SEM with Missing Data - Working Examples

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2019

KU

Outline

Outline

The HBSC data set

- A subset of the HBSC data (Health Behaviour in School-Aged Children; Iannotti, 2005-200) will be used for the demonstrating the missing data techniques implemented in lavaan (Rosseel, 2012) and Mplus (Muthén & Muthén, 2017)
- We will use responses from the 6th and 7th graders
- For demonstration purpose, we will artificially increase the missing percentage on the focal variables (this practice is consider MCAR)

```
## Loading pakcages
library(lavaan)
```

```
## The "data" folder contains the hbsc data
ddir <- "data"
hbsc.complete <- readRDS(file.path(ddir, "hbsc.rds"))
## hbsc contains grades 6 and 7 responses
hbsc <- hbsc.complete[hbsc.complete$Grade %in% c("6", "7"), ]
```

The HBSC data set ...

```
## The dimension of the data set "hbsc"
dim(hbsc)
```

```
[1] 4284   89
```

```
## Varibles in our demonstration data "hbsc"
names(hbsc)
```

```
 [1] "stud_id"  "schl_id"  "Gender"   "Age"      "Grade"    "body1_o"  "body2_o"  "body3_o"
 [9] "body4_o"  "body5_o"  "phys1_o"  "phys2_o"  "phys3_o"  "phys4_o"  "phys5_o"  "phys6_o"
[17] "phys7_o"  "phys8_o"  "depre1_o" "depre2_o" "depre3_o" "depre4_o" "depre5_o" "depre6_o"
[25] "gotBu1_o" "gotBu2_o" "gotBu3_o" "gotBu4_o" "gotBu5_o" "gotBu6_o" "gotBu7_o" "gotBu8_o"
[33] "gotBu9_o" "buOth1_o" "buOth2_o" "buOth3_o" "buOth4_o" "buOth5_o" "buOth6_o" "buOth7_o"
[41] "buOth8_o" "buOth9_o" "alc1_o"   "alc2_o"   "alc3_o"   "alc4_o"   "alc5_o"   "body1_i"
[49] "body2_i"  "body3_i"  "body4_i"  "body5_i"  "phys1_i"  "phys2_i"  "phys3_i"  "phys4_i"
[57] "phys5_i"  "phys6_i"  "phys7_i"  "phys8_i"  "depre1_i" "depre2_i" "depre3_i" "depre4_i"
[65] "depre5_i" "depre6_i" "gotBu1_i" "gotBu2_i" "gotBu3_i" "gotBu4_i" "gotBu5_i" "gotBu6_i"
[73] "gotBu7_i" "gotBu8_i" "gotBu9_i" "buOth1_i" "buOth2_i" "buOth3_i" "buOth4_i" "buOth5_i"
[81] "buOth6_i" "buOth7_i" "buOth8_i" "buOth9_i" "alc1_i"   "alc2_i"   "alc3_i"   "alc4_i"
[89] "alc5_i"
```

The HBSC data set ...

```
## Creating a name vector for the depre items
varName_depre_i <- c("depre1_i","depre2_i", "depre3_i",
    "depre4_i", "depre5_i", "depre6_i")
## Requesting summary information for the Depression items
summary(hbsc[ , varName_depre_i])
```

```
   depre1_i        depre2_i        depre3_i        depre4_i        depre5_i        depre6_i
Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000
1st Qu.:1.000   1st Qu.:2.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000
Median :2.000   Median :3.000   Median :1.000   Median :2.000   Median :2.000   Median :2.000
Mean   :2.332   Mean   :2.684   Mean   :1.817   Mean   :2.209   Mean   :2.485   Mean   :2.473
3rd Qu.:3.000   3rd Qu.:3.000   3rd Qu.:3.000   3rd Qu.:3.000   3rd Qu.:4.000   3rd Qu.:3.000
Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000
NA's   :78      NA's   :87      NA's   :96      NA's   :113     NA's   :117     NA's   :95
```

```
## Creating a demonstration data set (depre_i_miss) with
    increased missings
depre_i <- (hbsc[ , varName_depre_i])
depre_i_miss <- as.data.frame(lapply(depre_i, function(cc)
    cc[ sample(c(TRUE, NA), prob = c(0.90, 0.10), size =
    length(cc), replace = TRUE) ]))
summary(depre_i_miss)
```

The HBSC data set ...

```
   depre1_i        depre2_i        depre3_i        depre4_i        depre5_i        depre6_i
Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000
1st Qu.:1.000   1st Qu.:2.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000
Median :2.000   Median :3.000   Median :1.000   Median :2.000   Median :2.000   Median :2.000
Mean   :2.331   Mean   :2.678   Mean   :1.826   Mean   :2.204   Mean   :2.484   Mean   :2.475
3rd Qu.:3.000   3rd Qu.:3.000   3rd Qu.:3.000   3rd Qu.:3.000   3rd Qu.:4.000   3rd Qu.:3.000
Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000
NA's   :483     NA's   :482     NA's   :512     NA's   :524     NA's   :519     NA's   :503
```

Outline

Listwise deletion in lavaan - ordinal treated as numeric

```
## Specifying the model-structure object
## One latent factor with six indicators
cfa.01.v.01 <- '
 depress =~ NA*depre1_i + depre2_i + depre3_i +
              depre4_i + depre5_i + depre6_i
 depress ~~ 1*depress '
```

```
## Estimating cfa.01.v01
## with listwise deletion
cfa.01.v.01.fit.listwise <-
 cfa(model = cfa.01.v.01, data = depre_i_miss,
     mimic = "Mplus", estimator = "ML",
     missing = "listwise", meanstructure = TRUE)
```

```
## Requesting an estimation summary
## Please pay attention to
## The used and the total observations and
## The Minimum Function Test Statistics
summary(cfa.01.v.01.fit.listwise, fit.measures = TRUE,
        standardized = TRUE)
```

Listwise deletion in lavaan - ordinal treated as numeric ...

```
lavaan 0.6-3 ended normally after 17 iterations

  Optimization method                           NLMINB
  Number of free parameters                         18

                                                  Used       Total
  Number of observations                          2221        4284

  Estimator                                         ML
  Model Fit Test Statistic                     121.494
  Degrees of freedom                                 9
  P-value (Chi-square)                           0.000

Model test baseline model:

  Minimum Function Test Statistic             3165.412
  Degrees of freedom                                15
  P-value                                        0.000

User model versus baseline model:

  Comparative Fit Index (CFI)                    0.964
  Tucker-Lewis Index (TLI)                       0.940

Loglikelihood and Information Criteria:

  Loglikelihood user model (H0)             -20387.190
  Loglikelihood unrestricted model (H1)     -20326.443

  Number of free parameters                         18
  Akaike (AIC)                               40810.380
  Bayesian (BIC)                             40913.082
  Sample-size adjusted Bayesian (BIC)        40855.894
```

Listwise deletion in lavaan - ordinal treated as numeric ...

```
Root Mean Square Error of Approximation:

  RMSEA                                          0.075
  90 Percent Confidence Interval          0.063  0.087
  P-value RMSEA <= 0.05                          0.000

Standardized Root Mean Square Residual:

  SRMR                                           0.028

Parameter Estimates:

  Information                                 Expected
  Information saturated (h1) model          Structured
  Standard Errors                             Standard

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  depress =~
    depre1_i          0.741    0.024   31.427    0.000    0.741    0.664
    depre2_i          0.741    0.025   29.855    0.000    0.741    0.637
    depre3_i          0.788    0.026   30.755    0.000    0.788    0.652
    depre4_i          0.884    0.028   31.526    0.000    0.884    0.666
    depre5_i          0.740    0.031   24.233    0.000    0.740    0.534
    depre6_i          0.748    0.029   25.560    0.000    0.748    0.559

Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .depre1_i          2.334    0.024   98.567    0.000    2.334    2.091
   .depre2_i          2.694    0.025  109.118    0.000    2.694    2.315
   .depre3_i          1.806    0.026   70.473    0.000    1.806    1.495
   .depre4_i          2.210    0.028   78.438    0.000    2.210    1.664
   .depre5_i          2.485    0.029   84.546    0.000    2.485    1.794
```

Listwise deletion in lavaan - ordinal treated as numeric ...

```
   .depre6_i          2.485    0.028   87.533    0.000    2.485    1.857
    depress           0.000                              0.000    0.000

Variances:
                  Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    depress          1.000                              1.000    1.000
   .depre1_i         0.696    0.026   26.365    0.000    0.696    0.559
   .depre2_i         0.805    0.029   27.320    0.000    0.805    0.595
   .depre3_i         0.838    0.031   26.790    0.000    0.838    0.574
   .depre4_i         0.982    0.037   26.300    0.000    0.982    0.557
   .depre5_i         1.372    0.046   29.837    0.000    1.372    0.715
   .depre6_i         1.231    0.042   29.344    0.000    1.231    0.687
```

Outline

Pairwise deletion in lavaan - ordinal treated as numeric

```
## Estimating cfa.01.v01
## with pairwise deletion
cfa.01.v.01.fit.pairwise <-
 cfa(model = cfa.01.v.01, data = depre_i_miss,
     mimic = "Mplus", estimator = "ML",
     missing = "pairwise", meanstructure = TRUE)
```

```
## Requesting an estimation summary
## Please pay attention to
## The used and the total observations and
## The Minimum Function Test Statistics
summary(cfa.01.v.01.fit.pairwise, fit.measures = TRUE,
        standardized = TRUE)
```

Pairwise deletion in lavaan - ordinal treated as numeric ...

```
lavaan 0.6-3 ended normally after 17 iterations

  Optimization method                           NLMINB
  Number of free parameters                         18

                                                  Used       Total
  Number of observations                          4220        4284
  Number of missing patterns                        57

  Estimator                                         ML
  Model Fit Test Statistic                     279.026
  Degrees of freedom                                 9
  P-value (Chi-square)                           0.000

Model test baseline model:

  Minimum Function Test Statistic              5877.721
  Degrees of freedom                                15
  P-value                                        0.000

User model versus baseline model:

  Comparative Fit Index (CFI)                    0.954
  Tucker-Lewis Index (TLI)                       0.923

Loglikelihood and Information Criteria:

  Loglikelihood user model (H0)                -38741.991
  Loglikelihood unrestricted model (H1)        -38602.479

  Number of free parameters                         18
  Akaike (AIC)                                 77519.983
  Bayesian (BIC)                               77634.240
```

Pairwise deletion in lavaan - ordinal treated as numeric ...

```
  Sample-size adjusted Bayesian (BIC)        77577.043

Root Mean Square Error of Approximation:

  RMSEA                                          0.084
  90 Percent Confidence Interval          0.076  0.093
  P-value RMSEA <= 0.05                          0.000

Standardized Root Mean Square Residual:

  SRMR                                           0.031

Parameter Estimates:

  Information                                 Expected
  Information saturated (h1) model          Structured
  Standard Errors                             Standard

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  depress =~
    depre1_i          0.737    0.017   43.396    0.000    0.737    0.667
    depre2_i          0.713    0.018   39.600    0.000    0.713    0.619
    depre3_i          0.789    0.019   42.116    0.000    0.789    0.651
    depre4_i          0.875    0.020   42.710    0.000    0.875    0.659
    depre5_i          0.739    0.022   33.420    0.000    0.739    0.536
    depre6_i          0.732    0.021   34.166    0.000    0.732    0.546

Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .depre1_i          2.331    0.017  137.202    0.000    2.331    2.112
   .depre2_i          2.678    0.018  150.900    0.000    2.678    2.323
   .depre3_i          1.826    0.019   97.883    0.000    1.826    1.507
   .depre4_i          2.204    0.020  107.831    0.000    2.204    1.660
```

Pairwise deletion in lavaan - ordinal treated as numeric ...

```
   .depre5_i          2.484    0.021  117.051    0.000    2.484    1.802
   .depre6_i          2.475    0.021  119.974    0.000    2.475    1.847
    depress           0.000                              0.000    0.000

Variances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    depress           1.000                              1.000    1.000
   .depre1_i          0.676    0.019   35.881    0.000    0.676    0.555
   .depre2_i          0.820    0.021   38.194    0.000    0.820    0.617
   .depre3_i          0.846    0.023   36.728    0.000    0.846    0.576
   .depre4_i          0.998    0.027   36.345    0.000    0.998    0.566
   .depre5_i          1.355    0.033   40.941    0.000    1.355    0.713
   .depre6_i          1.260    0.031   40.661    0.000    1.260    0.702
```

```
library(semTable)
labs <- c("depress" = "Depression")
cfa.ld.pw <-
 semTable(list("listwise" = cfa.01.v.01.fit.listwise,
     "pairwise" = cfa.01.v.01.fit.pairwise), paramSets =
     c("loadings", "intercepts", "residualvariances",
     "fits"), columns = c("estsestars"), file =
     file.path(tdir, "cfa.ld.pw"), type = "tex", longtable =
     TRUE, varLabels = labs)
```

Pairwise deletion in lavaan - ordinal treated as numeric ...

	listwise	pairwise
	Estimate(Std.Err.)	Estimate(Std.Err.)
	Factor Loadings	
Depression		
depre1.i	0.74(0.02)***	0.74(0.02)***
depre2.i	0.74(0.02)***	0.71(0.02)***
depre3.i	0.79(0.03)***	0.79(0.02)***
depre4.i	0.88(0.03)***	0.87(0.02)***
depre5.i	0.74(0.03)***	0.74(0.02)***
depre6.i	0.75(0.03)***	0.73(0.02)***
	Intercepts	
depre1.i	2.33(0.02)***	2.33(0.02)***
depre2.i	2.69(0.02)***	2.68(0.02)***
depre3.i	1.81(0.03)***	1.83(0.02)***
depre4.i	2.21(0.03)***	2.20(0.02)***
depre5.i	2.49(0.03)***	2.48(0.02)***
depre6.i	2.49(0.03)***	2.47(0.02)***
	Residual Variances	
depre1.i	0.70(0.03)***	0.68(0.02)***
depre2.i	0.81(0.03)***	0.82(0.02)***
depre3.i	0.84(0.03)***	0.85(0.02)***

Pairwise deletion in lavaan - ordinal treated as numeric ...

depre4.i	0.98(0.04)***	1.00(0.03)***
depre5.i	1.37(0.05)***	1.35(0.03)***
depre6.i	1.23(0.04)***	1.26(0.03)***
	Fit Indices	
$\chi^2(\mathrm{df})$	121.49(9)***	279.03(9)***
CFI	0.96	0.95
TLI	0.94	0.92
RMSEA	0.08	0.08

+Fixed parameter

* p<0.05, ** p<0.01, ***p<0.001

Outline

FIML in lavaan - ordinal treated as numeric

```
## Estimating cfa.01.v01
## with full information maximum likelihood
cfa.01.v.01.fit.fiml <-
 cfa(model = cfa.01.v.01, data = depre_i_miss,
     mimic = "Mplus", estimator = "ML",
     missing = "ml", meanstructure = TRUE)
```

```
## Requesting an estimation summary
## Please pay attention to
## The used and the total observations and
## The Minimum Function Test Statistics
summary(cfa.01.v.01.fit.fiml, fit.measures = TRUE,
        standardized = TRUE)
```

