, especially when the ICC of y was low ($J \geq 200$ with ρ_{I_y}). By contrast, the use of data-dependent priors (JM-DDP) led to a noticeable decrease in bias; that is, much smaller samples were required for the bias in the parameter estimates to vanish ($J \geq 100$). These

results illustrate that the performance of JM may be substantially improved by employing data-dependent priors or, alternatively, by formulating a more reasonable "prior guess" of the variances and covariances at Level 1 and 2 on the basis of prior knowledge rather than relying on the standard least-informative priors.

Supplement D: Additional Tables

This section presents the complete results of the simulation studies reported in the main article. Note that the bias is calculated here in a "raw" metric for all procedures, that is, with the "true" values in the data-generating model as a point of reference. This is in contrast to the main article, where the bias was calculated on the basis of the results obtained from the complete data sets. The results are organized in a series of tables numbered according to the simulation study. Tables 1-1 to 1-30 contain the results of Study 1, and Tables 2-1 to 2-40 contain the results of Study 2.

Table 1-1

Study 1: Bias, RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With 20% Missing Data (MCAR, $\lambda = 0$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.20	0.20	0.20	0.20	0.20	94.1	93.8	89.5	94.5	94.5	94.2
$J = 50$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.14	0.15	0.15	0.15	0.15	0.15	94.9	94.9	91.9	95.3	95.1	94.9
$J = 100$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.10	0.11	0.11	0.11	0.11	0.11	95.3	94.7	90.7	94.9	94.7	95.2
$J = 200$	0.00	−0.00	−0.00	0.00	0.00	−0.00	0.07	0.08	0.08	0.08	0.08	0.08	94.6	94.6	89.9	94.5	94.6	95.2
$J = 500$	0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.04	0.05	0.05	0.05	0.05	0.05	95.5	95.0	91.3	95.4	95.4	95.5
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.03	0.04	0.04	0.04	0.04	0.04	94.7	94.4	89.7	94.3	93.7	94.8
$n = 20$																		
$J = 30$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.18	0.20	0.20	0.20	0.20	0.20	93.9	93.2	87.7	94.1	94.4	94.3
$J = 50$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.15	0.16	0.16	0.16	0.16	0.16	93.7	93.1	86.9	93.9	93.3	93.9
$J = 100$	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.11	0.11	0.11	0.11	0.11	93.9	94.3	86.7	94.7	93.8	93.9
$J = 200$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.07	0.08	0.08	0.08	0.08	0.08	95.1	95.1	89.0	95.3	95.6	96.0
$J = 500$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.04	0.05	0.05	0.05	0.05	0.05	96.7	95.4	89.2	96.1	95.5	96.1
$J = 1000$	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.03	0.03	94.8	95.8	88.5	95.1	96.0	95.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.21	0.21	0.21	0.21	0.21	92.5	92.5	88.1	93.4	93.0	92.5
$J = 50$	0.00	−0.00	0.00	0.00	0.00	0.00	0.14	0.15	0.15	0.15	0.15	0.15	94.4	95.2	90.9	95.1	95.1	94.7
$J = 100$	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.12	0.12	0.12	0.12	0.12	94.1	93.3	88.3	92.6	93.3	93.1
$J = 200$	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.08	0.08	0.08	0.08	0.08	95.5	95.7	91.8	95.1	95.1	95.3
$J = 500$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.05	0.05	0.05	0.05	0.05	0.05	95.3	95.5	90.3	94.8	95.1	94.1
$J = 1000$	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.04	0.04	0.04	0.04	93.9	95.1	88.8	95.2	95.6	94.8
$n = 20$																		
$J = 30$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.18	0.20	0.20	0.20	0.20	0.20	93.7	93.8	86.2	94.1	94.3	93.9
$J = 50$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.14	0.16	0.16	0.16	0.16	0.16	93.2	93.9	87.6	93.9	94.0	93.9
$J = 100$	−0.00	0.00	0.00	0.00	0.00	−0.00	0.10	0.11	0.11	0.11	0.11	0.11	94.8	93.9	88.3	93.9	94.5	94.9
$J = 200$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.07	0.08	0.08	0.08	0.08	0.08	93.9	92.9	86.9	93.3	93.2	93.5
$J = 500$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.04	0.05	0.05	0.05	0.05	0.05	95.3	94.6	89.3	94.7	94.4	94.4
$J = 1000$	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.03	0.03	95.6	95.1	89.9	95.0	95.3	95.7

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-2

Study 1: Bias, RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−0.00	−0.06	−0.05	−0.01	−0.00	−0.03	0.18	0.22	0.21	0.21	0.21	0.21	92.4	91.9	86.6	93.6	93.4	93.0
$J = 50$	0.00	−0.05	−0.04	0.00	0.01	−0.02	0.14	0.16	0.16	0.16	0.16	0.16	94.5	93.6	88.4	95.5	95.9	95.4
$J = 100$	−0.00	−0.05	−0.04	−0.00	0.00	−0.01	0.10	0.12	0.12	0.11	0.11	0.11	94.5	91.8	87.6	94.5	94.5	94.7
$J = 200$	−0.00	−0.05	−0.04	−0.00	0.00	−0.01	0.07	0.09	0.09	0.08	0.08	0.08	95.5	90.2	87.7	94.7	94.8	95.5
$J = 500$	−0.00	−0.05	−0.04	−0.00	−0.00	−0.00	0.04	0.07	0.06	0.05	0.05	0.05	96.8	81.8	80.6	95.4	95.0	95.2
$J = 1000$	−0.00	−0.05	−0.04	−0.00	−0.00	−0.00	0.03	0.06	0.05	0.04	0.04	0.04	94.7	67.7	70.1	94.8	94.6	95.0
$n = 20$																		
$J = 30$	−0.00	−0.07	−0.06	0.00	0.01	−0.03	0.18	0.22	0.21	0.21	0.21	0.21	93.1	91.9	83.7	93.5	93.2	92.6
$J = 50$	0.00	−0.07	−0.06	0.00	0.01	−0.02	0.15	0.18	0.17	0.16	0.17	0.16	94.1	90.7	83.1	94.5	94.3	94.1
$J = 100$	0.00	−0.07	−0.06	0.00	0.00	−0.01	0.10	0.13	0.12	0.11	0.11	0.11	94.7	90.5	82.7	95.5	95.1	95.1
$J = 200$	0.01	−0.07	−0.06	0.00	0.00	−0.00	0.07	0.11	0.10	0.08	0.08	0.08	94.2	84.1	76.8	94.4	93.8	94.4
$J = 500$	−0.00	−0.08	−0.07	−0.00	−0.00	−0.01	0.04	0.09	0.08	0.05	0.05	0.05	95.4	66.4	59.4	94.5	93.8	94.3
$J = 1000$	0.00	−0.07	−0.06	−0.00	0.00	−0.00	0.03	0.08	0.07	0.04	0.04	0.04	96.1	45.7	41.2	95.0	95.0	95.4
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	0.00	−0.07	−0.04	0.00	0.01	−0.02	0.19	0.22	0.21	0.22	0.22	0.21	92.1	90.9	85.7	93.0	92.5	92.5
$J = 50$	0.00	−0.07	−0.04	0.00	0.01	−0.01	0.14	0.17	0.16	0.16	0.16	0.15	94.3	92.2	88.3	94.1	94.3	95.1
$J = 100$	0.00	−0.07	−0.04	−0.00	−0.00	−0.01	0.10	0.13	0.12	0.11	0.11	0.11	93.9	88.3	86.1	94.2	94.0	94.1
$J = 200$	0.00	−0.07	−0.04	0.00	0.00	0.00	0.07	0.10	0.09	0.08	0.08	0.08	95.6	85.0	85.4	95.0	95.4	95.4
$J = 500$	−0.00	−0.07	−0.04	−0.00	−0.00	−0.00	0.04	0.09	0.07	0.05	0.05	0.05	94.7	68.1	77.1	94.7	94.7	95.3
$J = 1000$	0.00	−0.07	−0.04	0.00	0.00	−0.00	0.03	0.08	0.05	0.04	0.04	0.04	94.1	46.4	67.1	94.8	94.8	95.5
$n = 20$																		
$J = 30$	0.01	−0.08	−0.05	0.01	0.01	−0.01	0.18	0.21	0.20	0.20	0.20	0.20	94.4	92.1	86.6	94.9	95.1	94.5
$J = 50$	−0.00	−0.08	−0.05	0.00	0.00	−0.01	0.14	0.17	0.16	0.16	0.16	0.16	94.8	90.9	86.8	94.7	94.2	94.3
$J = 100$	0.00	−0.08	−0.06	0.00	0.00	−0.00	0.10	0.14	0.12	0.11	0.11	0.11	94.9	90.1	85.7	94.6	95.1	94.4
$J = 200$	0.00	−0.08	−0.05	0.00	0.00	0.00	0.07	0.11	0.10	0.08	0.08	0.08	94.4	81.4	79.3	94.1	94.7	94.9
$J = 500$	0.00	−0.08	−0.06	0.00	0.00	0.00	0.05	0.10	0.08	0.05	0.05	0.05	94.8	61.7	67.3	93.7	94.3	93.9
$J = 1000$	−0.00	−0.08	−0.06	0.00	0.00	−0.00	0.03	0.09	0.07	0.04	0.04	0.04	94.9	35.8	49.1	93.6	93.8	94.8

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-3

Study 1: Bias, RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With 20% Missing Data (MAR, $\lambda = 1$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	0.00	−0.10	−0.09	−0.00	0.01	−0.06	0.19	0.23	0.22	0.24	0.24	0.22	92.6	89.6	85.0	93.8	92.3	93.2
$J = 50$	−0.00	−0.10	−0.08	0.00	0.02	−0.04	0.14	0.19	0.18	0.18	0.18	0.17	95.3	89.2	85.2	95.7	93.5	95.3
$J = 100$	0.00	−0.10	−0.08	0.00	0.02	−0.03	0.10	0.15	0.14	0.12	0.12	0.12	95.0	84.6	81.3	95.2	94.0	94.8
$J = 200$	−0.00	−0.11	−0.09	−0.00	0.01	−0.02	0.07	0.13	0.12	0.09	0.09	0.09	94.9	71.0	68.7	94.5	93.3	93.4
$J = 500$	0.00	−0.10	−0.09	0.00	0.00	−0.01	0.04	0.12	0.10	0.05	0.05	0.05	95.9	42.5	47.2	95.2	94.1	96.1
$J = 1000$	0.00	−0.10	−0.08	0.00	0.00	−0.01	0.03	0.11	0.09	0.04	0.04	0.04	94.5	14.6	23.0	94.3	93.9	94.4
$n = 20$																		
$J = 30$	−0.00	−0.14	−0.13	0.00	0.01	−0.07	0.18	0.24	0.24	0.23	0.24	0.22	94.2	86.4	79.0	94.2	93.5	92.4
$J = 50$	0.01	−0.14	−0.13	0.01	0.02	−0.05	0.14	0.21	0.20	0.18	0.18	0.17	94.4	81.5	74.3	94.0	94.6	93.5
$J = 100$	0.00	−0.14	−0.13	0.00	0.01	−0.03	0.10	0.18	0.17	0.12	0.13	0.12	95.1	71.9	63.3	94.2	93.8	93.7
$J = 200$	0.01	−0.14	−0.13	0.00	0.01	−0.02	0.07	0.16	0.15	0.08	0.08	0.08	94.7	53.7	46.5	94.7	95.1	94.8
$J = 500$	−0.00	−0.14	−0.13	−0.00	−0.00	−0.01	0.04	0.15	0.14	0.05	0.05	0.05	95.5	13.0	11.3	95.0	94.6	94.2
$J = 1000$	−0.00	−0.15	−0.13	−0.00	−0.00	−0.01	0.03	0.15	0.14	0.04	0.04	0.04	93.6	0.9	1.0	94.1	94.1	94.1
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−0.00	−0.15	−0.10	−0.00	0.01	−0.05	0.19	0.25	0.22	0.23	0.24	0.22	93.0	85.7	82.8	93.9	92.9	92.9
$J = 50$	−0.00	−0.15	−0.10	−0.00	0.01	−0.03	0.14	0.21	0.18	0.18	0.18	0.17	94.1	81.6	80.6	93.8	93.8	93.7
$J = 100$	0.00	−0.14	−0.10	0.00	0.00	−0.01	0.10	0.18	0.15	0.12	0.12	0.12	95.1	71.3	75.8	94.3	94.3	94.9
$J = 200$	−0.00	−0.15	−0.10	−0.00	−0.00	−0.01	0.07	0.16	0.12	0.08	0.08	0.08	96.1	52.2	65.0	95.6	94.5	95.7
$J = 500$	−0.00	−0.15	−0.10	−0.00	−0.00	−0.00	0.04	0.15	0.11	0.05	0.05	0.05	95.5	13.2	34.9	95.2	95.6	95.0
$J = 1000$	0.00	−0.14	−0.10	−0.00	−0.00	−0.00	0.03	0.15	0.11	0.04	0.04	0.04	94.8	1.1	10.5	95.0	93.6	94.9
$n = 20$																		
$J = 30$	0.00	−0.16	−0.12	0.01	0.01	−0.03	0.18	0.25	0.23	0.22	0.22	0.21	94.3	84.5	78.9	94.8	94.1	94.1
$J = 50$	0.00	−0.16	−0.13	0.00	0.00	−0.03	0.14	0.22	0.20	0.18	0.18	0.17	93.8	79.8	76.3	93.9	94.2	93.0
$J = 100$	0.00	−0.16	−0.12	0.01	0.01	−0.01	0.10	0.19	0.16	0.12	0.12	0.12	94.3	67.5	67.1	94.5	94.2	94.6
$J = 200$	0.00	−0.17	−0.13	0.00	0.00	−0.01	0.07	0.18	0.15	0.08	0.08	0.08	95.2	39.1	44.8	95.2	95.5	95.0
$J = 500$	0.00	−0.17	−0.13	−0.00	−0.00	−0.00	0.04	0.17	0.14	0.05	0.05	0.05	96.0	5.1	11.0	95.3	94.5	94.8
$J = 1000$	0.00	−0.16	−0.13	0.00	0.00	−0.00	0.03	0.17	0.13	0.04	0.04	0.04	94.1	0.0	1.3	94.9	95.0	95.3

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-4

Study 1: Bias, RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With 40% Missing Data (MCAR, $\lambda = 0$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.18	0.23	0.23	0.24	0.24	0.24	94.1	92.7	81.1	92.9	93.9	93.1
$J = 50$	0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.14	0.19	0.18	0.18	0.18	0.19	93.5	93.6	82.4	93.8	93.9	93.7
$J = 100$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.10	0.13	0.13	0.13	0.13	0.13	94.7	94.1	81.5	95.4	94.8	94.9
$J = 200$	−0.00	0.00	0.00	−0.00	−0.00	−0.00	0.07	0.09	0.09	0.09	0.09	0.09	94.8	93.8	82.6	93.7	94.4	94.1
$J = 500$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.04	0.06	0.06	0.06	0.06	0.06	95.5	94.4	83.1	94.6	94.8	95.1
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.03	0.04	0.04	0.04	0.04	0.04	93.6	93.9	81.7	93.2	93.2	93.9
$n = 20$																		
$J = 30$	0.00	0.01	0.01	0.01	0.01	0.01	0.19	0.24	0.24	0.24	0.24	0.24	92.9	92.4	74.4	93.5	93.8	93.1
$J = 50$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.14	0.19	0.19	0.19	0.18	0.19	94.3	92.9	74.9	94.1	94.5	93.4
$J = 100$	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.13	0.13	0.13	0.13	0.13	94.5	94.3	76.5	94.5	94.1	94.3
$J = 200$	−0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.09	0.09	0.09	0.09	0.09	93.9	94.5	76.5	94.5	93.6	94.4
$J = 500$	0.00	0.00	−0.00	−0.00	−0.00	0.00	0.04	0.06	0.06	0.06	0.06	0.06	95.0	95.1	81.2	94.5	94.5	94.3
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.03	0.04	0.04	0.04	0.04	0.04	94.5	94.2	76.5	93.9	93.6	94.9
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.18	0.24	0.23	0.24	0.24	0.24	93.5	93.4	81.2	94.3	94.1	94.5
$J = 50$	0.00	0.00	0.00	0.00	0.01	0.01	0.14	0.18	0.18	0.18	0.18	0.18	94.1	94.4	82.9	94.6	94.1	94.1
$J = 100$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.10	0.12	0.12	0.13	0.13	0.13	94.5	94.9	84.6	95.1	94.9	94.7
$J = 200$	0.00	−0.00	−0.00	0.00	0.00	0.00	0.07	0.09	0.09	0.09	0.09	0.09	94.6	94.4	82.9	94.7	94.3	94.7
$J = 500$	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.06	0.06	0.06	0.06	0.06	95.5	95.6	84.4	95.6	95.3	95.9
$J = 1000$	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.04	0.04	0.04	0.04	94.9	94.9	82.2	94.1	94.2	95.7
$n = 20$																		
$J = 30$	0.01	0.01	0.01	0.01	0.01	0.00	0.19	0.24	0.23	0.24	0.24	0.24	93.8	92.9	75.6	93.7	94.1	94.1
$J = 50$	0.00	0.01	0.01	0.00	0.01	0.01	0.15	0.19	0.18	0.18	0.18	0.18	93.3	92.3	76.7	93.6	94.5	93.9
$J = 100$	−0.00	−0.00	−0.00	−0.00	0.00	−0.00	0.10	0.13	0.13	0.13	0.13	0.13	94.6	94.5	78.5	94.7	94.9	95.5
$J = 200$	0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.07	0.09	0.09	0.09	0.09	0.09	96.3	95.5	81.7	95.6	96.0	96.2
$J = 500$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.04	0.06	0.05	0.05	0.05	0.05	95.7	95.5	80.6	95.3	95.1	96.4
$J = 1000$	−0.00	−0.00	−0.00	0.00	0.00	0.00	0.03	0.04	0.04	0.04	0.04	0.04	94.9	95.2	80.6	95.0	94.9	95.7

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-5

Study 1: Bias, RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−0.00	−0.09	−0.06	0.01	0.02	−0.04	0.19	0.25	0.25	0.27	0.27	0.25	92.5	90.6	79.1	93.5	94.2	93.4
$J = 50$	−0.00	−0.10	−0.08	−0.00	0.01	−0.05	0.14	0.21	0.20	0.20	0.20	0.20	93.6	89.3	78.0	93.3	94.1	92.6
$J = 100$	0.00	−0.10	−0.07	0.00	0.01	−0.03	0.10	0.16	0.15	0.14	0.14	0.14	95.5	87.7	75.1	94.0	94.3	93.7
$J = 200$	−0.00	−0.10	−0.08	−0.00	0.00	−0.02	0.07	0.14	0.12	0.10	0.10	0.10	95.5	80.9	67.7	93.9	92.9	93.7
$J = 500$	−0.00	−0.10	−0.07	−0.00	0.00	−0.01	0.04	0.11	0.09	0.06	0.06	0.06	95.1	59.7	53.5	94.5	94.7	94.8
$J = 1000$	0.00	−0.10	−0.07	−0.00	0.00	−0.01	0.03	0.11	0.08	0.04	0.04	0.04	95.1	32.5	32.6	95.3	95.3	95.3
$n = 20$																		
$J = 30$	−0.01	−0.15	−0.13	−0.01	0.00	−0.08	0.18	0.28	0.27	0.25	0.26	0.25	93.1	87.5	69.0	93.9	93.8	92.3
$J = 50$	−0.00	−0.13	−0.12	0.00	0.01	−0.05	0.14	0.23	0.22	0.20	0.20	0.19	93.5	86.5	66.5	93.9	93.2	92.3
$J = 100$	−0.00	−0.13	−0.12	0.00	0.01	−0.03	0.10	0.19	0.17	0.14	0.14	0.14	94.8	80.7	59.1	93.6	93.5	93.3
$J = 200$	−0.00	−0.14	−0.12	−0.00	−0.00	−0.02	0.07	0.17	0.15	0.10	0.10	0.10	95.5	66.3	46.2	94.3	93.5	93.8
$J = 500$	0.00	−0.13	−0.12	−0.00	−0.00	−0.01	0.04	0.15	0.13	0.06	0.06	0.06	94.7	33.3	20.3	95.3	95.7	94.9
$J = 1000$	0.00	−0.13	−0.12	0.00	0.00	−0.00	0.03	0.14	0.12	0.04	0.04	0.04	95.5	9.5	4.9	93.2	94.8	95.1
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	0.00	−0.13	−0.08	0.00	0.01	−0.04	0.19	0.27	0.25	0.26	0.26	0.25	94.3	89.3	79.1	93.9	94.1	93.9
$J = 50$	−0.00	−0.14	−0.09	−0.00	0.00	−0.03	0.14	0.23	0.20	0.19	0.20	0.19	94.0	87.2	78.3	93.7	95.0	94.5
$J = 100$	0.00	−0.13	−0.08	0.00	0.00	−0.02	0.10	0.18	0.15	0.14	0.14	0.14	94.5	81.3	75.1	93.8	93.2	93.9
$J = 200$	−0.00	−0.13	−0.08	−0.00	−0.00	−0.01	0.07	0.16	0.12	0.09	0.09	0.09	95.6	68.7	68.6	94.6	94.8	94.9
$J = 500$	−0.00	−0.13	−0.08	0.00	0.00	−0.00	0.05	0.15	0.10	0.06	0.06	0.06	94.2	35.4	51.6	93.9	94.2	94.8
$J = 1000$	−0.00	−0.13	−0.08	0.00	−0.00	−0.00	0.03	0.14	0.09	0.04	0.04	0.04	95.6	8.0	27.0	93.8	94.4	95.5
$n = 20$																		
$J = 30$	−0.00	−0.15	−0.11	−0.00	0.00	−0.04	0.18	0.28	0.25	0.24	0.24	0.24	93.7	88.1	70.1	94.3	94.9	94.6
$J = 50$	0.00	−0.15	−0.11	0.00	0.00	−0.02	0.14	0.24	0.21	0.20	0.20	0.19	94.0	85.0	68.6	93.5	93.9	94.6
$J = 100$	0.00	−0.15	−0.10	0.01	0.01	−0.01	0.10	0.20	0.16	0.14	0.14	0.14	94.1	77.1	63.1	93.8	93.4	94.9
$J = 200$	0.01	−0.15	−0.10	0.00	0.01	−0.00	0.07	0.17	0.14	0.10	0.10	0.10	93.9	62.1	54.4	93.7	93.9	94.6
$J = 500$	0.00	−0.15	−0.11	0.00	0.00	−0.00	0.05	0.16	0.12	0.06	0.06	0.06	94.8	23.9	26.1	94.3	94.1	94.5
$J = 1000$	−0.00	−0.15	−0.11	−0.00	−0.00	−0.00	0.03	0.16	0.11	0.04	0.04	0.04	94.2	3.0	7.0	94.8	94.4	95.4

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-6

Study 1: Bias, RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With 40% Missing Data (MAR, $\lambda = 1$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	0.00	−0.19	−0.16	0.01	0.00	−0.13	0.18	0.30	0.28	0.37	0.35	0.28	95.1	83.7	72.6	92.7	92.1	92.1
$J = 50$	0.00	−0.20	−0.17	−0.00	0.02	−0.12	0.14	0.26	0.24	0.26	0.26	0.23	95.3	78.2	65.7	95.0	92.9	92.1
$J = 100$	0.00	−0.19	−0.16	0.01	0.04	−0.09	0.10	0.23	0.21	0.19	0.19	0.17	93.7	65.4	53.2	93.5	90.7	91.8
$J = 200$	0.00	−0.19	−0.16	0.00	0.03	−0.06	0.07	0.21	0.19	0.13	0.14	0.12	95.3	41.0	33.2	93.9	91.6	92.0
$J = 500$	−0.00	−0.19	−0.17	0.00	0.01	−0.04	0.05	0.20	0.18	0.08	0.08	0.08	94.3	6.3	6.1	94.1	92.6	92.5
$J = 1000$	0.00	−0.19	−0.16	−0.00	0.00	−0.02	0.03	0.20	0.17	0.06	0.06	0.06	93.6	0.2	0.5	94.2	93.2	92.5
$n = 20$																		
$J = 30$	−0.00	−0.27	−0.25	−0.01	0.02	−0.18	0.18	0.35	0.33	0.35	0.37	0.30	94.2	74.9	51.5	93.7	91.8	90.1
$J = 50$	0.00	−0.26	−0.25	0.00	0.03	−0.14	0.14	0.32	0.30	0.27	0.29	0.24	94.7	63.9	42.3	92.8	92.2	90.3
$J = 100$	−0.00	−0.27	−0.25	−0.00	0.01	−0.10	0.10	0.29	0.28	0.18	0.18	0.18	94.9	41.1	20.9	94.8	92.9	90.2
$J = 200$	0.00	−0.27	−0.25	0.00	0.01	−0.06	0.07	0.28	0.26	0.12	0.13	0.13	95.0	13.3	5.3	94.1	92.7	91.6
$J = 500$	−0.00	−0.27	−0.25	0.00	0.00	−0.03	0.04	0.27	0.25	0.08	0.08	0.08	95.3	0.3	0.1	93.8	92.8	92.0
$J = 1000$	−0.00	−0.27	−0.25	−0.00	−0.00	−0.02	0.03	0.27	0.25	0.05	0.05	0.06	94.8	0.0	0.0	94.3	93.9	94.6
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	0.00	−0.27	−0.21	−0.01	0.04	−0.13	0.19	0.35	0.31	0.36	0.38	0.29	93.2	74.4	66.3	93.9	92.7	92.3
$J = 50$	0.00	−0.27	−0.20	−0.00	0.03	−0.09	0.14	0.32	0.27	0.26	0.28	0.23	93.7	65.0	59.1	93.9	91.5	92.9
$J = 100$	0.01	−0.26	−0.19	0.01	0.02	−0.04	0.10	0.29	0.23	0.18	0.19	0.17	94.7	43.1	44.6	92.8	92.9	94.5
$J = 200$	−0.00	−0.27	−0.20	−0.00	0.00	−0.03	0.07	0.28	0.22	0.13	0.13	0.13	94.7	13.4	21.5	93.8	92.3	93.3
$J = 500$	0.00	−0.26	−0.20	0.00	0.00	−0.01	0.05	0.27	0.21	0.08	0.08	0.08	94.3	0.6	2.3	92.8	93.4	93.0
$J = 1000$	−0.00	−0.27	−0.20	0.00	0.00	−0.00	0.03	0.27	0.20	0.06	0.06	0.06	96.1	0.0	0.0	93.9	93.4	94.4
$n = 20$																		
$J = 30$	−0.01	−0.31	−0.26	−0.01	0.00	−0.12	0.18	0.38	0.34	0.33	0.35	0.30	94.6	67.1	49.4	95.2	93.1	92.7
$J = 50$	−0.00	−0.31	−0.25	−0.00	0.00	−0.08	0.14	0.35	0.31	0.26	0.26	0.23	94.5	54.8	38.1	93.3	94.3	93.1
$J = 100$	0.00	−0.31	−0.26	−0.00	−0.00	−0.05	0.10	0.33	0.28	0.17	0.17	0.17	95.1	25.5	18.1	94.8	94.0	95.0
$J = 200$	−0.00	−0.30	−0.25	−0.00	−0.00	−0.03	0.07	0.32	0.27	0.12	0.12	0.12	93.6	6.2	5.6	92.7	93.1	95.3
$J = 500$	0.00	−0.30	−0.25	0.01	0.01	−0.00	0.04	0.31	0.25	0.08	0.08	0.07	96.0	0.0	0.0	94.7	93.9	95.8
$J = 1000$	−0.00	−0.31	−0.25	0.00	0.00	−0.00	0.03	0.31	0.25	0.06	0.06	0.06	95.7	0.0	0.0	93.1	93.1	94.7

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-7

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With 20% Missing Data (MCAR, $\lambda = 0$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−2.6	−3.5	−18.6	1.5	1.4	−1.6	0.26	0.29	0.31	0.31	0.31	0.30	87.5	84.8	71.1	89.7	89.8	87.7
$J = 50$	−2.1	−2.6	−17.9	0.2	0.3	−1.6	0.20	0.23	0.27	0.24	0.23	0.23	89.5	87.5	69.8	91.8	90.9	89.7
$J = 100$	−1.5	−1.7	−17.3	−0.6	−0.3	−1.4	0.14	0.15	0.22	0.16	0.16	0.16	91.5	92.0	66.3	93.4	92.5	92.8
$J = 200$	−0.3	−0.4	−16.2	0.3	0.3	−0.2	0.10	0.11	0.19	0.11	0.11	0.11	93.8	93.5	54.1	94.7	94.5	94.3
$J = 500$	−0.0	−0.1	−16.1	0.2	0.1	−0.1	0.06	0.07	0.17	0.07	0.07	0.07	94.3	94.6	24.9	94.0	94.4	94.1
$J = 1000$	0.2	0.2	−15.8	0.3	0.3	0.2	0.04	0.05	0.16	0.05	0.05	0.05	94.6	95.3	5.8	95.2	94.8	95.1
$n = 20$																		
$J = 30$	−3.3	−4.2	−22.4	0.1	0.6	−2.4	0.25	0.28	0.32	0.30	0.29	0.28	86.6	84.8	67.5	88.8	89.7	88.0
$J = 50$	−1.6	−2.3	−20.9	0.2	0.2	−1.5	0.20	0.23	0.28	0.24	0.24	0.23	89.5	88.7	66.1	90.9	91.3	90.2
$J = 100$	−0.6	−0.8	−19.6	0.4	0.5	−0.6	0.14	0.16	0.24	0.16	0.16	0.16	92.3	91.9	60.1	92.9	93.2	92.9
$J = 200$	−0.5	−0.6	−19.5	−0.0	0.1	−0.5	0.10	0.11	0.22	0.11	0.11	0.11	94.0	94.4	43.3	95.0	94.5	94.7
$J = 500$	−0.3	−0.3	−19.3	−0.2	−0.2	−0.3	0.06	0.07	0.20	0.07	0.07	0.07	94.4	93.8	12.4	93.8	93.6	94.0
$J = 1000$	−0.1	0.0	−19.0	0.2	0.2	0.0	0.05	0.05	0.19	0.05	0.05	0.05	94.4	95.0	1.2	95.0	94.9	94.8
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−3.3	−4.4	−18.8	0.3	0.8	−2.1	0.25	0.28	0.31	0.30	0.30	0.29	87.5	86.1	71.6	90.5	90.9	89.8
$J = 50$	−3.2	−3.4	−18.2	−1.1	−1.0	−2.1	0.19	0.21	0.26	0.22	0.22	0.22	90.6	88.2	70.9	91.5	91.1	90.1
$J = 100$	−0.9	−1.1	−16.4	0.0	0.1	−0.5	0.14	0.16	0.21	0.16	0.16	0.16	92.3	92.7	66.9	93.9	93.7	93.3
$J = 200$	−0.4	−0.4	−15.9	0.2	0.2	−0.1	0.10	0.11	0.19	0.11	0.11	0.11	93.3	93.2	56.4	94.4	94.4	93.8
$J = 500$	−0.3	−0.2	−15.8	0.0	−0.0	−0.1	0.06	0.07	0.17	0.07	0.07	0.07	95.3	95.8	24.8	96.1	96.1	95.4
$J = 1000$	−0.1	−0.1	−15.8	−0.0	−0.0	−0.1	0.04	0.05	0.16	0.05	0.05	0.05	94.1	94.9	5.9	94.4	94.5	95.2
$n = 20$																		
$J = 30$	−2.8	−3.8	−21.3	0.3	0.4	−1.7	0.25	0.28	0.32	0.29	0.29	0.28	87.3	84.8	68.2	90.1	90.1	88.3
$J = 50$	−1.2	−0.8	−19.2	1.3	1.5	0.2	0.20	0.23	0.27	0.23	0.24	0.23	90.3	89.3	69.3	92.5	92.8	91.3
$J = 100$	−0.7	−1.0	−19.3	0.1	0.1	−0.3	0.14	0.15	0.23	0.16	0.16	0.16	93.5	93.2	61.5	94.1	94.1	94.2
$J = 200$	−0.4	−0.2	−18.7	0.2	0.2	−0.0	0.10	0.12	0.21	0.12	0.12	0.12	93.2	93.1	46.1	93.7	93.4	92.7
$J = 500$	−0.4	−0.4	−18.9	−0.2	−0.2	−0.3	0.06	0.07	0.20	0.07	0.07	0.07	94.2	93.6	14.6	93.9	94.3	94.2
$J = 1000$	0.1	0.1	−18.5	0.2	0.2	0.2	0.05	0.05	0.19	0.05	0.05	0.05	94.6	94.8	2.1	94.3	95.0	94.7

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-8

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−3.3	−5.1	−19.9	1.6	1.9	−2.6	0.25	0.28	0.31	0.31	0.31	0.29	87.6	85.8	70.5	90.6	90.2	88.6
$J = 50$	−2.3	−4.0	−19.2	0.1	0.6	−2.4	0.19	0.22	0.27	0.23	0.23	0.22	90.9	87.7	68.5	92.5	92.1	90.3
$J = 100$	−1.9	−2.9	−18.3	−0.4	−0.1	−1.6	0.14	0.16	0.23	0.16	0.17	0.16	92.1	90.7	62.5	92.7	92.5	91.9
$J = 200$	−0.7	−2.0	−17.3	−0.2	−0.1	−1.0	0.10	0.11	0.20	0.11	0.11	0.11	94.4	92.5	51.4	93.7	93.9	94.3
$J = 500$	−0.1	−1.1	−16.8	0.1	0.1	−0.2	0.06	0.07	0.18	0.07	0.07	0.07	94.2	92.7	22.2	93.9	93.2	94.5
$J = 1000$	−0.2	−1.2	−16.9	−0.0	−0.1	−0.2	0.05	0.05	0.17	0.05	0.05	0.05	94.1	93.3	3.5	94.2	94.7	93.7
$n = 20$																		
$J = 30$	−3.0	−5.6	−23.4	1.5	2.2	−2.9	0.26	0.29	0.33	0.32	0.32	0.29	87.0	83.4	66.3	89.9	89.9	87.2
$J = 50$	−1.8	−4.0	−22.2	0.6	1.0	−2.0	0.20	0.22	0.29	0.23	0.24	0.22	90.1	89.2	65.8	93.3	93.8	91.7
$J = 100$	−1.2	−3.1	−21.4	0.1	0.1	−1.4	0.14	0.15	0.25	0.16	0.16	0.16	92.7	91.9	54.9	94.1	93.7	93.6
$J = 200$	−0.7	−2.6	−21.1	−0.3	−0.2	−1.0	0.10	0.12	0.23	0.12	0.12	0.12	92.9	90.9	36.8	93.1	93.1	92.6
$J = 500$	−0.3	−2.0	−20.6	0.0	0.1	−0.3	0.06	0.07	0.21	0.07	0.07	0.07	95.3	93.4	7.4	95.9	95.7	95.2
$J = 1000$	0.1	−1.7	−20.3	0.2	0.2	0.0	0.04	0.05	0.21	0.05	0.05	0.05	95.3	91.8	0.6	95.4	95.4	94.3
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−3.5	−5.8	−20.2	1.4	2.0	−2.2	0.25	0.27	0.31	0.30	0.30	0.28	88.2	85.0	69.8	90.5	90.8	89.1
$J = 50$	−2.6	−4.5	−18.9	0.0	0.2	−1.6	0.20	0.23	0.27	0.23	0.24	0.23	88.7	86.6	68.4	91.4	91.5	89.6
$J = 100$	−1.6	−3.9	−18.7	−0.9	−0.8	−1.7	0.14	0.16	0.23	0.16	0.16	0.16	91.3	89.1	61.8	92.2	92.8	91.5
$J = 200$	−0.8	−2.7	−17.8	−0.2	−0.2	−0.6	0.11	0.12	0.20	0.12	0.12	0.12	91.3	88.3	48.8	92.3	92.4	91.8
$J = 500$	−0.3	−2.2	−17.2	−0.2	−0.1	−0.3	0.06	0.07	0.18	0.07	0.07	0.07	93.3	92.7	17.9	94.4	94.3	94.7
$J = 1000$	0.1	−1.7	−16.8	0.2	0.2	0.1	0.05	0.05	0.17	0.05	0.05	0.05	95.2	93.0	3.7	94.9	94.7	94.8
$n = 20$																		
$J = 30$	−4.4	−7.2	−24.3	0.0	−0.2	−2.9	0.25	0.29	0.34	0.31	0.31	0.30	87.2	82.2	64.2	88.9	89.3	86.9
$J = 50$	−2.2	−5.0	−22.1	−0.0	0.1	−1.6	0.20	0.22	0.29	0.23	0.23	0.23	90.1	87.7	63.6	91.1	91.2	90.2
$J = 100$	−0.9	−3.2	−21.1	0.4	0.4	−0.4	0.14	0.15	0.25	0.16	0.16	0.16	92.6	90.2	55.5	93.5	93.7	93.3
$J = 200$	−0.1	−2.7	−20.6	0.4	0.4	−0.1	0.10	0.11	0.23	0.12	0.12	0.11	93.5	90.9	36.7	94.2	94.1	93.0
$J = 500$	−0.2	−2.4	−20.4	0.2	0.2	0.1	0.06	0.08	0.21	0.08	0.08	0.08	93.7	90.8	9.7	93.9	93.9	94.4
$J = 1000$	−0.2	−2.6	−20.6	−0.1	−0.1	−0.2	0.04	0.05	0.21	0.05	0.05	0.05	95.5	91.1	0.2	95.8	95.8	95.6

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-9

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With 20% Missing Data (MAR, $\lambda = 1$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−3.4	−7.4	−21.7	7.4	8.8	−2.5	0.25	0.28	0.32	0.36	0.37	0.29	86.7	82.9	68.5	92.8	93.1	89.5
$J = 50$	−1.8	−5.8	−20.6	4.0	5.5	−1.9	0.21	0.22	0.28	0.26	0.27	0.23	89.2	86.7	65.4	93.6	93.8	91.4
$J = 100$	−0.8	−4.5	−19.4	2.1	3.4	−1.3	0.14	0.15	0.23	0.17	0.17	0.15	92.5	89.8	60.3	94.9	95.1	93.3
$J = 200$	−0.5	−4.4	−19.5	0.7	1.4	−1.3	0.10	0.11	0.21	0.12	0.12	0.11	94.4	89.0	40.7	95.6	95.4	93.7
$J = 500$	−0.1	−3.8	−19.1	0.5	0.7	−0.5	0.06	0.08	0.20	0.08	0.08	0.07	95.3	90.1	11.0	95.0	94.0	94.4
$J = 1000$	−0.2	−4.0	−19.2	0.0	0.2	−0.6	0.04	0.06	0.20	0.06	0.06	0.05	95.5	84.7	1.1	95.0	94.4	94.4
$n = 20$																		
$J = 30$	−1.9	−9.4	−26.3	7.9	9.6	−4.0	0.26	0.28	0.34	0.37	0.39	0.29	87.8	82.1	61.5	92.9	92.5	88.1
$J = 50$	−2.1	−9.7	−26.8	3.2	4.4	−4.3	0.20	0.22	0.32	0.26	0.27	0.23	90.2	82.9	55.0	92.7	92.7	89.4
$J = 100$	−0.9	−8.2	−25.7	1.7	1.9	−2.7	0.14	0.17	0.28	0.18	0.19	0.17	92.3	84.6	41.9	93.5	93.2	90.7
$J = 200$	−1.1	−8.7	−26.1	−0.4	−0.2	−2.8	0.10	0.13	0.27	0.13	0.13	0.12	92.7	80.5	17.0	92.6	93.4	91.4
$J = 500$	−0.4	−7.7	−25.2	−0.1	−0.1	−1.2	0.06	0.10	0.26	0.08	0.08	0.08	93.3	74.4	2.1	93.9	93.5	93.0
$J = 1000$	−0.1	−7.2	−24.8	0.2	0.2	−0.4	0.05	0.09	0.25	0.06	0.06	0.06	95.1	64.3	0.0	94.2	94.6	93.8
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−3.5	−11.2	−24.1	5.6	8.1	−2.8	0.25	0.28	0.33	0.35	0.37	0.30	87.1	80.9	62.9	92.2	92.6	88.3
$J = 50$	−1.9	−9.7	−23.0	2.8	4.2	−2.2	0.20	0.23	0.29	0.26	0.27	0.23	90.1	82.5	61.7	92.0	92.1	90.5
$J = 100$	−0.9	−8.2	−22.1	1.5	1.8	−0.8	0.14	0.17	0.26	0.18	0.19	0.17	91.6	84.7	51.2	93.1	93.7	92.6
$J = 200$	−0.7	−7.9	−21.8	0.2	0.3	−0.7	0.10	0.13	0.24	0.12	0.13	0.12	93.0	83.8	31.2	93.1	92.9	93.1
$J = 500$	−0.1	−7.1	−21.2	0.5	0.6	0.1	0.06	0.09	0.22	0.08	0.08	0.08	95.0	79.0	5.3	94.0	94.3	95.3
$J = 1000$	−0.0	−7.2	−21.3	0.1	0.2	−0.1	0.05	0.09	0.22	0.06	0.06	0.06	93.7	64.0	0.3	93.5	93.7	93.2
$n = 20$																		
$J = 30$	−4.2	−13.4	−29.1	4.9	4.9	−2.8	0.25	0.28	0.36	0.36	0.35	0.30	87.9	79.1	58.3	90.9	91.1	88.1
$J = 50$	−1.0	−10.4	−26.6	4.2	4.3	−0.3	0.20	0.23	0.32	0.28	0.28	0.25	90.1	81.9	54.5	92.9	91.9	89.5
$J = 100$	−1.3	−10.6	−26.9	1.2	1.4	−0.8	0.15	0.18	0.30	0.19	0.19	0.18	90.8	80.5	38.6	93.1	92.7	91.9
$J = 200$	−0.1	−9.6	−26.3	1.3	1.2	0.0	0.10	0.14	0.28	0.13	0.13	0.13	94.5	78.2	16.8	94.6	94.4	93.9
$J = 500$	−0.2	−9.7	−26.3	0.0	0.1	−0.3	0.06	0.12	0.27	0.08	0.08	0.08	93.3	63.7	0.6	92.9	93.3	93.5
$J = 1000$	−0.2	−9.6	−26.1	−0.1	−0.0	−0.2	0.04	0.11	0.26	0.06	0.06	0.06	95.1	43.0	0.1	94.3	94.5	94.0

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-10

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With 40% Missing Data (MCAR, $\lambda = 0$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−3.1	−5.7	−35.4	7.9	8.2	−0.4	0.25	0.33	0.42	0.41	0.42	0.34	87.4	82.0	47.6	91.5	90.9	87.9
$J = 50$	−1.7	−3.3	−33.6	3.8	4.4	−0.2	0.20	0.26	0.38	0.28	0.29	0.26	90.1	86.7	42.2	93.4	93.9	91.4
$J = 100$	−0.6	−1.3	−32.7	2.0	2.4	−0.2	0.15	0.18	0.35	0.19	0.20	0.19	91.3	91.0	27.2	93.4	93.7	92.3
$J = 200$	−0.5	−1.0	−32.6	0.7	1.0	−0.3	0.10	0.13	0.34	0.14	0.14	0.13	93.1	91.8	8.4	93.3	92.6	92.2
$J = 500$	−0.1	−0.1	−32.0	0.5	0.6	−0.0	0.06	0.08	0.33	0.08	0.08	0.08	95.3	94.6	0.3	95.2	95.4	94.6
$J = 1000$	−0.1	−0.2	−32.1	0.1	0.1	−0.2	0.04	0.06	0.32	0.06	0.06	0.06	95.3	94.0	0.0	93.9	93.6	93.9
$n = 20$																		
$J = 30$	−3.8	−7.4	−42.5	4.8	6.6	−2.9	0.25	0.32	0.48	0.38	0.40	0.33	88.4	81.9	36.8	91.7	92.7	87.9
$J = 50$	−1.9	−3.6	−39.9	3.1	3.5	−1.5	0.19	0.25	0.43	0.28	0.28	0.26	90.9	87.2	32.3	92.8	92.5	90.1
$J = 100$	−0.3	−1.3	−38.7	1.9	2.1	−0.5	0.14	0.18	0.41	0.19	0.19	0.18	94.0	91.7	14.7	94.5	93.9	92.5
$J = 200$	−1.0	−1.1	−38.6	0.4	0.5	−0.7	0.10	0.13	0.40	0.13	0.13	0.13	94.0	93.3	2.8	94.1	95.0	94.0
$J = 500$	−0.3	−0.4	−38.2	0.1	0.2	−0.3	0.06	0.08	0.39	0.08	0.08	0.08	95.7	94.1	0.0	94.9	93.5	94.5
$J = 1000$	0.1	−0.1	−38.0	0.2	0.2	−0.1	0.04	0.06	0.38	0.06	0.06	0.06	95.2	95.2	0.0	94.6	94.3	95.0
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−2.8	−5.3	−34.1	6.8	7.6	0.5	0.26	0.33	0.41	0.39	0.39	0.35	86.1	82.9	49.7	91.9	92.0	89.9
$J = 50$	−2.8	−3.3	−33.0	3.4	3.8	−0.0	0.20	0.25	0.38	0.28	0.28	0.26	89.2	87.1	43.5	92.1	92.7	91.5
$J = 100$	−1.2	−2.1	−32.6	1.0	1.1	−0.3	0.14	0.19	0.35	0.19	0.19	0.19	92.7	89.3	27.0	92.9	92.3	92.2
$J = 200$	−1.4	−1.2	−31.9	0.2	0.3	−0.5	0.10	0.12	0.33	0.13	0.13	0.13	93.7	92.9	8.4	93.9	94.4	93.7
$J = 500$	−0.0	0.0	−31.1	0.6	0.5	0.3	0.06	0.08	0.32	0.09	0.08	0.08	93.4	93.5	0.1	94.2	93.8	93.9
$J = 1000$	−0.0	−0.2	−31.4	0.1	0.1	0.0	0.04	0.06	0.32	0.06	0.06	0.06	94.6	95.4	0.0	95.0	95.2	95.0
$n = 20$																		
$J = 30$	−4.0	−6.5	−40.9	5.6	5.8	−0.2	0.26	0.34	0.47	0.40	0.39	0.36	86.1	80.2	40.3	90.6	90.9	89.1
$J = 50$	−2.3	−3.6	−38.9	2.7	3.5	−0.1	0.19	0.24	0.42	0.26	0.27	0.25	90.2	87.5	32.8	92.7	92.6	91.7
$J = 100$	−1.1	−1.6	−38.2	1.3	1.2	0.1	0.14	0.19	0.40	0.20	0.20	0.19	92.0	89.7	17.1	92.6	93.2	93.1
$J = 200$	−0.4	−0.7	−37.5	0.9	0.9	0.0	0.10	0.13	0.38	0.13	0.13	0.13	94.0	92.8	2.1	94.9	94.3	94.1
$J = 500$	−0.3	−0.3	−37.3	0.2	0.1	0.0	0.06	0.08	0.38	0.08	0.08	0.08	94.9	94.7	0.0	95.1	95.4	94.6
$J = 1000$	−0.0	−0.3	−37.4	0.1	−0.0	−0.1	0.05	0.06	0.38	0.06	0.06	0.06	93.8	93.7	0.0	94.6	93.1	94.1

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-11

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−4.7	−7.2	−36.0	10.6	10.0	−1.0	0.25	0.32	0.43	0.44	0.41	0.34	86.7	83.7	45.9	92.7	93.4	89.5
$J = 50$	−1.3	−4.7	−34.8	4.6	5.6	−1.1	0.20	0.26	0.39	0.30	0.30	0.27	89.7	84.7	39.3	92.1	92.6	90.1
$J = 100$	−0.7	−2.4	−33.3	2.8	3.5	−0.3	0.14	0.18	0.36	0.20	0.20	0.18	93.3	90.9	24.4	94.9	95.3	93.3
$J = 200$	−0.1	−1.7	−32.9	1.6	1.8	−0.1	0.10	0.13	0.34	0.14	0.14	0.14	93.4	90.9	7.8	94.4	93.5	92.8
$J = 500$	−0.0	−1.6	−32.9	0.5	0.6	−0.2	0.06	0.08	0.33	0.09	0.09	0.08	95.1	93.0	0.1	94.5	93.4	93.0
$J = 1000$	−0.1	−1.5	−33.0	0.1	0.2	−0.2	0.04	0.06	0.33	0.06	0.06	0.06	95.3	92.8	0.0	94.5	94.5	94.3
$n = 20$																		
$J = 30$	−3.5	−8.1	−42.9	9.2	10.9	−2.3	0.26	0.33	0.48	0.43	0.44	0.34	86.3	81.9	37.1	93.7	93.3	89.5
$J = 50$	−2.1	−6.4	−41.7	3.4	4.3	−2.7	0.20	0.25	0.45	0.28	0.29	0.26	89.7	84.4	28.1	92.3	92.9	90.1
$J = 100$	−0.8	−3.6	−40.1	2.4	2.4	−0.8	0.14	0.18	0.42	0.19	0.19	0.18	92.3	88.8	13.2	93.7	94.0	92.1
$J = 200$	−0.2	−2.8	−39.6	1.2	1.5	−0.5	0.10	0.13	0.41	0.13	0.14	0.13	94.8	92.2	1.2	94.6	94.3	93.7
$J = 500$	−0.0	−2.8	−39.6	0.3	0.5	−0.3	0.06	0.08	0.40	0.08	0.08	0.08	94.9	92.1	0.0	93.9	95.4	94.0
$J = 1000$	−0.0	−2.4	−39.4	0.4	0.4	0.1	0.05	0.06	0.40	0.06	0.06	0.06	94.3	91.9	0.0	94.4	93.5	93.9
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−2.2	−6.9	−34.5	10.8	12.3	1.7	0.26	0.33	0.42	0.43	0.44	0.35	87.7	80.6	49.7	92.3	92.3	89.7
$J = 50$	−2.4	−6.4	−35.1	3.9	4.7	−0.5	0.20	0.26	0.39	0.29	0.30	0.27	90.3	84.4	38.9	92.1	93.6	89.9
$J = 100$	−1.9	−5.0	−34.2	1.1	1.3	−0.9	0.14	0.18	0.37	0.20	0.19	0.19	91.6	87.4	23.0	92.3	93.1	91.7
$J = 200$	−0.2	−2.5	−32.7	1.6	1.7	0.8	0.10	0.13	0.34	0.14	0.14	0.14	93.6	90.7	8.0	94.2	94.9	94.3
$J = 500$	−0.2	−2.8	−33.0	0.3	0.4	0.0	0.06	0.09	0.34	0.09	0.09	0.09	93.9	90.5	0.1	93.4	92.5	93.0
$J = 1000$	−0.0	−2.5	−32.8	0.4	0.3	0.1	0.04	0.06	0.33	0.06	0.06	0.06	95.4	91.6	0.0	95.5	95.8	96.2
$n = 20$																		
$J = 30$	−3.1	−8.3	−42.2	9.2	9.0	1.4	0.26	0.33	0.48	0.42	0.41	0.37	87.5	80.9	37.2	92.1	92.3	89.3
$J = 50$	−1.4	−5.2	−40.3	5.4	5.3	1.5	0.20	0.25	0.44	0.29	0.29	0.27	90.1	85.1	31.7	93.5	93.5	91.5
$J = 100$	−0.7	−4.5	−39.9	2.0	2.1	0.2	0.14	0.18	0.42	0.20	0.20	0.19	92.2	87.9	12.4	93.9	93.3	93.0
$J = 200$	−0.6	−4.0	−39.5	0.8	0.7	−0.0	0.10	0.13	0.40	0.13	0.13	0.13	93.7	89.9	1.8	94.3	93.7	94.8
$J = 500$	−0.2	−3.5	−39.3	0.4	0.4	0.1	0.06	0.08	0.40	0.08	0.08	0.08	95.1	90.4	0.0	93.8	95.2	95.2
$J = 1000$	−0.1	−3.4	−39.2	0.2	0.2	0.1	0.05	0.07	0.39	0.06	0.06	0.06	94.2	88.0	0.0	94.6	95.5	94.6

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-12

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With 40% Missing Data (MAR, $\lambda = 1$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−3.4	−10.6	−38.3	25.9	21.3	−1.4	0.26	0.33	0.44	0.61	0.53	0.35	87.7	79.9	42.3	95.5	95.3	89.9
$J = 50$	−2.1	−8.6	−37.4	13.2	13.4	−1.8	0.20	0.26	0.41	0.38	0.37	0.27	89.7	81.9	34.5	94.6	95.5	89.3
$J = 100$	−1.1	−7.1	−36.5	6.1	7.6	−2.4	0.14	0.18	0.38	0.24	0.24	0.19	92.7	85.9	17.9	95.0	94.7	91.9
$J = 200$	−0.7	−5.7	−35.6	3.1	4.6	−1.7	0.10	0.14	0.37	0.15	0.16	0.14	93.8	85.6	3.8	94.9	95.2	92.2
$J = 500$	−0.3	−5.4	−35.5	1.3	2.0	−1.3	0.06	0.09	0.36	0.10	0.10	0.09	94.2	85.5	0.0	94.0	93.8	92.1
$J = 1000$	−0.1	−5.4	−35.6	0.3	0.5	−1.1	0.04	0.08	0.36	0.06	0.06	0.06	95.7	79.6	0.0	94.1	94.9	93.6
$n = 20$																		
$J = 30$	−3.1	−15.0	−47.0	21.7	26.5	−5.4	0.25	0.34	0.51	0.56	0.61	0.35	87.0	74.7	29.0	94.4	95.0	86.7
$J = 50$	−2.1	−12.9	−45.8	11.3	15.6	−5.5	0.20	0.26	0.48	0.37	0.40	0.26	89.5	80.5	20.1	94.9	94.8	89.4
$J = 100$	−1.3	−11.7	−45.1	4.9	6.5	−4.8	0.15	0.20	0.46	0.24	0.25	0.19	90.5	79.3	5.2	94.1	94.0	89.2
$J = 200$	−0.6	−11.0	−44.8	2.3	2.6	−3.6	0.10	0.16	0.45	0.16	0.16	0.14	94.3	75.8	0.2	94.4	95.2	91.3
$J = 500$	0.2	−9.8	−43.9	1.4	1.5	−1.4	0.06	0.12	0.44	0.10	0.10	0.09	95.5	69.3	0.0	95.0	94.4	93.5
$J = 1000$	−0.1	−10.1	−44.2	0.3	0.3	−1.0	0.04	0.11	0.44	0.07	0.07	0.07	95.3	49.8	0.0	94.8	94.7	94.4
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−3.0	−14.9	−40.4	24.5	30.0	−0.2	0.26	0.32	0.46	0.61	0.64	0.36	86.7	75.8	38.9	95.2	95.0	89.8
$J = 50$	−2.6	−13.9	−39.9	11.1	15.7	−1.9	0.20	0.26	0.43	0.37	0.41	0.27	89.5	77.6	29.0	94.4	95.5	90.6
$J = 100$	−1.2	−11.4	−38.8	5.9	7.4	−0.1	0.15	0.20	0.41	0.25	0.27	0.21	90.5	79.1	13.9	93.7	94.1	92.3
$J = 200$	−0.5	−10.8	−38.5	2.4	2.6	−0.3	0.10	0.16	0.39	0.16	0.17	0.15	94.7	76.8	1.5	93.9	93.4	92.8
$J = 500$	−0.4	−10.5	−38.4	0.7	0.8	−0.3	0.06	0.13	0.39	0.10	0.10	0.10	94.6	66.1	0.0	93.2	93.1	92.5
$J = 1000$	−0.3	−10.1	−38.2	0.6	0.6	0.1	0.05	0.11	0.38	0.07	0.07	0.07	93.7	49.6	0.0	93.5	93.2	94.5
$n = 20$																		
$J = 30$	−2.0	−17.1	−47.7	21.2	23.9	2.1	0.26	0.33	0.51	0.56	0.59	0.39	86.7	74.0	28.2	94.0	94.1	89.9
$J = 50$	−2.5	−16.3	−47.3	10.3	10.5	−0.2	0.20	0.27	0.50	0.38	0.37	0.30	90.1	75.3	16.7	93.9	93.1	90.7
$J = 100$	−1.3	−15.1	−46.9	4.5	4.4	−0.3	0.14	0.22	0.48	0.24	0.25	0.22	92.7	72.9	4.1	94.1	95.4	93.1
$J = 200$	−0.7	−13.7	−45.9	1.9	2.2	−0.2	0.10	0.18	0.47	0.17	0.17	0.16	93.0	69.6	0.1	93.2	94.4	94.2
$J = 500$	−0.1	−13.0	−45.7	1.5	1.5	0.6	0.06	0.15	0.46	0.11	0.10	0.10	93.8	54.2	0.0	94.3	93.9	94.7
$J = 1000$	−0.1	−13.0	−45.6	0.7	0.6	0.2	0.05	0.14	0.46	0.07	0.07	0.07	94.4	26.5	0.0	93.4	93.7	94.8