FIML in lavaan - ordinal treated as numeric ...

```
lavaan 0.6-3 ended normally after 26 iterations

  Optimization method                           NLMINB
  Number of free parameters                         18

                                                  Used       Total
  Number of observations                          4220        4284
  Number of missing patterns                        57

  Estimator                                         ML
  Model Fit Test Statistic                     209.383
  Degrees of freedom                                 9
  P-value (Chi-square)                           0.000

Model test baseline model:

  Minimum Function Test Statistic              4905.724
  Degrees of freedom                                15
  P-value                                        0.000

User model versus baseline model:

  Comparative Fit Index (CFI)                    0.959
  Tucker-Lewis Index (TLI)                       0.932

Loglikelihood and Information Criteria:

  Loglikelihood user model (H0)                -34856.418
  Loglikelihood unrestricted model (H1)        -34751.726

  Number of free parameters                         18
  Akaike (AIC)                                 69748.835
  Bayesian (BIC)                               69863.092
```

FIML in lavaan - ordinal treated as numeric ...

```
  Sample-size adjusted Bayesian (BIC)        69805.895

Root Mean Square Error of Approximation:

  RMSEA                                          0.073
  90 Percent Confidence Interval          0.064  0.081
  P-value RMSEA <= 0.05                          0.000

Standardized Root Mean Square Residual:

  SRMR                                           0.030

Parameter Estimates:

  Information                                 Observed
  Observed information based on                Hessian
  Standard Errors                             Standard

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  depress =~
    depre1_i          0.733    0.018   40.113    0.000    0.733    0.664
    depre2_i          0.715    0.019   36.826    0.000    0.715    0.620
    depre3_i          0.791    0.020   39.307    0.000    0.791    0.653
    depre4_i          0.866    0.022   39.227    0.000    0.866    0.653
    depre5_i          0.736    0.024   30.823    0.000    0.736    0.534
    depre6_i          0.728    0.023   31.786    0.000    0.728    0.544

Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .depre1_i          2.331    0.018  132.366    0.000    2.331    2.113
   .depre2_i          2.680    0.018  145.255    0.000    2.680    2.323
   .depre3_i          1.821    0.019   93.784    0.000    1.821    1.502
   .depre4_i          2.208    0.021  103.874    0.000    2.208    1.666
```

FIML in lavaan - ordinal treated as numeric ...

```
   .depre5_i          2.488    0.022  112.081    0.000    2.488    1.806
   .depre6_i          2.475    0.022  114.974    0.000    2.475    1.849
    depress           0.000                              0.000    0.000

Variances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    depress           1.000                              1.000    1.000
   .depre1_i          0.680    0.021   32.751    0.000    0.680    0.559
   .depre2_i          0.820    0.023   35.073    0.000    0.820    0.616
   .depre3_i          0.843    0.025   33.508    0.000    0.843    0.574
   .depre4_i          1.007    0.030   33.145    0.000    1.007    0.573
   .depre5_i          1.357    0.036   37.783    0.000    1.357    0.715
   .depre6_i          1.263    0.033   37.870    0.000    1.263    0.704
```

Comparison Table

```
library(semTable)
labs <- c("depress" = "Depression")
cfa0101tab <-
 semTable(list("listwise" = cfa.01.v.01.fit.listwise,
     "pairwise" = cfa.01.v.01.fit.pairwise, "fiml" =
     cfa.01.v.01.fit.fiml), paramSets = c("loadings",
     "intercepts", "residualvariances", "fits"), columns =
     c("estsestars"), file = file.path(tdir, "cfa0101a"),
     type = "tex", longtable = TRUE, varLabels = labs)
```

Comparison Table ...

	listwise	pairwise	fiml
	Estimate(Std.Err.)	Estimate(Std.Err.)	Estimate(Std.Err.)
		Factor Loadings	
Depression			
depre1.i	0.74(0.02)***	0.74(0.02)***	0.73(0.02)***
depre2.i	0.74(0.02)***	0.71(0.02)***	0.71(0.02)***
depre3.i	0.79(0.03)***	0.79(0.02)***	0.79(0.02)***
depre4.i	0.88(0.03)***	0.87(0.02)***	0.87(0.02)***
depre5.i	0.74(0.03)***	0.74(0.02)***	0.74(0.02)***
depre6.i	0.75(0.03)***	0.73(0.02)***	0.73(0.02)***
		Intercepts	
depre1.i	2.33(0.02)***	2.33(0.02)***	2.33(0.02)***
depre2.i	2.69(0.02)***	2.68(0.02)***	2.68(0.02)***
depre3.i	1.81(0.03)***	1.83(0.02)***	1.82(0.02)***
depre4.i	2.21(0.03)***	2.20(0.02)***	2.21(0.02)***
depre5.i	2.49(0.03)***	2.48(0.02)***	2.49(0.02)***
depre6.i	2.49(0.03)***	2.47(0.02)***	2.48(0.02)***
		Residual Variances	
depre1.i	0.70(0.03)***	0.68(0.02)***	0.68(0.02)***
depre2.i	0.81(0.03)***	0.82(0.02)***	0.82(0.02)***
depre3.i	0.84(0.03)***	0.85(0.02)***	0.84(0.03)***

Comparison Table ...

depre4.i	0.98(0.04)***	1.00(0.03)***	1.01(0.03)***
depre5.i	1.37(0.05)***	1.35(0.03)***	1.36(0.04)***
depre6.i	1.23(0.04)***	1.26(0.03)***	1.26(0.03)***
		Fit Indices	
$\chi^2(\mathrm{df})$	121.49(9)***	279.03(9)***	209.38(9)***
CFI	0.96	0.95	0.96
TLI	0.94	0.92	0.93
RMSEA	0.08	0.08	0.07

$^{+}$Fixed parameter

* p<0.05, ** p<0.01, ***p<0.001

Outline

FIML in lavaan - ordinal treated as ordinal

```
### Specifying the model-structure object
cfa.01.v.02 <- '
 depress =~ NA*depre1_i + depre2_i + depre3_i +
            depre4_i + depre5_i + depre6_i
 depress ~~ 1*depress '
```

```
## Estimating cfa.01.v.02
## cfa.01.v.02.fit.fiml <-
## cfa(model = cfa.01.v.02, data = depre_i_miss,
##     mimic = "Mplus", estimator = "WLSMV",
##     missing = "ml", meanstructure = TRUE,
##     ordered = c("depre1_i", "depre2_i",
##                 "depre3_i", "depre4_i",
##                 "depre5_i", "depre6_i"))
```

```
Error in lav_options_set(opt) : lavaan ERROR:
    missing="ml" is not allowed for estimator MLM,
    MLMV, GLS, ULS, ULSM, ULSMV, DWLS, WLS, WLSM,
    WLSMV, PML
```

Pairwise deletion in lavaan - ordinal treated as ordinal

```
## Estimating cfa.01.v.02
## With pairwise deletion
cfa.01.v.02.fit.pairwise <-
 cfa(model = cfa.01.v.02, data = depre_i_miss,
     mimic = "Mplus", estimator = "WLSMV",
     missing = "pairwise", meanstructure = TRUE,
     ordered = c("depre1_i", "depre2_i",
                 "depre3_i", "depre4_i",
                 "depre5_i", "depre6_i"))
summary(cfa.01.v.02.fit.pairwise, fit.measures = TRUE,
        standardized = TRUE)
```

```
lavaan 0.6-3 ended normally after 11 iterations

  Optimization method                           NLMINB
  Number of free parameters                         30

                                                  Used       Total
  Number of observations                          4220        4284
  Number of missing patterns                        57

  Estimator                                       DWLS      Robust
  Model Fit Test Statistic                     162.985     261.530
  Degrees of freedom                                 9           9
  P-value (Chi-square)                           0.000       0.000
  Scaling correction factor                                  0.624
```

Pairwise deletion in lavaan - ordinal treated as ordinal ...

```
  Shift parameter                                       0.207
    for simple second-order correction (WLSMV)

Model test baseline model:

  Minimum Function Test Statistic            14275.959   11499.317
  Degrees of freedom                                15          15
  P-value                                        0.000       0.000

User model versus baseline model:

  Comparative Fit Index (CFI)                    0.989       0.978
  Tucker-Lewis Index (TLI)                       0.982       0.963

  Robust Comparative Fit Index (CFI)                            NA
  Robust Tucker-Lewis Index (TLI)                               NA

Root Mean Square Error of Approximation:

  RMSEA                                          0.064       0.082
  90 Percent Confidence Interval          0.055  0.072       0.073  0.090
  P-value RMSEA <= 0.05                          0.004       0.000

  Robust RMSEA                                                  NA
  90 Percent Confidence Interval                                NA     NA

Standardized Root Mean Square Residual:

  SRMR                                           0.035       0.035

Weighted Root Mean Square Residual:

  WRMR                                           2.044       2.044
```

Pairwise deletion in lavaan - ordinal treated as ordinal ...

```
Parameter Estimates:

  Information                                 Expected
  Information saturated (h1) model        Unstructured
  Standard Errors                           Robust.sem

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  depress =~
    depre1_i          0.710    0.011   63.181    0.000    0.710    0.710
    depre2_i          0.660    0.011   58.102    0.000    0.660    0.660
    depre3_i          0.736    0.013   56.793    0.000    0.736    0.736
    depre4_i          0.723    0.011   65.066    0.000    0.723    0.723
    depre5_i          0.599    0.013   44.771    0.000    0.599    0.599
    depre6_i          0.584    0.013   43.556    0.000    0.584    0.584

Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .depre1_i          0.000                               0.000    0.000
   .depre2_i          0.000                               0.000    0.000
   .depre3_i          0.000                               0.000    0.000
   .depre4_i          0.000                               0.000    0.000
   .depre5_i          0.000                               0.000    0.000
   .depre6_i          0.000                               0.000    0.000
    depress           0.000                               0.000    0.000

Thresholds:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    depre1_i|t1      -0.558    0.022  -25.930    0.000   -0.558   -0.558
    depre1_i|t2       0.136    0.020    6.663    0.000    0.136    0.136
    depre1_i|t3       1.095    0.025   43.024    0.000    1.095    1.095
    depre1_i|t4       1.792    0.038   47.133    0.000    1.792    1.792
    depre2_i|t1      -0.869    0.023  -37.153    0.000   -0.869   -0.869
    depre2_i|t2      -0.185    0.020   -9.043    0.000   -0.185   -0.185
```

Pairwise deletion in lavaan - ordinal treated as ordinal ...

```
    depre2_i|t3       0.735    0.022   32.725    0.000    0.735    0.735
    depre2_i|t4       1.508    0.031   47.990    0.000    1.508    1.508
    depre3_i|t1       0.273    0.021   13.202    0.000    0.273    0.273
    depre3_i|t2       0.649    0.022   29.423    0.000    0.649    0.649
    depre3_i|t3       1.164    0.026   44.216    0.000    1.164    1.164
    depre3_i|t4       1.614    0.034   47.863    0.000    1.614    1.614
    depre4_i|t1      -0.106    0.020   -5.184    0.000   -0.106   -0.106
    depre4_i|t2       0.262    0.021   12.638    0.000    0.262    0.262
    depre4_i|t3       0.888    0.024   37.534    0.000    0.888    0.888
    depre4_i|t4       1.421    0.030   47.313    0.000    1.421    1.421
    depre5_i|t1      -0.378    0.021  -18.025    0.000   -0.378   -0.378
    depre5_i|t2       0.066    0.020    3.210    0.001    0.066    0.066
    depre5_i|t3       0.664    0.022   29.966    0.000    0.664    0.664
    depre5_i|t4       1.228    0.027   45.242    0.000    1.228    1.228
    depre6_i|t1      -0.437    0.021  -20.691    0.000   -0.437   -0.437
    depre6_i|t2       0.075    0.020    3.690    0.000    0.075    0.075
    depre6_i|t3       0.739    0.023   32.792    0.000    0.739    0.739
    depre6_i|t4       1.248    0.027   45.629    0.000    1.248    1.248

Variances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    depress           1.000                              1.000    1.000
   .depre1_i          0.495                              0.495    0.495
   .depre2_i          0.564                              0.564    0.564
   .depre3_i          0.458                              0.458    0.458
   .depre4_i          0.478                              0.478    0.478
   .depre5_i          0.642                              0.642    0.642
   .depre6_i          0.659                              0.659    0.659

Scales y*:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
    depre1_i          1.000                              1.000    1.000
    depre2_i          1.000                              1.000    1.000
    depre3_i          1.000                              1.000    1.000
```

Pairwise deletion in lavaan - ordinal treated as ordinal ...

```
    depre4_i          1.000                           1.000    1.000
    depre5_i          1.000                           1.000    1.000
    depre6_i          1.000                           1.000    1.000
```

Comparison Table

```
## 20190602: bug appears in output below, don't know why!
## 20190606: bug solved
labs <- c("depress" = "Depression")
cfapairwise <-
 semTable(list("Pairwise CFA ml" = cfa.01.v.01.fit.pairwise,
     "Pairwise CFA wlsmv" = cfa.01.v.02.fit.pairwise),
     paramSets = c("loadings", "thresholds", "intercepts",
     "residualvariances", "fits"), columns = c("estsestars"),
     file = file.path(tdir, "cfa0101b"), type = "tex",
     longtable = TRUE, varLabels = labs)
```

Comparison Table ...

	Pairwise CFA ml	Pairwise CFA wlsmv
	Estimate(Std.Err.)	Estimate(Std.Err.)
	Factor Loadings	
Depression		
depre1.i	0.74(0.02)***	0.71(0.01)***
depre2.i	0.71(0.02)***	0.66(0.01)***
depre3.i	0.79(0.02)***	0.74(0.01)***
depre4.i	0.87(0.02)***	0.72(0.01)***
depre5.i	0.74(0.02)***	0.60(0.01)***
depre6.i	0.73(0.02)***	0.58(0.01)***
	Intercepts	
depre1.i	2.33(0.02)***	0.00+
depre2.i	2.68(0.02)***	0.00+
depre3.i	1.83(0.02)***	0.00+
depre4.i	2.20(0.02)***	0.00+
depre5.i	2.48(0.02)***	0.00+
depre6.i	2.47(0.02)***	0.00+
	Residual Variances	
depre1.i	0.68(0.02)***	0.50+
depre2.i	0.82(0.02)***	0.56+
depre3.i	0.85(0.02)***	0.46+

Comparison Table ...

depre4.i	1.00(0.03)***	0.48+
depre5.i	1.35(0.03)***	0.64+
depre6.i	1.26(0.03)***	0.66+
	Thresholds	
depre1.i(1)		−0.56(0.02)***
depre1.i(2)		0.14(0.02)***
depre1.i(3)		1.09(0.03)***
depre1.i(4)		1.79(0.04)***
depre2.i(1)		−0.87(0.02)***
depre2.i(2)		−0.18(0.02)***
depre2.i(3)		0.73(0.02)***
depre2.i(4)		1.51(0.03)***
depre3.i(1)		0.27(0.02)***
depre3.i(2)		0.65(0.02)***
depre3.i(3)		1.16(0.03)***
depre3.i(4)		1.61(0.03)***
depre4.i(1)		−0.11(0.02)***
depre4.i(2)		0.26(0.02)***
depre4.i(3)		0.89(0.02)***
depre4.i(4)		1.42(0.03)***
depre5.i(1)		−0.38(0.02)***
depre5.i(2)		0.07(0.02)**

Comparison Table ...

depre5.i(3)		0.66(0.02)***
depre5.i(4)		1.23(0.03)***
depre6.i(1)		−0.44(0.02)***
depre6.i(2)		0.08(0.02)***
depre6.i(3)		0.74(0.02)***
depre6.i(4)		1.25(0.03)***
	Fit Indices	
$\chi^2(\mathrm{df})$	279.03(9)***	162.99
CFI	0.95	0.99
TLI	0.92	0.98
RMSEA	0.08	0.06
Scaled $\chi^2(\mathrm{df})$		261.53(9)***

+Fixed parameter

* p<0.05, ** p<0.01, ***p<0.001

Outline

FIML in Mplus - ordinal treated as numeric

When the ESTIMATOR = ML is specified (or MLR) in Mplus for numeric data, Mplus will apply FIML if there are missing values detected

```
Mplus VERSION 8 (Linux)
MUTHEN & MUTHEN
05/30/2018   4:51 PM

INPUT INSTRUCTIONS


  TITLE:
    Example 7
  Health Behavior in School Children
  Confirmatory Factor Analysis with Continuous Data using MLR
  1-Factor CFA Model for Depression;

  DATA:
    FILE IS "../../../data/hbsc-subset2/hbsc-subset2.dat";

  VARIABLE:
    NAMES ARE
    stud_id schl_id Gender Age Grade body1r body2 body3r body4 body5r
    phyhlth1 phyhlth2 phyhlth3 phyhlth4 phyhlth5 phyhlth6 phyhlth7
    phyhlth8 Depress1 Depress2 Depress3 Depress4 Depress5 Depress6
    Bullied1 Bullied2 Bullied3 Bullied4 Bullied5 Bullied6 Bullied7
    Bullied8 Bullied9 Bullier1 Bullier2 Bullier3 Bullier4 Bullier5
    Bullier6 Bullier7 Bullier8 Bullier9 Alc1 Alc2 Alc3 Alc4 Alc5;

    USEVARIABLES ARE
    Depress1-Depress6;

    MISSING ARE all(-999);
```

FIML in Mplus - ordinal treated as numeric ...

```
  ANALYSIS:
    ESTIMATOR = MLR;

  MODEL:
    Depress BY Depress1* Depress2-Depress6;
    Depress@1;

  OUTPUT:
    TECH1;
    STDYX;
```

```
*** WARNING
  Data set contains cases with missing on all variables.
  These cases were not included in the analysis.
  Number of cases with missing on all variables:  140
   1 WARNING(S) FOUND IN THE INPUT INSTRUCTIONS
```

```
Example 7
Health Behavior in School Children
Confirmatory Factor Analysis with Continuous Data using MLR
1-Factor CFA Model for Depression;

SUMMARY OF ANALYSIS

Number of groups                                         1
Number of observations                                9087

Number of dependent variables                            6
```

FIML in Mplus - ordinal treated as numeric ...

```
Number of independent variables                                   0
Number of continuous latent variables                             1

Observed dependent variables

  Continuous
   DEPRESS1    DEPRESS2    DEPRESS3    DEPRESS4    DEPRESS5    DEPRESS6

Continuous latent variables
   DEPRESS


Estimator                                                       MLR
Information matrix                                        OBSERVED
Maximum number of iterations                                  1000
Convergence criterion                                    0.500D-04
Maximum number of steepest descent iterations                   20
Maximum number of iterations for H1                           2000
Convergence criterion for H1                             0.100D-03

Input data file(s)
  ../../../data/hbsc-subset2/hbsc-subset2.dat

Input data format  FREE


SUMMARY OF DATA

     Number of missing data patterns            31


COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value   0.100
```

FIML in Mplus - ordinal treated as numeric ...

```
     PROPORTION OF DATA PRESENT


           Covariance Coverage
              DEPRESS1       DEPRESS2       DEPRESS3       DEPRESS4       DEPRESS5
              --------       --------       --------       --------       --------
 DEPRESS1       0.998
 DEPRESS2       0.996          0.997
 DEPRESS3       0.994          0.994          0.995
 DEPRESS4       0.992          0.991          0.990          0.993
 DEPRESS5       0.990          0.990          0.989          0.987          0.992
 DEPRESS6       0.994          0.994          0.993          0.991          0.990


           Covariance Coverage
              DEPRESS6
              --------
 DEPRESS6       0.996


 UNIVARIATE SAMPLE STATISTICS


     UNIVARIATE HIGHER-ORDER MOMENT DESCRIPTIVE STATISTICS

         Variable/         Mean/     Skewness/   Minimum/ % with                Percentiles
        Sample Size      Variance    Kurtosis    Maximum  Min/Max      20%/60%    40%/80%    Median

     DEPRESS1              2.404       0.389       1.000   25.83%       1.000      2.000      2.000
           9070.000        1.240      -0.581       5.000    4.26%       3.000      3.000
     DEPRESS2              2.768       0.071       1.000   15.68%       2.000      3.000      3.000
```

FIML in Mplus - ordinal treated as numeric ...

```
          9056.000      1.246     -0.648      5.000      6.54%      3.000      4.000
     DEPRESS3           1.895      1.171      1.000     56.14%      1.000      1.000      1.000
          9043.000      1.481      0.231      5.000      5.46%      2.000      3.000
     DEPRESS4           2.249      0.639      1.000     43.77%      1.000      1.000      2.000
          9020.000      1.771     -0.855      5.000      7.78%      3.000      3.000
     DEPRESS5           2.516      0.389      1.000     33.00%      1.000      2.000      2.000
          9011.000      1.847     -1.074      5.000     10.75%      3.000      4.000
     DEPRESS6           2.624      0.310      1.000     27.90%      1.000      2.000      3.000
          9048.000      1.799     -1.054      5.000     11.93%      3.000      4.000


THE MODEL ESTIMATION TERMINATED NORMALLY



MODEL FIT INFORMATION

Number of Free Parameters                       18

Loglikelihood

          H0 Value                       -82045.027
          H0 Scaling Correction Factor        0.9943
            for MLR
          H1 Value                       -81755.006
          H1 Scaling Correction Factor        1.0943
            for MLR

Information Criteria

          Akaike (AIC)                   164126.054
          Bayesian (BIC)                 164254.117
          Sample-Size Adjusted BIC       164196.916
            (n* = (n + 2) / 24)
```

FIML in Mplus - ordinal treated as numeric ...

```
Chi-Square Test of Model Fit

          Value                            448.097*
          Degrees of Freedom                     9
          P-Value                           0.0000
          Scaling Correction Factor         1.2945
            for MLR

*   The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV cannot be used
    for chi-square difference testing in the regular way.  MLM, MLR and WLSM
    chi-square difference testing is described on the Mplus website.  MLMV, WLSMV,
    and ULSMV difference testing is done using the DIFFTEST option.

RMSEA (Root Mean Square Error Of Approximation)

          Estimate                           0.073
          90 Percent C.I.                    0.068  0.079
          Probability RMSEA <= .05           0.000

CFI/TLI

          CFI                                0.959
          TLI                                0.931

Chi-Square Test of Model Fit for the Baseline Model

          Value                          10695.144
          Degrees of Freedom                    15
          P-Value                           0.0000

SRMR (Standardized Root Mean Square Residual)

          Value                              0.029
```

FIML in Mplus - ordinal treated as numeric ...

```
MODEL RESULTS

                                                    Two-Tailed
                  Estimate       S.E.  Est./S.E.    P-Value

 DEPRESS  BY
    DEPRESS1         0.776      0.012     65.901      0.000
    DEPRESS2         0.703      0.012     59.830      0.000
    DEPRESS3         0.809      0.014     58.995      0.000
    DEPRESS4         0.879      0.014     64.889      0.000
    DEPRESS5         0.779      0.014     53.758      0.000
    DEPRESS6         0.761      0.014     53.529      0.000

 Intercepts
    DEPRESS1         2.405      0.012    205.677      0.000
    DEPRESS2         2.769      0.012    236.130      0.000
    DEPRESS3         1.895      0.013    148.228      0.000
    DEPRESS4         2.249      0.014    160.704      0.000
    DEPRESS5         2.516      0.014    175.943      0.000
    DEPRESS6         2.624      0.014    186.214      0.000

 Variances
    DEPRESS          1.000      0.000    999.000    999.000

 Residual Variances
    DEPRESS1         0.637      0.014     45.704      0.000
    DEPRESS2         0.752      0.014     52.196      0.000
    DEPRESS3         0.827      0.017     47.493      0.000
    DEPRESS4         0.997      0.020     49.684      0.000
    DEPRESS5         1.240      0.022     56.362      0.000
    DEPRESS6         1.220      0.021     57.725      0.000
```

FIML in Mplus - ordinal treated as numeric ...

STANDARDIZED MODEL RESULTS

STDYX Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY				
DEPRESS1	0.697	0.008	83.912	0.000
DEPRESS2	0.630	0.009	71.437	0.000
DEPRESS3	0.664	0.008	78.860	0.000
DEPRESS4	0.661	0.009	77.483	0.000
DEPRESS5	0.573	0.010	58.930	0.000
DEPRESS6	0.567	0.010	58.830	0.000
Intercepts				
DEPRESS1	2.159	0.014	152.719	0.000
DEPRESS2	2.480	0.018	138.539	0.000
DEPRESS3	1.558	0.008	203.406	0.000
DEPRESS4	1.691	0.009	186.900	0.000
DEPRESS5	1.852	0.011	169.712	0.000
DEPRESS6	1.957	0.012	163.369	0.000
Variances				
DEPRESS	1.000	0.000	999.000	999.000
Residual Variances				
DEPRESS1	0.514	0.012	44.358	0.000
DEPRESS2	0.603	0.011	54.315	0.000
DEPRESS3	0.559	0.011	49.880	0.000
DEPRESS4	0.563	0.011	49.994	0.000

FIML in Mplus - ordinal treated as numeric ...

```
    DEPRESS5           0.672      0.011     60.243      0.000
    DEPRESS6           0.678      0.011     62.017      0.000


R-SQUARE

    Observed                                        Two-Tailed
    Variable        Estimate       S.E.  Est./S.E.    P-Value

    DEPRESS1           0.486      0.012     41.956      0.000
    DEPRESS2           0.397      0.011     35.718      0.000
    DEPRESS3           0.441      0.011     39.430      0.000
    DEPRESS4           0.437      0.011     38.741      0.000
    DEPRESS5           0.328      0.011     29.465      0.000
    DEPRESS6           0.322      0.011     29.415      0.000


QUALITY OF NUMERICAL RESULTS

     Condition Number for the Information Matrix              0.906E-01
       (ratio of smallest to largest eigenvalue)


TECHNICAL 1 OUTPUT


     PARAMETER SPECIFICATION


           NU
              DEPRESS1      DEPRESS2      DEPRESS3      DEPRESS4      DEPRESS5
              --------      --------      --------      --------      --------
                  1             2             3             4             5
```

FIML in Mplus - ordinal treated as numeric ...

```
           NU
              DEPRESS6
              --------
                  6


           LAMBDA
              DEPRESS
              --------
DEPRESS1           7
DEPRESS2           8
DEPRESS3           9
DEPRESS4          10
DEPRESS5          11
DEPRESS6          12


           THETA
              DEPRESS1      DEPRESS2      DEPRESS3      DEPRESS4      DEPRESS5
              --------      --------      --------      --------      --------
DEPRESS1          13
DEPRESS2           0            14
DEPRESS3           0             0            15
DEPRESS4           0             0             0            16
DEPRESS5           0             0             0             0            17
DEPRESS6           0             0             0             0             0


           THETA
              DEPRESS6
              --------
DEPRESS6          18
```

FIML in Mplus - ordinal treated as numeric ...

```
          ALPHA
             DEPRESS
             --------
                0


          BETA
             DEPRESS
             --------
DEPRESS         0


          PSI
             DEPRESS
             --------
DEPRESS         0


    STARTING VALUES


          NU
             DEPRESS1      DEPRESS2      DEPRESS3      DEPRESS4      DEPRESS5
             --------      --------      --------      --------      --------
               2.404         2.768         1.895         2.249         2.516


          NU
             DEPRESS6
             --------
               2.624
```

FIML in Mplus - ordinal treated as numeric ...

```
          LAMBDA
             DEPRESS
             --------
DEPRESS1       1.000
DEPRESS2       1.000
DEPRESS3       1.000
DEPRESS4       1.000
DEPRESS5       1.000
DEPRESS6       1.000


          THETA
             DEPRESS1      DEPRESS2      DEPRESS3      DEPRESS4      DEPRESS5
             --------      --------      --------      --------      --------
DEPRESS1       0.620
DEPRESS2       0.000         0.623
DEPRESS3       0.000         0.000         0.740
DEPRESS4       0.000         0.000         0.000         0.886
DEPRESS5       0.000         0.000         0.000         0.000         0.923
DEPRESS6       0.000         0.000         0.000         0.000         0.000


          THETA
             DEPRESS6
             --------
DEPRESS6       0.899


          ALPHA
             DEPRESS
             --------
               0.000
```

FIML in Mplus - ordinal treated as numeric ...

```
           BETA
              DEPRESS
              --------
DEPRESS         0.000


           PSI
              DEPRESS
              --------
DEPRESS         1.000


     Beginning Time:  16:51:22
        Ending Time:  16:51:22
       Elapsed Time:  00:00:00



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```

If users want to change the default FIML behavior in Mplus, LISTWISE = ON in the DATA COMMAND can be specified

FIML in Mplus - ordinal treated as ordinal

To our knowledge, Mplus is currently the only SEM software that allows FIML estimation to be used for ordinal data with missing values

- Parameters of categorical variables are estimated (e.g., thresholds)
- Individual-level information are used, instead of covariance information, for model estimation
- Time consuming (a three-factor model can take about 20mins to converge)
- Some times large models do not converge at all

```
Mplus VERSION 8 (Linux)
MUTHEN & MUTHEN
05/30/2018   4:50 PM

INPUT INSTRUCTIONS


  TITLE:
    Example 7
  Health Behavior in School Children
  Confirmatory Factor Analysis with Ordinal-Categorical Data using MLR
  1-Factor Graded Response IRT Model for Depression;

  DATA:
    FILE IS "../../../data/hbsc-subset2/hbsc-subset2.dat";
```

FIML in Mplus - ordinal treated as ordinal ...

```
VARIABLE:
  NAMES ARE
  stud_id schl_id Gender Age Grade body1r body2 body3r body4 body5r
  phyhlth1 phyhlth2 phyhlth3 phyhlth4 phyhlth5 phyhlth6 phyhlth7
  phyhlth8 Depress1 Depress2 Depress3 Depress4 Depress5 Depress6
  Bullied1 Bullied2 Bullied3 Bullied4 Bullied5 Bullied6 Bullied7
  Bullied8 Bullied9 Bullier1 Bullier2 Bullier3 Bullier4 Bullier5
  Bullier6 Bullier7 Bullier8 Bullier9 Alc1 Alc2 Alc3 Alc4 Alc5;

  USEVARIABLES ARE
  Depress1-Depress6;

  CATEGORICAL ARE
  Depress1-Depress6;

  MISSING ARE all(-999);

ANALYSIS:
  ESTIMATOR = MLR;

MODEL:
Depress BY Depress1* Depress2-Depress6;
Depress@1;

OUTPUT:
  TECH1;
  STDYX;
```

```
*** WARNING
  Data set contains cases with missing on all variables.
  These cases were not included in the analysis.
```

FIML in Mplus - ordinal treated as ordinal ...

```
  Number of cases with missing on all variables:  140
   1 WARNING(S) FOUND IN THE INPUT INSTRUCTIONS



Example 7
Health Behavior in School Children
Confirmatory Factor Analysis with Ordinal-Categorical Data using MLR
1-Factor Graded Response IRT Model for Depression;

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                        9087

Number of dependent variables                                    6
Number of independent variables                                  0
Number of continuous latent variables                            1

Observed dependent variables

  Binary and ordered categorical (ordinal)
   DEPRESS1    DEPRESS2    DEPRESS3    DEPRESS4    DEPRESS5    DEPRESS6

Continuous latent variables
   DEPRESS


Estimator                                                      MLR
Information matrix                                        OBSERVED
Optimization Specifications for the Quasi-Newton Algorithm for
Continuous Outcomes
  Maximum number of iterations                                 100
```

FIML in Mplus - ordinal treated as ordinal ...