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-13

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With 20% Missing Data (MCAR, $\lambda = 0$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−3.7	−4.5	−18.3	−3.9	−0.7	−11.8	0.10	0.11	0.10	0.11	0.11	0.10	91.8	91.8	87.9	93.4	93.4	93.8
$J = 50$	−3.1	−4.3	−17.8	−3.5	−1.0	−10.0	0.08	0.08	0.08	0.09	0.09	0.08	93.3	93.1	89.2	93.4	94.1	93.8
$J = 100$	−0.5	−0.3	−14.7	−0.3	1.6	−4.7	0.06	0.06	0.06	0.06	0.06	0.06	93.7	93.7	89.3	94.1	94.1	94.6
$J = 200$	0.2	−0.1	−14.4	0.1	1.0	−2.6	0.04	0.04	0.04	0.04	0.04	0.04	94.5	93.8	87.7	94.9	94.3	94.8
$J = 500$	−0.1	−0.2	−14.5	0.1	0.4	−1.4	0.03	0.03	0.03	0.03	0.03	0.03	94.3	95.1	79.9	94.6	95.1	94.8
$J = 1000$	0.2	−0.0	−14.5	−0.1	0.1	−0.8	0.02	0.02	0.03	0.02	0.02	0.02	93.6	94.3	68.8	94.4	94.5	94.4
$n = 20$																		
$J = 30$	−4.0	−4.3	−20.8	−3.7	−2.8	−11.1	0.07	0.08	0.08	0.08	0.08	0.08	90.8	90.0	80.7	92.0	91.9	91.0
$J = 50$	−1.0	−1.7	−18.5	−1.3	−0.8	−7.1	0.06	0.07	0.06	0.06	0.06	0.06	92.5	91.1	82.0	93.1	92.9	91.5
$J = 100$	−0.5	−0.7	−17.8	−0.6	−0.3	−4.1	0.04	0.05	0.05	0.04	0.04	0.04	93.7	93.7	81.9	94.5	94.1	93.2
$J = 200$	−0.4	−0.8	−17.7	−0.4	−0.2	−2.3	0.03	0.03	0.04	0.03	0.03	0.03	94.8	93.9	76.3	94.5	93.9	94.5
$J = 500$	−0.6	−0.7	−17.7	−0.8	−0.8	−1.4	0.02	0.02	0.03	0.02	0.02	0.02	94.1	93.6	58.2	94.0	94.0	93.2
$J = 1000$	−0.2	−0.2	−17.3	0.0	0.0	−0.5	0.01	0.01	0.03	0.01	0.01	0.01	94.6	94.0	37.5	95.0	95.0	95.0
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−4.2	−6.6	−16.4	−5.0	−3.5	−9.5	0.12	0.14	0.13	0.14	0.14	0.14	90.7	89.7	84.5	92.2	92.1	91.5
$J = 50$	−3.5	−3.8	−14.5	−3.5	−2.8	−5.9	0.10	0.11	0.11	0.11	0.11	0.11	91.1	91.4	86.6	92.9	92.4	92.2
$J = 100$	0.0	−0.1	−11.2	0.4	0.5	−1.1	0.07	0.08	0.08	0.08	0.08	0.08	94.9	94.3	88.2	95.1	94.6	94.7
$J = 200$	0.3	0.2	−11.0	0.4	0.3	−0.5	0.05	0.06	0.06	0.06	0.06	0.06	93.6	93.4	84.7	94.3	94.0	94.0
$J = 500$	0.1	0.3	−11.0	0.3	0.2	−0.1	0.03	0.04	0.04	0.04	0.04	0.04	94.9	95.7	78.0	95.7	95.6	95.9
$J = 1000$	−0.7	−0.5	−11.7	−0.6	−0.6	−0.8	0.02	0.02	0.04	0.02	0.02	0.02	95.6	94.2	64.3	94.7	94.6	94.8
$n = 20$																		
$J = 30$	−3.9	−5.2	−17.7	−4.4	−4.1	−8.1	0.11	0.12	0.12	0.12	0.12	0.12	89.4	88.0	80.6	90.7	91.1	89.5
$J = 50$	−1.3	−0.8	−14.1	−0.6	−0.8	−2.9	0.09	0.10	0.10	0.10	0.10	0.10	90.7	91.9	81.6	92.5	92.3	92.3
$J = 100$	−0.5	−0.8	−14.0	−0.5	−0.7	−1.7	0.06	0.07	0.07	0.07	0.07	0.07	93.6	93.9	84.3	94.5	94.6	94.5
$J = 200$	−0.4	−0.1	−13.5	−0.5	−0.4	−0.9	0.05	0.05	0.06	0.05	0.05	0.05	93.1	93.1	79.0	93.8	92.9	94.0
$J = 500$	−0.5	−0.5	−13.7	−0.5	−0.4	−0.6	0.03	0.03	0.05	0.03	0.03	0.03	94.7	93.9	67.9	94.8	94.8	94.6
$J = 1000$	0.3	0.4	−13.0	0.3	0.3	0.1	0.02	0.02	0.04	0.02	0.02	0.02	96.1	95.2	52.0	95.2	94.8	95.2

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-14

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−3.9	−16.3	−26.3	−6.1	−2.2	−17.5	0.10	0.11	0.10	0.12	0.12	0.11	92.2	90.2	86.3	93.6	93.2	93.7
$J = 50$	−1.4	−11.5	−22.0	−0.9	2.6	−10.8	0.08	0.08	0.08	0.09	0.09	0.08	94.1	91.5	87.0	95.3	94.8	94.1
$J = 100$	−3.0	−13.5	−23.6	−3.0	−0.2	−9.4	0.06	0.06	0.06	0.07	0.07	0.06	93.8	91.2	84.5	93.5	94.1	94.2
$J = 200$	−0.1	−10.9	−21.2	−0.2	1.6	−4.5	0.04	0.04	0.05	0.04	0.04	0.04	95.4	92.2	82.3	96.0	95.4	95.6
$J = 500$	−0.7	−10.9	−21.5	−0.8	−0.2	−2.8	0.03	0.03	0.04	0.03	0.03	0.03	94.2	86.6	67.0	94.7	94.2	94.6
$J = 1000$	−0.3	−10.5	−21.1	−0.0	0.2	−1.2	0.02	0.02	0.04	0.02	0.02	0.02	95.4	84.0	46.2	95.7	95.5	95.6
$n = 20$																		
$J = 30$	−2.6	−13.3	−26.9	−1.9	−0.5	−14.1	0.07	0.08	0.08	0.09	0.09	0.08	90.5	86.1	77.4	92.8	92.5	91.9
$J = 50$	0.3	−10.9	−25.0	−0.3	0.8	−8.8	0.06	0.06	0.06	0.07	0.07	0.06	93.3	89.1	77.8	94.1	93.7	92.9
$J = 100$	−2.1	−12.3	−26.1	−2.0	−1.7	−6.8	0.04	0.05	0.06	0.05	0.05	0.05	92.7	88.4	71.3	92.9	93.3	93.1
$J = 200$	−0.6	−11.3	−25.4	−1.2	−0.8	−3.8	0.03	0.04	0.05	0.03	0.03	0.03	93.3	87.3	58.8	94.5	94.2	94.8
$J = 500$	0.2	−10.1	−24.4	0.4	0.5	−0.8	0.02	0.02	0.04	0.02	0.02	0.02	95.3	85.7	33.6	95.9	96.1	95.8
$J = 1000$	0.3	−10.5	−24.6	−0.0	0.1	−0.7	0.01	0.02	0.04	0.02	0.02	0.02	93.2	75.6	8.7	95.1	94.1	94.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−4.5	−15.0	−21.4	−4.5	−2.2	−11.1	0.13	0.14	0.13	0.15	0.15	0.14	90.1	85.6	82.3	92.7	93.1	91.7
$J = 50$	−2.9	−13.1	−19.2	−2.7	−1.8	−7.2	0.10	0.11	0.11	0.11	0.12	0.11	91.7	87.5	83.6	93.1	93.1	92.2
$J = 100$	−1.8	−13.2	−19.3	−3.0	−2.4	−5.0	0.07	0.08	0.09	0.08	0.08	0.08	92.3	88.0	80.5	93.1	93.1	93.3
$J = 200$	−0.2	−10.8	−17.1	−0.2	−0.0	−1.2	0.05	0.06	0.07	0.06	0.06	0.06	93.7	88.1	76.5	92.8	93.2	92.6
$J = 500$	−0.7	−11.2	−17.3	−1.0	−0.9	−1.3	0.03	0.05	0.06	0.04	0.04	0.04	93.1	83.0	60.2	94.0	94.6	94.6
$J = 1000$	0.3	−10.1	−16.3	0.3	0.4	0.0	0.02	0.04	0.05	0.03	0.03	0.03	95.3	78.6	42.8	94.9	95.2	94.3
$n = 20$																		
$J = 30$	−5.2	−15.3	−24.3	−5.0	−5.4	−10.3	0.12	0.13	0.13	0.13	0.14	0.13	87.8	82.6	74.0	90.2	89.6	88.2
$J = 50$	−2.3	−13.1	−21.8	−2.5	−2.5	−6.1	0.09	0.10	0.10	0.10	0.10	0.10	92.0	86.5	77.0	93.3	93.1	92.1
$J = 100$	−1.2	−11.7	−20.8	−1.4	−1.3	−3.1	0.06	0.07	0.08	0.07	0.07	0.07	92.6	87.0	73.3	93.9	94.1	93.0
$J = 200$	−0.3	−10.9	−19.9	−0.2	−0.1	−1.0	0.04	0.05	0.07	0.05	0.05	0.05	96.2	87.7	68.3	95.4	95.2	96.3
$J = 500$	−0.3	−10.4	−19.5	0.1	0.1	−0.3	0.03	0.04	0.06	0.03	0.03	0.03	95.1	82.0	43.6	96.1	96.2	95.8
$J = 1000$	−0.1	−10.4	−19.5	0.1	0.2	−0.0	0.02	0.04	0.06	0.02	0.02	0.02	94.7	72.2	15.5	94.7	94.4	94.7

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-15

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With 20% Missing Data (MAR, $\lambda = 1$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−4.0	−45.5	−47.2	−5.0	2.1	−32.4	0.10	0.11	0.11	0.15	0.16	0.12	91.9	86.2	78.6	94.8	92.8	93.9
$J = 50$	−2.7	−43.4	−45.0	−2.3	7.2	−25.0	0.08	0.09	0.09	0.11	0.12	0.10	92.5	83.5	76.0	94.3	93.7	94.0
$J = 100$	−1.5	−42.4	−44.0	−1.3	6.3	−17.6	0.05	0.08	0.08	0.08	0.08	0.07	94.3	75.0	65.9	94.0	93.7	93.7
$J = 200$	−0.1	−42.1	−43.8	−0.4	4.0	−11.6	0.04	0.07	0.08	0.05	0.06	0.05	95.6	55.7	44.4	94.9	94.0	94.5
$J = 500$	0.7	−41.1	−43.0	0.5	2.3	−5.1	0.02	0.07	0.07	0.03	0.03	0.03	95.4	18.5	10.7	95.5	94.3	94.7
$J = 1000$	−0.3	−41.8	−43.7	−0.4	0.4	−3.7	0.02	0.07	0.07	0.03	0.03	0.03	94.4	2.4	1.1	92.8	92.1	93.1
$n = 20$																		
$J = 30$	−2.3	−42.5	−49.3	−1.6	1.6	−28.3	0.08	0.09	0.10	0.11	0.11	0.09	91.2	65.3	57.4	93.7	92.3	91.5
$J = 50$	−1.1	−42.0	−48.8	0.3	3.1	−20.3	0.06	0.08	0.09	0.08	0.09	0.07	91.2	59.0	48.8	93.3	92.6	90.3
$J = 100$	−0.2	−41.6	−48.5	0.5	1.2	−12.4	0.04	0.07	0.08	0.06	0.06	0.05	94.3	44.7	29.9	93.8	92.9	93.2
$J = 200$	−0.5	−42.6	−49.4	−1.0	−0.5	−8.9	0.03	0.07	0.08	0.04	0.04	0.04	93.3	17.9	6.2	93.9	94.4	93.0
$J = 500$	−0.8	−42.2	−49.0	−0.8	−0.8	−4.4	0.02	0.07	0.08	0.02	0.03	0.02	94.4	1.2	0.0	95.8	94.5	93.5
$J = 1000$	−0.2	−41.8	−48.7	−0.3	−0.2	−2.1	0.01	0.07	0.08	0.02	0.02	0.02	95.4	0.0	0.0	93.5	93.5	94.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−3.1	−44.0	−39.4	−3.8	2.2	−19.6	0.13	0.16	0.16	0.18	0.19	0.16	89.7	64.6	70.2	93.5	92.7	90.7
$J = 50$	−2.4	−43.1	−38.5	−2.4	0.6	−13.8	0.10	0.14	0.14	0.14	0.14	0.13	92.2	60.1	67.2	93.3	92.9	92.8
$J = 100$	−0.7	−42.4	−37.3	−0.9	0.3	−6.7	0.07	0.13	0.12	0.10	0.10	0.10	93.1	45.0	55.9	93.3	92.7	93.3
$J = 200$	−1.1	−42.5	−37.5	−1.6	−1.2	−4.2	0.05	0.12	0.11	0.07	0.07	0.07	93.9	19.5	33.1	93.5	92.3	93.2
$J = 500$	−0.2	−42.0	−37.0	−0.6	−0.2	−1.5	0.03	0.12	0.11	0.04	0.05	0.04	95.3	1.0	5.6	94.0	94.2	94.8
$J = 1000$	0.1	−41.8	−36.7	−0.3	−0.0	−0.7	0.02	0.12	0.10	0.03	0.03	0.03	94.3	0.0	0.1	94.7	93.6	94.8
$n = 20$																		
$J = 30$	−6.1	−45.3	−45.0	−4.7	−4.4	−17.8	0.11	0.15	0.15	0.16	0.16	0.14	89.7	56.9	55.4	93.7	93.1	91.3
$J = 50$	−1.7	−42.5	−42.1	−1.3	−1.1	−10.0	0.09	0.14	0.14	0.13	0.13	0.12	91.7	53.0	51.2	92.9	93.2	92.3
$J = 100$	−1.1	−42.2	−41.8	−0.8	−0.5	−5.2	0.06	0.13	0.13	0.09	0.09	0.08	94.1	37.0	35.4	93.3	93.6	93.5
$J = 200$	0.2	−41.9	−41.4	0.8	0.4	−2.0	0.04	0.12	0.12	0.06	0.06	0.06	94.9	12.5	12.3	95.2	95.3	95.1
$J = 500$	−0.3	−42.1	−41.7	−0.7	−0.6	−1.5	0.03	0.12	0.12	0.04	0.04	0.04	95.1	0.2	0.2	93.9	94.1	94.7
$J = 1000$	−0.1	−41.6	−41.2	−0.1	−0.1	−0.5	0.02	0.12	0.11	0.03	0.03	0.03	95.6	0.0	0.0	94.3	95.0	94.2

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-16

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With 40% Missing Data (MCAR, $\lambda = 0$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−4.6	−6.7	−33.4	−5.9	−1.7	−24.5	0.10	0.13	0.11	0.13	0.14	0.11	91.2	89.5	81.9	94.5	93.1	93.7
$J = 50$	−1.4	−3.2	−30.8	−1.6	3.8	−16.7	0.08	0.10	0.09	0.10	0.11	0.09	93.5	91.7	80.8	95.4	93.8	93.4
$J = 100$	−0.4	−2.4	−30.4	−1.7	2.9	−12.2	0.05	0.07	0.07	0.07	0.07	0.07	94.1	93.2	76.2	94.5	93.3	94.1
$J = 200$	−0.2	−1.5	−30.0	−0.3	2.5	−7.7	0.04	0.05	0.06	0.05	0.05	0.05	95.2	94.3	68.0	94.9	94.7	94.4
$J = 500$	−0.9	−1.5	−29.7	−1.2	−0.4	−4.8	0.02	0.03	0.05	0.03	0.03	0.03	96.0	93.4	42.5	93.5	93.7	93.5
$J = 1000$	−0.5	−0.6	−29.2	−0.4	0.0	−2.5	0.02	0.02	0.05	0.02	0.02	0.02	95.7	95.0	17.1	95.3	94.9	95.2
$n = 20$																		
$J = 30$	−2.2	−6.0	−38.1	−2.9	0.7	−22.1	0.07	0.10	0.09	0.10	0.10	0.09	89.7	86.3	65.8	93.1	92.9	89.9
$J = 50$	−0.8	−2.2	−35.6	−0.8	0.7	−15.2	0.06	0.08	0.08	0.07	0.08	0.07	91.5	89.6	63.5	93.1	92.4	91.3
$J = 100$	0.4	−0.9	−34.8	0.2	0.8	−8.5	0.04	0.05	0.07	0.05	0.05	0.05	94.3	92.6	54.9	94.3	93.8	93.3
$J = 200$	−0.7	−0.5	−34.6	−0.0	0.5	−4.9	0.03	0.04	0.06	0.04	0.04	0.04	94.7	93.8	36.1	94.4	93.6	94.1
$J = 500$	0.1	0.3	−34.0	0.4	0.6	−1.7	0.02	0.02	0.06	0.02	0.02	0.02	95.0	95.6	8.1	95.4	95.9	95.2
$J = 1000$	0.1	0.0	−34.2	0.1	0.1	−1.1	0.01	0.02	0.06	0.02	0.02	0.02	95.7	94.7	0.3	95.2	95.4	95.4
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−2.3	−3.1	−25.3	−2.4	0.6	−13.2	0.13	0.17	0.15	0.17	0.17	0.16	91.0	88.3	77.3	93.1	93.7	92.1
$J = 50$	−2.2	−3.6	−25.0	−2.5	−0.6	−9.8	0.10	0.13	0.12	0.13	0.13	0.12	91.7	90.3	75.8	92.9	93.1	92.9
$J = 100$	−1.1	−1.9	−23.9	−1.0	−0.4	−4.6	0.07	0.09	0.10	0.09	0.09	0.09	92.7	91.9	71.7	92.9	93.9	92.7
$J = 200$	−1.3	−0.9	−22.9	−0.4	−0.1	−1.8	0.05	0.06	0.08	0.06	0.06	0.06	94.0	93.8	64.5	94.5	94.7	94.8
$J = 500$	−0.0	0.0	−22.3	0.0	0.0	−0.8	0.03	0.04	0.07	0.04	0.04	0.04	95.9	94.7	44.1	95.2	94.4	94.8
$J = 1000$	−0.1	−0.3	−22.6	−0.2	−0.2	−0.5	0.02	0.03	0.07	0.03	0.03	0.03	94.8	95.3	18.0	95.0	94.8	93.8
$n = 20$																		
$J = 30$	−5.7	−7.7	−32.4	−5.2	−4.4	−14.9	0.11	0.15	0.14	0.14	0.14	0.14	88.3	85.7	66.0	92.4	92.5	90.8
$J = 50$	−1.1	−2.6	−28.1	−0.4	0.5	−6.2	0.09	0.11	0.11	0.11	0.11	0.10	91.5	90.8	66.1	94.2	93.6	92.9
$J = 100$	−0.1	−0.3	−27.1	−0.2	−0.0	−3.0	0.06	0.08	0.09	0.08	0.08	0.07	94.2	92.9	61.5	94.7	94.4	94.1
$J = 200$	−1.2	−1.4	−27.5	−0.5	−0.4	−2.2	0.04	0.06	0.09	0.06	0.05	0.05	95.2	93.6	44.7	94.9	94.0	94.9
$J = 500$	0.1	0.0	−26.5	0.1	0.1	−0.5	0.03	0.04	0.08	0.03	0.03	0.03	96.1	95.2	19.0	95.6	96.0	95.7
$J = 1000$	−0.2	−0.4	−27.0	−0.3	−0.3	−0.7	0.02	0.03	0.08	0.02	0.02	0.02	95.8	95.4	2.7	95.8	95.4	94.9

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-17

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−4.0	−17.1	−38.3	−0.1	5.3	−27.4	0.10	0.12	0.11	0.15	0.15	0.11	92.5	90.8	80.1	94.3	93.9	94.7
$J = 50$	−1.4	−16.5	−38.3	−2.0	4.1	−24.1	0.08	0.10	0.09	0.11	0.11	0.10	93.3	90.3	77.5	95.3	94.1	94.8
$J = 100$	0.7	−13.5	−35.7	2.0	7.3	−13.3	0.05	0.07	0.07	0.08	0.08	0.07	95.2	90.8	73.4	94.7	94.3	94.9
$J = 200$	−0.8	−15.2	−37.1	−0.4	3.1	−9.9	0.04	0.05	0.07	0.05	0.06	0.05	94.6	88.8	56.3	93.5	93.0	93.2
$J = 500$	−0.4	−15.5	−37.3	−0.4	0.8	−5.8	0.03	0.04	0.06	0.03	0.03	0.03	95.1	85.0	24.2	94.7	93.0	93.5
$J = 1000$	0.2	−14.4	−36.6	0.1	0.7	−2.7	0.02	0.03	0.06	0.02	0.02	0.02	94.5	79.9	4.1	94.4	94.2	94.9
$n = 20$																		
$J = 30$	−1.9	−17.6	−44.7	−1.7	2.9	−25.9	0.07	0.09	0.09	0.11	0.11	0.09	89.3	83.3	60.1	93.3	93.6	91.3
$J = 50$	−1.1	−16.7	−43.9	−1.5	0.5	−20.1	0.06	0.07	0.08	0.08	0.08	0.07	92.4	85.4	55.9	94.6	93.5	91.5
$J = 100$	−1.4	−15.1	−43.0	−0.6	0.1	−11.9	0.04	0.05	0.08	0.05	0.05	0.05	92.7	87.0	40.7	94.9	94.4	92.8
$J = 200$	0.4	−13.8	−42.1	0.8	1.0	−6.2	0.03	0.04	0.07	0.04	0.04	0.04	94.0	86.7	18.7	95.7	95.1	95.1
$J = 500$	0.1	−14.6	−42.7	−0.1	0.1	−2.8	0.02	0.03	0.07	0.02	0.03	0.03	93.7	78.3	1.1	94.3	93.2	93.6
$J = 1000$	−0.3	−14.5	−42.6	−0.1	−0.0	−1.5	0.01	0.03	0.07	0.02	0.02	0.02	95.1	67.7	0.0	93.8	94.3	94.3
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−2.8	−20.0	−33.4	−3.0	1.3	−18.0	0.13	0.16	0.15	0.18	0.19	0.16	89.2	81.2	72.1	92.6	91.8	90.3
$J = 50$	−3.5	−19.1	−32.9	−3.1	−0.8	−12.9	0.10	0.13	0.13	0.14	0.14	0.13	91.9	84.6	69.3	93.1	93.4	91.5
$J = 100$	−2.3	−17.6	−31.7	−2.6	−1.5	−7.7	0.07	0.10	0.11	0.10	0.10	0.09	93.5	84.1	63.2	93.9	94.7	92.9
$J = 200$	−0.4	−14.2	−29.1	0.3	0.2	−2.4	0.05	0.07	0.09	0.07	0.07	0.06	93.3	86.6	52.5	95.1	94.8	95.3
$J = 500$	−0.2	−14.6	−29.2	0.0	0.2	−1.0	0.03	0.06	0.09	0.04	0.04	0.04	94.4	76.2	24.2	94.8	94.2	94.7
$J = 1000$	−0.0	−14.1	−28.8	0.4	0.2	−0.3	0.02	0.05	0.08	0.03	0.03	0.03	95.3	68.2	4.4	94.8	93.9	95.0
$n = 20$																		
$J = 30$	−3.4	−19.0	−37.9	−3.3	−2.4	−15.3	0.12	0.15	0.15	0.16	0.16	0.15	88.9	79.9	60.3	92.1	92.3	89.9
$J = 50$	−1.5	−15.8	−35.3	−0.8	−0.8	−8.5	0.09	0.11	0.13	0.12	0.12	0.11	91.9	84.6	58.2	94.3	94.4	93.3
$J = 100$	−0.5	−15.3	−34.8	−0.6	−0.4	−4.7	0.06	0.09	0.11	0.09	0.08	0.08	93.2	83.6	46.7	93.5	93.9	93.2
$J = 200$	−0.5	−15.2	−34.7	−0.7	−0.7	−2.7	0.04	0.07	0.10	0.06	0.06	0.06	95.3	83.4	27.4	94.8	94.3	94.5
$J = 500$	−0.3	−15.1	−34.4	−0.3	−0.4	−1.2	0.03	0.05	0.10	0.04	0.04	0.04	94.8	73.1	4.5	95.8	94.4	94.8
$J = 1000$	−0.0	−14.3	−33.9	0.2	0.1	−0.2	0.02	0.05	0.09	0.03	0.03	0.03	93.8	60.0	0.1	94.6	95.5	95.3

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-18

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With 40% Missing Data (MAR, $\lambda = 1$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−3.5	−58.1	−64.5	1.1	−1.3	−51.1	0.10	0.12	0.12	0.21	0.21	0.13	92.3	88.6	70.5	95.3	93.1	94.7
$J = 50$	0.7	−58.4	−64.2	−0.2	8.9	−43.3	0.08	0.11	0.12	0.16	0.16	0.11	92.3	85.1	60.9	95.2	92.2	94.1
$J = 100$	−0.3	−58.0	−64.2	1.9	13.1	−34.2	0.06	0.10	0.11	0.11	0.11	0.09	94.1	71.1	38.7	94.1	93.4	92.9
$J = 200$	−0.2	−58.2	−64.5	−0.3	9.0	−24.5	0.04	0.10	0.11	0.07	0.08	0.07	94.6	42.3	12.6	93.6	91.5	91.5
$J = 500$	0.0	−57.3	−63.7	1.0	5.1	−12.9	0.02	0.09	0.10	0.05	0.05	0.05	95.3	6.3	0.3	93.0	90.8	91.8
$J = 1000$	−0.7	−58.4	−64.8	−1.4	0.0	−9.6	0.02	0.09	0.10	0.03	0.03	0.03	95.8	0.1	0.0	93.9	92.4	92.9
$n = 20$																		
$J = 30$	−4.5	−60.0	−71.3	−5.7	3.5	−51.0	0.07	0.11	0.12	0.14	0.15	0.11	91.0	52.2	33.4	93.6	92.8	89.6
$J = 50$	−1.4	−57.9	−69.9	−2.0	6.3	−40.0	0.06	0.10	0.12	0.11	0.12	0.09	93.3	42.2	21.7	94.3	92.5	89.1
$J = 100$	−1.6	−58.9	−70.5	−1.9	1.3	−29.9	0.04	0.10	0.11	0.07	0.08	0.07	93.1	20.7	4.5	93.7	92.7	89.1
$J = 200$	−0.4	−58.1	−70.0	−0.6	0.4	−18.4	0.03	0.09	0.11	0.05	0.05	0.05	94.4	3.9	0.1	93.8	93.8	90.3
$J = 500$	−0.4	−57.9	−69.8	−0.4	−0.3	−9.2	0.02	0.09	0.11	0.03	0.03	0.03	94.4	0.0	0.0	94.5	92.8	92.9
$J = 1000$	−0.2	−58.2	−69.9	−1.0	−0.9	−5.4	0.01	0.09	0.11	0.02	0.02	0.02	94.2	0.0	0.0	94.0	93.0	93.0
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−2.8	−60.4	−59.1	−4.8	6.7	−37.9	0.13	0.19	0.19	0.26	0.28	0.20	89.5	50.7	56.7	93.6	92.4	90.9
$J = 50$	−2.6	−60.2	−58.6	−3.5	6.1	−28.3	0.10	0.18	0.18	0.19	0.21	0.17	91.9	38.4	44.5	94.2	91.7	91.8
$J = 100$	−0.6	−58.0	−56.4	0.5	3.9	−13.8	0.07	0.17	0.17	0.13	0.14	0.12	92.7	21.7	29.3	93.9	92.6	93.0
$J = 200$	−0.3	−58.4	−56.7	−0.6	0.5	−7.8	0.05	0.16	0.16	0.09	0.09	0.09	94.3	4.3	7.5	94.3	93.8	93.2
$J = 500$	−0.2	−57.9	−56.1	−0.3	0.3	−3.0	0.03	0.16	0.16	0.06	0.06	0.06	95.3	0.0	0.0	93.6	93.4	94.6
$J = 1000$	0.1	−57.5	−55.8	0.8	0.9	−0.6	0.02	0.16	0.15	0.04	0.04	0.04	94.8	0.0	0.0	93.5	93.3	94.4
$n = 20$																		
$J = 30$	−3.2	−60.1	−63.5	−4.1	−1.8	−30.8	0.12	0.19	0.19	0.21	0.21	0.18	89.5	38.6	35.3	93.8	93.9	91.8
$J = 50$	−3.5	−59.7	−63.4	−3.2	−2.0	−22.3	0.09	0.18	0.18	0.16	0.16	0.14	91.7	28.4	23.3	93.5	93.4	91.1
$J = 100$	−1.1	−59.2	−62.9	−1.4	−1.4	−11.8	0.06	0.17	0.18	0.11	0.11	0.11	93.8	12.6	7.0	93.5	93.8	93.3
$J = 200$	−1.1	−58.5	−62.2	−1.7	−1.5	−7.1	0.05	0.16	0.17	0.08	0.08	0.08	91.9	1.1	0.1	93.7	94.3	94.2
$J = 500$	0.3	−57.4	−61.2	1.2	1.2	−1.2	0.03	0.16	0.17	0.05	0.05	0.05	94.5	0.0	0.0	94.4	93.8	95.8
$J = 1000$	0.0	−57.5	−61.3	0.6	0.4	−0.7	0.02	0.16	0.17	0.04	0.04	0.04	96.2	0.0	0.0	92.3	92.1	94.3

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-19

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With 20% Missing Data (MCAR, $\lambda = 0$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−1.8	−1.0	0.4	−4.2	−1.4	−9.5	0.10	0.11	0.11	0.11	0.11	0.10	90.5	89.0	89.4	90.7	90.8	93.2
$J = 50$	−0.8	−1.5	0.2	−3.1	−0.9	−8.1	0.07	0.08	0.08	0.08	0.08	0.08	92.1	92.1	92.1	93.0	92.1	94.6
$J = 100$	0.9	1.3	3.0	0.3	1.9	−3.2	0.05	0.06	0.06	0.06	0.06	0.06	93.7	93.3	92.7	94.3	93.4	94.9
$J = 200$	0.5	0.4	2.2	−0.1	0.9	−2.4	0.04	0.04	0.04	0.04	0.04	0.04	93.3	94.1	93.9	93.7	94.3	94.8
$J = 500$	−0.1	0.0	1.9	0.0	0.3	−1.3	0.02	0.03	0.03	0.03	0.03	0.03	93.8	94.5	93.5	94.1	93.7	94.8
$J = 1000$	0.0	−0.2	1.6	−0.3	−0.2	−1.0	0.02	0.02	0.02	0.02	0.02	0.02	94.1	94.6	93.6	94.0	94.0	94.9
$n = 20$																		
$J = 30$	−1.0	−0.4	1.9	−3.1	−2.7	−8.2	0.07	0.08	0.08	0.07	0.07	0.07	91.1	89.6	89.8	91.6	91.0	94.4
$J = 50$	0.6	0.5	2.9	−1.0	−0.8	−5.3	0.05	0.06	0.06	0.05	0.05	0.05	94.2	92.3	92.0	93.6	94.1	94.3
$J = 100$	0.1	0.1	2.4	−0.7	−0.6	−3.3	0.04	0.04	0.04	0.04	0.04	0.04	94.0	94.1	93.5	93.9	94.3	94.8
$J = 200$	0.1	−0.2	2.2	−0.3	−0.1	−1.6	0.03	0.03	0.03	0.03	0.03	0.03	94.1	93.6	93.2	93.8	93.2	93.8
$J = 500$	−0.3	−0.4	1.9	−0.7	−0.6	−1.1	0.02	0.02	0.02	0.02	0.02	0.02	94.2	93.5	92.0	93.7	94.2	93.7
$J = 1000$	−0.1	−0.2	2.1	−0.1	−0.1	−0.5	0.01	0.01	0.01	0.01	0.01	0.01	94.8	94.9	93.9	94.4	94.7	94.9
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−0.7	−2.1	3.1	−4.2	−3.2	−6.7	0.11	0.13	0.14	0.13	0.13	0.13	91.9	90.5	90.2	91.8	91.5	93.0
$J = 50$	−0.4	−0.5	4.5	−2.1	−1.5	−3.6	0.09	0.10	0.10	0.10	0.10	0.10	92.5	91.7	91.7	93.1	92.7	94.1
$J = 100$	1.0	1.0	6.3	0.6	0.6	−0.4	0.06	0.07	0.07	0.07	0.07	0.06	94.1	94.1	92.6	94.2	94.0	94.3
$J = 200$	0.6	0.5	5.8	0.2	0.2	−0.4	0.04	0.05	0.05	0.05	0.05	0.05	93.5	93.9	91.1	94.3	94.4	94.1
$J = 500$	0.4	0.5	5.7	0.3	0.3	0.1	0.03	0.03	0.04	0.03	0.03	0.03	94.0	93.8	90.5	94.4	94.5	94.2
$J = 1000$	−0.5	−0.4	4.8	−0.6	−0.5	−0.7	0.02	0.02	0.03	0.02	0.02	0.02	95.9	95.2	91.2	95.8	95.6	95.9
$n = 20$																		
$J = 30$	−0.8	−1.1	5.2	−3.2	−3.0	−5.4	0.10	0.11	0.12	0.11	0.11	0.11	90.0	89.7	88.4	91.7	91.4	92.5
$J = 50$	−0.1	−0.0	6.2	−1.4	−1.7	−2.7	0.08	0.08	0.09	0.08	0.08	0.08	92.0	90.7	89.7	92.5	91.9	93.5
$J = 100$	0.3	0.2	6.6	−0.3	−0.5	−1.1	0.05	0.06	0.06	0.06	0.06	0.06	93.5	93.5	91.3	93.5	93.5	93.8
$J = 200$	0.1	0.2	6.5	−0.5	−0.4	−0.7	0.04	0.04	0.05	0.04	0.04	0.04	92.4	93.0	89.8	93.6	93.2	93.6
$J = 500$	−0.1	−0.1	6.4	−0.2	−0.2	−0.3	0.02	0.03	0.03	0.02	0.02	0.02	94.9	94.4	88.0	94.8	94.7	95.8
$J = 1000$	0.2	0.2	6.7	0.1	0.1	0.0	0.02	0.02	0.03	0.02	0.02	0.02	96.0	95.9	82.6	95.6	95.4	95.6

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-20

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−0.6	−11.4	−7.6	−7.2	−4.1	−14.5	0.10	0.11	0.11	0.11	0.11	0.10	89.1	89.4	90.4	90.4	89.6	93.6
$J = 50$	1.2	−7.4	−3.1	−0.8	2.0	−8.1	0.07	0.08	0.08	0.08	0.09	0.08	92.6	91.8	93.1	93.4	91.6	95.0
$J = 100$	−1.3	−10.9	−6.6	−2.9	−0.6	−8.0	0.05	0.06	0.06	0.06	0.06	0.06	94.6	92.7	93.9	94.3	93.9	95.3
$J = 200$	0.7	−9.0	−4.6	−0.1	1.6	−3.6	0.04	0.04	0.04	0.04	0.04	0.04	95.0	93.7	94.6	95.1	94.1	95.2
$J = 500$	−0.7	−9.9	−5.7	−1.0	−0.4	−2.7	0.02	0.03	0.03	0.03	0.03	0.03	94.1	88.5	93.3	94.8	94.5	95.0
$J = 1000$	−0.1	−9.4	−5.1	0.0	0.2	−0.9	0.02	0.02	0.02	0.02	0.02	0.02	95.2	86.2	92.8	94.6	94.2	94.7
$n = 20$																		
$J = 30$	0.1	−8.1	−4.4	−3.3	−2.6	−11.0	0.07	0.07	0.08	0.07	0.07	0.07	91.6	89.9	90.7	92.3	92.0	94.5
$J = 50$	2.1	−7.3	−3.7	−1.0	−0.5	−6.9	0.05	0.05	0.06	0.06	0.06	0.05	92.5	92.1	93.1	92.9	93.1	95.1
$J = 100$	−1.0	−9.7	−6.2	−2.4	−2.1	−5.7	0.03	0.04	0.04	0.04	0.04	0.04	93.5	91.5	92.6	94.0	93.6	94.3
$J = 200$	0.1	−8.9	−5.4	−0.9	−0.6	−2.8	0.03	0.03	0.03	0.03	0.03	0.03	94.4	90.6	92.6	94.4	93.8	95.0
$J = 500$	0.5	−8.3	−4.7	0.3	0.4	−0.6	0.02	0.02	0.02	0.02	0.02	0.02	94.6	87.7	91.3	95.3	95.8	95.9
$J = 1000$	0.2	−8.9	−5.4	−0.2	−0.2	−0.7	0.01	0.02	0.02	0.01	0.01	0.01	94.5	77.4	88.0	94.0	93.9	94.5
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−1.0	−9.3	−1.2	−5.1	−3.7	−8.5	0.11	0.13	0.13	0.13	0.13	0.13	90.9	89.7	90.5	91.7	91.0	93.1
$J = 50$	−0.2	−9.0	−0.3	−2.7	−2.0	−5.7	0.09	0.10	0.10	0.10	0.10	0.10	92.3	91.1	91.5	93.3	92.5	94.3
$J = 100$	−0.3	−9.7	−0.8	−2.2	−1.8	−3.6	0.06	0.07	0.07	0.07	0.07	0.07	93.3	90.8	93.3	93.8	94.1	94.7
$J = 200$	0.6	−8.4	0.8	−0.1	0.0	−0.8	0.04	0.05	0.05	0.05	0.05	0.05	94.6	91.3	93.6	94.3	94.3	95.1
$J = 500$	−0.4	−9.2	−0.2	−0.9	−0.8	−1.1	0.03	0.04	0.03	0.03	0.03	0.03	93.9	85.7	93.2	93.8	93.7	93.6
$J = 1000$	0.2	−8.6	0.6	0.0	0.1	−0.1	0.02	0.03	0.02	0.02	0.02	0.02	95.4	79.6	95.1	95.6	95.3	95.3
$n = 20$																		
$J = 30$	−0.6	−8.7	0.5	−4.6	−4.8	−7.5	0.10	0.11	0.12	0.11	0.11	0.11	90.8	89.1	88.5	91.8	91.7	93.4
$J = 50$	−0.2	−8.4	0.6	−2.4	−2.6	−4.5	0.07	0.08	0.09	0.08	0.08	0.08	93.1	91.4	91.3	94.5	94.1	94.5
$J = 100$	−0.4	−8.9	0.3	−1.9	−1.8	−2.8	0.05	0.06	0.06	0.06	0.06	0.06	94.3	90.6	92.1	94.3	94.3	93.8
$J = 200$	−0.1	−8.3	1.0	−0.4	−0.4	−0.8	0.03	0.04	0.04	0.04	0.04	0.04	95.3	91.0	94.3	95.9	95.3	96.0
$J = 500$	−0.1	−8.2	1.1	−0.1	−0.1	−0.3	0.02	0.03	0.03	0.03	0.03	0.03	95.3	85.0	94.5	95.7	95.2	95.8
$J = 1000$	0.1	−8.0	1.4	0.2	0.3	0.1	0.02	0.03	0.02	0.02	0.02	0.02	94.2	75.1	93.1	94.3	95.0	94.4

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-21

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With 20% Missing Data (MAR, $\lambda = 1$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−1.8	−42.2	−34.0	−17.2	−12.2	−33.3	0.10	0.11	0.12	0.13	0.14	0.12	92.1	78.5	89.3	90.2	87.1	94.9
$J = 50$	−0.8	−39.9	−30.7	−9.5	−2.4	−24.7	0.07	0.09	0.09	0.10	0.10	0.09	92.1	77.3	89.1	91.5	89.0	95.2
$J = 100$	−0.8	−39.7	−30.5	−5.5	0.4	−17.7	0.05	0.08	0.07	0.07	0.07	0.07	94.3	69.6	86.2	93.1	92.3	94.4
$J = 200$	0.5	−39.2	−29.9	−2.0	1.5	−11.0	0.04	0.07	0.06	0.05	0.05	0.05	95.1	48.1	79.0	93.5	92.1	94.9
$J = 500$	0.8	−38.8	−29.6	−0.4	1.1	−5.0	0.02	0.06	0.05	0.03	0.03	0.03	95.6	12.9	54.2	95.6	93.8	95.4
$J = 1000$	−0.1	−39.5	−30.3	−0.7	−0.0	−3.4	0.02	0.06	0.05	0.02	0.02	0.02	94.3	1.8	22.6	93.6	92.7	94.1
$n = 20$																		
$J = 30$	−0.9	−37.2	−31.6	−12.7	−11.8	−27.2	0.07	0.09	0.09	0.09	0.09	0.09	91.3	73.5	83.2	92.4	90.6	94.8
$J = 50$	0.6	−36.1	−30.4	−6.0	−4.8	−18.5	0.05	0.07	0.07	0.07	0.07	0.07	92.5	69.5	81.5	92.9	92.4	94.7
$J = 100$	0.7	−36.4	−30.7	−2.7	−2.3	−11.1	0.04	0.07	0.06	0.04	0.05	0.05	93.9	54.3	73.6	94.3	92.9	95.4
$J = 200$	0.5	−37.2	−31.6	−1.5	−1.2	−7.0	0.02	0.06	0.06	0.03	0.03	0.03	95.2	25.6	52.8	95.1	94.4	96.2
$J = 500$	−0.4	−37.4	−31.8	−1.1	−1.1	−3.5	0.02	0.06	0.05	0.02	0.02	0.02	93.8	1.8	15.1	94.6	94.8	94.8
$J = 1000$	−0.1	−37.3	−31.8	−0.7	−0.7	−1.9	0.01	0.06	0.05	0.01	0.01	0.01	95.6	0.0	0.7	94.1	94.1	93.9
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	0.2	−36.9	−20.5	−12.6	−9.3	−19.5	0.12	0.15	0.15	0.15	0.15	0.15	90.5	74.2	87.9	91.2	89.9	93.2
$J = 50$	−0.3	−36.7	−20.0	−7.4	−6.0	−13.4	0.09	0.13	0.12	0.12	0.12	0.12	92.3	70.9	89.8	93.1	92.0	94.5
$J = 100$	0.3	−37.3	−19.9	−4.1	−3.3	−7.6	0.06	0.12	0.09	0.08	0.08	0.08	94.2	51.5	86.1	93.0	92.1	93.9
$J = 200$	−0.4	−37.7	−20.3	−2.7	−2.4	−4.4	0.04	0.11	0.08	0.06	0.06	0.06	93.7	25.5	79.9	93.6	92.5	93.8
$J = 500$	−0.2	−37.6	−20.1	−1.5	−1.2	−2.0	0.03	0.11	0.06	0.04	0.04	0.04	94.9	1.6	60.7	94.6	94.2	95.1
$J = 1000$	0.1	−37.3	−19.6	−0.6	−0.4	−0.8	0.02	0.10	0.06	0.02	0.02	0.02	94.0	0.0	33.7	94.8	94.5	95.3
$n = 20$																		
$J = 30$	−1.9	−36.7	−22.1	−11.8	−11.2	−17.7	0.10	0.14	0.13	0.12	0.12	0.13	91.0	71.5	85.1	92.5	92.6	94.1
$J = 50$	−0.7	−35.9	−21.2	−7.5	−7.5	−11.9	0.07	0.12	0.11	0.10	0.10	0.10	92.9	64.7	84.5	92.7	93.5	93.9
$J = 100$	0.2	−35.5	−20.4	−3.3	−3.2	−5.8	0.05	0.11	0.08	0.07	0.07	0.07	94.4	47.5	79.9	94.8	94.2	95.0
$J = 200$	0.4	−35.7	−20.4	−1.1	−1.4	−2.6	0.04	0.10	0.07	0.04	0.04	0.04	94.4	18.6	71.2	95.7	95.7	95.9
$J = 500$	−0.1	−35.9	−20.9	−1.0	−1.0	−1.5	0.02	0.10	0.06	0.03	0.03	0.03	94.1	0.8	40.1	92.9	94.4	93.7
$J = 1000$	0.1	−35.4	−20.3	−0.2	−0.2	−0.5	0.02	0.10	0.06	0.02	0.02	0.02	94.5	0.0	15.2	92.9	93.7	94.6

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-22

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With 40% Missing Data (MCAR, $\lambda = 0$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−1.7	−1.2	2.3	−9.5	−5.8	−21.7	0.10	0.13	0.14	0.12	0.13	0.11	89.9	87.5	89.4	91.6	90.1	94.3
$J = 50$	0.2	0.0	4.1	−3.9	0.2	−15.3	0.08	0.10	0.10	0.10	0.10	0.09	92.8	90.5	91.0	92.9	91.5	93.9
$J = 100$	0.3	−0.8	3.6	−2.9	1.1	−11.4	0.05	0.07	0.07	0.07	0.07	0.06	93.3	92.4	91.7	93.1	91.9	94.3
$J = 200$	0.3	−0.6	3.9	−0.9	1.6	−7.2	0.04	0.05	0.05	0.04	0.04	0.04	94.2	94.0	94.0	93.9	94.3	95.5
$J = 500$	−0.8	−1.3	3.4	−1.7	−1.0	−4.7	0.02	0.03	0.03	0.03	0.03	0.03	94.1	93.8	92.6	94.2	93.5	93.9
$J = 1000$	−0.3	−0.3	4.2	−0.4	−0.1	−2.3	0.02	0.02	0.02	0.02	0.02	0.02	95.8	95.4	93.0	94.3	94.5	95.3
$n = 20$																		
$J = 30$	1.4	1.3	8.0	−4.6	−2.7	−17.6	0.07	0.09	0.10	0.09	0.09	0.08	90.9	88.9	87.9	91.7	91.1	95.1
$J = 50$	1.0	1.7	7.7	−2.2	−1.2	−12.5	0.05	0.07	0.07	0.07	0.07	0.06	91.8	89.7	89.1	92.2	91.4	94.7
$J = 100$	0.7	0.4	6.5	−1.2	−0.9	−7.5	0.03	0.05	0.05	0.04	0.04	0.04	93.9	91.8	90.6	92.9	92.8	95.7
$J = 200$	0.4	0.6	6.7	−0.2	0.1	−4.0	0.02	0.03	0.04	0.03	0.03	0.03	94.1	94.1	91.9	94.1	94.5	95.6
$J = 500$	0.4	0.8	6.8	0.4	0.5	−1.2	0.01	0.02	0.02	0.02	0.02	0.02	96.0	95.2	90.5	95.3	95.1	95.5
$J = 1000$	0.0	0.1	6.1	−0.1	−0.1	−1.0	0.01	0.01	0.02	0.01	0.01	0.01	96.2	94.5	89.1	94.5	95.4	95.4
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	0.6	1.6	12.8	−6.0	−3.9	−12.0	0.12	0.16	0.18	0.15	0.15	0.15	90.9	87.7	86.3	92.6	91.5	94.5
$J = 50$	0.4	−0.4	11.9	−4.4	−2.9	−8.8	0.09	0.12	0.13	0.11	0.11	0.11	92.9	91.5	89.3	93.0	92.9	94.4
$J = 100$	0.1	0.1	12.7	−1.6	−1.1	−4.0	0.06	0.08	0.10	0.08	0.08	0.08	93.2	93.2	88.4	92.8	93.4	95.2
$J = 200$	0.1	0.5	13.3	−0.3	−0.1	−1.0	0.04	0.06	0.07	0.05	0.05	0.05	95.1	94.5	87.3	94.4	94.2	94.2
$J = 500$	0.0	0.0	12.8	−0.4	−0.4	−0.9	0.03	0.03	0.05	0.03	0.03	0.03	94.8	95.1	79.3	94.6	95.3	94.6
$J = 1000$	−0.1	−0.1	12.8	−0.3	−0.2	−0.5	0.02	0.02	0.04	0.02	0.02	0.02	94.9	94.9	69.4	94.1	93.9	95.3
$n = 20$																		
$J = 30$	−1.6	−1.4	15.1	−7.1	−6.6	−12.4	0.10	0.13	0.16	0.13	0.13	0.12	91.4	89.0	84.7	92.8	92.9	94.9
$J = 50$	1.3	1.0	18.0	−1.8	−1.7	−5.0	0.08	0.10	0.12	0.09	0.09	0.09	91.0	91.3	85.5	93.7	92.8	94.5
$J = 100$	1.1	1.5	18.5	−0.7	−0.4	−2.4	0.05	0.07	0.09	0.06	0.06	0.06	94.2	93.5	84.8	94.8	94.4	94.9
$J = 200$	−0.7	−0.6	16.1	−1.1	−1.0	−1.9	0.04	0.05	0.07	0.05	0.05	0.05	93.8	93.2	80.8	94.0	93.8	94.4
$J = 500$	0.5	0.3	17.1	0.1	0.1	−0.4	0.02	0.03	0.06	0.03	0.03	0.03	95.2	96.2	63.7	96.2	95.2	96.2
$J = 1000$	−0.2	−0.2	16.6	−0.3	−0.3	−0.6	0.02	0.02	0.05	0.02	0.02	0.02	95.7	95.2	44.3	95.2	95.1	95.6

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-23

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	0.9	−10.7	−3.6	−8.6	−2.6	−24.6	0.10	0.13	0.14	0.13	0.13	0.11	90.7	87.5	90.7	90.0	88.7	95.8
$J = 50$	−0.0	−12.1	−5.0	−5.7	−0.9	−22.3	0.07	0.09	0.10	0.10	0.10	0.09	92.8	90.1	92.8	93.2	90.7	96.0
$J = 100$	1.3	−11.6	−3.8	−1.4	3.0	−13.1	0.05	0.06	0.07	0.07	0.07	0.06	94.6	92.5	95.0	94.1	92.5	96.3
$J = 200$	−0.8	−14.0	−6.5	−2.4	0.7	−10.1	0.04	0.05	0.05	0.05	0.05	0.05	95.3	90.6	94.1	94.2	92.8	95.0
$J = 500$	−0.4	−14.1	−6.6	−1.0	0.0	−5.6	0.02	0.04	0.03	0.03	0.03	0.03	95.4	85.2	93.7	95.0	93.8	95.1
$J = 1000$	0.3	−13.1	−5.4	−0.1	0.5	−2.5	0.02	0.03	0.02	0.02	0.02	0.02	95.1	82.9	93.8	94.9	94.0	95.6
$n = 20$																		
$J = 30$	1.5	−10.2	−2.9	−7.7	−5.3	−22.5	0.07	0.09	0.09	0.09	0.09	0.08	90.8	87.6	90.4	91.7	90.8	95.5
$J = 50$	0.9	−10.6	−3.3	−4.0	−3.2	−16.9	0.05	0.07	0.07	0.07	0.07	0.07	92.9	89.5	91.6	93.7	92.3	95.3
$J = 100$	−0.6	−11.9	−4.8	−2.9	−2.1	−11.0	0.04	0.05	0.05	0.05	0.05	0.05	93.1	90.6	93.6	93.6	94.4	95.1
$J = 200$	0.6	−11.3	−4.0	−0.5	−0.6	−5.7	0.02	0.03	0.03	0.03	0.03	0.03	94.8	90.6	93.9	95.4	95.1	96.7
$J = 500$	0.1	−12.2	−5.0	−0.5	−0.5	−2.6	0.02	0.03	0.02	0.02	0.02	0.02	93.7	82.5	92.9	93.8	93.4	95.0
$J = 1000$	−0.2	−12.4	−5.2	−0.5	−0.4	−1.5	0.01	0.02	0.02	0.01	0.01	0.01	94.7	68.2	90.8	94.7	93.5	94.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	−1.3	−15.1	0.1	−11.6	−9.4	−19.4	0.12	0.15	0.17	0.15	0.15	0.15	90.4	86.4	89.5	92.6	90.9	94.3
$J = 50$	−1.2	−13.4	3.4	−6.5	−4.9	−12.2	0.09	0.12	0.13	0.12	0.12	0.12	91.9	88.7	90.1	92.9	91.9	94.3
$J = 100$	−0.3	−13.3	3.7	−3.8	−2.9	−7.1	0.06	0.09	0.09	0.08	0.08	0.08	94.0	90.3	92.0	93.3	93.7	94.7
$J = 200$	−0.3	−11.9	5.4	−1.4	−1.5	−3.1	0.04	0.06	0.06	0.05	0.05	0.05	94.5	89.5	92.8	95.3	95.2	95.8
$J = 500$	−0.1	−12.1	5.7	−0.3	−0.2	−1.1	0.03	0.05	0.04	0.04	0.04	0.04	93.9	81.3	89.5	94.1	93.2	94.2
$J = 1000$	0.0	−11.9	5.8	−0.1	−0.1	−0.4	0.02	0.04	0.03	0.02	0.02	0.02	94.4	72.1	89.4	94.8	95.2	96.1
$n = 20$																		
$J = 30$	−0.6	−12.0	7.7	−9.6	−8.8	−15.8	0.10	0.14	0.16	0.14	0.13	0.13	91.1	84.7	85.7	91.1	90.9	93.4
$J = 50$	−0.1	−10.9	8.8	−5.1	−4.9	−9.2	0.07	0.10	0.11	0.10	0.10	0.09	92.2	89.0	88.9	93.0	93.5	95.3
$J = 100$	0.2	−11.4	8.5	−2.6	−2.4	−4.9	0.05	0.07	0.08	0.07	0.07	0.07	92.0	88.8	88.7	93.9	93.7	94.6
$J = 200$	0.1	−11.7	8.1	−1.4	−1.4	−2.7	0.04	0.06	0.06	0.05	0.05	0.05	94.4	86.2	88.5	93.6	93.6	93.3
$J = 500$	−0.1	−12.0	8.0	−0.8	−0.8	−1.3	0.02	0.04	0.04	0.03	0.03	0.03	94.1	77.1	86.6	94.7	95.1	94.7
$J = 1000$	0.0	−11.3	8.7	0.0	−0.1	−0.3	0.02	0.04	0.03	0.02	0.02	0.02	95.4	65.0	78.4	95.3	94.7	95.3

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-24

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With 40% Missing Data (MAR, $\lambda = 1$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	−0.2	−53.2	−42.3	−25.2	−20.9	−51.4	0.10	0.13	0.13	0.15	0.16	0.13	90.1	72.3	92.7	88.1	86.8	95.1
$J = 50$	2.7	−54.5	−43.4	−18.2	−9.0	−43.6	0.08	0.11	0.11	0.12	0.13	0.11	90.9	65.9	92.1	89.9	86.7	95.7
$J = 100$	0.8	−54.8	−43.8	−9.0	0.5	−34.1	0.05	0.10	0.09	0.09	0.09	0.09	94.4	47.6	87.8	91.4	89.1	95.7
$J = 200$	0.7	−55.5	−44.7	−5.7	1.8	−24.1	0.04	0.09	0.08	0.07	0.07	0.07	93.8	20.5	73.8	92.8	89.7	92.7
$J = 500$	0.4	−54.9	−43.8	−1.6	1.8	−12.6	0.02	0.09	0.07	0.04	0.04	0.04	95.3	1.3	41.9	93.3	90.7	93.0
$J = 1000$	−0.6	−56.0	−45.4	−2.3	−1.0	−9.0	0.02	0.09	0.07	0.03	0.03	0.03	96.1	0.1	7.8	92.9	91.2	94.1
$n = 20$																		
$J = 30$	−1.1	−52.9	−45.8	−26.1	−21.9	−48.7	0.07	0.11	0.11	0.11	0.12	0.11	91.8	59.7	86.1	91.4	89.1	94.5
$J = 50$	0.9	−52.0	−44.5	−16.8	−13.5	−38.3	0.05	0.10	0.09	0.09	0.09	0.09	92.8	49.7	82.2	92.5	90.7	94.3
$J = 100$	−0.4	−53.6	−46.2	−9.8	−8.4	−28.1	0.04	0.09	0.08	0.06	0.06	0.07	94.1	26.7	70.7	94.3	92.6	93.9
$J = 200$	0.2	−53.0	−45.5	−4.7	−4.1	−16.8	0.02	0.09	0.08	0.04	0.04	0.05	96.0	6.5	46.6	93.5	92.8	94.1
$J = 500$	−0.6	−53.3	−46.0	−2.6	−2.5	−8.6	0.02	0.09	0.07	0.03	0.03	0.03	93.5	0.0	6.3	92.6	92.7	94.1
$J = 1000$	−0.1	−53.5	−46.1	−1.7	−1.6	−4.8	0.01	0.09	0.07	0.02	0.02	0.02	94.2	0.0	0.1	95.0	94.1	94.2
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	0.5	−53.6	−32.7	−27.0	−21.5	−40.8	0.12	0.19	0.20	0.20	0.20	0.19	90.1	59.5	88.9	91.3	89.6	93.7
$J = 50$	−0.2	−54.0	−32.2	−18.0	−14.2	−30.1	0.09	0.17	0.16	0.15	0.15	0.15	93.1	49.5	89.2	92.3	89.1	94.9
$J = 100$	0.5	−52.4	−28.9	−8.2	−6.8	−16.1	0.06	0.16	0.12	0.10	0.10	0.11	93.1	29.2	85.9	92.7	91.1	94.7
$J = 200$	0.2	−53.4	−29.9	−4.8	−4.1	−9.4	0.04	0.15	0.10	0.07	0.07	0.07	95.0	6.0	76.8	94.4	92.9	95.2
$J = 500$	0.1	−53.0	−29.0	−1.9	−1.3	−3.5	0.03	0.15	0.09	0.04	0.04	0.04	95.2	0.0	53.2	94.3	93.0	95.3
$J = 1000$	0.4	−52.7	−28.6	−0.3	−0.1	−1.2	0.02	0.15	0.08	0.03	0.03	0.03	94.8	0.0	24.9	93.9	92.9	93.5
$n = 20$																		
$J = 30$	−1.2	−51.3	−29.7	−23.2	−22.9	−34.7	0.10	0.17	0.17	0.16	0.16	0.16	90.5	53.3	85.1	92.5	92.9	94.3
$J = 50$	−0.9	−52.1	−30.8	−16.3	−15.5	−25.6	0.08	0.16	0.14	0.12	0.12	0.13	91.5	42.2	82.7	93.9	94.5	95.0
$J = 100$	0.1	−51.9	−30.1	−8.4	−8.3	−14.3	0.05	0.15	0.11	0.09	0.09	0.09	94.7	20.6	78.4	94.7	94.8	95.3
$J = 200$	−0.5	−51.8	−30.1	−5.0	−5.2	−8.5	0.04	0.15	0.10	0.06	0.06	0.06	93.5	3.3	65.3	94.7	94.2	96.7
$J = 500$	0.4	−51.0	−28.6	−1.0	−1.0	−2.6	0.02	0.14	0.09	0.03	0.04	0.04	95.0	0.0	38.9	94.0	92.6	96.1
$J = 1000$	0.1	−51.2	−29.0	−0.5	−0.6	−1.3	0.02	0.14	0.08	0.03	0.03	0.03	94.7	0.0	12.2	93.7	93.1	93.9