```
  Convergence criterion                                  0.100D-05
Optimization Specifications for the EM Algorithm
  Maximum number of iterations                                500
  Convergence criteria
    Loglikelihood change                                 0.100D-02
    Relative loglikelihood change                        0.100D-05
    Derivative                                           0.100D-02
Optimization Specifications for the M step of the EM Algorithm for
Categorical Latent variables
  Number of M step iterations                                   1
  M step convergence criterion                           0.100D-02
  Basis for M step termination                           ITERATION
Optimization Specifications for the M step of the EM Algorithm for
Censored, Binary or Ordered Categorical (Ordinal), Unordered
Categorical (Nominal) and Count Outcomes
  Number of M step iterations                                   1
  M step convergence criterion                           0.100D-02
  Basis for M step termination                           ITERATION
  Maximum value for logit thresholds                            15
  Minimum value for logit thresholds                           -15
  Minimum expected cell size for chi-square              0.100D-01
Maximum number of iterations for H1                           2000
Convergence criterion for H1                             0.100D-03
Optimization algorithm                                         EMA
Integration Specifications
  Type                                                    STANDARD
  Number of integration points                                  15
  Dimensions of numerical integration                            1
  Adaptive quadrature                                           ON
Link                                                         LOGIT
Cholesky                                                        ON

Input data file(s)
  ../../../data/hbsc-subset2/hbsc-subset2.dat
```

FIML in Mplus - ordinal treated as ordinal ...

```
Input data format  FREE


SUMMARY OF DATA

     Number of missing data patterns            31
     Number of y missing data patterns           0
     Number of u missing data patterns          31


COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value   0.100


     PROPORTION OF DATA PRESENT FOR U


           Covariance Coverage
              DEPRESS1       DEPRESS2       DEPRESS3       DEPRESS4       DEPRESS5
              --------       --------       --------       --------       --------
 DEPRESS1       0.998
 DEPRESS2       0.996          0.997
 DEPRESS3       0.994          0.994          0.995
 DEPRESS4       0.992          0.991          0.990          0.993
 DEPRESS5       0.990          0.990          0.989          0.987          0.992
 DEPRESS6       0.994          0.994          0.993          0.991          0.990


           Covariance Coverage
              DEPRESS6
              --------
 DEPRESS6       0.996
```

FIML in Mplus - ordinal treated as ordinal ...

```
UNIVARIATE PROPORTIONS AND COUNTS FOR CATEGORICAL VARIABLES

    DEPRESS1
      Category 1    0.258          2343.000
      Category 2    0.278          2519.000
      Category 3    0.308          2792.000
      Category 4    0.114          1030.000
      Category 5    0.043           386.000
    DEPRESS2
      Category 1    0.157          1420.000
      Category 2    0.230          2083.000
      Category 3    0.367          3321.000
      Category 4    0.181          1640.000
      Category 5    0.065           592.000
    DEPRESS3
      Category 1    0.561          5077.000
      Category 2    0.164          1482.000
      Category 3    0.147          1331.000
      Category 4    0.073           659.000
      Category 5    0.055           494.000
    DEPRESS4
      Category 1    0.438          3948.000
      Category 2    0.152          1375.000
      Category 3    0.211          1904.000
      Category 4    0.121          1091.000
      Category 5    0.078           702.000
    DEPRESS5
      Category 1    0.330          2974.000
      Category 2    0.185          1667.000
      Category 3    0.231          2086.000
      Category 4    0.146          1315.000
      Category 5    0.108           969.000
    DEPRESS6
```

FIML in Mplus - ordinal treated as ordinal ...

```
      Category 1    0.279          2524.000
      Category 2    0.202          1828.000
      Category 3    0.254          2301.000
      Category 4    0.145          1316.000
      Category 5    0.119          1079.000


THE MODEL ESTIMATION TERMINATED NORMALLY



MODEL FIT INFORMATION

Number of Free Parameters                       30

Loglikelihood

          H0 Value                       -71988.417
          H0 Scaling Correction Factor      1.0190
            for MLR

Information Criteria

          Akaike (AIC)                   144036.834
          Bayesian (BIC)                 144250.272
          Sample-Size Adjusted BIC       144154.937
            (n* = (n + 2) / 24)

Chi-Square Test of Model Fit for the Binary and Ordered Categorical
(Ordinal) Outcomes**

          Pearson Chi-Square
```

FIML in Mplus - ordinal treated as ordinal ...

```
          Value                          21102.439
          Degrees of Freedom                 15496
          P-Value                          0.0000

          Likelihood Ratio Chi-Square

          Value                          11118.302
          Degrees of Freedom                 15496
          P-Value                          1.0000

** Of the 40775 cells in the frequency table, 98
   were deleted in the calculation of chi-square due to extreme values.

Chi-Square Test for MCAR under the Unrestricted Latent Class Indicator Model

          Pearson Chi-Square

          Value                           2233.670
          Degrees of Freedom                 25120
          P-Value                          1.0000

          Likelihood Ratio Chi-Square

          Value                            572.725
          Degrees of Freedom                 25120
          P-Value                          1.0000



MODEL RESULTS

                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value
```

FIML in Mplus - ordinal treated as ordinal ...

DEPRESS BY				
DEPRESS1	1.948	0.048	40.580	0.000
DEPRESS2	1.636	0.039	41.733	0.000
DEPRESS3	1.983	0.052	38.158	0.000
DEPRESS4	1.812	0.046	39.286	0.000
DEPRESS5	1.394	0.037	37.804	0.000
DEPRESS6	1.370	0.035	38.740	0.000
Thresholds				
DEPRESS1$1	-1.676	0.042	-40.228	0.000
DEPRESS1$2	0.176	0.033	5.299	0.000
DEPRESS1$3	2.571	0.049	52.009	0.000
DEPRESS1$4	4.633	0.081	56.991	0.000
DEPRESS2$1	-2.375	0.044	-53.831	0.000
DEPRESS2$2	-0.692	0.032	-21.780	0.000
DEPRESS2$3	1.568	0.036	43.324	0.000
DEPRESS2$4	3.665	0.061	60.179	0.000
DEPRESS3$1	0.368	0.034	10.665	0.000
DEPRESS3$2	1.499	0.040	37.070	0.000
DEPRESS3$3	2.956	0.056	52.717	0.000
DEPRESS3$4	4.310	0.079	54.882	0.000
DEPRESS4$1	-0.412	0.033	-12.632	0.000
DEPRESS4$2	0.510	0.033	15.636	0.000
DEPRESS4$3	2.048	0.043	48.020	0.000
DEPRESS4$4	3.595	0.063	56.855	0.000
DEPRESS5$1	-0.954	0.030	-31.303	0.000
DEPRESS5$2	0.072	0.028	2.572	0.010
DEPRESS5$3	1.426	0.033	42.588	0.000
DEPRESS5$4	2.753	0.047	58.306	0.000
DEPRESS6$1	-1.268	0.032	-39.566	0.000
DEPRESS6$2	-0.118	0.028	-4.228	0.000
DEPRESS6$3	1.333	0.032	41.223	0.000
DEPRESS6$4	2.583	0.044	58.699	0.000

FIML in Mplus - ordinal treated as ordinal ...

```
 Variances
    DEPRESS            1.000      0.000    999.000    999.000


STANDARDIZED MODEL RESULTS


STDYX Standardization

                                                    Two-Tailed
                  Estimate       S.E.  Est./S.E.    P-Value

 DEPRESS  BY
    DEPRESS1         0.732      0.008     87.367      0.000
    DEPRESS2         0.670      0.009     75.704      0.000
    DEPRESS3         0.738      0.009     83.772      0.000
    DEPRESS4         0.707      0.009     78.492      0.000
    DEPRESS5         0.609      0.010     60.145      0.000
    DEPRESS6         0.603      0.010     60.835      0.000

 Thresholds
    DEPRESS1$1      -0.630      0.014    -46.162      0.000
    DEPRESS1$2       0.066      0.012      5.284      0.000
    DEPRESS1$3       0.966      0.016     60.536      0.000
    DEPRESS1$4       1.741      0.025     69.189      0.000
    DEPRESS2$1      -0.972      0.016    -62.641      0.000
    DEPRESS2$2      -0.283      0.013    -22.512      0.000
    DEPRESS2$3       0.642      0.014     46.135      0.000
    DEPRESS2$4       1.500      0.022     69.312      0.000
    DEPRESS3$1       0.137      0.013     10.792      0.000
    DEPRESS3$2       0.558      0.014     40.963      0.000
    DEPRESS3$3       1.100      0.017     64.800      0.000
    DEPRESS3$4       1.604      0.023     70.095      0.000
    DEPRESS4$1      -0.161      0.013    -12.755      0.000
```

FIML in Mplus - ordinal treated as ordinal ...

```
    DEPRESS4$2         0.199      0.013     15.750      0.000
    DEPRESS4$3         0.799      0.015     54.133      0.000
    DEPRESS4$4         1.402      0.020     69.217      0.000
    DEPRESS5$1        -0.417      0.013    -32.408      0.000
    DEPRESS5$2         0.032      0.012      2.572      0.010
    DEPRESS5$3         0.623      0.014     45.602      0.000
    DEPRESS5$4         1.203      0.018     66.802      0.000
    DEPRESS6$1        -0.558      0.013    -42.056      0.000
    DEPRESS6$2        -0.052      0.012     -4.233      0.000
    DEPRESS6$3         0.586      0.014     43.417      0.000
    DEPRESS6$4         1.136      0.017     65.553      0.000

 Variances
    DEPRESS            1.000      0.000    999.000    999.000


R-SQUARE

    Observed                                        Two-Tailed
    Variable        Estimate       S.E.  Est./S.E.    P-Value

    DEPRESS1           0.536      0.012     43.683      0.000
    DEPRESS2           0.449      0.012     37.852      0.000
    DEPRESS3           0.545      0.013     41.886      0.000
    DEPRESS4           0.499      0.013     39.246      0.000
    DEPRESS5           0.371      0.012     30.073      0.000
    DEPRESS6           0.363      0.012     30.418      0.000


QUALITY OF NUMERICAL RESULTS

     Condition Number for the Information Matrix              0.162E-01
       (ratio of smallest to largest eigenvalue)
```

FIML in Mplus - ordinal treated as ordinal ...

```
TECHNICAL 1 OUTPUT


     PARAMETER SPECIFICATION


           TAU
              DEPRESS1      DEPRESS1      DEPRESS1      DEPRESS1      DEPRESS2
              --------      --------      --------      --------      --------
                    7             8             9            10            11

           TAU
              DEPRESS2      DEPRESS2      DEPRESS2      DEPRESS3      DEPRESS3
              --------      --------      --------      --------      --------
                   12            13            14            15            16

           TAU
              DEPRESS3      DEPRESS3      DEPRESS4      DEPRESS4      DEPRESS4
              --------      --------      --------      --------      --------
                   17            18            19            20            21

           TAU
              DEPRESS4      DEPRESS5      DEPRESS5      DEPRESS5      DEPRESS5
              --------      --------      --------      --------      --------
                   22            23            24            25            26

           TAU
              DEPRESS6      DEPRESS6      DEPRESS6      DEPRESS6
              --------      --------      --------      --------
```

FIML in Mplus - ordinal treated as ordinal ...

```
              27             28             29             30

           NU
              DEPRESS1       DEPRESS2       DEPRESS3       DEPRESS4       DEPRESS5
              --------       --------       --------       --------       --------
                    0              0              0              0              0

           NU
              DEPRESS6
              --------
                    0

           LAMBDA
              DEPRESS
              --------
DEPRESS1            1
DEPRESS2            2
DEPRESS3            3
DEPRESS4            4
DEPRESS5            5
DEPRESS6            6

           THETA
              DEPRESS1       DEPRESS2       DEPRESS3       DEPRESS4       DEPRESS5
              --------       --------       --------       --------       --------
DEPRESS1            0
DEPRESS2            0              0
DEPRESS3            0              0              0
DEPRESS4            0              0              0              0
DEPRESS5            0              0              0              0              0
```

FIML in Mplus - ordinal treated as ordinal ...

```
DEPRESS6           0              0              0              0              0

           THETA
              DEPRESS6
              --------
DEPRESS6            0

           ALPHA
              DEPRESS
              --------
                    0

           BETA
              DEPRESS
              --------
DEPRESS             0

           PSI
              DEPRESS
              --------
DEPRESS             0

    STARTING VALUES

           TAU
              DEPRESS1       DEPRESS1       DEPRESS1       DEPRESS1       DEPRESS2
              --------       --------       --------       --------       --------
               -1.055          0.144          1.687          3.113         -1.682
```

FIML in Mplus - ordinal treated as ordinal ...

```
TAU
   DEPRESS2      DEPRESS2      DEPRESS2      DEPRESS3      DEPRESS3
   --------      --------      --------      --------      --------
     -0.461         1.118         2.660         0.247         0.971

TAU
   DEPRESS3      DEPRESS3      DEPRESS4      DEPRESS4      DEPRESS4
   --------      --------      --------      --------      --------
      1.923         2.851        -0.251         0.365         1.394

TAU
   DEPRESS4      DEPRESS5      DEPRESS5      DEPRESS5      DEPRESS5
   --------      --------      --------      --------      --------
      2.472        -0.708         0.060         1.080         2.116

TAU
   DEPRESS6      DEPRESS6      DEPRESS6      DEPRESS6
   --------      --------      --------      --------
     -0.950        -0.076         1.022         2.000

NU
   DEPRESS1      DEPRESS2      DEPRESS3      DEPRESS4      DEPRESS5
   --------      --------      --------      --------      --------
      0.000         0.000         0.000         0.000         0.000

NU
   DEPRESS6
```

FIML in Mplus - ordinal treated as ordinal ...

```
              --------
                0.000


           LAMBDA
              DEPRESS
              --------
DEPRESS1        1.000
DEPRESS2        1.000
DEPRESS3        1.000
DEPRESS4        1.000
DEPRESS5        1.000
DEPRESS6        1.000


           THETA
              DEPRESS1       DEPRESS2       DEPRESS3       DEPRESS4       DEPRESS5
              --------       --------       --------       --------       --------
DEPRESS1        1.000
DEPRESS2        0.000          1.000
DEPRESS3        0.000          0.000          1.000
DEPRESS4        0.000          0.000          0.000          1.000
DEPRESS5        0.000          0.000          0.000          0.000          1.000
DEPRESS6        0.000          0.000          0.000          0.000          0.000


           THETA
              DEPRESS6
              --------
DEPRESS6        1.000


           ALPHA
              DEPRESS
```

FIML in Mplus - ordinal treated as ordinal ...

```
              --------
                0.000


           BETA
              DEPRESS
              --------
DEPRESS         0.000


           PSI
              DEPRESS
              --------
DEPRESS         1.000


     Beginning Time:  16:50:29
        Ending Time:  16:50:30
       Elapsed Time:  00:00:01



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```

FIML in Mplus - ordinal treated as ordinal ...

If users want to change the default FIML behavior in Mplus,
LISTWISE = ON in the DATA COMMAND can be specified

Outline

Two Types of Imputation

- mice: "fcs" fully conditional specification
  - very slow with lots of ordinal variables
- Amelia: multivariate normal approximation
  - faster!

Packages you'll need

I installed "mice", "amelia", "mitools" to get this going. Probably several others will come along with those if you install them.

Mice ran slowly in this case

- The imputation with mice is launched as follows. This takes several hours, so don't launch it unless you really mean it!
- I only asked for default number of completed sets, m=5, because I hoped it would be fast. Usually I'd want more. But even this was slow.

```
library(mice)
## I was careless, did not look at hbsc carefully first
set5 <- mice(hbsc, m = 5)
## To see what you get, do this
par(ask = TRUE)
plot(set5)
```

After inspecting the initial set with 5 iterations, I concluded the results were inadequate, so I ran several additional commands to add more samples. To add more iterations, use "mice.mids".

Mice ran slowly in this case ...

```
set15 <- mice.mids(set5, maxit = 10)
## That was not adequate keep going
set25 <- mice.mids(set15, maxit = 10)
## Inadequate, keep going
set30 <- mice.mids(set25, maxit = 5)
## Expectations crashed that was not good
set45 <- mice.mids(set45, maxit = 25)
## Stop there, I had enough
saveRDS(set45, file.path(wdir, "mice-45.rds"))
```

Load the saved mice file from workingdata

```
wdir <- "workingdata"
list.files(wdir)
```

```
[1] "amelia-imps.rds" "mice-05.rds"     "mice-15.rds"     "mice-25.rds"     "mice-35.rds"
[6] "mice-45.rds"
```

```
library(mice)
miceimputed <- readRDS(file.path(wdir, "mice-45.rds"))
if(interactive()){
    par(ask=TRUE)
    plot(miceimputed)
 }
```

Load the saved mice file from workingdata ...

- I want to fit this structural equation model

```
sem.01.int <- '
 ## the measurement model
 gotBully =~ NA*gotBu1_i + gotBu2_i + gotBu3_i
              + gotBu4_i + gotBu5_i + gotBu6_i
              + gotBu7_i + gotBu8_i + gotBu9_i
 gotBully ~~ 1*gotBully

 alcohol =~ NA*alc1_i + alc2_i + alc3_i
             + alc4_i + alc5_i
 alcohol ~~ 1*alcohol

 # regress
 alcohol ~ gotBully
 '
```

- mice offers a way to run a set of models, one for each imputed data set. However in this case it does not work.

Load the saved mice file from workingdata ...

```
fits.mice <- with(data = miceimputed, exp =
   sem(model = sem.01.int, mimic = "Mplus",
       estimator = "ML"))
```

- That returns without error, but further inspection indicates the model was not estimated and that the usual function "summary(fits.mice)" does not understand lavaan objects.
- So we fall back to manual method.

Step 1: pull a completed data set for each imputation

Create a new list called `imps` ("imputations") and use the `complete` function to get the data frames

```
imps <- list()
for(i in 1:5){
     imps[[i]] <- complete(miceimputed, action = i)
 }
```

- When the imputation ran, it only filled in values for the ordinal "_o" variables, it left NAs on the integer ones.

```
summary(imps[[1]])
```

Step 1: pull a completed data set for each imputation ...

```
    stud_id         schl_id          Gender           Age             Grade        body1_o    body2_o
Min.   :   1   Min.   :  2.0   Min.   :0.000   Min.   :11.0   Min.   :6.000   SA: 807   SA: 847
1st Qu.:2278   1st Qu.: 59.0   1st Qu.:0.000   1st Qu.:12.0   1st Qu.:6.000   A : 804   A : 696
Median :4588   Median :122.0   Median :1.000   Median :12.0   Median :6.000   U : 755   U : 725
Mean   :4606   Mean   :117.2   Mean   :0.507   Mean   :12.1   Mean   :6.439   D : 751   D :1135
3rd Qu.:6925   3rd Qu.:172.0   3rd Qu.:1.000   3rd Qu.:13.0   3rd Qu.:7.000   SD:1167   SD: 881
Max.   :9224   Max.   :227.0   Max.   :1.000   Max.   :17.0   Max.   :7.000

body3_o   body4_o   body5_o          phys1_o            phys2_o            phys3_o
SA: 763   SA: 857   SA: 728   EveryDay     : 328   EveryDay     : 214   EveryDay     : 310
A : 449   A : 596   A : 354   EveryWeek    : 443   EveryWeek    : 384   EveryWeek    : 315
U : 620   U : 736   U : 723   MoreOnceWeek: 425   MoreOnceWeek: 423   MoreOnceWeek: 342
D : 592   D : 983   D : 491   EveryMonth   :1117   EveryMonth   :1263   EveryMonth   : 685
SD:1860   SD:1112   SD:1988   Never        :1971   Never        :2000   Never        :2632


       phys4_o            phys5_o            phys6_o            phys7_o
EveryDay     : 341   EveryDay     : 558   EveryDay     : 488   EveryDay     : 731
EveryWeek    : 323   EveryWeek    : 541   EveryWeek    : 505   EveryWeek    : 422
MoreOnceWeek: 351   MoreOnceWeek: 541   MoreOnceWeek: 654   MoreOnceWeek: 416
EveryMonth   : 742   EveryMonth   : 981   EveryMonth   :1000   EveryMonth   : 612
Never        :2527   Never        :1663   Never        :1637   Never        :2103


       phys8_o          depre1_o          depre2_o          depre3_o          depre4_o
EveryDay     : 256   Never     :1229   Never     : 816   Never     :2600   Never     :1939
EveryWeek    : 278   Seldom    :1132   Seldom    : 987   Seldom    : 584   Seldom    : 611
MoreOnceWeek: 263   Sometimes:1323   Sometimes:1470   Sometimes: 569   Sometimes: 911
EveryMonth   : 577   Often     : 428   Often     : 711   Often     : 294   Often     : 489
Never        :2910   Always    : 172   Always    : 300   Always    : 237   Always    : 334


     depre5_o          depre6_o              gotBu1_o              gotBu2_o
```

Step 1: pull a completed data set for each imputation ...

```
Never     :1505   Never     :1416   never          :1831   never          :2049
Seldom    : 738   Seldom    : 843   1 or 2         : 668   1 or 2         : 539
Sometimes: 934   Sometimes:1019   2-3 p/month    : 402   2-3 p/month    : 603
Often     : 628   Often     : 540   1 p/week       : 625   1 p/week       : 413
Always    : 479   Always    : 466   Several p/week: 758   Several p/week: 680


          gotBu3_o                gotBu4_o                gotBu5_o                gotBu6_o
never          :2452   never          :1864   never          :2519   never          :2669
1 or 2         : 305   1 or 2         : 629   1 or 2         : 262   1 or 2         : 173
2-3 p/month    : 475   2-3 p/month    : 469   2-3 p/month    : 429   2-3 p/month    : 150
1 p/week       : 520   1 p/week       : 574   1 p/week       : 484   1 p/week       : 995
Several p/week: 532   Several p/week: 748   Several p/week: 590   Several p/week: 297


          gotBu7_o                gotBu8_o                gotBu9_o                buOth1_o
never          :2217   never          :2723   never          :2785   never          :1966
1 or 2         : 388   1 or 2         : 146   1 or 2         :  97   1 or 2         : 705
2-3 p/month    : 409   2-3 p/month    : 460   2-3 p/month    : 507   2-3 p/month    : 387
1 p/week       : 660   1 p/week       : 484   1 p/week       : 581   1 p/week       : 646
Several p/week: 610   Several p/week: 471   Several p/week: 314   Several p/week: 580


          buOth2_o                buOth3_o                buOth4_o                buOth5_o
never          :2273   never          :2525   never          :2555   never          :2704
1 or 2         : 477   1 or 2         : 262   1 or 2         : 297   1 or 2         : 159
2-3 p/month    : 449   2-3 p/month    : 189   2-3 p/month    : 405   2-3 p/month    : 386
1 p/week       : 509   1 p/week       : 536   1 p/week       : 511   1 p/week       : 495
Several p/week: 576   Several p/week: 772   Several p/week: 516   Several p/week: 540


          buOth6_o                buOth7_o                buOth8_o                buOth9_o
never          :2767   never          :2618   never          :2758   never          :2819
1 or 2         : 190   1 or 2         : 216   1 or 2         : 144   1 or 2         :  94
```

Step 1: pull a completed data set for each imputation ...

```
2-3 p/month    : 613   2-3 p/month    : 204   2-3 p/month    : 345   2-3 p/month    : 579
1 p/week       : 409   1 p/week       : 678   1 p/week       : 633   1 p/week       : 217
Several p/week: 305   Several p/week: 568   Several p/week: 404   Several p/week: 575


     alc1_o          alc2_o          alc3_o          alc4_o          alc5_o         body1_i
Never   :3597   Never   :3455   Never   :3766   Never   :3469   Never   :3589   Min.    :1.000
Rarely : 448    Rarely : 578    Rarely : 254    Rarely : 463    Rarely : 408    1st Qu.:3.000
Monthly:  85    Monthly:  87    Monthly:  83    Monthly: 146    Monthly:  88    Median :4.000
Weekly :  37    Weekly :  63    Weekly :  73    Weekly :  78    Weekly :  76    Mean   :3.623
Daily  : 117    Daily  : 101    Daily  : 108    Daily  : 128    Daily  : 123    3rd Qu.:5.000
                                                                                Max.   :5.000
                                                                                NA's   :1300
   body2_i         body3_i         body4_i         body5_i         phys1_i         phys2_i
Min.   :1.000   Min.   :1.000   Min.   :1.00   Min.   :1.000   Min.   :1.000   Min.   :1.000
1st Qu.:3.000   1st Qu.:4.000   1st Qu.:3.00   1st Qu.:4.000   1st Qu.:3.000   1st Qu.:4.000
Median :4.000   Median :5.000   Median :4.00   Median :5.000   Median :4.000   Median :4.000
Mean   :3.558   Mean   :4.167   Mean   :3.68   Mean   :4.256   Mean   :3.938   Mean   :4.053
3rd Qu.:5.000   3rd Qu.:5.000   3rd Qu.:5.00   3rd Qu.:5.000   3rd Qu.:5.000   3rd Qu.:5.000
Max.   :5.000   Max.   :5.000   Max.   :5.00   Max.   :5.000   Max.   :5.000   Max.   :5.000
NA's   :1315    NA's   :1308    NA's   :1311   NA's   :1307    NA's   :78      NA's   :90
   phys3_i         phys4_i         phys5_i         phys6_i         phys7_i         phys8_i
Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000
1st Qu.:4.000   1st Qu.:4.000   1st Qu.:2.000   1st Qu.:3.000   1st Qu.:2.000   1st Qu.:4.000
Median :5.000   Median :5.000   Median :4.000   Median :4.000   Median :4.000   Median :5.000
Mean   :4.186   Mean   :4.135   Mean   :3.638   Mean   :3.666   Mean   :3.693   Mean   :4.325
3rd Qu.:5.000   3rd Qu.:5.000   3rd Qu.:5.000   3rd Qu.:5.000   3rd Qu.:5.000   3rd Qu.:5.000
Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000
NA's   :107     NA's   :140     NA's   :109     NA's   :121     NA's   :100     NA's   :111
   depre1_i        depre2_i        depre3_i        depre4_i        depre5_i        depre6_i
Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000
1st Qu.:1.000   1st Qu.:2.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000
Median :2.000   Median :3.000   Median :1.000   Median :2.000   Median :2.000   Median :2.000
Mean   :2.332   Mean   :2.684   Mean   :1.817   Mean   :2.209   Mean   :2.485   Mean   :2.473
```

Step 1: pull a completed data set for each imputation ...

```
 3rd Qu.:3.000   3rd Qu.:3.000   3rd Qu.:3.000   3rd Qu.:3.000   3rd Qu.:4.000   3rd Qu.:3.000
 Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000
 NA's   :78      NA's   :87      NA's   :96      NA's   :113     NA's   :117     NA's   :95
    gotBu1_i        gotBu2_i        gotBu3_i        gotBu4_i        gotBu5_i        gotBu6_i
 Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000
 1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000
 Median :1.000   Median :1.000   Median :1.000   Median :1.000   Median :1.000   Median :1.000
 Mean   :1.848   Mean   :1.652   Mean   :1.398   Mean   :1.759   Mean   :1.353   Mean   :1.235
 3rd Qu.:2.000   3rd Qu.:2.000   3rd Qu.:1.000   3rd Qu.:2.000   3rd Qu.:1.000   3rd Qu.:1.000
 Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000
 NA's   :1322    NA's   :1329    NA's   :1340    NA's   :1331    NA's   :1351    NA's   :1359
    gotBu7_i        gotBu8_i        gotBu9_i        buOth1_i        buOth2_i        buOth3_i
 Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.00   Min.   :1.000
 1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.00   1st Qu.:1.000
 Median :1.000   Median :1.000   Median :1.000   Median :1.000   Median :1.00   Median :1.000
 Mean   :1.568   Mean   :1.195   Mean   :1.166   Mean   :1.579   Mean   :1.42   Mean   :1.292
 3rd Qu.:2.000   3rd Qu.:1.000   3rd Qu.:1.000   3rd Qu.:2.000   3rd Qu.:1.00   3rd Qu.:1.000
 Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.00   Max.   :5.000
 NA's   :1347    NA's   :1357    NA's   :1355    NA's   :1339    NA's   :1349   NA's   :1364
    buOth4_i        buOth5_i        buOth6_i        buOth7_i        buOth8_i        buOth9_i
 Min.   :1.000   Min.   :1.0     Min.   :1.000   Min.   :1.00    Min.   :1.000   Min.   :1.000
 1st Qu.:1.000   1st Qu.:1.0     1st Qu.:1.000   1st Qu.:1.00    1st Qu.:1.000   1st Qu.:1.000
 Median :1.000   Median :1.0     Median :1.000   Median :1.00    Median :1.000   Median :1.000
 Mean   :1.264   Mean   :1.2     Mean   :1.158   Mean   :1.25    Mean   :1.155   Mean   :1.147
 3rd Qu.:1.000   3rd Qu.:1.0     3rd Qu.:1.000   3rd Qu.:1.00    3rd Qu.:1.000   3rd Qu.:1.000
 Max.   :5.000   Max.   :5.0     Max.   :5.000   Max.   :5.00    Max.   :5.000   Max.   :5.000
 NA's   :1358    NA's   :1355    NA's   :1356    NA's   :1359    NA's   :1365    NA's   :1357
     alc1_i          alc2_i          alc3_i          alc4_i          alc5_i
 Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000   Min.   :1.000
 1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000
 Median :1.000   Median :1.000   Median :1.000   Median :1.000   Median :1.000
 Mean   :1.191   Mean   :1.224   Mean   :1.152   Mean   :1.251   Mean   :1.206
 3rd Qu.:1.000   3rd Qu.:1.000   3rd Qu.:1.000   3rd Qu.:1.000   3rd Qu.:1.000
 Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000   Max.   :5.000
```

Step 1: pull a completed data set for each imputation ...

```
NA's   :192     NA's   :207     NA's   :257     NA's   :246     NA's   :206
```

- Replace the "_i" variables with fillins from "_o" data (as.integer coerces to integer).

```
ordvars <- grep("^.*_o$", colnames(imps[[1]]), value = TRUE)
## Re-create the integer coded variables
for(i in seq_along(imps)){
    oneds <- imps[[i]]
    for(j in ordvars){
        newvar <- as.integer(oneds[ , j])
        newname <- gsub("_o$", "_i", j)
        oneds[ , newname] <- as.integer(oneds[ , j])
    }
    imps[[i]] <- oneds
 }
```

Step 2: Run each data set

```
sem.01.int.fits <- list()
for(i in seq_along(imps)){
     sem.01.int.fits[[i]] <- sem(model = sem.01.int, mimic =
         "Mplus",
                          estimator = "ML", data = imps[[i]])
 }
```