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-25

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With 20% Missing Data (MCAR, $\lambda = 0$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	45.0	45.9	25.9	34.0	39.3	33.1	2.64	3.42	2.29	2.31	2.40	2.28	88.3	86.9	86.6	92.3	92.3	92.6
$J = 50$	35.7	35.8	12.3	27.2	29.9	22.2	2.28	1.99	1.55	1.68	1.73	1.74	92.1	90.4	89.2	93.1	93.5	93.6
$J = 100$	18.9	22.6	2.7	18.4	20.8	13.9	1.25	1.29	1.05	1.16	1.17	1.13	92.3	92.7	86.6	93.1	92.8	92.4
$J = 200$	9.7	13.4	−6.7	9.3	10.5	6.1	0.67	0.88	0.58	0.69	0.71	0.65	95.8	95.3	87.3	95.9	96.4	95.8
$J = 500$	3.4	4.7	−11.5	3.7	4.1	2.0	0.34	0.40	0.35	0.37	0.37	0.35	96.2	96.0	83.9	96.0	96.1	95.8
$J = 1000$	1.7	1.7	−13.2	1.4	1.6	0.6	0.23	0.26	0.30	0.25	0.25	0.24	95.2	95.4	76.0	95.0	94.7	94.8
$n = 20$																		
$J = 30$	8.1	11.9	−11.2	7.9	9.3	−0.8	0.88	1.25	0.81	0.94	0.98	0.87	92.5	91.5	86.6	93.5	92.8	94.4
$J = 50$	5.3	6.5	−13.5	5.1	5.6	−1.5	0.59	0.70	0.59	0.67	0.67	0.61	93.7	93.4	87.1	94.0	94.3	95.1
$J = 100$	2.3	2.7	−15.5	2.2	2.5	−1.5	0.39	0.44	0.44	0.44	0.44	0.41	94.3	93.7	83.8	94.3	94.1	95.4
$J = 200$	1.0	1.4	−16.6	0.9	1.2	−0.9	0.26	0.29	0.36	0.29	0.29	0.28	94.9	94.9	77.0	94.4	94.2	94.6
$J = 500$	−0.3	−0.5	−17.5	−0.5	−0.5	−1.2	0.16	0.18	0.32	0.19	0.18	0.18	95.6	94.2	53.5	94.1	94.2	94.1
$J = 1000$	0.2	0.5	−17.0	0.4	0.4	−0.1	0.12	0.13	0.29	0.13	0.13	0.13	94.5	94.5	31.5	94.6	94.8	94.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	6.5	10.8	−7.2	6.4	8.2	1.0	0.72	0.66	0.53	0.61	0.62	0.54	93.6	92.9	89.5	94.7	93.9	94.8
$J = 50$	3.1	4.9	−9.2	3.1	3.8	0.0	0.35	0.42	0.35	0.39	0.40	0.37	93.5	93.4	89.0	93.7	93.7	94.6
$J = 100$	2.6	3.3	−9.1	2.9	3.1	1.4	0.22	0.25	0.23	0.24	0.25	0.24	94.2	94.2	90.1	95.5	94.3	95.4
$J = 200$	1.3	1.7	−10.1	1.4	1.4	0.6	0.15	0.17	0.18	0.17	0.17	0.17	94.8	94.6	87.6	94.0	94.6	94.9
$J = 500$	1.1	1.3	−10.1	1.4	1.3	1.0	0.10	0.11	0.13	0.11	0.11	0.11	95.2	93.9	80.2	94.7	94.0	94.6
$J = 1000$	−0.2	−0.1	−11.3	−0.1	−0.1	−0.3	0.07	0.07	0.12	0.07	0.07	0.07	96.1	95.4	62.5	94.7	95.3	95.9
$n = 20$																		
$J = 30$	1.6	1.8	−13.1	1.3	1.8	−2.9	0.33	0.38	0.35	0.38	0.38	0.37	91.3	90.9	85.5	93.1	93.1	93.5
$J = 50$	1.0	1.6	−12.4	1.6	1.4	−0.8	0.25	0.28	0.27	0.29	0.28	0.28	93.1	92.9	86.3	94.1	93.8	94.1
$J = 100$	0.8	0.8	−13.0	0.8	0.6	−0.4	0.18	0.19	0.21	0.19	0.20	0.19	93.3	94.1	84.7	94.1	93.7	94.5
$J = 200$	0.4	0.4	−12.9	0.3	0.4	−0.2	0.12	0.14	0.17	0.14	0.14	0.14	93.2	93.7	77.6	93.8	94.1	94.0
$J = 500$	−0.1	−0.0	−13.4	−0.1	−0.0	−0.2	0.07	0.08	0.14	0.09	0.08	0.08	95.0	95.4	60.3	95.2	94.7	95.8
$J = 1000$	0.1	0.1	−13.2	0.1	0.1	−0.1	0.05	0.06	0.13	0.06	0.06	0.06	94.4	93.3	36.8	93.0	93.3	94.0

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-26

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	43.7	64.3	14.5	25.1	30.1	19.2	2.90	4.63	2.39	2.20	2.37	2.26	87.8	87.4	86.3	93.3	93.4	94.2
$J = 50$	32.1	77.4	9.9	27.9	31.9	20.5	1.87	3.18	1.69	1.65	1.74	1.68	91.5	91.2	84.9	93.5	93.1	92.9
$J = 100$	14.7	61.5	−7.8	13.6	16.9	7.0	1.07	2.32	1.01	1.09	1.13	1.04	92.9	94.4	82.4	94.2	94.7	94.0
$J = 200$	7.6	48.3	−15.0	7.1	9.4	2.5	0.64	1.43	0.61	0.65	0.70	0.65	94.6	97.4	80.5	95.1	95.3	93.8
$J = 500$	2.8	34.7	−18.7	2.8	3.4	0.6	0.33	0.87	0.41	0.36	0.37	0.34	95.8	99.7	72.2	96.8	96.2	96.1
$J = 1000$	2.2	32.8	−19.2	2.5	2.6	1.2	0.23	0.67	0.36	0.25	0.25	0.24	95.9	91.8	59.0	96.0	95.5	95.8
$n = 20$																		
$J = 30$	9.5	23.2	−16.8	9.8	11.7	−3.6	0.90	1.36	0.89	1.02	1.05	0.92	91.5	92.5	82.7	92.7	92.7	94.4
$J = 50$	5.7	14.0	−20.3	5.3	6.4	−4.0	0.58	0.82	0.63	0.69	0.70	0.62	93.3	93.1	81.5	93.7	93.9	94.5
$J = 100$	1.4	8.6	−23.4	1.4	1.8	−3.7	0.39	0.52	0.52	0.46	0.46	0.43	94.0	94.2	75.3	94.2	94.2	95.2
$J = 200$	1.3	7.1	−23.9	0.8	1.3	−1.9	0.26	0.36	0.45	0.31	0.32	0.30	95.1	94.3	60.4	94.3	93.4	94.8
$J = 500$	0.2	6.2	−24.4	0.4	0.5	−0.9	0.16	0.22	0.41	0.19	0.19	0.18	95.8	93.7	27.8	95.1	95.4	95.0
$J = 1000$	0.2	5.6	−24.6	−0.1	0.0	−0.7	0.12	0.17	0.40	0.14	0.14	0.13	95.1	91.1	6.0	95.2	94.4	94.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	10.6	26.6	−8.7	10.6	13.5	2.6	0.55	0.87	0.52	0.62	0.64	0.57	93.5	93.9	87.7	94.5	94.5	95.3
$J = 50$	5.0	14.5	−12.6	5.4	6.5	0.1	0.36	0.54	0.36	0.42	0.43	0.39	93.6	94.6	87.4	94.4	94.5	94.7
$J = 100$	1.1	7.5	−16.9	−0.1	0.6	−2.2	0.22	0.30	0.27	0.26	0.27	0.26	93.7	95.3	83.1	94.7	94.7	95.0
$J = 200$	1.4	8.2	−15.8	1.5	1.6	0.3	0.16	0.22	0.21	0.19	0.19	0.18	94.7	93.7	78.4	93.9	93.5	94.3
$J = 500$	0.2	5.8	−16.7	−0.2	−0.1	−0.5	0.10	0.13	0.18	0.11	0.11	0.11	94.0	93.6	60.7	94.7	95.0	95.3
$J = 1000$	0.3	6.2	−16.3	0.4	0.5	0.1	0.07	0.10	0.16	0.08	0.08	0.08	95.1	90.8	36.1	95.5	94.5	93.7
$n = 20$																		
$J = 30$	−0.5	1.3	−20.4	−0.5	−1.0	−6.2	0.33	0.41	0.39	0.41	0.42	0.39	91.0	89.2	80.7	92.1	92.1	93.5
$J = 50$	1.0	2.5	−19.1	0.7	0.7	−3.0	0.25	0.30	0.30	0.29	0.29	0.29	92.6	92.9	81.8	94.5	93.6	94.4
$J = 100$	−0.2	1.0	−20.0	−0.4	−0.3	−2.1	0.17	0.21	0.25	0.21	0.21	0.20	94.1	94.2	74.6	94.7	94.9	94.5
$J = 200$	0.8	2.4	−19.0	0.9	1.0	0.1	0.12	0.14	0.21	0.14	0.14	0.14	95.7	95.9	64.0	95.7	95.7	96.0
$J = 500$	−0.1	1.7	−19.3	0.3	0.3	−0.0	0.08	0.09	0.19	0.09	0.09	0.09	94.5	94.5	31.0	94.7	94.9	95.0
$J = 1000$	0.0	1.6	−19.4	0.2	0.3	0.1	0.05	0.07	0.19	0.06	0.07	0.07	94.4	93.6	7.9	95.8	94.4	94.3

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-27

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With 20% Missing Data (MAR, $\lambda = 1$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	49.3	182.8	−5.7	13.1	22.5	1.2	3.07	7.90	2.46	2.22	2.32	2.12	89.8	68.0	81.2	94.3	93.6	95.5
$J = 50$	35.0	253.5	−17.7	15.2	26.1	−1.1	2.44	6.97	1.85	1.72	1.86	1.65	91.4	67.0	75.5	94.8	94.5	95.2
$J = 100$	22.6	318.5	−24.6	18.7	28.5	1.5	1.18	6.68	1.24	1.27	1.40	1.11	93.0	54.0	68.8	93.8	94.0	93.2
$J = 200$	7.5	359.0	−38.9	6.9	12.0	−5.3	0.58	6.51	0.76	0.71	0.76	0.62	94.9	34.6	53.6	95.7	96.1	94.8
$J = 500$	3.1	395.7	−41.6	2.9	4.9	−3.1	0.33	6.45	0.70	0.41	0.43	0.37	96.6	8.5	25.9	96.9	95.7	95.6
$J = 1000$	1.0	438.5	−43.0	0.9	1.7	−2.5	0.22	7.06	0.70	0.29	0.29	0.27	95.9	0.9	6.6	94.6	94.1	94.8
$n = 20$																		
$J = 30$	9.4	90.1	−41.5	10.1	13.6	−20.1	0.90	4.63	0.97	1.26	1.30	0.96	91.4	91.2	64.0	93.0	91.0	94.8
$J = 50$	4.7	83.0	−44.9	6.2	9.4	−16.0	0.59	2.33	0.86	0.86	0.90	0.72	93.2	93.9	55.4	93.4	91.4	95.2
$J = 100$	1.7	63.6	−47.1	2.4	3.1	−11.1	0.39	1.59	0.81	0.56	0.58	0.50	94.5	92.0	32.2	93.2	92.5	94.9
$J = 200$	0.7	54.2	−48.6	0.2	0.7	−7.9	0.26	1.09	0.80	0.37	0.37	0.37	95.4	84.2	8.3	94.2	94.7	93.6
$J = 500$	−0.5	48.7	−48.8	−0.4	−0.4	−4.1	0.16	0.87	0.78	0.24	0.24	0.23	94.4	52.3	0.0	93.7	93.5	94.2
$J = 1000$	0.2	48.7	−48.4	0.1	0.2	−1.7	0.12	0.82	0.77	0.18	0.18	0.17	94.9	18.1	0.0	92.9	93.0	94.3
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	10.1	117.1	−31.1	7.8	15.5	−10.3	0.52	2.68	0.53	0.68	0.75	0.56	92.9	91.4	78.3	93.5	91.5	95.3
$J = 50$	4.5	92.7	−34.1	4.2	8.1	−8.4	0.35	1.66	0.44	0.49	0.52	0.42	93.7	94.9	72.7	94.5	93.1	95.1
$J = 100$	2.1	70.5	−35.6	1.6	3.0	−4.5	0.22	1.09	0.39	0.33	0.34	0.31	94.7	94.5	56.9	94.3	93.0	94.5
$J = 200$	0.7	57.9	−36.4	0.1	0.5	−2.5	0.15	0.70	0.36	0.22	0.22	0.21	95.5	86.4	33.0	93.6	92.5	95.1
$J = 500$	0.1	51.9	−36.8	−0.4	0.0	−1.2	0.09	0.53	0.35	0.14	0.14	0.14	95.6	51.1	4.3	94.9	93.4	95.3
$J = 1000$	0.4	51.6	−36.5	−0.0	0.3	−0.4	0.07	0.50	0.34	0.10	0.10	0.10	94.7	15.8	0.3	93.8	94.2	94.5
$n = 20$																		
$J = 30$	−1.3	12.3	−42.1	−0.2	0.4	−14.2	0.33	0.60	0.48	0.50	0.51	0.45	90.7	89.6	60.9	93.8	93.1	94.2
$J = 50$	1.0	12.2	−40.2	1.4	1.5	−7.8	0.26	0.44	0.44	0.39	0.39	0.36	93.1	91.3	53.4	91.9	92.3	94.8
$J = 100$	0.8	11.1	−40.6	1.0	1.2	−3.6	0.18	0.31	0.40	0.27	0.27	0.25	93.9	92.4	30.6	92.5	93.4	93.8
$J = 200$	0.6	10.3	−41.1	1.2	0.8	−1.6	0.12	0.21	0.39	0.18	0.18	0.17	95.2	92.7	7.9	94.7	95.0	94.8
$J = 500$	0.1	9.0	−41.4	−0.3	−0.2	−1.1	0.08	0.15	0.38	0.12	0.12	0.12	94.2	89.8	0.0	93.1	94.2	94.3
$J = 1000$	−0.1	9.1	−41.1	−0.0	0.0	−0.5	0.05	0.12	0.38	0.08	0.08	0.08	95.6	83.5	0.0	93.8	93.7	94.5

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-28

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With 40% Missing Data (MCAR, $\lambda = 0$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	42.3	37.4	−5.4	16.0	23.0	7.6	3.20	3.63	1.95	2.13	2.29	2.16	88.3	84.2	82.7	93.8	94.9	94.0
$J = 50$	32.3	42.6	−7.2	20.6	26.1	10.0	2.12	3.15	1.50	1.71	1.72	1.67	91.6	89.0	80.6	94.6	94.2	93.5
$J = 100$	21.8	32.5	−13.6	16.8	22.0	7.4	1.26	1.65	1.13	1.19	1.25	1.21	93.4	92.2	79.6	94.6	95.3	94.2
$J = 200$	11.5	21.5	−21.4	11.6	15.1	3.1	0.67	1.04	0.64	0.76	0.80	0.67	96.5	96.2	73.4	96.2	96.5	96.1
$J = 500$	1.5	3.7	−28.2	1.1	1.9	−2.8	0.32	0.44	0.52	0.38	0.38	0.35	95.2	95.0	53.2	95.3	94.9	94.8
$J = 1000$	1.5	2.5	−27.9	1.5	1.9	−0.7	0.23	0.30	0.48	0.27	0.27	0.25	95.3	95.9	35.0	95.6	95.7	95.0
$n = 20$																		
$J = 30$	6.9	15.0	−32.6	5.2	9.8	−16.1	0.84	1.49	0.87	1.08	1.14	0.88	92.9	89.9	72.3	93.9	93.2	93.9
$J = 50$	4.4	9.4	−32.7	4.1	6.1	−11.7	0.57	0.91	0.71	0.76	0.80	0.65	92.9	92.3	68.9	94.1	93.0	95.0
$J = 100$	3.2	5.1	−33.1	2.9	3.5	−6.3	0.38	0.54	0.62	0.50	0.51	0.45	94.0	93.3	54.9	94.2	93.5	95.3
$J = 200$	0.1	1.6	−34.1	0.8	1.3	−4.3	0.26	0.35	0.59	0.34	0.34	0.32	94.6	94.3	32.4	94.3	94.0	96.1
$J = 500$	0.1	0.6	−34.0	0.4	0.7	−1.6	0.16	0.21	0.56	0.21	0.21	0.20	95.2	96.0	5.7	94.5	95.1	94.5
$J = 1000$	0.1	0.1	−34.2	0.0	0.1	−1.1	0.11	0.14	0.55	0.14	0.14	0.14	95.3	95.8	0.1	95.4	94.6	95.0
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	7.3	14.4	−19.0	6.2	10.5	−6.0	0.53	0.82	0.50	0.63	0.67	0.55	93.6	90.9	82.4	92.5	93.1	95.3
$J = 50$	4.1	11.7	−20.9	3.7	6.3	−4.8	0.34	1.11	0.38	0.45	0.47	0.39	93.5	92.7	81.7	93.9	93.3	94.9
$J = 100$	2.6	4.5	−21.4	2.6	3.4	−1.3	0.23	0.32	0.30	0.30	0.31	0.28	94.2	93.5	75.8	94.0	94.0	94.6
$J = 200$	0.1	1.8	−21.9	1.0	1.3	−0.5	0.15	0.20	0.25	0.19	0.19	0.19	94.7	95.2	65.4	94.6	95.3	95.2
$J = 500$	0.3	0.5	−22.1	0.3	0.4	−0.5	0.10	0.12	0.22	0.12	0.12	0.12	95.6	94.6	38.8	95.0	94.4	94.6
$J = 1000$	0.1	0.1	−22.5	−0.1	0.0	−0.3	0.06	0.09	0.22	0.08	0.08	0.08	95.4	95.7	10.0	95.5	95.1	95.5
$n = 20$																		
$J = 30$	0.1	2.0	−28.8	0.7	1.5	−10.2	0.34	0.48	0.42	0.48	0.48	0.42	91.0	87.3	69.8	92.0	92.1	93.8
$J = 50$	1.4	3.2	−26.6	2.2	3.1	−4.2	0.24	0.33	0.34	0.33	0.33	0.30	92.3	91.8	69.5	94.7	94.1	95.0
$J = 100$	0.4	0.6	−26.8	0.4	0.5	−2.5	0.17	0.22	0.30	0.23	0.22	0.22	95.3	93.9	56.4	94.3	94.7	94.5
$J = 200$	−0.4	0.3	−27.0	0.2	0.3	−1.4	0.12	0.16	0.28	0.16	0.16	0.16	93.8	93.8	38.4	93.8	94.3	94.2
$J = 500$	0.2	0.3	−26.5	0.2	0.2	−0.4	0.07	0.10	0.25	0.10	0.10	0.10	95.3	95.6	8.3	95.7	95.6	95.3
$J = 1000$	−0.0	−0.2	−26.8	−0.1	−0.1	−0.5	0.05	0.07	0.25	0.07	0.07	0.07	95.4	95.9	0.3	95.3	95.1	95.4

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-29

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	35.9	70.1	−9.7	12.7	20.8	0.6	2.53	4.50	1.92	2.10	2.09	2.01	89.4	83.7	81.0	94.2	95.1	94.8
$J = 50$	38.3	96.8	−9.0	23.6	31.4	5.7	2.11	4.14	1.49	1.71	1.82	1.63	91.4	88.0	78.3	94.1	94.5	94.1
$J = 100$	20.9	93.1	−21.3	19.3	24.8	3.1	1.16	2.83	0.97	1.20	1.24	1.09	93.7	91.3	72.9	94.5	94.9	94.0
$J = 200$	7.6	81.4	−31.4	7.7	12.1	−2.8	0.65	2.44	0.72	0.76	0.82	0.68	95.2	93.9	61.3	95.4	94.6	93.7
$J = 500$	3.8	64.2	−34.8	3.8	5.1	−2.1	0.36	1.49	0.61	0.43	0.45	0.38	96.6	97.5	39.6	95.7	95.0	95.6
$J = 1000$	1.2	53.4	−36.0	1.0	1.7	−1.8	0.22	1.10	0.59	0.27	0.27	0.25	94.6	97.2	14.6	95.8	95.7	96.0
$n = 20$																		
$J = 30$	9.4	31.6	−38.0	8.0	13.6	−18.4	0.94	2.10	0.96	1.20	1.26	0.94	91.2	90.9	67.6	93.4	92.2	94.8
$J = 50$	4.1	21.1	−40.8	3.6	6.1	−16.5	0.57	1.14	0.80	0.79	0.84	0.68	93.7	93.2	59.5	94.5	92.9	94.8
$J = 100$	1.2	13.4	−41.5	2.1	2.9	−9.9	0.39	0.66	0.73	0.53	0.54	0.49	93.3	94.3	40.5	94.0	93.5	95.3
$J = 200$	1.2	11.0	−41.5	1.6	1.9	−5.5	0.27	0.44	0.69	0.36	0.36	0.34	94.4	94.8	18.4	95.0	93.6	95.1
$J = 500$	0.6	9.2	−42.4	0.4	0.5	−2.4	0.17	0.30	0.68	0.23	0.23	0.23	93.8	91.8	0.3	94.8	93.7	95.5
$J = 1000$	−0.1	8.6	−42.5	0.0	0.1	−1.3	0.11	0.22	0.68	0.16	0.16	0.16	95.0	89.2	0.0	95.0	94.5	94.9
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	12.1	41.5	−24.1	9.8	15.6	−7.1	0.56	1.68	0.54	0.71	0.77	0.59	92.7	90.7	78.9	93.4	92.6	95.1
$J = 50$	2.8	23.5	−29.0	2.9	5.9	−8.3	0.35	0.78	0.42	0.49	0.52	0.43	93.6	94.5	75.5	93.5	93.7	95.1
$J = 100$	1.6	14.4	−29.2	1.2	2.6	−4.4	0.24	0.42	0.35	0.33	0.33	0.30	93.8	94.9	66.7	93.2	94.3	94.4
$J = 200$	1.4	11.9	−27.8	2.2	2.1	−0.5	0.16	0.27	0.30	0.21	0.22	0.21	93.6	94.8	52.6	94.8	93.8	95.3
$J = 500$	0.2	9.8	−28.9	0.5	0.7	−0.6	0.10	0.18	0.28	0.13	0.14	0.13	94.3	91.6	19.0	94.0	93.3	94.5
$J = 1000$	0.3	9.5	−28.6	0.7	0.6	0.1	0.07	0.14	0.27	0.10	0.10	0.09	93.3	88.8	3.3	94.1	93.8	94.6
$n = 20$																		
$J = 30$	0.1	3.9	−36.2	−0.3	0.5	−13.1	0.34	0.54	0.46	0.50	0.50	0.45	91.2	87.3	63.7	91.6	91.5	93.4
$J = 50$	1.4	5.4	−33.5	2.2	2.3	−6.0	0.25	0.38	0.39	0.37	0.37	0.34	92.4	90.9	60.5	93.5	93.1	95.1
$J = 100$	0.6	3.2	−34.1	0.7	0.8	−3.5	0.17	0.26	0.36	0.26	0.26	0.25	94.1	92.6	42.6	92.9	93.7	93.5
$J = 200$	0.6	2.6	−34.0	0.4	0.4	−1.7	0.12	0.18	0.33	0.17	0.18	0.17	94.2	94.2	20.4	94.7	93.7	95.0
$J = 500$	−0.0	2.0	−34.2	−0.0	−0.0	−0.9	0.08	0.11	0.32	0.11	0.11	0.11	94.4	94.3	0.8	94.0	93.9	93.9
$J = 1000$	0.0	2.3	−33.8	0.3	0.2	−0.1	0.05	0.08	0.31	0.07	0.07	0.07	95.7	95.8	0.0	94.8	95.6	95.8

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 1-30

Study 1: Bias (in %), RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With 40% Missing Data (MAR, $\lambda = 1$)

	Bias (%)						RMSE						Coverage (%)					
	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM	CD	LD	FCS-SL	FCS-MAN	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)																		
$n = 5$																		
$J = 30$	43.2	180.3	−43.9	−12.5	−4.4	−38.9	2.79	9.10	2.02	2.07	2.19	1.94	88.7	60.0	74.8	94.2	94.0	95.1
$J = 50$	35.9	301.8	−46.6	−0.8	12.6	−29.8	1.83	9.47	1.57	1.64	1.78	1.45	91.8	54.9	68.2	93.9	94.3	94.6
$J = 100$	20.6	443.2	−53.6	8.5	23.1	−24.0	1.23	9.55	1.23	1.24	1.34	1.14	94.5	41.1	49.2	94.8	95.1	93.7
$J = 200$	7.9	523.4	−61.8	5.7	16.6	−20.1	0.58	9.66	1.03	0.86	0.95	0.72	96.0	21.9	26.7	95.5	95.0	94.5
$J = 500$	2.8	615.3	−62.9	3.4	7.8	−11.2	0.35	10.26	1.01	0.54	0.58	0.47	95.6	2.2	3.5	94.5	93.1	92.8
$J = 1000$	1.3	667.9	−64.2	0.6	2.1	−8.0	0.22	10.74	1.02	0.36	0.37	0.33	95.4	0.0	0.0	94.7	94.0	94.0
$n = 20$																		
$J = 30$	8.8	192.4	−66.7	3.9	14.7	−45.6	0.89	8.88	1.20	1.58	1.76	1.11	93.2	80.1	41.2	91.8	88.2	93.6
$J = 50$	6.2	222.1	−67.3	4.8	14.5	−36.5	0.61	7.47	1.13	1.18	1.32	0.91	93.5	84.6	25.4	91.7	89.4	92.7
$J = 100$	1.9	256.8	−69.4	1.7	5.3	−28.1	0.39	6.57	1.12	0.76	0.82	0.69	93.4	88.7	4.5	93.3	91.7	91.8
$J = 200$	0.3	211.8	−69.7	0.0	1.0	−18.2	0.27	4.59	1.11	0.52	0.53	0.50	94.3	93.3	0.2	93.5	94.0	92.5
$J = 500$	0.7	191.2	−69.4	0.7	0.9	−8.2	0.17	3.54	1.10	0.33	0.34	0.33	94.3	64.7	0.0	93.6	91.7	93.0
$J = 1000$	−0.1	174.2	−69.9	−0.9	−0.7	−5.3	0.12	2.99	1.11	0.22	0.22	0.23	93.9	9.3	0.0	94.4	93.3	93.6
Moderate intraclass correlation ($\rho_{Iy} = .30$)																		
$n = 5$																		
$J = 30$	7.6	233.3	−55.4	1.6	14.7	−34.4	0.52	5.82	0.65	0.93	1.02	0.67	92.0	80.1	63.5	92.9	89.8	94.1
$J = 50$	5.1	269.1	−56.0	3.4	14.9	−24.4	0.35	4.84	0.59	0.69	0.78	0.54	93.5	83.8	52.5	92.5	88.4	94.7
$J = 100$	2.0	286.2	−55.5	3.0	7.0	−12.3	0.23	4.14	0.54	0.45	0.49	0.39	93.7	87.5	29.8	93.9	91.0	94.3
$J = 200$	1.5	254.0	−56.0	1.4	2.5	−6.3	0.16	3.03	0.53	0.31	0.32	0.29	94.3	91.0	5.5	93.9	92.4	94.2
$J = 500$	0.3	219.2	−56.0	0.2	0.9	−2.5	0.10	2.44	0.52	0.19	0.19	0.18	94.4	75.7	0.0	93.3	92.4	94.0
$J = 1000$	0.1	197.5	−55.8	0.8	1.0	−0.6	0.07	1.97	0.51	0.13	0.14	0.13	95.1	15.6	0.0	93.5	91.9	93.4
$n = 20$																		
$J = 30$	2.2	35.6	−62.1	1.4	3.8	−28.7	0.34	1.24	0.62	0.72	0.75	0.56	91.7	89.2	35.5	93.3	92.9	95.5
$J = 50$	0.7	29.4	−62.1	1.0	2.4	−19.5	0.26	0.83	0.60	0.54	0.55	0.46	92.6	90.5	21.4	92.9	92.7	94.4
$J = 100$	0.6	22.6	−62.4	0.3	0.3	−10.6	0.17	0.49	0.59	0.36	0.36	0.33	93.9	91.7	2.9	93.5	93.6	95.1
$J = 200$	0.1	19.7	−61.9	−0.5	−0.4	−6.1	0.13	0.34	0.57	0.25	0.25	0.24	93.5	90.5	0.0	93.6	94.0	95.1
$J = 500$	0.2	20.7	−61.2	1.1	1.1	−1.2	0.07	0.27	0.56	0.16	0.16	0.16	95.0	81.8	0.0	93.5	93.3	95.9
$J = 1000$	0.0	19.6	−61.3	0.6	0.4	−0.7	0.05	0.22	0.56	0.12	0.12	0.11	93.8	70.7	0.0	92.0	91.3	93.9