Step 3: Pool the fits

```
library(mitools)
int.betas <- MIextract(sem.01.int.fits, fun = coef)
int.vars <- MIextract(sem.01.int.fits, fun = vcov)
int.fits.pooled <- summary(MIcombine(int.betas, int.vars))
```

And the result is

```
int.fits.pooled
```

```
                      results           se      (lower     upper) missInfo
gotBully=~gotBu1_i 1.1982834 0.025817251 1.14548816 1.2510786     41 %
gotBully=~gotBu2_i 1.2450029 0.027455181 1.18693907 1.3030667     54 %
gotBully=~gotBu3_i 1.3261447 0.027159753 1.26782438 1.3844651     59 %
gotBully=~gotBu4_i 1.2742133 0.023171474 1.22774321 1.3206833     30 %
gotBully=~gotBu5_i 1.3822795 0.024417522 1.33151645 1.4330425     48 %
gotBully=~gotBu6_i 1.3933757 0.032275120 1.31864261 1.4681088     77 %
gotBully=~gotBu7_i 1.3330777 0.029120884 1.27003544 1.3961200     62 %
gotBully=~gotBu8_i 1.3018800 0.034611116 1.22027251 1.3834875     80 %
gotBully=~gotBu9_i 1.2643364 0.022848186 1.21635226 1.3123205     52 %
alcohol=~alc1_i    0.6476732 0.015491549 0.61347024 0.6818762     67 %
alcohol=~alc2_i    0.6086073 0.020824494 0.55889546 0.6583191     82 %
alcohol=~alc3_i    0.7075967 0.019749221 0.66025848 0.7549349     83 %
alcohol=~alc4_i    0.7256755 0.021750158 0.67421283 0.7771382     81 %
alcohol=~alc5_i    0.7334636 0.019139446 0.68869426 0.7782330     79 %
alcohol~gotBully   0.1355003 0.022911952 0.08691018 0.1840905     55 %
gotBu1_i~~gotBu1_i 1.0353404 0.033400361 0.96454949 1.1061312     55 %
gotBu2_i~~gotBu2_i 0.8295723 0.023851361 0.78103522 0.8781094     39 %
gotBu3_i~~gotBu3_i 0.5582119 0.021624500 0.51050299 0.6059207     67 %
gotBu4_i~~gotBu4_i 0.8244160 0.027230818 0.76663301 0.8821990     56 %
gotBu5_i~~gotBu5_i 0.4669792 0.014498018 0.43749403 0.4964644     38 %
gotBu6_i~~gotBu6_i 0.2842870 0.012326163 0.25745551 0.3111184     63 %
gotBu7_i~~gotBu7_i 0.6816414 0.026360862 0.62313504 0.7401477     68 %
gotBu8_i~~gotBu8_i 0.4134766 0.035781117 0.32026300 0.5066903     94 %
gotBu9_i~~gotBu9_i 0.3682245 0.016117252 0.33193495 0.4045141     71 %
alc1_i~~alc1_i     0.1776069 0.006686170 0.16328234 0.1919314     59 %
alc2_i~~alc2_i     0.2215927 0.008605126 0.20263426 0.2405512     66 %
alc3_i~~alc3_i     0.1044154 0.005932963 0.09089545 0.1179353     74 %
alc4_i~~alc4_i     0.2137228 0.013176746 0.18133817 0.2461073     86 %
alc5_i~~alc5_i     0.1330404 0.008305480 0.11322733 0.1528534     82 %
```

And the result is ...

```
gotBu1_i~1          2.4945845 0.025778243 2.44379283 2.5453762     14 %
gotBu2_i~1          2.3512138 0.026920128 2.29756704 2.4048606     25 %
gotBu3_i~1          2.1739496 0.027201024 2.11944390 2.2284553     29 %
gotBu4_i~1          2.4711951 0.024249163 2.42365625 2.5187340      3 %
gotBu5_i~1          2.1598973 0.028645275 2.10191830 2.2178763     36 %
gotBu6_i~1          2.0893091 0.029804433 2.02768726 2.1509308     46 %
gotBu7_i~1          2.3285714 0.027479934 2.27375776 2.3833851     26 %
gotBu8_i~1          2.0049953 0.028322632 1.94686221 2.0631285     43 %
gotBu9_i~1          1.9584967 0.024992128 1.90845074 2.0085427     29 %
alc1_i~1            1.2745098 0.013620703 1.24734524 1.3016744     26 %
alc2_i~1            1.3049953 0.013959416 1.27695972 1.3330309     31 %
alc3_i~1            1.2450980 0.015150098 1.21408709 1.2761090     41 %
alc4_i~1            1.3452848 0.014556527 1.31649282 1.3740767     19 %
alc5_i~1            1.3007470 0.014168749 1.27260883 1.3288851     22 %
```

Ordinal version of the SEM

```
sem.01.ord <- '
 ## the measurement model
 gotBully =~ NA*gotBu1_o + gotBu2_o + gotBu3_o
              + gotBu4_o + gotBu5_o + gotBu6_o
              + gotBu7_o + gotBu8_o + gotBu9_o
 gotBully ~~ 1*gotBully
 alcohol =~ NA*alc1_o + alc2_o + alc3_o
             + alc4_o + alc5_o
 alcohol ~~ 1*alcohol
 # regress
 alcohol ~ gotBully
 '
## Run on each imputed data set
sem.01.ord.fits <- list()
for(i in seq_along(imps)){
     sem.01.ord.fits[[i]] <- sem(model = sem.01.ord, mimic =
         "Mplus",
                         estimator = "DWLS", data = imps[[i]])
 }
```

Ordinal version of the SEM ...

```
ord.betas <- MIextract(sem.01.ord.fits, fun = coef)
ord.vars <- MIextract(sem.01.ord.fits, fun = vcov)
ord.fits.pooled <- summary(MIcombine(ord.betas, ord.vars))
```

And the result is

```
ord.fits.pooled
```

```
                       results          se       (lower      upper) missInfo
gotBully=~gotBu1_o  0.84958774 0.006344951  0.834605389 0.86457008      80 %
gotBully=~gotBu2_o  0.88391019 0.006161330  0.869160713 0.89865966      82 %
gotBully=~gotBu3_o  0.90993262 0.004768570  0.899023760 0.92084148      74 %
gotBully=~gotBu4_o  0.88371316 0.006461694  0.868053337 0.89937298      84 %
gotBully=~gotBu5_o  0.93298054 0.003428420  0.925764495 0.94019658      53 %
gotBully=~gotBu6_o  0.94237464 0.003834359  0.933823365 0.95092592      69 %
gotBully=~gotBu7_o  0.89415037 0.006826189  0.877197891 0.91110285      88 %
gotBully=~gotBu8_o  0.93080094 0.006285709  0.915263005 0.94633887      87 %
gotBully=~gotBu9_o  0.92745771 0.005222476  0.915054060 0.93986135      81 %
alcohol=~alc1_o     0.89462489 0.005797322  0.883249783 0.90600000       6 %
alcohol=~alc2_o     0.84983885 0.007716939  0.834169168 0.86550853      37 %
alcohol=~alc3_o     0.96226982 0.005996541  0.950088279 0.97445136      38 %
alcohol=~alc4_o     0.91009138 0.006728283  0.896163608 0.92401915      46 %
alcohol=~alc5_o     0.93570462 0.005306686  0.925230649 0.94617859      16 %
alcohol~gotBully    0.13621288 0.019672222  0.083554569 0.18887120      96 %
gotBu1_o|t1        -0.18025162 0.019848098 -0.219192761 -0.14131047      6 %
gotBu1_o|t2         0.20648468 0.020346800  0.166484034 0.24648532      10 %
gotBu1_o|t3         0.44699079 0.024149766  0.398111417 0.49587016      36 %
gotBu1_o|t4         0.92536957 0.026863698  0.871229173 0.97950998      33 %
gotBu2_o|t1        -0.05842792 0.019585078 -0.096835130 -0.02002071      4 %
gotBu2_o|t2         0.25661456 0.020393365  0.216530774 0.29669834      10 %
gotBu2_o|t3         0.64642332 0.023177563  0.600416892 0.69242976      22 %
gotBu2_o|t4         0.95377132 0.036924031  0.871842355 1.03570029      68 %
gotBu3_o|t1         0.17620880 0.019708607  0.137556871 0.21486073       5 %
gotBu3_o|t2         0.36111032 0.020595593  0.320637161 0.40158348      10 %
gotBu3_o|t3         0.66554355 0.032212191  0.595179233 0.73590786      64 %
gotBu3_o|t4         1.11739421 0.037715373  1.034872364 1.19991605      64 %
gotBu4_o|t1        -0.16682771 0.020046256 -0.206190214 -0.12746520      8 %
gotBu4_o|t2         0.20457132 0.019985784  0.165345464 0.24379718       7 %
```

And the result is ...

```
gotBu4_o|t3          0.50652007 0.023907583  0.458394041  0.55464609     32 %
gotBu4_o|t4          0.91648471 0.030057757  0.853816238  0.97915318     49 %
gotBu5_o|t1          0.22132930 0.019573921  0.182957534  0.25970106      3 %
gotBu5_o|t2          0.37840721 0.021549667  0.335807367  0.42100705     18 %
gotBu5_o|t3          0.65724665 0.032582587  0.585762639  0.72873066     65 %
gotBu5_o|t4          1.08342164 0.033644126  1.012162629  1.15468064     55 %
gotBu6_o|t1          0.31206147 0.019982841  0.272868070  0.35125486      5 %
gotBu6_o|t2          0.42573197 0.020966849  0.384490407  0.46697354     11 %
gotBu6_o|t3          0.51517916 0.022955533  0.469435865  0.56092245     25 %
gotBu6_o|t4          1.45569057 0.104533640  1.181433079  1.72994806     94 %
gotBu7_o|t1          0.04073535 0.019458141  0.002587177  0.07888353      3 %
gotBu7_o|t2          0.27504051 0.019969890  0.235864824  0.31421620      6 %
gotBu7_o|t3          0.51497543 0.029971895  0.450334428  0.57961643     61 %
gotBu7_o|t4          1.03725488 0.034444277  0.963288705  1.11122105     59 %
gotBu8_o|t1          0.34516588 0.020247499  0.305429630  0.38490212      7 %
gotBu8_o|t2          0.43844745 0.020415602  0.398395506  0.47849940      6 %
gotBu8_o|t3          0.83578886 0.058537977  0.688547829  0.98302990     89 %
gotBu8_o|t4          1.23989330 0.044668817  1.138618682  1.34116792     73 %
gotBu9_o|t1          0.38305674 0.020457485  0.342891571  0.42322192      8 %
gotBu9_o|t2          0.44761238 0.020359360  0.407680912  0.48754385      5 %
gotBu9_o|t3          0.82460462 0.042447256  0.725171596  0.92403763     79 %
gotBu9_o|t4          1.43632886 0.044858570  1.337739615  1.53491811     66 %
alc1_o|t1            1.00068096 0.024685676  0.952064348  1.04929756     13 %
alc1_o|t2            1.59633019 0.036545128  1.523121350  1.66953904     29 %
alc1_o|t3            1.81698110 0.044636984  1.726485983  1.90747622     37 %
alc1_o|t4            1.94090120 0.042844866  1.856559580  2.02524282     13 %
alc2_o|t1            0.87375797 0.023377110  0.827772782  0.91974316     11 %
alc2_o|t2            1.58979976 0.039621433  1.508565753  1.67103377     42 %
alc2_o|t3            1.79894166 0.043221272  1.711759492  1.88612382     34 %
alc2_o|t4            2.01736685 0.049045720  1.919576104  2.11515759     26 %
alc3_o|t1            1.18149348 0.029036807  1.123349481  1.23963747     29 %
alc3_o|t2            1.54035669 0.036845312  1.465707848  1.61500552     36 %
alc3_o|t3            1.74254979 0.046671227  1.645072080  1.84002751     50 %
alc3_o|t4            1.98039030 0.049366118  1.881069379  2.07971122     32 %
```

And the result is ...

alc4_o|t1	0.88650811	0.023037441	0.841278008	0.93173822	8 %
alc4_o|t2	1.39286736	0.030031505	1.333606443	1.45212827	16 %
alc4_o|t3	1.67533889	0.040814007	1.592315132	1.75836265	38 %
alc4_o|t4	1.89882735	0.042206396	1.815520394	1.98213430	16 %
alc5_o|t1	0.98269055	0.024306087	0.934874273	1.03050682	12 %
alc5_o|t2	1.49938979	0.032866291	1.434206701	1.56457288	21 %
alc5_o|t3	1.70311709	0.041466716	1.618843963	1.78739021	38 %
alc5_o|t4	1.93267970	0.045629373	1.841740117	2.02361929	25 %

For comparison

```
sem.01.ord.ld <- sem(model = sem.01.ord, mimic = "Mplus",
                     estimator = "DWLS", data = hbsc,
                         missing = "listwise")
sem.01.ord.pair <- sem(model = sem.01.ord, mimic = "Mplus",
                     estimator = "DWLS", data = hbsc,
                         missing = "pairwise")
```

```
table509 <- semTable(list("listwise" = sem.01.ord.ld,
    "pairwise" = sem.01.ord.pair),
              columns = c("estsestars","rsquare"), type =
                  "tex", longtable=TRUE,
              file = file.path(odir, "semtable509"),
                  print.results=FALSE)
```

Double-check a couple of the fitted models

Results on coefficients are quite different.

1. Listwise deletion much like pairwise complete analysis
2. Note Regression slope with listwise deletion twice as large, is this meaningful?
3. Wondered if there is something wrong in the pooling, check a couple of models from the list

```
summary(sem.01.ord.fits[[1]])
```

```
lavaan 0.6-3 ended normally after 25 iterations

  Optimization method                           NLMINB
  Number of free parameters                         71

  Number of observations                          4284

  Estimator                                       DWLS
  Model Fit Test Statistic                     655.170
  Degrees of freedom                                76
  P-value (Chi-square)                           0.000
```

Double-check a couple of the fitted models ...

```
Parameter Estimates:

  Information                                     Expected
  Information saturated (h1) model          Unstructured
  Standard Errors                                Standard

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)
  gotBully =~
    gotBu1_o          0.844    0.003  261.198    0.000
    gotBu2_o          0.875    0.003  293.967    0.000
    gotBu3_o          0.905    0.003  335.418    0.000
    gotBu4_o          0.875    0.003  294.915    0.000
    gotBu5_o          0.932    0.002  373.082    0.000
    gotBu6_o          0.943    0.002  406.795    0.000
    gotBu7_o          0.891    0.003  323.355    0.000
    gotBu8_o          0.938    0.003  375.064    0.000
    gotBu9_o          0.927    0.003  366.829    0.000
  alcohol =~
    alc1_o            0.896    0.005  164.537    0.000
    alc2_o            0.856    0.006  141.664    0.000
    alc3_o            0.958    0.005  201.311    0.000
    alc4_o            0.912    0.005  182.528    0.000
    alc5_o            0.934    0.005  194.569    0.000

Regressions:
```

Double-check a couple of the fitted models ...

```
                   Estimate  Std.Err  z-value  P(>|z|)
  alcohol ~
    gotBully          0.156    0.004   36.084    0.000

Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)
   .gotBu1_o          0.000
   .gotBu2_o          0.000
   .gotBu3_o          0.000
   .gotBu4_o          0.000
   .gotBu5_o          0.000
   .gotBu6_o          0.000
   .gotBu7_o          0.000
   .gotBu8_o          0.000
   .gotBu9_o          0.000
   .alc1_o            0.000
   .alc2_o            0.000
   .alc3_o            0.000
   .alc4_o            0.000
   .alc5_o            0.000
    gotBully          0.000
   .alcohol           0.000

Thresholds:
                   Estimate  Std.Err  z-value  P(>|z|)
    gotBu1_o|t1      -0.183    0.019   -9.497    0.000
```

Double-check a couple of the fitted models ...

```
    gotBu1_o|t2      0.210    0.019    10.900    0.000
    gotBu1_o|t3      0.460    0.020    23.100    0.000
    gotBu1_o|t4      0.927    0.022    41.271    0.000
    gotBu2_o|t1     -0.054    0.019    -2.841    0.004
    gotBu2_o|t2      0.264    0.019    13.611    0.000
    gotBu2_o|t3      0.658    0.021    31.749    0.000
    gotBu2_o|t4      1.000    0.023    43.335    0.000
    gotBu3_o|t1      0.182    0.019     9.467    0.000
    gotBu3_o|t2      0.368    0.020    18.747    0.000
    gotBu3_o|t3      0.689    0.021    32.951    0.000
    gotBu3_o|t4      1.154    0.025    46.939    0.000
    gotBu4_o|t1     -0.163    0.019    -8.490    0.000
    gotBu4_o|t2      0.207    0.019    10.717    0.000
    gotBu4_o|t3      0.500    0.020    24.935    0.000
    gotBu4_o|t4      0.936    0.023    41.540    0.000
    gotBu5_o|t1      0.222    0.019    11.509    0.000
    gotBu5_o|t2      0.383    0.020    19.474    0.000
    gotBu5_o|t3      0.672    0.021    32.306    0.000
    gotBu5_o|t4      1.091    0.024    45.588    0.000
    gotBu6_o|t1      0.313    0.019    16.075    0.000
    gotBu6_o|t2      0.422    0.020    21.319    0.000
    gotBu6_o|t3      0.520    0.020    25.835    0.000
    gotBu6_o|t4      1.481    0.029    50.847    0.000
    gotBu7_o|t1      0.044    0.019     2.291    0.022
    gotBu7_o|t2      0.274    0.019    14.129    0.000
    gotBu7_o|t3      0.535    0.020    26.494    0.000
```

Double-check a couple of the fitted models ...

```
    gotBu7_o|t4      1.070    0.024    45.102    0.000
    gotBu8_o|t1      0.347    0.020    17.715    0.000
    gotBu8_o|t2      0.439    0.020    22.135    0.000
    gotBu8_o|t3      0.762    0.021    35.763    0.000
    gotBu8_o|t4      1.227    0.025    48.244    0.000
    gotBu9_o|t1      0.386    0.020    19.595    0.000
    gotBu9_o|t2      0.447    0.020    22.527    0.000
    gotBu9_o|t3      0.810    0.022    37.474    0.000
    gotBu9_o|t4      1.452    0.029    50.703    0.000
    alc1_o|t1        0.993    0.023    43.154    0.000
    alc1_o|t2        1.591    0.031    51.042    0.000
    alc1_o|t3        1.800    0.036    49.973    0.000
    alc1_o|t4        1.922    0.040    48.562    0.000
    alc2_o|t1        0.865    0.022    39.326    0.000
    alc2_o|t2        1.567    0.031    51.046    0.000
    alc2_o|t3        1.771    0.035    50.225    0.000
    alc2_o|t4        1.985    0.042    47.635    0.000
    alc3_o|t1        1.170    0.025    47.250    0.000
    alc3_o|t2        1.541    0.030    51.022    0.000
    alc3_o|t3        1.725    0.034    50.560    0.000
    alc3_o|t4        1.956    0.041    48.071    0.000
    alc4_o|t1        0.877    0.022    39.714    0.000
    alc4_o|t2        1.391    0.028    50.273    0.000
    alc4_o|t3        1.664    0.033    50.875    0.000
    alc4_o|t4        1.883    0.038    49.074    0.000
    alc5_o|t1        0.985    0.023    42.945    0.000
```

Double-check a couple of the fitted models ...

```
    alc5_o|t2          1.499    0.029   50.916    0.000
    alc5_o|t3          1.680    0.033   50.806    0.000
    alc5_o|t4          1.900    0.039   48.853    0.000

Variances:
                   Estimate  Std.Err  z-value  P(>|z|)
    gotBully          1.000
   .alcohol           1.000
   .gotBu1_o          0.287
   .gotBu2_o          0.234
   .gotBu3_o          0.182
   .gotBu4_o          0.234
   .gotBu5_o          0.131
   .gotBu6_o          0.111
   .gotBu7_o          0.207
   .gotBu8_o          0.120
   .gotBu9_o          0.141
   .alc1_o            0.178
   .alc2_o            0.250
   .alc3_o            0.060
   .alc4_o            0.149
   .alc5_o            0.107

Scales y*:
                   Estimate  Std.Err  z-value  P(>|z|)
    gotBu1_o          1.000
```

Double-check a couple of the fitted models ...

```
    gotBu2_o          1.000
    gotBu3_o          1.000
    gotBu4_o          1.000
    gotBu5_o          1.000
    gotBu6_o          1.000
    gotBu7_o          1.000
    gotBu8_o          1.000
    gotBu9_o          1.000
    alc1_o            1.000
    alc2_o            1.000
    alc3_o            1.000
    alc4_o            1.000
    alc5_o            1.000
```

```
summary(sem.01.ord.fits[[4]])
```

Double-check a couple of the fitted models ...

```
lavaan 0.6-3 ended normally after 28 iterations

  Optimization method                           NLMINB
  Number of free parameters                         71

  Number of observations                          4284

  Estimator                                       DWLS
  Model Fit Test Statistic                     642.392
  Degrees of freedom                                76
  P-value (Chi-square)                           0.000

Parameter Estimates:

  Information                                 Expected
  Information saturated (h1) model          Unstructured
  Standard Errors                             Standard

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)
  gotBully =~
    gotBu1_o          0.851    0.003  272.363    0.000
    gotBu2_o          0.887    0.003  307.660    0.000
    gotBu3_o          0.910    0.003  340.966    0.000
    gotBu4_o          0.884    0.003  305.526    0.000
```

Double-check a couple of the fitted models ...

```
    gotBu5_o          0.936    0.002  379.021    0.000
    gotBu6_o          0.941    0.002  404.475    0.000
    gotBu7_o          0.889    0.003  320.817    0.000
    gotBu8_o          0.924    0.003  345.769    0.000
    gotBu9_o          0.927    0.003  361.097    0.000
  alcohol =~
    alc1_o            0.895    0.006  159.786    0.000
    alc2_o            0.848    0.006  134.403    0.000
    alc3_o            0.960    0.005  197.400    0.000
    alc4_o            0.911    0.005  178.514    0.000
    alc5_o            0.939    0.005  193.104    0.000

Regressions:
                   Estimate  Std.Err  z-value  P(>|z|)
  alcohol ~
    gotBully          0.135    0.004   31.283    0.000

Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)
   .gotBu1_o          0.000
   .gotBu2_o          0.000
   .gotBu3_o          0.000
   .gotBu4_o          0.000
   .gotBu5_o          0.000
   .gotBu6_o          0.000
   .gotBu7_o          0.000
```

Double-check a couple of the fitted models ...

```
    .gotBu8_o          0.000
    .gotBu9_o          0.000
    .alc1_o            0.000
    .alc2_o            0.000
    .alc3_o            0.000
    .alc4_o            0.000
    .alc5_o            0.000
     gotBully          0.000
    .alcohol           0.000

Thresholds:
                   Estimate  Std.Err  z-value  P(>|z|)
     gotBu1_o|t1     -0.186    0.019   -9.650    0.000
     gotBu1_o|t2      0.199    0.019   10.321    0.000
     gotBu1_o|t3      0.436    0.020   21.984    0.000
     gotBu1_o|t4      0.928    0.022   41.298    0.000
     gotBu2_o|t1     -0.064    0.019   -3.330    0.001
     gotBu2_o|t2      0.249    0.019   12.850    0.000
     gotBu2_o|t3      0.643    0.021   31.101    0.000
     gotBu2_o|t4      0.934    0.023   41.486    0.000
     gotBu3_o|t1      0.174    0.019    9.039    0.000
     gotBu3_o|t2      0.355    0.020   18.110    0.000
     gotBu3_o|t3      0.691    0.021   33.038    0.000
     gotBu3_o|t4      1.120    0.024   46.228    0.000
     gotBu4_o|t1     -0.175    0.019   -9.100    0.000
     gotBu4_o|t2      0.197    0.019   10.199    0.000
```

Double-check a couple of the fitted models ...

```
    gotBu4_o|t3     0.512    0.020    25.505    0.000
    gotBu4_o|t4     0.916    0.022    40.946    0.000
    gotBu5_o|t1     0.217    0.019    11.235    0.000
    gotBu5_o|t2     0.365    0.020    18.625    0.000
    gotBu5_o|t3     0.650    0.021    31.425    0.000
    gotBu5_o|t4     1.066    0.024    45.003    0.000
    gotBu6_o|t1     0.305    0.019    15.680    0.000
    gotBu6_o|t2     0.422    0.020    21.319    0.000
    gotBu6_o|t3     0.510    0.020    25.385    0.000
    gotBu6_o|t4     1.509    0.030    50.951    0.000
    gotBu7_o|t1     0.037    0.019     1.955    0.051
    gotBu7_o|t2     0.269    0.019    13.885    0.000
    gotBu7_o|t3     0.535    0.020    26.494    0.000
    gotBu7_o|t4     1.036    0.023    44.281    0.000
    gotBu8_o|t1     0.337    0.020    17.230    0.000
    gotBu8_o|t2     0.431    0.020    21.773    0.000
    gotBu8_o|t3     0.880    0.022    39.824    0.000
    gotBu8_o|t4     1.199    0.025    47.768    0.000
    gotBu9_o|t1     0.375    0.020    19.080    0.000
    gotBu9_o|t2     0.441    0.020    22.225    0.000
    gotBu9_o|t3     0.852    0.022    38.880    0.000
    gotBu9_o|t4     1.419    0.028    50.494    0.000
    alc1_o|t1       0.999    0.023    43.309    0.000
    alc1_o|t2       1.591    0.031    51.042    0.000
    alc1_o|t3       1.809    0.036    49.888    0.000
    alc1_o|t4       1.949    0.040    48.186    0.000
```

Double-check a couple of the fitted models ...

```
    alc2_o|t1          0.873    0.022   39.575    0.000
    alc2_o|t2          1.587    0.031   51.044    0.000
    alc2_o|t3          1.794    0.036   50.027    0.000
    alc2_o|t4          2.033    0.043   46.839    0.000
    alc3_o|t1          1.186    0.025   47.533    0.000
    alc3_o|t2          1.539    0.030   51.019    0.000
    alc3_o|t3          1.749    0.035   50.397    0.000
    alc3_o|t4          1.981    0.042   47.700    0.000
    alc4_o|t1          0.888    0.022   40.072    0.000
    alc4_o|t2          1.391    0.028   50.273    0.000
    alc4_o|t3          1.666    0.033   50.866    0.000
    alc4_o|t4          1.893    0.039   48.943    0.000
    alc5_o|t1          0.980    0.023   42.788    0.000
    alc5_o|t2          1.497    0.029   50.910    0.000
    alc5_o|t3          1.702    0.034   50.696    0.000
    alc5_o|t4          1.937    0.040   48.353    0.000

Variances:
                   Estimate  Std.Err  z-value  P(>|z|)
    gotBully          1.000
   .alcohol           1.000
   .gotBu1_o          0.275
   .gotBu2_o          0.214
   .gotBu3_o          0.172
   .gotBu4_o          0.218
   .gotBu5_o          0.123
```

Double-check a couple of the fitted models ...

```
    .gotBu6_o          0.114
    .gotBu7_o          0.209
    .gotBu8_o          0.146
    .gotBu9_o          0.140
    .alc1_o            0.184
    .alc2_o            0.267
    .alc3_o            0.061
    .alc4_o            0.154
    .alc5_o            0.103

Scales y*:
                  Estimate  Std.Err  z-value  P(>|z|)
    gotBu1_o         1.000
    gotBu2_o         1.000
    gotBu3_o         1.000
    gotBu4_o         1.000
    gotBu5_o         1.000
    gotBu6_o         1.000
    gotBu7_o         1.000
    gotBu8_o         1.000
    gotBu9_o         1.000
    alc1_o           1.000
    alc2_o           1.000
    alc3_o           1.000
    alc4_o           1.000
    alc5_o           1.000
```

Double-check a couple of the fitted models ...

Multivariate Normal Imputation

```
library(Amelia)
## Drop the redundant integer versions of the variables
dato <- hbsc[ , grep("^.*_i$", colnames(hbsc), invert = TRUE)]
## Don't have good reason for emburn setting, but
## run was quitting so quickly I was not comfortable
datoamelia <- amelia(dato, m = 5L, p2s=0,  idvars = "stud_id",
                     ords = grep("^.*_o$", colnames(hbsc),
                         value = TRUE),
                     noms = c("Gender", "Grade"),
                     emburn = c(100L, 10L))
## Extract the imputed complete data sets
imps <- datoamelia$imputations
## Now re-create the integer coded variables
ordvars <- grep("^.*_o$", colnames(imps[[1]]), value = TRUE)
for(i in seq_along(imps)){
     oneds <- imps[[i]]
     for(j in ordvars){
         newvar <- as.integer(oneds[ , j])
         newname <- gsub("_o$", "_i", j)
         oneds[ , newname] <- as.integer(oneds[ , j])
     }
```

Multivariate Normal Imputation ...

```
      imps[[i]] <- oneds
  }
saveRDS(imps, file.path(wdir, "amelia-imps.rds"))
```

Run Models with Saved Amelia Imputations

```
imps <- readRDS(file.path(wdir, "amelia-imps.rds"))
```

```
## Run same model for each imputed data set
ord.amelia.fits <- list()
for (i in seq_along(imps)){
     ord.amelia.fits[[i]] <- sem(model = sem.01.ord, data =
         imps[[i]],
             mimic = "Mplus", estimator = "DWLS")
 }
```

```
ord.amelia.betas <- MIextract(ord.amelia.fits, fun = coef)
ord.amelia.vars <- MIextract(ord.amelia.fits, fun = vcov)
ord.amelia.fits.pooled <- summary(MIcombine(ord.amelia.betas,
    ord.amelia.vars))
```

Run Models with Saved Amelia Imputations

```
Multiple imputation results:
      MIcombine.default(ord.amelia.betas, ord.amelia.vars)
                       results          se        (lower    upper)
                           missInfo
gotBully=~gotBu1_o 0.6991060 0.014690604  0.6652397635 0.7329723      76
     %
gotBully=~gotBu2_o 0.7243062 0.014202636  0.6920209397 0.7565914      73
     %
gotBully=~gotBu3_o 0.7389645 0.011076978  0.7160359961 0.7618930      46
     %
gotBully=~gotBu4_o 0.7362147 0.014396653  0.7032196288 0.7692097      75
     %
gotBully=~gotBu5_o 0.7717544 0.012933985  0.7436246697 0.7998842      63
     %
gotBully=~gotBu6_o 0.7975737 0.009336515  0.7792017503 0.8159457      12
     %
gotBully=~gotBu7_o 0.7123489 0.011458063  0.6882973027 0.7364005      52
     %
gotBully=~gotBu8_o 0.7681203 0.017041575  0.7290167509 0.8072238      75
     %
gotBully=~gotBu9_o 0.7625237 0.017669718  0.7218136093 0.8032338      76
     %
alcohol=~alc1_o    0.8184650 0.010053358  0.7984271789 0.8385027      25
     %
```