Note. n = cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-1

Study 2: Bias, Relative RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With Moderately Unbalanced Data (Uniform, ±40%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−0.01	−0.00	−0.00	0.00	−0.02	0.15	0.17	0.17	0.17	0.17	93.9	93.0	93.8	93.2	93.4
$J = 200$	0.00	0.00	−0.00	0.00	−0.01	0.07	0.08	0.08	0.08	0.08	93.7	94.4	93.9	93.9	93.9
$J = 1000$	0.00	0.00	−0.00	0.00	−0.00	0.03	0.04	0.04	0.04	0.04	95.3	94.9	95.4	94.7	94.5
$\bar{n} = 20$															
$J = 50$	0.01	0.01	0.01	0.01	−0.01	0.14	0.16	0.16	0.16	0.16	94.4	95.6	95.2	94.5	94.4
$J = 200$	−0.00	−0.00	−0.00	−0.00	−0.01	0.07	0.08	0.08	0.08	0.08	94.4	95.7	96.0	95.3	95.6
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.00	0.03	0.04	0.04	0.04	0.04	95.0	95.0	94.2	94.0	93.8
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	0.00	0.01	0.01	0.01	−0.01	0.14	0.16	0.17	0.16	0.16	94.8	94.2	94.3	94.9	94.2
$J = 200$	0.00	0.00	0.00	0.00	0.00	0.07	0.08	0.08	0.08	0.08	95.2	95.0	95.1	94.8	95.5
$J = 1000$	0.00	0.00	0.00	0.00	−0.00	0.03	0.03	0.03	0.03	0.03	95.7	95.8	96.0	96.0	95.9
$\bar{n} = 20$															
$J = 50$	0.01	0.01	0.01	0.01	−0.00	0.14	0.16	0.16	0.16	0.15	95.3	94.1	94.9	94.2	94.2
$J = 200$	0.00	0.00	−0.00	−0.00	−0.00	0.07	0.08	0.08	0.08	0.08	95.7	95.5	95.4	95.5	95.8
$J = 1000$	−0.00	0.00	0.00	0.00	−0.00	0.03	0.04	0.04	0.03	0.03	94.7	95.0	94.6	94.4	94.8

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-2

Study 2: Bias, Relative RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With Strongly Unbalanced Data (Uniform, ±80%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	0.00	0.00	0.00	0.01	−0.01	0.14	0.16	0.16	0.16	0.16	95.1	95.5	95.2	94.5	95.2
$J = 200$	0.00	0.01	0.00	0.01	−0.00	0.07	0.08	0.08	0.08	0.08	94.1	94.4	93.6	94.3	94.4
$J = 1000$	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.03	96.3	96.1	95.4	95.7	96.0
$\bar{n} = 20$															
$J = 50$	0.00	0.01	0.01	0.01	−0.02	0.14	0.16	0.16	0.16	0.16	94.7	94.5	95.2	95.0	94.2
$J = 200$	−0.00	−0.00	−0.00	−0.00	−0.01	0.07	0.08	0.08	0.08	0.08	94.6	94.9	95.1	95.5	94.5
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.00	0.03	0.04	0.04	0.04	0.04	95.1	95.0	95.0	95.0	94.4
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	0.00	0.01	0.01	0.01	−0.01	0.14	0.16	0.16	0.16	0.16	94.6	95.2	94.6	95.0	94.7
$J = 200$	0.00	0.00	−0.00	−0.00	−0.00	0.07	0.08	0.08	0.07	0.08	95.6	95.2	95.8	96.1	95.6
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.00	0.03	0.03	0.03	0.03	0.03	95.7	95.0	95.1	95.0	95.5
$\bar{n} = 20$															
$J = 50$	0.00	0.01	0.01	0.01	−0.00	0.14	0.16	0.16	0.16	0.16	94.5	94.9	96.0	94.7	95.2
$J = 200$	−0.00	−0.00	0.00	−0.00	−0.00	0.07	0.08	0.08	0.08	0.08	94.9	94.5	94.6	94.8	94.5
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.00	0.03	0.04	0.04	0.04	0.04	94.1	93.9	93.7	93.7	93.8

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-3

Study 2: Bias, Relative RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With Moderately Unbalanced Data (Bimodal, ±40%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	0.00	0.01	0.01	0.01	−0.01	0.15	0.17	0.17	0.17	0.16	94.0	94.0	95.2	94.4	94.4
$J = 200$	0.00	0.00	0.00	0.00	−0.01	0.07	0.08	0.08	0.08	0.08	94.6	94.9	95.2	95.3	94.2
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.00	0.03	0.04	0.04	0.04	0.04	94.7	95.0	94.5	94.7	94.6
$\bar{n} = 20$															
$J = 50$	−0.00	−0.00	−0.00	−0.00	−0.03	0.14	0.16	0.16	0.16	0.16	93.6	94.4	94.5	93.7	93.6
$J = 200$	0.00	0.00	0.00	0.00	−0.00	0.07	0.08	0.08	0.08	0.08	93.9	94.3	94.2	93.8	94.5
$J = 1000$	−0.00	0.00	0.00	0.00	−0.00	0.03	0.04	0.04	0.04	0.04	94.6	95.4	95.1	95.1	94.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	0.01	0.00	0.01	0.01	−0.01	0.14	0.16	0.16	0.16	0.16	94.6	95.4	95.7	95.3	95.4
$J = 200$	0.00	0.00	0.00	0.00	−0.00	0.07	0.08	0.08	0.08	0.08	92.7	93.4	93.4	93.4	94.0
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.00	0.03	0.04	0.04	0.04	0.04	96.0	95.2	95.0	95.0	95.6
$\bar{n} = 20$															
$J = 50$	−0.00	−0.00	−0.00	−0.00	−0.01	0.14	0.16	0.16	0.16	0.16	95.5	94.2	94.8	94.9	94.0
$J = 200$	0.00	0.00	0.00	0.00	0.00	0.07	0.08	0.08	0.08	0.08	95.3	95.4	95.4	94.5	95.3
$J = 1000$	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.04	0.04	0.04	94.4	93.1	93.3	93.3	93.0

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-4

Study 2: Bias, Relative RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With Strongly Unbalanced Data (Bimodal, ±80%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−0.00	0.00	−0.00	0.00	−0.01	0.14	0.17	0.17	0.17	0.17	94.1	93.5	93.9	93.5	93.3
$J = 200$	0.00	0.00	0.00	0.00	−0.00	0.07	0.08	0.08	0.08	0.08	95.3	95.9	95.6	96.1	95.8
$J = 1000$	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.04	0.04	0.04	95.2	95.1	95.8	95.5	95.6
$\bar{n} = 20$															
$J = 50$	0.00	0.01	0.01	0.01	−0.01	0.14	0.16	0.16	0.16	0.16	93.7	94.6	93.9	94.2	93.6
$J = 200$	0.00	0.01	0.00	0.00	−0.00	0.07	0.08	0.08	0.08	0.08	94.8	95.9	95.9	95.3	95.7
$J = 1000$	0.00	0.00	0.00	0.00	−0.00	0.03	0.04	0.04	0.04	0.04	93.2	93.0	92.5	92.3	92.4
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−0.00	0.00	−0.00	0.00	−0.01	0.13	0.15	0.16	0.15	0.15	96.0	95.7	94.8	95.0	95.1
$J = 200$	−0.00	0.00	−0.00	−0.00	−0.00	0.07	0.08	0.08	0.08	0.08	94.7	95.3	95.7	95.0	94.8
$J = 1000$	0.00	0.00	−0.00	−0.00	−0.00	0.03	0.04	0.04	0.04	0.04	95.3	95.4	95.8	95.5	95.4
$\bar{n} = 20$															
$J = 50$	−0.00	0.00	−0.00	0.00	−0.01	0.14	0.16	0.16	0.16	0.16	94.5	95.1	95.4	94.9	95.1
$J = 200$	0.00	0.00	0.00	0.00	0.00	0.07	0.08	0.08	0.08	0.08	93.5	95.2	94.6	93.8	94.7
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.00	0.03	0.04	0.04	0.04	0.04	94.5	94.0	93.6	94.0	93.8

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-5

Study 2: Bias, Relative RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With Moderately Unbalanced Data (Uniform, ±40%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−0.00	0.01	0.01	0.02	−0.04	0.15	0.20	0.21	0.21	0.20	92.6	95.1	94.2	93.3	92.8
$J = 200$	−0.00	−0.01	−0.00	0.00	−0.02	0.07	0.09	0.09	0.09	0.09	95.2	95.4	94.8	94.9	94.7
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.01	0.03	0.04	0.04	0.04	0.04	94.7	93.7	93.4	94.4	94.8
$\bar{n} = 20$															
$J = 50$	−0.00	−0.00	−0.00	0.00	−0.05	0.14	0.18	0.19	0.19	0.19	95.2	95.5	95.9	95.0	93.8
$J = 200$	−0.00	0.00	0.00	0.00	−0.02	0.07	0.09	0.09	0.09	0.09	94.6	93.7	95.4	95.0	94.9
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.01	0.03	0.04	0.04	0.04	0.04	95.6	95.6	94.1	95.2	94.8
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−0.00	−0.00	−0.00	0.00	−0.03	0.14	0.19	0.20	0.19	0.19	94.0	94.0	95.4	94.0	93.5
$J = 200$	−0.00	−0.00	−0.00	−0.00	−0.01	0.07	0.10	0.10	0.10	0.09	95.3	94.6	94.7	93.8	95.1
$J = 1000$	0.00	−0.00	−0.00	0.00	−0.00	0.03	0.04	0.04	0.04	0.04	93.8	94.1	93.8	93.7	93.6
$\bar{n} = 20$															
$J = 50$	0.00	−0.01	−0.01	−0.01	−0.03	0.14	0.19	0.19	0.19	0.19	94.3	94.0	95.5	94.4	95.2
$J = 200$	0.00	0.00	−0.00	0.00	−0.00	0.07	0.10	0.10	0.10	0.10	95.5	94.3	94.5	94.2	94.9
$J = 1000$	−0.00	0.00	−0.00	0.00	−0.00	0.03	0.04	0.04	0.04	0.04	94.2	94.3	94.4	94.1	93.9

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-6

Study 2: Bias, Relative RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With Strongly Unbalanced Data (Uniform, ±80%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	0.00	−0.00	−0.00	0.01	−0.04	0.15	0.22	0.22	0.21	0.20	92.2	91.4	93.1	92.3	91.2
$J = 200$	0.00	−0.00	0.00	0.01	−0.02	0.07	0.10	0.10	0.10	0.10	95.7	94.1	94.7	93.9	93.5
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.01	0.03	0.04	0.04	0.04	0.04	95.5	94.7	95.0	94.3	93.7
$\bar{n} = 20$															
$J = 50$	−0.00	−0.00	−0.00	0.00	−0.05	0.14	0.19	0.19	0.19	0.19	94.6	95.0	95.3	95.8	94.4
$J = 200$	−0.00	−0.01	−0.01	−0.01	−0.03	0.07	0.09	0.09	0.09	0.10	94.9	94.5	94.8	94.3	94.1
$J = 1000$	0.00	0.00	0.00	0.00	−0.00	0.03	0.04	0.04	0.04	0.04	94.7	94.2	94.8	95.0	95.1
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−0.00	−0.01	−0.01	−0.00	−0.04	0.14	0.19	0.20	0.20	0.19	94.9	94.1	95.0	92.9	91.9
$J = 200$	−0.00	−0.00	−0.00	0.00	−0.01	0.07	0.09	0.10	0.09	0.09	95.5	94.6	95.3	95.2	95.2
$J = 1000$	−0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.04	0.04	0.04	94.4	95.3	94.9	94.4	94.6
$\bar{n} = 20$															
$J = 50$	0.01	0.01	0.01	0.01	−0.01	0.14	0.19	0.20	0.19	0.19	94.2	94.1	96.0	94.5	94.4
$J = 200$	0.00	−0.00	−0.00	−0.00	−0.01	0.07	0.09	0.09	0.09	0.09	94.5	94.6	94.5	94.6	95.3
$J = 1000$	−0.00	0.00	−0.00	0.00	−0.00	0.03	0.04	0.04	0.04	0.04	95.7	94.9	95.9	95.1	95.6

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-7

Study 2: Bias, Relative RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With Moderately Unbalanced Data (Bimodal, ±40%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−0.00	−0.00	−0.00	0.01	−0.04	0.14	0.19	0.20	0.19	0.19	93.6	94.7	95.3	93.3	93.5
$J = 200$	0.00	0.00	0.00	0.01	−0.01	0.07	0.09	0.09	0.09	0.09	95.0	94.1	95.1	94.1	95.2
$J = 1000$	−0.00	−0.00	0.00	0.00	−0.00	0.03	0.04	0.04	0.04	0.04	95.0	94.1	94.6	93.9	94.6
$\bar{n} = 20$															
$J = 50$	−0.00	0.00	−0.00	0.00	−0.05	0.14	0.20	0.20	0.20	0.20	94.8	94.8	94.8	93.9	93.7
$J = 200$	0.00	−0.00	0.00	0.00	−0.02	0.07	0.10	0.10	0.10	0.10	94.0	93.1	93.2	93.0	93.5
$J = 1000$	0.00	−0.00	−0.00	−0.00	−0.01	0.03	0.04	0.04	0.04	0.04	95.3	93.6	94.5	94.8	94.4
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	0.00	−0.00	−0.00	0.00	−0.03	0.15	0.19	0.20	0.19	0.19	93.0	94.8	94.8	93.8	94.8
$J = 200$	−0.00	−0.00	−0.00	−0.00	−0.01	0.07	0.10	0.10	0.10	0.10	94.9	94.2	94.1	93.2	93.5
$J = 1000$	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.04	0.04	0.04	95.6	95.8	95.3	95.3	95.7
$\bar{n} = 20$															
$J = 50$	0.00	−0.00	−0.00	−0.00	−0.02	0.14	0.20	0.21	0.20	0.20	93.6	93.4	94.2	92.4	93.9
$J = 200$	−0.00	−0.00	−0.00	−0.00	−0.01	0.07	0.09	0.10	0.09	0.10	94.9	94.3	94.4	94.7	95.2
$J = 1000$	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.04	0.04	0.04	93.5	95.0	95.4	94.4	95.4

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-8

Study 2: Bias, Relative RMSE, and Coverage of the 95% Confidence Interval for the Mean of z ($\hat{\mu}_z$) With Strongly Unbalanced Data (Bimodal, ±80%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−0.00	−0.00	−0.00	0.00	−0.03	0.14	0.20	0.21	0.19	0.19	94.0	94.0	93.6	93.6	93.3
$J = 200$	0.00	−0.00	−0.00	0.00	−0.01	0.07	0.10	0.10	0.10	0.10	94.7	94.0	94.1	93.5	94.3
$J = 1000$	0.00	−0.00	−0.00	0.00	−0.00	0.03	0.04	0.04	0.04	0.04	96.5	95.8	95.7	95.9	96.2
$\bar{n} = 20$															
$J = 50$	0.00	0.00	0.00	0.00	−0.04	0.14	0.19	0.20	0.19	0.19	95.0	94.4	95.0	94.9	93.6
$J = 200$	0.00	0.00	−0.00	0.00	−0.02	0.07	0.10	0.10	0.09	0.10	95.4	94.4	95.0	94.3	93.7
$J = 1000$	0.00	−0.00	0.00	0.00	−0.00	0.03	0.04	0.04	0.04	0.04	94.8	94.8	95.2	94.4	94.9
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−0.00	−0.01	−0.01	−0.01	−0.03	0.15	0.21	0.21	0.20	0.20	92.9	93.8	93.1	93.4	93.9
$J = 200$	0.00	−0.00	0.00	0.00	−0.01	0.07	0.10	0.10	0.10	0.10	94.4	93.7	92.9	93.5	94.0
$J = 1000$	−0.00	−0.00	−0.00	−0.00	−0.00	0.03	0.04	0.04	0.04	0.04	94.5	93.9	93.6	93.6	94.6
$\bar{n} = 20$															
$J = 50$	−0.00	−0.00	−0.01	−0.00	−0.03	0.14	0.19	0.20	0.19	0.19	93.3	95.4	95.4	93.8	94.2
$J = 200$	0.00	−0.00	−0.00	0.00	−0.01	0.07	0.09	0.10	0.09	0.09	95.9	94.8	94.4	95.0	94.9
$J = 1000$	−0.00	−0.00	0.00	0.00	0.00	0.03	0.04	0.04	0.04	0.04	95.1	93.7	94.3	94.0	94.8

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-9

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With Moderately Unbalanced Data (Uniform, ±40%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−1.3	0.9	4.5	1.5	−1.4	0.20	0.24	0.25	0.24	0.22	90.2	92.3	94.4	92.7	92.5
$J = 200$	0.4	1.1	1.7	1.2	0.2	0.10	0.11	0.12	0.11	0.11	95.3	95.3	96.0	95.6	94.9
$J = 1000$	−0.1	−0.0	0.0	−0.1	−0.2	0.05	0.05	0.05	0.05	0.05	94.2	93.7	94.3	94.7	94.1
$\bar{n} = 20$															
$J = 50$	−1.8	0.7	4.6	0.8	−2.0	0.20	0.24	0.27	0.24	0.23	89.7	90.6	93.1	90.8	89.4
$J = 200$	−0.5	0.0	0.6	−0.0	−0.8	0.10	0.12	0.12	0.12	0.11	93.4	94.0	94.4	93.6	93.6
$J = 1000$	−0.2	0.0	0.1	−0.0	−0.1	0.04	0.05	0.05	0.05	0.05	94.6	95.1	95.4	95.7	95.0
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−3.4	−1.0	2.0	−0.8	−2.9	0.21	0.23	0.24	0.23	0.23	88.2	91.9	95.0	92.0	90.0
$J = 200$	−0.6	−0.2	0.5	−0.1	−0.6	0.10	0.12	0.12	0.12	0.11	93.5	93.7	94.0	93.0	93.2
$J = 1000$	0.0	0.1	0.2	0.1	0.0	0.04	0.05	0.05	0.05	0.05	95.5	95.4	95.7	94.0	95.0
$\bar{n} = 20$															
$J = 50$	−1.5	0.8	3.6	0.6	−0.9	0.20	0.24	0.25	0.24	0.24	90.1	91.2	93.4	91.5	90.2
$J = 200$	−0.0	0.7	1.3	0.7	0.4	0.10	0.12	0.12	0.12	0.12	93.6	93.7	93.4	93.1	93.5
$J = 1000$	−0.1	0.1	0.2	0.1	0.0	0.05	0.05	0.05	0.05	0.05	94.6	94.5	94.0	94.4	94.1

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-10

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With Strongly Unbalanced Data (Uniform, ±80%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−3.2	−0.2	3.4	−0.6	−2.8	0.19	0.22	0.24	0.22	0.21	90.2	92.3	93.5	91.6	91.3
$J = 200$	−0.4	0.3	0.8	0.1	−0.5	0.10	0.11	0.11	0.11	0.11	93.4	94.5	94.8	93.9	93.7
$J = 1000$	0.0	0.3	0.2	0.1	−0.1	0.05	0.05	0.05	0.05	0.05	94.9	94.4	95.0	94.1	94.1
$\bar{n} = 20$															
$J = 50$	−1.4	1.6	4.9	1.5	−1.6	0.20	0.24	0.26	0.24	0.23	91.4	92.1	94.3	93.3	91.7
$J = 200$	−0.6	0.4	0.8	0.2	−0.6	0.10	0.11	0.11	0.11	0.11	94.7	95.7	96.0	95.4	94.4
$J = 1000$	−0.2	0.1	0.1	−0.0	−0.2	0.05	0.05	0.05	0.05	0.05	94.8	94.4	94.5	94.7	94.9
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−2.5	0.8	3.9	0.5	−1.7	0.19	0.24	0.25	0.23	0.22	91.1	92.1	93.5	93.0	91.6
$J = 200$	−0.2	0.5	0.9	0.2	−0.1	0.10	0.11	0.11	0.11	0.11	94.5	93.9	94.5	93.8	93.8
$J = 1000$	−0.1	0.1	0.0	−0.1	−0.1	0.04	0.05	0.05	0.05	0.05	94.9	94.9	95.1	94.6	94.5
$\bar{n} = 20$															
$J = 50$	−1.3	1.2	4.4	1.4	−0.5	0.21	0.25	0.26	0.25	0.24	88.7	91.6	93.5	91.0	90.6
$J = 200$	−0.6	0.1	0.7	0.0	−0.3	0.10	0.12	0.12	0.12	0.12	92.3	93.2	93.7	92.4	93.0
$J = 1000$	−0.2	−0.1	−0.0	−0.1	−0.2	0.04	0.05	0.05	0.05	0.05	94.4	94.4	94.7	94.7	94.8

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-11

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With Moderately Unbalanced Data (Bimodal, ±40%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−1.6	0.6	3.9	0.7	−2.0	0.21	0.24	0.26	0.24	0.23	90.2	91.6	93.1	91.1	91.0
$J = 200$	−0.9	−0.3	0.3	−0.2	−1.0	0.10	0.11	0.11	0.11	0.11	93.7	93.9	94.2	94.0	94.3
$J = 1000$	0.0	0.3	0.3	0.2	0.1	0.05	0.05	0.05	0.05	0.05	93.3	94.0	93.8	93.4	94.6
$\bar{n} = 20$															
$J = 50$	−2.5	0.7	3.5	0.7	−2.5	0.19	0.23	0.25	0.23	0.22	90.7	92.3	94.0	92.3	90.7
$J = 200$	−0.5	−0.2	0.2	−0.3	−1.1	0.10	0.11	0.11	0.11	0.11	93.9	94.7	94.7	94.5	94.0
$J = 1000$	0.2	0.4	0.5	0.4	0.2	0.04	0.05	0.05	0.05	0.05	96.2	96.3	96.4	96.6	95.9
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−3.4	−0.3	2.4	−0.5	−2.2	0.19	0.22	0.24	0.22	0.22	89.8	93.4	94.6	92.5	91.3
$J = 200$	−0.5	0.1	0.6	0.1	−0.2	0.10	0.11	0.12	0.11	0.11	94.3	92.8	93.3	93.6	93.7
$J = 1000$	−0.0	0.1	0.2	0.2	0.1	0.04	0.05	0.05	0.05	0.05	94.2	93.9	94.2	94.5	93.9
$\bar{n} = 20$															
$J = 50$	−2.1	0.4	3.5	0.4	−1.2	0.20	0.24	0.25	0.24	0.24	89.6	90.9	93.0	91.1	89.3
$J = 200$	−0.5	0.1	0.7	0.1	−0.2	0.10	0.11	0.11	0.11	0.11	93.8	94.7	95.1	94.3	94.6
$J = 1000$	−0.0	0.2	0.3	0.2	0.1	0.04	0.05	0.05	0.05	0.05	95.4	94.7	95.0	94.9	94.6

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-12

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With Strongly Unbalanced Data (Bimodal, ±80%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−2.2	1.4	4.1	0.7	−1.4	0.21	0.24	0.25	0.24	0.23	88.9	91.7	93.8	91.4	90.6
$J = 200$	−1.0	−0.0	0.3	−0.3	−0.9	0.10	0.12	0.11	0.11	0.11	92.3	92.8	94.1	93.0	92.5
$J = 1000$	−0.1	0.3	0.1	0.1	−0.1	0.05	0.05	0.05	0.05	0.05	94.6	94.0	94.5	94.6	94.7
$\bar{n} = 20$															
$J = 50$	−2.9	0.6	3.1	0.5	−2.4	0.19	0.23	0.23	0.23	0.22	90.7	93.1	95.0	92.6	90.9
$J = 200$	−0.7	0.3	0.5	−0.0	−0.7	0.10	0.11	0.11	0.11	0.11	92.4	94.7	94.5	93.9	92.8
$J = 1000$	−0.1	0.2	0.0	−0.0	−0.2	0.05	0.05	0.05	0.05	0.05	93.9	92.7	93.0	93.3	92.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−1.7	1.8	4.2	1.1	−0.6	0.19	0.23	0.24	0.23	0.22	90.5	92.5	94.2	92.4	91.9
$J = 200$	−0.8	−0.0	0.3	−0.2	−0.7	0.10	0.11	0.11	0.11	0.11	94.5	94.7	95.2	94.8	94.7
$J = 1000$	−0.2	0.1	−0.1	−0.1	−0.1	0.05	0.05	0.05	0.05	0.05	95.0	94.7	93.7	94.0	94.0
$\bar{n} = 20$															
$J = 50$	−3.2	0.2	2.8	−0.0	−1.7	0.20	0.23	0.25	0.23	0.23	90.6	92.0	94.5	92.4	91.4
$J = 200$	−0.6	−0.0	0.4	−0.1	−0.5	0.10	0.11	0.11	0.11	0.11	94.1	93.9	94.7	94.2	94.1
$J = 1000$	−0.2	0.0	0.0	−0.1	−0.1	0.04	0.05	0.05	0.05	0.05	94.7	95.0	95.4	94.7	95.7

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-13

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With Moderately Unbalanced Data (Uniform, ±40%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−2.4	4.0	16.0	4.6	−2.0	0.20	0.29	0.38	0.29	0.26	90.0	94.1	96.3	93.1	90.7
$J = 200$	−0.2	1.0	2.9	1.3	−0.5	0.10	0.14	0.14	0.14	0.13	93.5	94.6	95.9	95.7	93.8
$J = 1000$	−0.3	−0.2	0.2	−0.1	−0.5	0.04	0.06	0.06	0.06	0.06	93.6	92.9	93.6	93.3	93.4
$\bar{n} = 20$															
$J = 50$	−2.0	4.6	14.5	5.3	−1.5	0.19	0.28	0.36	0.29	0.25	90.6	94.0	96.0	92.7	91.5
$J = 200$	−0.1	1.5	2.9	1.3	−0.5	0.10	0.14	0.14	0.14	0.13	94.8	94.6	94.4	95.1	93.8
$J = 1000$	−0.1	0.3	0.6	0.3	−0.0	0.05	0.06	0.06	0.06	0.06	93.9	93.4	94.9	94.4	95.0
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−2.0	5.0	15.9	6.0	0.4	0.20	0.28	0.39	0.29	0.26	90.1	94.5	97.2	94.0	91.6
$J = 200$	−0.3	1.2	2.9	1.2	0.3	0.10	0.13	0.14	0.14	0.13	93.4	94.7	95.7	94.8	94.8
$J = 1000$	−0.1	0.4	0.6	0.3	0.2	0.04	0.06	0.06	0.06	0.06	96.1	93.3	94.5	95.0	94.3
$\bar{n} = 20$															
$J = 50$	−2.0	3.4	13.1	4.0	−0.0	0.21	0.29	0.36	0.29	0.28	88.4	92.2	95.3	92.7	90.7
$J = 200$	−0.6	0.8	2.2	0.8	0.0	0.10	0.14	0.14	0.14	0.14	93.0	93.1	93.7	92.6	93.2
$J = 1000$	−0.0	0.1	0.4	0.1	−0.1	0.05	0.06	0.06	0.06	0.06	93.9	93.8	94.2	94.2	93.8

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-14

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With Strongly Unbalanced Data (Uniform, ±80%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−1.9	5.3	17.2	5.6	−0.4	0.21	0.31	0.41	0.31	0.28	89.4	91.7	95.4	91.8	88.4
$J = 200$	−0.7	1.2	3.0	1.2	−0.8	0.10	0.14	0.15	0.14	0.13	93.2	94.3	94.2	94.0	93.8
$J = 1000$	−0.2	0.2	0.4	0.1	−0.4	0.05	0.06	0.06	0.06	0.06	94.0	94.0	94.6	93.9	93.4
$\bar{n} = 20$															
$J = 50$	−2.1	5.3	15.4	5.0	−1.8	0.20	0.30	0.39	0.31	0.26	88.7	91.6	95.7	92.3	90.9
$J = 200$	−0.8	−0.0	1.8	0.0	−1.8	0.10	0.14	0.14	0.14	0.14	93.4	92.6	93.5	92.3	91.9
$J = 1000$	−0.1	0.4	0.7	0.4	−0.0	0.04	0.06	0.06	0.06	0.06	95.4	95.0	95.1	95.9	94.8
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−1.5	6.9	17.1	7.3	1.3	0.19	0.30	0.38	0.30	0.26	90.5	95.2	97.4	94.1	93.3
$J = 200$	−1.0	0.6	2.2	0.6	−0.5	0.10	0.14	0.14	0.14	0.14	93.3	93.0	94.8	93.7	93.0
$J = 1000$	−0.4	0.0	0.2	−0.1	−0.3	0.04	0.06	0.06	0.06	0.06	95.4	95.6	96.1	95.4	94.8
$\bar{n} = 20$															
$J = 50$	−1.0	6.1	16.0	5.8	2.2	0.20	0.30	0.37	0.29	0.28	89.1	94.1	96.6	92.5	92.7
$J = 200$	−0.5	0.4	2.1	0.5	−0.3	0.10	0.14	0.15	0.14	0.14	93.4	93.4	93.4	92.5	93.2
$J = 1000$	−0.1	0.1	0.4	0.1	−0.1	0.05	0.06	0.06	0.06	0.06	94.8	94.1	93.8	93.9	93.2

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-15

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With Moderately Unbalanced Data (Bimodal, ±40%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−2.2	5.1	14.8	4.9	−1.3	0.20	0.30	0.37	0.30	0.27	89.6	93.3	95.6	92.1	89.5
$J = 200$	−0.4	1.0	2.7	1.4	−0.7	0.10	0.14	0.14	0.14	0.13	93.1	93.1	94.9	93.9	93.4
$J = 1000$	−0.3	−0.1	0.2	−0.0	−0.5	0.04	0.06	0.06	0.06	0.06	94.9	94.5	94.9	94.4	94.4
$\bar{n} = 20$															
$J = 50$	−2.2	5.4	14.2	6.0	−0.8	0.19	0.30	0.36	0.30	0.26	89.4	94.0	97.3	94.1	91.3
$J = 200$	−0.4	0.6	2.4	0.7	−1.3	0.10	0.14	0.14	0.14	0.13	94.6	93.3	93.9	93.9	92.3
$J = 1000$	−0.5	−0.2	0.1	−0.3	−0.7	0.05	0.06	0.06	0.06	0.06	93.9	94.4	94.0	93.0	92.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−1.1	4.8	15.1	5.5	0.6	0.20	0.30	0.50	0.31	0.27	91.4	92.9	95.7	93.9	91.2
$J = 200$	−0.6	1.0	2.7	1.0	−0.2	0.10	0.14	0.14	0.14	0.13	93.6	93.6	95.5	94.4	93.5
$J = 1000$	−0.2	0.3	0.5	0.3	0.2	0.04	0.06	0.06	0.06	0.06	94.4	94.9	94.9	95.7	94.7
$\bar{n} = 20$															
$J = 50$	−1.6	3.8	13.0	4.2	0.3	0.20	0.29	0.35	0.29	0.27	89.4	93.1	95.8	93.2	91.7
$J = 200$	−0.6	0.9	2.5	0.8	0.1	0.10	0.14	0.14	0.14	0.14	94.1	93.8	93.8	93.4	93.8
$J = 1000$	−0.1	0.2	0.5	0.2	0.0	0.04	0.06	0.06	0.06	0.06	95.2	94.1	94.0	93.3	93.6

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-16

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Variance of z ($\hat{\sigma}_z^2$) With Strongly Unbalanced Data (Bimodal, ±80%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−2.2	5.3	14.5	4.1	−1.2	0.20	0.29	0.36	0.28	0.26	89.5	93.7	96.3	93.2	90.2
$J = 200$	−1.0	0.8	2.5	0.8	−0.6	0.10	0.13	0.14	0.14	0.13	93.4	93.5	95.5	93.0	92.9
$J = 1000$	−0.2	0.1	0.3	0.1	−0.1	0.04	0.06	0.06	0.06	0.06	95.3	94.9	94.2	94.7	94.0
$\bar{n} = 20$															
$J = 50$	−3.0	2.9	11.6	2.5	−3.3	0.20	0.28	0.33	0.27	0.25	88.4	93.5	96.2	92.7	90.8
$J = 200$	−0.1	2.0	3.6	1.9	0.0	0.10	0.13	0.14	0.13	0.13	93.5	95.0	95.8	95.2	93.9
$J = 1000$	0.0	0.4	0.6	0.2	−0.1	0.04	0.06	0.06	0.06	0.06	96.7	94.8	94.5	95.4	95.2
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−0.4	6.5	16.4	6.8	0.8	0.20	0.31	0.38	0.31	0.27	91.9	94.3	96.2	93.7	91.5
$J = 200$	−0.6	0.3	2.0	0.2	−0.8	0.10	0.14	0.14	0.13	0.13	93.4	94.0	95.1	94.9	93.2
$J = 1000$	−0.0	0.1	0.4	0.1	−0.1	0.04	0.06	0.06	0.06	0.06	95.5	93.8	94.5	94.2	93.7
$\bar{n} = 20$															
$J = 50$	−2.5	2.8	12.1	3.1	−1.3	0.20	0.28	0.35	0.28	0.26	89.2	92.5	96.1	92.6	91.2
$J = 200$	−0.5	1.0	2.7	1.1	0.2	0.10	0.14	0.14	0.14	0.14	94.4	93.2	95.7	93.7	93.3
$J = 1000$	0.0	0.4	0.6	0.3	0.2	0.05	0.06	0.06	0.06	0.06	94.9	93.7	93.2	93.4	94.1

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-17

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With Moderately Unbalanced Data (Uniform, ±40%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	0.2	0.7	1.2	5.4	−8.2	0.08	0.09	0.10	0.10	0.09	93.2	94.5	95.3	94.0	94.5
$J = 200$	0.2	0.2	0.4	2.3	−3.6	0.04	0.05	0.04	0.05	0.04	95.9	96.1	96.5	95.5	96.7
$J = 1000$	0.1	−0.9	−0.4	−0.1	−1.5	0.02	0.02	0.02	0.02	0.02	94.9	93.8	94.3	94.5	94.1
$\bar{n} = 20$															
$J = 50$	−1.8	−1.8	−0.9	−0.8	−9.7	0.06	0.07	0.07	0.07	0.07	91.8	92.6	93.9	92.4	91.4
$J = 200$	−0.9	−1.3	−1.3	−1.2	−4.2	0.03	0.03	0.03	0.03	0.03	92.6	94.1	94.4	94.1	93.9
$J = 1000$	−0.1	−0.3	−0.2	−0.1	−0.7	0.01	0.01	0.01	0.01	0.01	94.4	94.7	94.2	94.8	95.0
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−1.8	−1.4	−1.1	−0.5	−5.5	0.10	0.12	0.12	0.12	0.11	92.4	94.0	95.3	94.5	93.7
$J = 200$	−1.1	−1.3	−1.1	−1.0	−2.4	0.05	0.06	0.06	0.06	0.06	93.6	94.0	93.8	93.8	94.2
$J = 1000$	0.1	−0.2	−0.1	−0.0	−0.2	0.02	0.03	0.03	0.03	0.03	95.2	93.7	95.0	93.8	94.5
$\bar{n} = 20$															
$J = 50$	−0.3	−0.4	−0.9	−0.5	−4.1	0.09	0.10	0.11	0.10	0.10	92.5	93.0	93.9	93.2	93.0
$J = 200$	0.4	0.5	0.5	0.5	−0.3	0.05	0.05	0.05	0.05	0.05	94.8	94.4	94.3	94.1	93.4
$J = 1000$	−0.2	0.0	−0.0	0.0	−0.2	0.02	0.02	0.02	0.02	0.02	94.6	94.7	94.9	94.6	94.9

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-18

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With Strongly Unbalanced Data (Uniform, ±80%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−4.9	−5.6	−2.5	−0.6	−12.0	0.08	0.09	0.10	0.09	0.09	93.4	94.3	96.1	93.9	94.2
$J = 200$	−1.9	−4.2	−1.5	−0.2	−5.5	0.04	0.05	0.05	0.05	0.05	94.6	94.1	94.1	93.8	93.6
$J = 1000$	0.2	−3.0	−0.1	0.3	−1.1	0.02	0.02	0.02	0.02	0.02	94.8	94.2	94.7	94.1	94.3
$\bar{n} = 20$															
$J = 50$	−0.4	0.7	1.1	1.8	−7.9	0.06	0.07	0.07	0.07	0.06	93.1	94.1	95.0	93.7	93.6
$J = 200$	−0.1	−0.5	0.1	0.4	−2.6	0.03	0.03	0.03	0.03	0.03	94.8	94.3	94.7	94.7	94.5
$J = 1000$	0.1	−0.8	−0.2	−0.0	−0.7	0.01	0.02	0.02	0.02	0.02	94.4	94.4	94.2	93.8	94.1
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−2.5	−3.4	−2.7	−2.5	−8.0	0.10	0.12	0.12	0.12	0.12	93.2	93.7	94.1	93.3	92.6
$J = 200$	0.1	−1.0	−0.2	−0.1	−1.2	0.05	0.06	0.06	0.06	0.06	93.4	93.6	93.5	93.6	93.9
$J = 1000$	0.1	−1.0	−0.1	0.3	0.1	0.02	0.03	0.03	0.03	0.03	95.2	94.2	94.6	93.8	93.9
$\bar{n} = 20$															
$J = 50$	−0.4	0.3	0.9	0.9	−3.0	0.09	0.10	0.10	0.10	0.10	91.4	93.5	93.9	93.5	92.7
$J = 200$	−0.9	−1.2	−0.7	−0.9	−1.6	0.05	0.05	0.05	0.05	0.05	94.8	94.5	94.7	94.6	94.0
$J = 1000$	−0.2	−0.4	−0.4	−0.3	−0.5	0.02	0.02	0.02	0.02	0.02	93.7	94.5	94.3	94.3	94.1

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-19

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With Moderately Unbalanced Data (Bimodal, ±40%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−3.8	−4.2	−2.4	−0.2	−12.0	0.08	0.10	0.10	0.10	0.09	90.6	92.9	93.1	92.4	92.5
$J = 200$	−0.4	−1.2	−0.2	1.2	−4.2	0.04	0.05	0.05	0.05	0.04	94.4	93.8	95.0	94.0	94.3
$J = 1000$	0.4	−0.7	0.5	0.7	−0.7	0.02	0.02	0.02	0.02	0.02	94.6	94.4	94.2	94.6	94.3
$\bar{n} = 20$															
$J = 50$	−1.1	−0.6	−0.6	0.2	−9.5	0.06	0.07	0.07	0.07	0.06	93.5	93.5	94.0	92.9	92.4
$J = 200$	−0.5	−1.3	−1.2	−1.1	−4.0	0.03	0.03	0.03	0.03	0.03	94.8	95.1	95.5	95.5	95.2
$J = 1000$	0.2	0.1	0.3	0.4	−0.2	0.01	0.02	0.02	0.02	0.02	94.2	94.3	94.6	94.5	94.6
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−2.5	−1.6	−1.5	−0.8	−5.7	0.10	0.12	0.12	0.12	0.11	91.8	93.5	94.3	93.6	93.2
$J = 200$	0.5	0.2	0.0	0.6	−0.7	0.05	0.06	0.06	0.06	0.06	94.2	95.2	94.7	94.6	94.3
$J = 1000$	0.1	−0.3	−0.1	0.1	−0.2	0.02	0.03	0.03	0.03	0.03	95.2	95.0	94.9	94.2	94.9
$\bar{n} = 20$															
$J = 50$	−1.9	−1.9	−1.6	−1.7	−5.0	0.09	0.11	0.11	0.11	0.10	91.0	92.8	93.7	93.1	92.2
$J = 200$	−0.4	0.0	−0.1	−0.0	−0.8	0.05	0.05	0.05	0.05	0.05	94.5	94.5	95.0	94.9	94.4
$J = 1000$	0.2	0.4	0.4	0.4	0.2	0.02	0.02	0.02	0.02	0.02	95.6	94.8	94.6	94.7	94.0

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-20

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With Strongly Unbalanced Data (Bimodal, ±80%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−2.6	−6.1	−0.8	0.3	−9.6	0.09	0.10	0.10	0.10	0.09	92.3	93.7	94.2	92.6	92.7
$J = 200$	−0.5	−6.5	−0.4	1.0	−3.7	0.04	0.05	0.05	0.05	0.05	94.5	93.8	95.3	95.3	95.0
$J = 1000$	−0.6	−7.6	−1.2	−0.5	−1.6	0.02	0.02	0.02	0.02	0.02	94.3	91.0	94.0	94.0	94.5
$\bar{n} = 20$															
$J = 50$	−2.3	−3.8	−1.6	−0.4	−9.8	0.06	0.07	0.07	0.07	0.07	92.0	93.1	94.2	93.3	92.6
$J = 200$	−0.3	−2.9	−0.7	−0.2	−3.0	0.03	0.04	0.04	0.04	0.04	94.0	94.4	95.3	94.3	94.1
$J = 1000$	−0.2	−3.0	−0.6	0.1	−0.8	0.01	0.02	0.02	0.02	0.02	94.4	92.9	94.0	93.6	93.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−3.9	−5.3	−3.6	−1.7	−6.8	0.11	0.12	0.12	0.12	0.12	94.3	94.5	95.3	94.7	94.2
$J = 200$	−0.3	−3.2	−0.9	−0.1	−1.6	0.05	0.06	0.06	0.06	0.06	95.1	94.7	95.2	95.0	95.4
$J = 1000$	0.3	−2.7	−0.4	0.2	−0.0	0.02	0.03	0.03	0.03	0.03	95.8	95.1	95.5	95.0	94.7
$\bar{n} = 20$															
$J = 50$	−2.6	−1.7	−1.9	−1.2	−5.1	0.09	0.11	0.11	0.11	0.10	93.4	93.4	94.2	93.6	92.8
$J = 200$	0.2	−0.5	−0.2	0.0	−1.0	0.05	0.05	0.05	0.05	0.05	93.8	94.5	94.4	94.4	94.5
$J = 1000$	−0.5	−0.9	−0.6	−0.4	−0.6	0.02	0.02	0.02	0.02	0.02	95.7	95.8	95.7	95.4	96.5

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-21

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With Moderately Unbalanced Data (Uniform, ±40%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−0.5	0.2	1.4	7.7	−21.0	0.08	0.11	0.12	0.11	0.09	92.9	96.2	96.7	95.1	96.3
$J = 200$	2.1	−0.6	1.1	4.5	−8.6	0.04	0.05	0.05	0.06	0.05	94.7	93.7	94.7	93.2	94.6
$J = 1000$	−0.3	−2.2	−0.8	−0.2	−3.3	0.02	0.02	0.02	0.02	0.02	95.6	94.0	94.4	93.7	94.1
$\bar{n} = 20$															
$J = 50$	−4.1	−2.9	−2.2	−0.1	−20.5	0.06	0.08	0.08	0.08	0.07	88.9	93.2	94.0	91.7	90.3
$J = 200$	0.1	1.1	0.7	1.1	−6.1	0.03	0.04	0.04	0.04	0.04	94.5	96.2	95.9	95.5	94.3
$J = 1000$	−0.3	−0.6	−0.5	−0.3	−1.8	0.01	0.02	0.02	0.02	0.02	94.6	94.6	93.9	94.7	94.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−1.0	−1.1	0.2	2.3	−10.7	0.10	0.14	0.15	0.14	0.13	92.8	94.7	94.6	94.5	93.3
$J = 200$	−0.3	−0.8	−0.2	−0.0	−2.8	0.05	0.07	0.07	0.07	0.07	94.7	94.0	94.6	93.6	94.7
$J = 1000$	−0.3	−0.6	−0.3	−0.2	−0.7	0.02	0.03	0.03	0.03	0.03	95.0	93.6	93.5	93.8	94.7
$\bar{n} = 20$															
$J = 50$	−3.1	−4.8	−4.3	−4.0	−11.5	0.09	0.12	0.13	0.12	0.12	91.4	92.3	93.2	93.1	90.8
$J = 200$	−0.2	−0.2	−0.4	−0.3	−2.1	0.05	0.06	0.06	0.06	0.06	94.6	93.2	93.2	92.6	94.1
$J = 1000$	0.0	0.0	0.0	0.1	−0.3	0.02	0.03	0.03	0.03	0.03	94.3	93.7	94.0	93.8	93.5

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-22

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With Strongly Unbalanced Data (Uniform, ±80%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−3.3	−11.8	−3.6	1.8	−25.1	0.08	0.11	0.12	0.11	0.10	92.5	94.4	95.4	92.4	92.7
$J = 200$	−0.8	−7.7	−0.4	2.9	−9.7	0.04	0.05	0.05	0.06	0.05	95.3	94.1	95.8	94.9	94.6
$J = 1000$	0.3	−7.5	−0.4	0.6	−2.7	0.02	0.03	0.02	0.02	0.02	95.0	92.1	95.5	93.8	94.6
$\bar{n} = 20$															
$J = 50$	−1.3	−1.9	−0.1	1.5	−20.1	0.06	0.08	0.08	0.08	0.07	93.0	93.7	95.4	94.5	91.5
$J = 200$	−0.8	−4.1	−1.5	−1.3	−8.1	0.03	0.04	0.04	0.04	0.04	92.6	94.1	95.1	93.2	92.5
$J = 1000$	0.2	−1.6	0.1	0.5	−1.1	0.01	0.02	0.02	0.02	0.02	95.4	95.5	96.0	95.9	96.2
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	0.1	−0.9	2.4	3.6	−9.6	0.11	0.15	0.15	0.15	0.13	91.8	94.0	96.2	93.5	93.7
$J = 200$	−1.5	−3.9	−1.5	−0.5	−3.6	0.05	0.07	0.07	0.07	0.07	93.8	92.7	93.6	93.5	94.1
$J = 1000$	−0.4	−2.8	−0.8	−0.3	−0.7	0.02	0.03	0.03	0.03	0.03	95.2	93.7	94.5	94.0	95.3
$\bar{n} = 20$															
$J = 50$	−1.4	−1.0	−0.9	−0.6	−8.3	0.09	0.12	0.13	0.12	0.12	91.4	93.1	94.0	92.5	92.0
$J = 200$	0.2	−0.4	0.1	−0.0	−2.1	0.05	0.06	0.06	0.06	0.06	93.8	92.9	94.1	93.2	93.1
$J = 1000$	−0.2	−0.5	−0.4	−0.2	−0.6	0.02	0.03	0.03	0.03	0.03	94.7	93.5	95.1	93.3	94.7

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-23

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With Moderately Unbalanced Data (Bimodal, ±40%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−2.9	−3.4	−2.2	5.6	−21.9	0.08	0.11	0.12	0.12	0.10	93.0	94.6	95.0	93.6	93.2
$J = 200$	0.1	−2.2	0.1	4.3	−9.0	0.04	0.05	0.06	0.06	0.05	94.3	94.2	93.8	93.2	93.9
$J = 1000$	−0.7	−3.2	−0.6	0.4	−3.0	0.02	0.02	0.02	0.02	0.02	94.3	94.7	93.3	93.6	93.6
$\bar{n} = 20$															
$J = 50$	−3.0	−1.8	−2.2	0.4	−20.2	0.06	0.08	0.08	0.08	0.07	93.9	94.8	94.9	93.6	91.9
$J = 200$	−0.8	−2.0	−1.2	−1.2	−8.1	0.03	0.04	0.04	0.04	0.04	94.2	94.1	94.3	93.9	92.9
$J = 1000$	0.0	−1.0	−0.4	−0.2	−2.0	0.01	0.02	0.02	0.02	0.02	94.8	94.4	94.1	94.4	94.8
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−1.4	−2.2	−2.1	1.2	−10.9	0.10	0.14	0.15	0.14	0.13	91.6	92.6	95.0	92.8	92.3
$J = 200$	−1.0	−1.4	−1.0	−0.6	−3.7	0.05	0.07	0.07	0.07	0.07	93.3	94.4	95.0	94.4	94.4
$J = 1000$	−0.1	−0.7	−0.0	0.3	−0.2	0.02	0.03	0.03	0.03	0.03	94.3	94.5	94.7	95.3	94.7
$\bar{n} = 20$															
$J = 50$	−1.5	−2.8	−2.7	−2.1	−10.0	0.09	0.12	0.13	0.12	0.12	92.2	92.9	94.0	93.9	92.2
$J = 200$	−0.2	0.1	0.2	0.1	−1.8	0.05	0.06	0.06	0.06	0.06	93.3	94.5	92.9	94.5	94.3
$J = 1000$	0.1	−0.0	0.1	0.2	−0.2	0.02	0.03	0.03	0.03	0.03	94.5	93.1	94.6	93.5	94.5

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-24

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Covariance of y With z ($\hat{\sigma}_{yz}$) With Strongly Unbalanced Data (Bimodal, ±80%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−2.5	−15.5	−4.7	−0.4	−24.5	0.08	0.11	0.13	0.12	0.10	93.1	94.5	95.5	93.5	92.8
$J = 200$	−0.7	−17.5	−2.5	0.9	−10.0	0.04	0.06	0.05	0.06	0.05	94.6	92.8	95.5	94.2	94.6
$J = 1000$	0.2	−16.8	−1.5	0.3	−2.7	0.02	0.04	0.02	0.02	0.02	95.4	81.4	94.4	93.3	94.1
$\bar{n} = 20$															
$J = 50$	−2.2	−7.6	−2.4	−0.7	−20.2	0.06	0.09	0.09	0.08	0.08	91.4	94.3	95.9	93.8	92.3
$J = 200$	−0.1	−6.8	−1.1	0.2	−7.2	0.03	0.04	0.04	0.04	0.04	95.6	94.5	95.3	95.3	94.9
$J = 1000$	−0.0	−7.1	−1.1	−0.1	−1.8	0.01	0.02	0.02	0.02	0.02	93.7	90.0	94.9	94.4	94.3
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−0.7	−8.6	−2.2	−0.2	−13.0	0.11	0.16	0.16	0.16	0.14	92.9	92.6	94.0	92.3	92.4
$J = 200$	−0.9	−8.9	−2.6	−1.6	−4.9	0.05	0.08	0.07	0.07	0.07	94.8	92.1	94.4	95.2	94.3
$J = 1000$	−0.3	−7.8	−1.3	−0.3	−0.8	0.02	0.04	0.03	0.03	0.03	95.5	89.7	94.6	94.5	95.2
$\bar{n} = 20$															
$J = 50$	−0.6	−3.2	−2.6	−1.9	−10.7	0.10	0.12	0.13	0.13	0.12	90.6	93.9	95.0	94.7	93.7
$J = 200$	0.1	−2.1	−0.7	−0.2	−2.5	0.05	0.06	0.06	0.06	0.06	94.6	93.7	93.8	93.6	93.9
$J = 1000$	−0.0	−1.3	−0.2	0.2	−0.1	0.02	0.03	0.03	0.03	0.03	95.3	94.3	93.8	94.6	95.0

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-25

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With Moderately Unbalanced Data (Uniform, ±40%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	0.6	−0.9	−3.4	2.8	−7.3	0.07	0.09	0.08	0.09	0.08	91.9	93.6	94.3	91.3	95.7
$J = 200$	−0.2	−1.0	−1.3	0.9	−3.9	0.04	0.04	0.04	0.04	0.04	95.0	94.8	95.2	93.8	95.9
$J = 1000$	0.2	−0.8	−0.5	0.0	−1.3	0.02	0.02	0.02	0.02	0.02	94.6	94.3	93.6	94.2	95.0
$\bar{n} = 20$															
$J = 50$	−0.1	−2.6	−5.0	−1.7	−7.8	0.05	0.06	0.06	0.06	0.06	91.6	93.3	92.8	91.7	94.0
$J = 200$	−0.3	−1.4	−1.9	−1.2	−3.5	0.03	0.03	0.03	0.03	0.03	92.8	94.6	94.4	93.9	94.8
$J = 1000$	0.0	−0.3	−0.3	−0.1	−0.6	0.01	0.01	0.01	0.01	0.01	94.9	94.9	94.9	94.4	94.4
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	1.9	−0.3	−2.7	0.5	−2.6	0.09	0.10	0.10	0.10	0.10	92.3	94.0	94.2	93.1	94.5
$J = 200$	−0.4	−1.2	−1.6	−1.0	−1.8	0.04	0.05	0.05	0.05	0.05	93.8	94.4	93.9	94.4	94.8
$J = 1000$	0.0	−0.4	−0.3	−0.2	−0.2	0.02	0.02	0.02	0.02	0.02	95.2	94.3	94.0	94.3	93.4
$\bar{n} = 20$															
$J = 50$	1.5	−1.0	−3.9	−1.0	−3.2	0.07	0.08	0.08	0.08	0.08	92.7	93.4	93.6	93.5	93.5
$J = 200$	0.4	−0.2	−0.8	−0.2	−0.8	0.04	0.04	0.04	0.04	0.04	94.6	95.2	94.5	95.2	95.2
$J = 1000$	−0.1	−0.0	−0.2	−0.1	−0.2	0.02	0.02	0.02	0.02	0.02	94.6	95.1	95.1	94.9	95.1

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-26

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With Strongly Unbalanced Data (Uniform, ±80%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−1.7	−6.0	−5.7	−0.5	−9.6	0.08	0.09	0.09	0.09	0.08	92.1	93.8	93.8	91.9	94.5
$J = 200$	−1.6	−4.7	−2.6	−0.6	−5.1	0.04	0.04	0.04	0.04	0.04	94.0	95.1	95.1	92.6	94.7
$J = 1000$	0.2	−3.3	−0.3	0.2	−1.0	0.02	0.02	0.02	0.02	0.02	94.5	94.3	94.7	94.1	94.9
$\bar{n} = 20$															
$J = 50$	1.1	−0.8	−3.2	0.5	−5.9	0.05	0.06	0.06	0.06	0.06	92.5	93.0	93.5	92.2	94.7
$J = 200$	0.5	−1.0	−0.8	0.0	−2.1	0.03	0.03	0.03	0.03	0.03	94.4	94.9	94.3	93.8	94.8
$J = 1000$	0.3	−0.9	−0.3	−0.0	−0.6	0.01	0.01	0.01	0.01	0.01	94.0	94.6	94.6	93.8	94.9
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	0.2	−4.1	−5.8	−2.9	−6.3	0.09	0.11	0.11	0.11	0.11	92.5	93.0	93.0	92.7	93.0
$J = 200$	0.2	−1.7	−1.3	−0.5	−1.2	0.05	0.05	0.05	0.05	0.05	93.4	93.8	93.9	92.9	93.9
$J = 1000$	0.2	−1.0	−0.1	0.3	0.1	0.02	0.02	0.02	0.02	0.02	95.5	95.1	94.5	94.6	94.9
$\bar{n} = 20$															
$J = 50$	0.9	−0.6	−2.8	−0.0	−2.2	0.08	0.08	0.08	0.08	0.08	92.6	93.3	93.8	92.9	93.9
$J = 200$	−0.3	−1.2	−1.4	−0.9	−1.3	0.04	0.04	0.04	0.04	0.04	94.2	93.9	94.2	94.4	94.4
$J = 1000$	−0.0	−0.3	−0.4	−0.2	−0.4	0.02	0.02	0.02	0.02	0.02	95.3	95.3	95.3	95.3	94.5

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-27

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With Moderately Unbalanced Data (Bimodal, ±40%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−2.2	−5.1	−6.0	−1.3	−10.1	0.08	0.09	0.09	0.09	0.08	91.3	91.8	91.5	90.4	93.5
$J = 200$	0.6	−1.0	−0.6	1.2	−3.2	0.04	0.04	0.04	0.04	0.04	93.7	94.0	94.0	93.7	95.4
$J = 1000$	0.4	−1.0	0.1	0.4	−0.8	0.02	0.02	0.02	0.02	0.02	95.8	94.7	94.5	94.7	94.9
$\bar{n} = 20$															
$J = 50$	1.6	−1.3	−3.8	−0.6	−7.0	0.05	0.06	0.06	0.06	0.06	93.7	93.6	93.8	92.5	95.2
$J = 200$	−0.1	−1.2	−1.5	−0.9	−2.9	0.02	0.03	0.03	0.03	0.03	95.9	95.4	96.3	95.6	95.6
$J = 1000$	−0.1	−0.3	−0.2	−0.0	−0.5	0.01	0.01	0.01	0.01	0.01	94.0	94.6	93.5	94.1	94.6
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	1.0	−1.5	−3.8	−0.6	−3.7	0.09	0.10	0.10	0.10	0.10	92.7	94.0	94.3	93.5	94.1
$J = 200$	1.0	−0.1	−0.7	0.3	−0.6	0.04	0.05	0.05	0.05	0.05	93.8	94.6	95.1	94.5	94.5
$J = 1000$	0.1	−0.5	−0.4	−0.1	−0.2	0.02	0.02	0.02	0.02	0.02	93.9	94.6	94.5	94.3	94.3
$\bar{n} = 20$															
$J = 50$	0.1	−2.4	−5.0	−2.2	−4.1	0.08	0.08	0.08	0.08	0.08	92.8	94.2	94.5	94.8	95.2
$J = 200$	0.2	−0.1	−0.8	−0.2	−0.6	0.04	0.04	0.04	0.04	0.04	93.5	95.2	94.9	94.7	94.9
$J = 1000$	0.3	0.1	0.1	0.2	0.1	0.02	0.02	0.02	0.02	0.02	94.4	94.5	93.7	94.3	93.8

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-28

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With Strongly Unbalanced Data (Bimodal, ±80%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−0.2	−7.7	−4.7	−0.7	−8.3	0.08	0.09	0.09	0.10	0.09	90.7	93.0	91.5	89.3	93.1
$J = 200$	0.4	−6.8	−0.9	1.0	−3.0	0.04	0.04	0.04	0.04	0.04	93.4	95.2	95.2	93.5	95.4
$J = 1000$	−0.5	−7.9	−1.4	−0.7	−1.5	0.02	0.02	0.02	0.02	0.02	94.5	92.8	95.2	94.3	95.4
$\bar{n} = 20$															
$J = 50$	0.3	−4.8	−4.5	−1.2	−7.7	0.06	0.06	0.06	0.07	0.06	92.6	94.1	94.1	92.9	94.5
$J = 200$	0.5	−3.2	−1.1	−0.2	−2.3	0.03	0.03	0.03	0.03	0.03	94.0	94.5	93.8	94.8	95.7
$J = 1000$	−0.0	−3.2	−0.6	0.1	−0.6	0.01	0.02	0.01	0.01	0.01	92.9	93.8	94.9	94.3	94.8
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−2.0	−6.8	−7.1	−2.6	−5.9	0.10	0.11	0.11	0.11	0.10	92.9	94.1	94.4	93.4	94.3
$J = 200$	0.3	−3.3	−1.3	0.0	−1.0	0.05	0.05	0.05	0.05	0.05	95.5	95.1	95.3	95.2	95.6
$J = 1000$	0.5	−2.9	−0.3	0.3	0.1	0.02	0.02	0.02	0.02	0.02	96.1	94.9	96.0	95.9	95.9
$\bar{n} = 20$															
$J = 50$	0.6	−2.0	−4.2	−1.2	−3.4	0.08	0.09	0.09	0.09	0.09	93.9	93.6	94.4	93.9	94.0
$J = 200$	0.8	−0.5	−0.6	0.1	−0.5	0.04	0.04	0.04	0.04	0.04	93.9	94.7	95.0	93.5	94.5
$J = 1000$	−0.3	−0.9	−0.7	−0.3	−0.5	0.02	0.02	0.02	0.02	0.02	95.2	95.5	95.3	95.4	95.6

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-29

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With Moderately Unbalanced Data (Uniform, ±40%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	1.9	−3.6	−10.8	3.2	−18.4	0.07	0.10	0.10	0.10	0.09	92.3	92.7	93.4	91.4	96.3
$J = 200$	2.4	−1.7	−1.8	3.1	−8.0	0.04	0.05	0.05	0.05	0.05	94.0	92.8	93.6	92.4	94.1
$J = 1000$	0.0	−2.0	−1.0	−0.1	−2.9	0.02	0.02	0.02	0.02	0.02	96.4	94.7	94.6	94.2	94.5
$\bar{n} = 20$															
$J = 50$	−2.5	−7.5	−13.7	−5.5	−19.1	0.05	0.07	0.07	0.07	0.07	91.6	93.3	93.8	91.8	94.3
$J = 200$	0.3	−0.3	−2.0	−0.1	−5.4	0.02	0.03	0.03	0.03	0.03	94.5	95.1	95.3	94.7	95.2
$J = 1000$	−0.2	−0.9	−1.1	−0.6	−1.8	0.01	0.01	0.01	0.01	0.01	94.9	94.7	94.6	94.3	94.1
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	1.0	−5.4	−12.0	−3.3	−10.7	0.09	0.12	0.12	0.12	0.12	91.6	92.8	92.9	91.3	95.0
$J = 200$	0.1	−2.1	−3.2	−1.4	−3.3	0.04	0.06	0.06	0.06	0.06	94.0	95.0	94.3	93.6	94.7
$J = 1000$	−0.3	−1.0	−1.0	−0.5	−0.9	0.02	0.03	0.03	0.02	0.03	95.3	95.4	94.3	95.0	95.1
$\bar{n} = 20$															
$J = 50$	−1.2	−7.6	−13.5	−7.3	−11.2	0.08	0.10	0.10	0.10	0.10	90.9	93.8	93.2	93.8	94.4
$J = 200$	0.4	−1.0	−2.6	−1.1	−2.2	0.04	0.05	0.05	0.05	0.05	94.2	94.1	95.2	94.7	95.0
$J = 1000$	0.1	−0.1	−0.4	−0.0	−0.3	0.02	0.02	0.02	0.02	0.02	94.7	94.7	95.0	95.0	95.3

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-30

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With Strongly Unbalanced Data (Uniform, ±80%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−1.2	−16.6	−16.8	−3.5	−24.1	0.08	0.10	0.10	0.10	0.10	91.3	93.3	94.0	91.4	95.6
$J = 200$	−0.0	−8.9	−3.2	1.6	−8.9	0.04	0.05	0.05	0.05	0.05	94.9	94.9	94.0	92.8	95.6
$J = 1000$	0.6	−7.7	−0.8	0.5	−2.4	0.02	0.02	0.02	0.02	0.02	94.5	92.6	95.2	93.1	95.0
$\bar{n} = 20$															
$J = 50$	0.8	−6.3	−11.3	−2.6	−17.6	0.05	0.07	0.07	0.07	0.07	93.0	93.4	94.6	93.2	95.7
$J = 200$	−0.0	−4.2	−3.3	−1.4	−6.5	0.03	0.03	0.03	0.03	0.03	93.8	94.7	94.6	94.1	94.3
$J = 1000$	0.3	−1.9	−0.6	0.1	−1.1	0.01	0.01	0.01	0.01	0.01	95.3	95.6	95.0	94.6	94.9
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	1.3	−7.6	−11.4	−4.0	−11.2	0.09	0.12	0.12	0.12	0.12	91.8	93.5	93.6	91.3	94.2
$J = 200$	−0.5	−4.7	−3.7	−1.3	−3.3	0.05	0.06	0.06	0.06	0.06	93.9	95.1	95.0	94.5	95.3
$J = 1000$	−0.1	−2.9	−1.0	−0.2	−0.4	0.02	0.03	0.02	0.02	0.02	94.8	95.2	95.9	96.0	95.4
$\bar{n} = 20$															
$J = 50$	−0.4	−6.2	−12.6	−5.4	−9.9	0.08	0.10	0.10	0.10	0.10	91.2	93.2	92.5	93.0	93.9
$J = 200$	0.7	−0.8	−1.9	−0.5	−1.9	0.04	0.05	0.05	0.05	0.05	92.7	94.1	93.8	93.6	94.5
$J = 1000$	−0.1	−0.6	−0.8	−0.3	−0.6	0.02	0.02	0.02	0.02	0.02	95.2	94.9	94.8	94.3	95.2

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-31

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With Moderately Unbalanced Data (Bimodal, ±40%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−0.9	−9.2	−14.9	−1.1	−21.2	0.07	0.10	0.10	0.10	0.09	92.5	92.6	93.0	90.8	95.0
$J = 200$	0.4	−3.5	−2.7	2.6	−8.5	0.04	0.05	0.05	0.05	0.05	94.2	94.8	94.7	92.1	95.2
$J = 1000$	−0.4	−3.2	−0.9	0.3	−2.6	0.02	0.02	0.02	0.02	0.02	94.6	94.5	94.2	93.7	95.0
$\bar{n} = 20$															
$J = 50$	−0.4	−6.2	−12.6	−4.7	−18.4	0.05	0.07	0.07	0.07	0.07	92.3	92.6	92.5	90.8	93.7
$J = 200$	−0.4	−2.7	−3.6	−1.9	−6.9	0.03	0.03	0.03	0.03	0.03	94.7	94.7	94.4	94.4	95.4
$J = 1000$	0.6	−0.8	−0.5	0.1	−1.3	0.01	0.01	0.01	0.01	0.01	94.2	94.0	95.0	93.7	94.5
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−0.5	−6.2	−12.9	−3.9	−11.2	0.09	0.12	0.12	0.12	0.12	91.6	94.3	93.8	92.0	95.3
$J = 200$	−0.5	−2.5	−3.7	−1.6	−3.6	0.05	0.06	0.06	0.06	0.06	93.5	94.1	93.8	94.0	94.6
$J = 1000$	0.1	−1.1	−0.6	0.0	−0.4	0.02	0.02	0.02	0.02	0.02	94.1	95.9	94.6	95.2	95.9
$\bar{n} = 20$															
$J = 50$	−0.1	−5.8	−12.4	−5.7	−10.3	0.08	0.10	0.11	0.10	0.10	91.7	91.6	92.5	93.1	94.8
$J = 200$	0.4	−0.8	−2.4	−0.8	−2.0	0.04	0.05	0.05	0.05	0.05	93.6	93.7	93.5	93.5	94.1
$J = 1000$	0.1	−0.2	−0.4	−0.1	−0.3	0.02	0.02	0.02	0.02	0.02	95.8	95.0	95.2	94.2	95.3

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-32

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of y on z ($\hat{\beta}_{yz}$) With Strongly Unbalanced Data (Bimodal, ±80%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	−0.1	−19.5	−14.1	−2.7	−21.9	0.08	0.11	0.11	0.12	0.10	90.4	93.2	91.8	89.0	94.5
$J = 200$	0.2	−18.1	−4.9	−0.0	−9.4	0.04	0.05	0.05	0.05	0.05	94.1	94.3	95.1	93.0	94.8
$J = 1000$	0.3	−17.0	−1.8	0.2	−2.5	0.02	0.03	0.02	0.02	0.02	95.8	81.2	94.1	93.3	94.5
$\bar{n} = 20$															
$J = 50$	0.9	−9.3	−10.5	−2.1	−16.3	0.06	0.08	0.08	0.08	0.07	92.3	94.8	94.3	90.6	96.0
$J = 200$	0.2	−8.7	−4.4	−1.7	−7.1	0.03	0.04	0.03	0.04	0.04	95.5	94.8	94.2	94.0	95.6
$J = 1000$	−0.0	−7.5	−1.7	−0.3	−1.7	0.01	0.02	0.02	0.02	0.02	93.0	89.6	95.0	94.3	94.6
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	−0.2	−14.3	−14.6	−6.4	−13.5	0.10	0.14	0.13	0.14	0.13	93.2	93.8	93.6	90.4	93.9
$J = 200$	−0.3	−9.3	−4.5	−1.8	−4.1	0.05	0.07	0.06	0.06	0.06	95.3	94.5	94.8	94.9	95.6
$J = 1000$	−0.3	−7.9	−1.8	−0.4	−0.7	0.02	0.03	0.03	0.03	0.03	95.2	89.5	95.1	94.0	95.8
$\bar{n} = 20$															
$J = 50$	1.7	−5.7	−11.7	−4.4	−9.4	0.08	0.10	0.11	0.11	0.10	91.0	95.0	94.6	93.1	95.4
$J = 200$	0.7	−3.1	−3.3	−1.4	−2.8	0.04	0.05	0.05	0.05	0.05	94.7	94.5	94.1	94.7	94.6
$J = 1000$	−0.1	−1.6	−0.8	−0.2	−0.4	0.02	0.02	0.02	0.02	0.02	95.1	95.4	95.7	95.1	95.5

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-33

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With Moderately Unbalanced Data (Uniform, ±40%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	32.5	27.3	28.3	33.3	21.3	1.80	1.67	1.72	1.77	1.71	91.2	92.2	93.3	92.4	92.6
$J = 200$	9.6	8.7	10.0	12.1	5.2	0.62	0.67	0.69	0.71	0.63	95.9	96.6	96.5	96.3	95.9
$J = 1000$	1.4	−0.0	1.0	1.4	−0.1	0.22	0.25	0.25	0.25	0.25	95.5	95.5	95.4	95.2	95.3
$\bar{n} = 20$															
$J = 50$	4.5	4.2	5.3	5.6	−4.2	0.61	0.72	0.74	0.74	0.65	93.9	94.4	94.5	93.0	94.5
$J = 200$	1.1	0.4	0.6	0.7	−2.5	0.27	0.31	0.31	0.31	0.30	94.3	94.6	94.0	94.0	94.6
$J = 1000$	−0.0	−0.3	−0.1	0.0	−0.6	0.12	0.13	0.14	0.13	0.13	95.1	95.1	94.4	94.6	95.6
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	3.4	3.6	4.3	5.0	−0.7	0.35	0.40	0.41	0.41	0.37	93.4	94.2	95.1	93.8	94.4
$J = 200$	0.4	−0.1	0.3	0.4	−1.0	0.16	0.18	0.18	0.18	0.18	94.2	94.4	94.9	94.2	95.3
$J = 1000$	0.3	−0.2	0.1	0.2	−0.0	0.07	0.08	0.08	0.08	0.08	94.7	95.4	96.2	95.0	95.2
$\bar{n} = 20$															
$J = 50$	2.0	1.6	1.2	1.5	−2.2	0.25	0.30	0.31	0.30	0.29	90.8	92.7	93.1	92.7	93.8
$J = 200$	0.6	0.7	0.8	0.7	−0.1	0.12	0.14	0.14	0.15	0.14	93.7	94.2	94.4	94.4	94.7
$J = 1000$	−0.2	0.1	0.0	0.1	−0.1	0.05	0.06	0.06	0.06	0.06	95.1	95.1	95.5	95.2	95.1

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-34

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With Strongly Unbalanced Data (Uniform, ±80%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	35.2	25.5	32.9	35.0	24.5	2.29	1.77	1.89	1.89	1.82	92.2	93.8	94.8	93.3	93.5
$J = 200$	9.2	3.8	9.6	11.3	5.0	0.64	0.63	0.70	0.72	0.65	94.7	94.9	95.1	95.4	94.7
$J = 1000$	1.4	−3.7	1.1	1.5	0.1	0.22	0.23	0.24	0.25	0.24	95.3	93.0	94.7	94.8	95.0
$\bar{n} = 20$															
$J = 50$	8.2	7.6	9.0	10.3	−0.6	0.63	0.70	0.74	0.74	0.64	93.2	93.9	94.6	93.0	94.9
$J = 200$	1.5	0.4	1.7	2.0	−1.1	0.27	0.32	0.32	0.32	0.31	94.8	94.4	95.5	94.3	95.0
$J = 1000$	0.2	−1.3	−0.1	0.1	−0.6	0.12	0.14	0.14	0.14	0.14	94.8	94.1	94.3	93.9	95.1
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	5.5	2.9	5.4	6.2	−0.7	0.39	0.44	0.48	0.47	0.42	93.2	93.4	93.7	92.5	94.3
$J = 200$	1.7	−0.6	1.3	1.4	0.3	0.17	0.19	0.19	0.19	0.19	93.7	94.5	93.8	93.5	95.1
$J = 1000$	0.4	−1.6	0.2	0.5	0.3	0.07	0.08	0.08	0.08	0.08	95.5	95.1	95.3	95.0	94.9
$\bar{n} = 20$															
$J = 50$	2.9	3.5	4.3	4.4	0.3	0.26	0.31	0.33	0.32	0.30	91.8	92.7	93.0	92.7	93.4
$J = 200$	−0.3	−0.7	−0.2	−0.3	−1.0	0.12	0.15	0.15	0.15	0.15	94.3	94.0	94.2	94.1	94.6
$J = 1000$	0.0	−0.3	−0.2	−0.0	−0.3	0.06	0.07	0.07	0.07	0.07	94.5	94.5	94.7	94.9	94.2

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-35

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With Moderately Unbalanced Data (Bimodal, ±40%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	26.7	24.8	26.3	30.1	20.0	2.56	1.70	1.80	1.80	1.77	92.1	94.5	94.7	94.1	94.7
$J = 200$	9.0	6.3	9.2	10.9	4.4	0.64	0.65	0.69	0.72	0.63	94.8	94.9	95.2	95.8	94.7
$J = 1000$	1.2	−1.1	1.2	1.5	0.0	0.22	0.24	0.25	0.25	0.24	95.1	94.5	95.1	95.1	94.3
$\bar{n} = 20$															
$J = 50$	4.7	4.7	5.5	6.3	−4.6	0.60	0.71	0.75	0.75	0.65	93.5	93.9	94.8	92.7	94.6
$J = 200$	1.1	−0.1	0.3	0.5	−2.5	0.26	0.30	0.30	0.31	0.29	94.9	96.0	96.0	95.2	95.9
$J = 1000$	0.2	−0.2	0.3	0.4	−0.2	0.12	0.14	0.14	0.14	0.14	94.8	94.4	94.3	94.9	94.5
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	4.7	4.5	5.4	6.4	0.6	0.37	0.40	0.42	0.42	0.38	93.5	95.1	95.2	94.6	95.7
$J = 200$	1.4	0.7	1.0	1.5	0.2	0.16	0.18	0.18	0.19	0.18	95.4	93.9	95.0	93.6	94.8
$J = 1000$	0.3	−0.4	0.2	0.4	0.1	0.07	0.08	0.08	0.08	0.08	96.5	95.0	96.2	95.3	95.4
$\bar{n} = 20$															
$J = 50$	0.2	0.1	0.4	0.4	−3.2	0.26	0.31	0.32	0.31	0.30	90.9	92.2	92.3	92.4	92.9
$J = 200$	0.6	1.0	0.9	1.0	0.2	0.12	0.15	0.15	0.15	0.14	94.5	94.6	93.9	93.0	94.8
$J = 1000$	0.3	0.3	0.4	0.4	0.2	0.05	0.07	0.07	0.07	0.07	95.5	94.2	94.6	94.8	94.0

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-36

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With Strongly Unbalanced Data (Bimodal, ±80%) and 20% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	31.4	16.0	25.3	29.7	17.3	2.14	1.72	1.69	1.77	1.67	92.0	94.1	94.5	93.6	93.8
$J = 200$	8.0	−2.2	7.7	9.5	3.9	0.59	0.56	0.63	0.65	0.59	95.3	93.8	95.4	95.3	95.2
$J = 1000$	0.8	−8.6	0.2	0.8	−0.3	0.21	0.25	0.23	0.23	0.23	95.7	91.2	95.7	94.8	95.0
$\bar{n} = 20$															
$J = 50$	5.7	−0.8	5.4	6.7	−4.1	0.69	0.71	0.81	0.81	0.69	92.4	95.1	94.1	93.5	94.5
$J = 200$	1.9	−3.0	1.6	1.9	−1.0	0.29	0.32	0.34	0.34	0.33	94.9	96.4	95.0	94.1	95.3
$J = 1000$	0.3	−4.3	−0.1	0.5	−0.3	0.13	0.16	0.15	0.15	0.15	94.3	94.1	94.5	93.8	94.5
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	7.4	1.9	8.0	9.9	4.0	0.45	0.46	0.51	0.51	0.47	91.8	94.1	94.0	92.7	94.3
$J = 200$	1.1	−4.0	0.6	1.3	−0.2	0.17	0.19	0.20	0.20	0.19	93.4	94.1	94.1	93.2	94.6
$J = 1000$	0.2	−4.7	−0.4	0.1	−0.0	0.07	0.09	0.08	0.08	0.09	96.1	92.4	94.0	94.8	93.7
$\bar{n} = 20$															
$J = 50$	1.4	1.2	2.1	2.7	−1.5	0.27	0.32	0.34	0.33	0.32	93.2	93.0	93.2	92.3	94.1
$J = 200$	1.2	−0.1	0.8	1.0	−0.0	0.13	0.15	0.16	0.16	0.15	95.1	94.3	93.8	93.9	94.6
$J = 1000$	−0.2	−1.2	−0.3	−0.1	−0.3	0.06	0.07	0.07	0.07	0.07	95.9	95.1	94.8	95.6	95.6

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-37

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With Moderately Unbalanced Data (Uniform, ±40%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	40.0	23.0	25.6	35.2	9.0	2.52	1.60	1.72	1.76	1.70	92.2	94.2	94.1	95.0	94.9
$J = 200$	11.3	6.0	10.0	14.0	−1.2	0.70	0.74	0.80	0.84	0.69	95.4	95.0	95.7	95.0	94.3
$J = 1000$	1.9	−1.0	1.4	2.1	−1.3	0.22	0.26	0.27	0.28	0.26	95.7	95.2	95.3	95.3	95.0
$\bar{n} = 20$															
$J = 50$	2.4	3.0	4.2	6.9	−16.1	0.58	0.82	0.88	0.87	0.70	93.0	93.2	95.0	91.5	94.2
$J = 200$	1.1	1.9	1.7	2.1	−5.2	0.26	0.36	0.36	0.36	0.34	94.7	94.5	95.5	95.4	95.0
$J = 1000$	−0.3	−0.7	−0.4	−0.2	−1.8	0.12	0.16	0.17	0.17	0.16	94.8	94.1	93.5	93.9	93.7
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	5.3	4.0	6.0	8.9	−5.8	0.35	0.47	0.53	0.51	0.43	94.4	95.0	95.5	94.0	96.6
$J = 200$	1.1	0.1	1.0	1.3	−1.6	0.16	0.21	0.22	0.22	0.21	94.3	94.4	95.1	94.0	95.2
$J = 1000$	0.1	−0.4	0.1	0.2	−0.2	0.07	0.09	0.10	0.10	0.10	95.6	93.4	94.1	94.9	94.7
$\bar{n} = 20$															
$J = 50$	0.0	−1.7	−1.4	−0.9	−8.9	0.26	0.38	0.41	0.39	0.36	92.1	92.4	93.6	92.8	93.9
$J = 200$	0.3	0.1	−0.1	0.0	−1.8	0.12	0.18	0.18	0.17	0.17	94.7	94.2	93.4	94.3	95.7
$J = 1000$	−0.0	−0.1	−0.0	0.1	−0.4	0.05	0.08	0.08	0.08	0.08	95.7	94.9	94.4	94.6	93.9

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-38

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With Strongly Unbalanced Data (Uniform, ±80%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	38.2	11.5	24.0	32.3	5.6	1.90	1.86	1.84	1.90	1.70	92.5	93.1	94.1	94.3	94.0
$J = 200$	6.6	−5.8	6.6	10.1	−4.6	0.60	0.59	0.69	0.73	0.58	96.4	95.3	97.2	96.8	95.2
$J = 1000$	2.4	−8.1	1.9	2.7	−0.8	0.22	0.27	0.27	0.28	0.25	96.1	91.7	95.3	95.1	95.2
$\bar{n} = 20$															
$J = 50$	4.8	1.5	5.8	8.1	−15.9	0.60	0.78	0.87	0.88	0.70	93.8	94.2	94.9	92.8	95.0
$J = 200$	0.7	−3.8	0.1	0.3	−6.8	0.27	0.37	0.38	0.38	0.36	94.9	94.2	94.6	93.5	93.7
$J = 1000$	0.1	−2.6	−0.0	0.5	−1.2	0.12	0.16	0.16	0.16	0.15	95.8	95.6	96.0	94.8	95.1
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	6.9	2.0	8.8	10.7	−4.7	0.38	0.47	0.54	0.55	0.44	92.6	94.7	95.1	91.8	95.6
$J = 200$	0.6	−3.5	0.7	1.6	−1.6	0.16	0.22	0.23	0.23	0.22	94.0	93.2	94.1	93.5	93.8
$J = 1000$	0.0	−3.7	−0.4	0.2	−0.2	0.07	0.10	0.09	0.09	0.09	95.4	94.0	95.2	94.4	96.0
$\bar{n} = 20$															
$J = 50$	1.4	1.4	1.7	2.3	−6.0	0.27	0.39	0.41	0.39	0.36	91.0	92.3	93.7	92.4	94.3
$J = 200$	0.5	−0.4	0.3	0.2	−1.9	0.13	0.18	0.18	0.18	0.18	93.2	93.2	93.8	93.1	94.6
$J = 1000$	0.1	−0.4	−0.1	0.1	−0.3	0.06	0.08	0.08	0.08	0.08	93.5	92.9	94.6	92.6	94.2

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-39

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With Moderately Unbalanced Data (Bimodal, ±40%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	38.0	18.3	21.2	29.0	6.1	2.19	1.75	1.80	1.82	1.71	92.1	94.4	94.5	94.6	93.8
$J = 200$	6.8	1.1	6.9	11.5	−3.6	0.59	0.66	0.73	0.76	0.62	95.8	95.2	96.6	96.1	95.1
$J = 1000$	0.9	−3.4	1.0	2.1	−1.5	0.21	0.25	0.27	0.27	0.25	96.4	94.8	95.4	95.8	95.4
$\bar{n} = 20$															
$J = 50$	4.4	3.8	4.5	7.6	−15.0	0.57	0.81	0.89	0.88	0.70	95.7	94.3	95.0	93.5	95.7
$J = 200$	0.8	−1.0	0.5	0.5	−6.7	0.26	0.36	0.37	0.37	0.35	95.0	94.6	94.3	93.5	95.4
$J = 1000$	0.0	−1.5	−0.4	−0.2	−2.0	0.12	0.16	0.17	0.17	0.17	94.3	94.6	94.6	94.3	93.8
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	5.7	3.2	5.4	8.6	−5.3	0.37	0.47	0.55	0.53	0.43	94.1	94.0	95.7	92.6	95.1
$J = 200$	1.0	−0.0	1.0	1.6	−1.7	0.17	0.22	0.23	0.23	0.22	94.5	94.2	94.7	94.0	94.7
$J = 1000$	0.1	−1.0	0.2	0.6	0.1	0.07	0.10	0.10	0.10	0.10	94.7	93.3	94.2	94.4	94.0
$\bar{n} = 20$															
$J = 50$	−0.2	−1.9	−1.6	−1.0	−9.2	0.26	0.37	0.40	0.37	0.35	92.7	91.9	95.1	93.3	94.1
$J = 200$	0.2	0.4	0.5	0.5	−1.5	0.12	0.18	0.19	0.18	0.18	93.6	93.6	92.6	92.6	94.4
$J = 1000$	0.2	0.0	0.2	0.3	−0.1	0.06	0.08	0.08	0.08	0.08	94.8	93.5	93.7	93.5	95.5

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

Table 2-40

Study 2: Bias (in %), Relative RMSE, and Coverage of the 95% Confidence Interval for the Regression Coefficient of z on y ($\hat{\beta}_{zy}$) With Strongly Unbalanced Data (Bimodal, ±80%) and 40% Missing Data (MAR, $\lambda = 0.5$)

	Bias (%)					Rel. RMSE					Coverage (%)				
	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM	CD	FCS-MAN	FCS-NJ	FCS-LAT	JM
Small intraclass correlation ($\rho_{Iy} = .10$)															
$\bar{n} = 5$															
$J = 50$	21.1	−9.2	6.5	14.6	−8.8	1.76	1.42	1.69	1.74	1.55	92.1	94.5	94.7	94.0	94.7
$J = 200$	6.1	−16.8	4.6	7.8	−4.9	0.62	0.63	0.71	0.73	0.62	94.9	90.6	95.6	94.3	94.7
$J = 1000$	1.4	−19.1	−0.1	1.5	−1.6	0.21	0.37	0.26	0.27	0.25	95.5	76.4	94.2	94.2	94.8
$\bar{n} = 20$															
$J = 50$	3.0	−9.5	2.6	4.4	−17.4	0.64	0.79	0.94	0.91	0.74	92.7	94.8	95.2	92.4	94.8
$J = 200$	1.7	−8.8	0.7	1.7	−5.9	0.29	0.38	0.40	0.40	0.37	94.0	93.9	94.3	93.3	95.1
$J = 1000$	0.4	−9.4	−0.6	0.3	−1.4	0.13	0.22	0.17	0.17	0.17	95.2	86.1	95.1	94.3	94.3
Moderate intraclass correlation ($\rho_{Iy} = .30$)															
$\bar{n} = 5$															
$J = 50$	9.2	−8.1	6.3	7.8	−6.9	0.42	0.50	0.60	0.59	0.48	93.0	93.3	94.1	91.3	94.7
$J = 200$	1.4	−10.6	−0.5	0.4	−3.1	0.16	0.22	0.22	0.22	0.22	95.9	94.1	95.5	95.7	95.7
$J = 1000$	0.2	−10.2	−0.8	0.1	−0.4	0.07	0.13	0.10	0.10	0.10	94.2	84.5	94.8	94.2	94.4
$\bar{n} = 20$															
$J = 50$	2.2	−1.9	0.9	1.2	−8.3	0.28	0.38	0.43	0.40	0.36	91.0	93.4	93.8	93.4	94.8
$J = 200$	0.6	−2.7	−0.2	0.3	−2.0	0.13	0.19	0.19	0.20	0.19	95.1	94.4	94.2	93.2	94.5
$J = 1000$	0.2	−1.9	0.0	0.4	0.1	0.06	0.08	0.08	0.08	0.08	95.9	95.0	95.1	94.3	95.1

Note. $\bar{n}$ = average cluster size; J = number of clusters; CD = complete data sets; LD = listwise deletion; FCS-SL = single-level FCS; FCS-MAN = two-level FCS with manifest cluster means; FCS-LAT = two-level FCS with latent cluster means; JM = joint modeling.

References

Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D., Vehtari, A., & Rubin, D. B. (2014). *Bayesian data analysis* (3rd ed.). Boca Raton, FL: CRC press.

Grund, S., Lüdtke, O., & Robitzsch, A. (2016). Multiple imputation of missing covariate values in multilevel models with random slopes: A cautionary note. *Behavior Research Methods*, *48*, 640–649. doi: 10.3758/s13428-015-0590-3

McNeish, D. M. (2016). Using data-dependent priors to mitigate small sample bias in latent growth models: A discussion and illustration using M*plus*. *Journal of Educational and Behavioral Statistics*, *41*, 27–56. doi: 10.3102/1076998615621299

Muthén, B. O. (1994). Multilevel covariance structure analysis. *Sociological Methods & Research*, *22*, 376–398. doi: 10.1177/0049124194022003006

Muthén, L. K., & Muthén, B. O. (2012). *Mplus user's guide* (7th ed.). Los Angeles, LA: Muthén & Muthén.

OECD. (2014). *PISA 2012 technical report*. Paris, France: Author.

R Core Team. (2016). *R: A language and environment for statistical computing (Version 3.3.0).* Retrieved from `http://www.R-project.org/`

Robitzsch, A., Grund, S., & Henke, T. (2017). *Miceadds: Some additional multiple imputation functions, especiallly for mice (Version 2.3-0).* Retrieved from `http://CRAN.R-project.org/package=miceadds`

Rubin, D. B. (1987). *Multiple imputation for nonresponse in surveys*. Hoboken, NJ: Wiley.

Schafer, J. L., & Yucel, R. M. (2002). Computational strategies for multivariate linear mixed-effects models with missing values. *Journal of Computational and Graphical Statistics*, *11*, 437–457. doi: 10.1198/106186002760180608