Run Models with Saved Amelia Imputations ...

```
alcohol=~alc2_o      0.7531594 0.010397894  0.7325270365 0.7737918      22
     %
alcohol=~alc3_o      0.8963321 0.010472284  0.8749751740 0.9176891      40
     %
alcohol=~alc4_o      0.8342438 0.012003417  0.8086249009 0.8598628      57
     %
alcohol=~alc5_o      0.8709425 0.009381282  0.8522183869 0.8896667      27
     %
alcohol~gotBully     0.2783286 0.019147646  0.2299428918 0.3267144      90
     %
gotBu1_o|t1          0.1186529 0.048091023 -0.0007469421 0.2380527      88
     %
gotBu1_o|t2          0.6728061 0.064265091  0.5075447513 0.8380675      92
     %
gotBu1_o|t3          0.9953136 0.068846094  0.8191122512 1.1715150      92
     %
gotBu1_o|t4          1.3462670 0.058942318  1.2042684901 1.4882655      83
     %
gotBu2_o|t1          0.2721201 0.056432193  0.1282898763 0.4159502      91
     %
gotBu2_o|t2          0.8106289 0.067512230  0.6367509433 0.9845068      92
     %
gotBu2_o|t3          1.1539149 0.073731234  0.9651324268 1.3426973      92
     %
gotBu2_o|t4          1.5588790 0.058184826  1.4235723569 1.6941856      78
     %
```

Run Models with Saved Amelia Imputations ...

```
gotBu3_o|t1          0.6540871 0.034721587  0.5763373553 0.7318369      70
     %
gotBu3_o|t2          1.1352009 0.035439489  1.0594056868 1.2109961      58
     %
gotBu3_o|t3          1.4975565 0.041633297  1.4092835583 1.5858295      55
     %
gotBu3_o|t4          1.8481843 0.042570916  1.7633933573 1.9329752      25
     %
gotBu4_o|t1          0.1920224 0.043319456  0.0869304765 0.2971144      84
     %
gotBu4_o|t2          0.7822849 0.049881329  0.6603305509 0.9042393      86
     %
gotBu4_o|t3          1.1556472 0.040862486  1.0644153123 1.2468791      69
     %
gotBu4_o|t4          1.5234609 0.039862383  1.4405296675 1.6063921      48
     %
gotBu5_o|t1          0.7505417 0.042038828  0.6517395218 0.8493438      79
     %
gotBu5_o|t2          1.2074801 0.044195285  1.1071336105 1.3078267      73
     %
gotBu5_o|t3          1.5503738 0.036405629  1.4769764757 1.6237710      33
     %
gotBu5_o|t4          1.9065720 0.040104990  1.8279089877 1.9852350       5
     %
gotBu6_o|t1          0.9320516 0.065301696  0.7656765430 1.0984267      91
     %
```

Run Models with Saved Amelia Imputations ...

```
gotBu6_o|t2          1.4160054 0.052945798  1.2931994510 1.5388114      77
     %
gotBu6_o|t3          1.7967755 0.046768174  1.7002307643 1.8933202      45
     %
gotBu6_o|t4          2.1329846 0.053211634  2.0273388751 2.2386304      22
     %
gotBu7_o|t1          0.5002629 0.045196983  0.3905328519 0.6099929      85
     %
gotBu7_o|t2          0.9791734 0.050717131  0.8565431823 1.1018037      84
     %
gotBu7_o|t3          1.2960440 0.044000713  1.1975933131 1.3944947      70
     %
gotBu7_o|t4          1.6678122 0.041616117  1.5825504498 1.7530740      42
     %
gotBu8_o|t1          1.0504286 0.065349344  0.8851193259 1.2157379      90
     %
gotBu8_o|t2          1.5328972 0.068389775  1.3665558493 1.6992386      85
     %
gotBu8_o|t3          1.8669101 0.059157175  1.7374506710 1.9963695      65
     %
gotBu8_o|t4          2.1634166 0.052867643  2.0590930006 2.2677401      16
     %
gotBu9_o|t1          1.1085327 0.075344119  0.9144716568 1.3025938      92
     %
gotBu9_o|t2          1.5723952 0.080658357  1.3705164486 1.7742739      89
     %
```

Run Models with Saved Amelia Imputations ...

```
gotBu9_o|t3          1.8972073 0.060949151  1.7635665748 2.0308480      65
     %
gotBu9_o|t4          2.1744520 0.052956630  2.0700847467 2.2788192      14
     %
alc1_o|t1            1.0838649 0.024713178  1.0353598145 1.1323700       7
     %
alc1_o|t2            1.8222068 0.039079810  1.7452678606 1.8991457      13
     %
alc1_o|t3            2.1559579 0.049407506  2.0590743034 2.2528415       4
     %
alc1_o|t4            2.3232203 0.057023186  2.2114559065 2.4349847       1
     %
alc2_o|t1            0.9452435 0.023049797  0.9000471012 0.9904399       4
     %
alc2_o|t2            1.7927941 0.037263199  1.7196338040 1.8659544       8
     %
alc2_o|t3            2.0799246 0.045649850  1.9904424129 2.1694068       2
     %
alc2_o|t4            2.4162240 0.063465181  2.2918060063 2.5406419       3
     %
alc3_o|t1            1.2920387 0.028085131  1.2367279968 1.3473493      13
     %
alc3_o|t2            1.7904809 0.037574521  1.7166399793 1.8643217      10
     %
alc3_o|t3            2.0749249 0.046437800  1.9838075236 2.1660423       6
     %
```

Run Models with Saved Amelia Imputations ...

```
alc3_o|t4          2.3576145 0.059155343  2.2416692259 2.4735597       1
     %
alc4_o|t1          0.9670501 0.022932909  0.9221002399 1.0119999       1
     %
alc4_o|t2          1.5780912 0.033629754  1.5116963884 1.6444859      16
     %
alc4_o|t3          1.9339211 0.040759499  1.8539977309 2.0138445       4
     %
alc4_o|t4          2.2118150 0.051891286  2.1100745672 2.3135553       3
     %
alc5_o|t1          1.0686177 0.024414241  1.0207193669 1.1165161       6
     %
alc5_o|t2          1.7269411 0.039685571  1.6475528981 1.8063294      28
     %
alc5_o|t3          2.0362106 0.044757629  1.9484083280 2.1240128       6
     %
alc5_o|t4          2.3045093 0.056033477  2.1946835865 2.4143349       1
     %
```

Amelia imutation results contradict

- Note the estimate here for the alcohol ~ bully linkage is about the same as we got with listwise deletion
- Again, I wondered if there is something wrong in the pooling, check a couple of models from the list

```
summary(ord.amelia.fits[[1]])
```

```
lavaan 0.6-3 ended normally after 17 iterations

  Optimization method                           NLMINB
  Number of free parameters                         71

  Number of observations                          4284

  Estimator                                       DWLS
  Model Fit Test Statistic                     764.863
  Degrees of freedom                                76
  P-value (Chi-square)                           0.000

Parameter Estimates:

  Information                                 Expected
```

Amelia imutation results contradict ...

```
  Information saturated (h1) model          Unstructured
  Standard Errors                               Standard

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)
  gotBully =~
    gotBu1_o          0.715    0.008   92.431    0.000
    gotBu2_o          0.737    0.008   94.100    0.000
    gotBu3_o          0.737    0.008   89.405    0.000
    gotBu4_o          0.750    0.008   97.328    0.000
    gotBu5_o          0.772    0.008   93.973    0.000
    gotBu6_o          0.797    0.009   93.741    0.000
    gotBu7_o          0.718    0.008   88.441    0.000
    gotBu8_o          0.776    0.009   84.381    0.000
    gotBu9_o          0.764    0.009   81.406    0.000
  alcohol =~
    alc1_o            0.815    0.009   92.833    0.000
    alc2_o            0.753    0.009   81.492    0.000
    alc3_o            0.890    0.008  106.425    0.000
    alc4_o            0.832    0.008  100.727    0.000
    alc5_o            0.872    0.008  107.576    0.000

Regressions:
                   Estimate  Std.Err  z-value  P(>|z|)
  alcohol ~
    gotBully          0.291    0.007   42.121    0.000
```

Amelia imutation results contradict ...

```
Intercepts:
                    Estimate   Std.Err   z-value   P(>|z|)
   .gotBu1_o           0.000
   .gotBu2_o           0.000
   .gotBu3_o           0.000
   .gotBu4_o           0.000
   .gotBu5_o           0.000
   .gotBu6_o           0.000
   .gotBu7_o           0.000
   .gotBu8_o           0.000
   .gotBu9_o           0.000
   .alc1_o             0.000
   .alc2_o             0.000
   .alc3_o             0.000
   .alc4_o             0.000
   .alc5_o             0.000
    gotBully           0.000
   .alcohol            0.000

Thresholds:
                    Estimate   Std.Err   z-value   P(>|z|)
    gotBu1_o|t1        0.133     0.019     6.934     0.000
    gotBu1_o|t2        0.691     0.021    33.067     0.000
    gotBu1_o|t3        1.017     0.023    43.798     0.000
    gotBu1_o|t4        1.361     0.027    49.995     0.000
```

Amelia imutation results contradict ...

```
    gotBu2_o|t1     0.283    0.019    14.585    0.000
    gotBu2_o|t2     0.820    0.022    37.814    0.000
    gotBu2_o|t3     1.157    0.025    46.984    0.000
    gotBu2_o|t4     1.569    0.031    51.047    0.000
    gotBu3_o|t1     0.640    0.021    31.012    0.000
    gotBu3_o|t2     1.143    0.024    46.713    0.000
    gotBu3_o|t3     1.500    0.029    50.922    0.000
    gotBu3_o|t4     1.849    0.037    49.466    0.000
    gotBu4_o|t1     0.171    0.019     8.856    0.000
    gotBu4_o|t2     0.760    0.021    35.677    0.000
    gotBu4_o|t3     1.142    0.024    46.690    0.000
    gotBu4_o|t4     1.506    0.030    50.940    0.000
    gotBu5_o|t1     0.731    0.021    34.609    0.000
    gotBu5_o|t2     1.190    0.025    47.619    0.000
    gotBu5_o|t3     1.524    0.030    50.990    0.000
    gotBu5_o|t4     1.893    0.039    48.943    0.000
    gotBu6_o|t1     0.896    0.022    40.319    0.000
    gotBu6_o|t2     1.378    0.027    50.165    0.000
    gotBu6_o|t3     1.779    0.035    50.154    0.000
    gotBu6_o|t4     2.114    0.047    45.375    0.000
    gotBu7_o|t1     0.486    0.020    24.304    0.000
    gotBu7_o|t2     0.961    0.023    42.261    0.000
    gotBu7_o|t3     1.265    0.026    48.831    0.000
    gotBu7_o|t4     1.659    0.033    50.893    0.000
    gotBu8_o|t1     1.062    0.024    44.929    0.000
    gotBu8_o|t2     1.524    0.030    50.990    0.000
```

Amelia imutation results contradict ...

```
    gotBu8_o|t3      1.883     0.038    49.074     0.000
    gotBu8_o|t4      2.172     0.049    44.214     0.000
    gotBu9_o|t1      1.094     0.024    45.660     0.000
    gotBu9_o|t2      1.591     0.031    51.042     0.000
    gotBu9_o|t3      1.904     0.039    48.806     0.000
    gotBu9_o|t4      2.172     0.049    44.214     0.000
    alc1_o|t1        1.088     0.024    45.539     0.000
    alc1_o|t2        1.812     0.036    49.859     0.000
    alc1_o|t3        2.166     0.049    44.341     0.000
    alc1_o|t4        2.325     0.057    40.814     0.000
    alc2_o|t1        0.941     0.023    41.674     0.000
    alc2_o|t2        1.803     0.036    49.945     0.000
    alc2_o|t3        2.072     0.045    46.159     0.000
    alc2_o|t4        2.401     0.062    38.979     0.000
    alc3_o|t1        1.286     0.026    49.125     0.000
    alc3_o|t2        1.774     0.035    50.202     0.000
    alc3_o|t3        2.062     0.044    46.338     0.000
    alc3_o|t4        2.352     0.059    40.173     0.000
    alc4_o|t1        0.966     0.023    42.420     0.000
    alc4_o|t2        1.587     0.031    51.044     0.000
    alc4_o|t3        1.933     0.040    48.406     0.000
    alc4_o|t4        2.217     0.051    43.252     0.000
    alc5_o|t1        1.073     0.024    45.175     0.000
    alc5_o|t2        1.730     0.034    50.526     0.000
    alc5_o|t3        2.038     0.044    46.759     0.000
    alc5_o|t4        2.300     0.056    41.408     0.000
```

Amelia imutation results contradict ...

```
Variances:
                    Estimate   Std.Err   z-value   P(>|z|)
     gotBully          1.000
    .alcohol           1.000
    .gotBu1_o          0.489
    .gotBu2_o          0.457
    .gotBu3_o          0.457
    .gotBu4_o          0.437
    .gotBu5_o          0.404
    .gotBu6_o          0.364
    .gotBu7_o          0.484
    .gotBu8_o          0.398
    .gotBu9_o          0.417
    .alc1_o            0.280
    .alc2_o            0.385
    .alc3_o            0.141
    .alc4_o            0.249
    .alc5_o            0.176

Scales y*:
                    Estimate   Std.Err   z-value   P(>|z|)
     gotBu1_o          1.000
     gotBu2_o          1.000
     gotBu3_o          1.000
     gotBu4_o          1.000
```

Amelia imutation results contradict ...

```
    gotBu5_o          1.000
    gotBu6_o          1.000
    gotBu7_o          1.000
    gotBu8_o          1.000
    gotBu9_o          1.000
    alc1_o            1.000
    alc2_o            1.000
    alc3_o            1.000
    alc4_o            1.000
    alc5_o            1.000
```

```
summary(ord.amelia.fits[[4]])
```

```
lavaan 0.6-3 ended normally after 18 iterations

  Optimization method                           NLMINB
  Number of free parameters                         71

  Number of observations                          4284

  Estimator                                       DWLS
  Model Fit Test Statistic                     903.987
  Degrees of freedom                                76
  P-value (Chi-square)                           0.000
```

Amelia imutation results contradict ...

```
Parameter Estimates:

  Information                                   Expected
  Information saturated (h1) model        Unstructured
  Standard Errors                             Standard

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)
  gotBully =~
    gotBu1_o          0.696    0.008   85.674    0.000
    gotBu2_o          0.716    0.008   87.057    0.000
    gotBu3_o          0.732    0.009   84.147    0.000
    gotBu4_o          0.720    0.008   87.517    0.000
    gotBu5_o          0.777    0.009   88.781    0.000
    gotBu6_o          0.802    0.009   87.388    0.000
    gotBu7_o          0.713    0.009   82.949    0.000
    gotBu8_o          0.780    0.010   79.846    0.000
    gotBu9_o          0.785    0.010   78.526    0.000
  alcohol =~
    alc1_o            0.815    0.009   92.809    0.000
    alc2_o            0.748    0.009   80.726    0.000
    alc3_o            0.893    0.008  106.294    0.000
    alc4_o            0.829    0.008   99.381    0.000
    alc5_o            0.865    0.008  105.867    0.000
```

Amelia imutation results contradict ...

```
Regressions:
                   Estimate  Std.Err  z-value  P(>|z|)
  alcohol ~
    gotBully          0.298    0.007   41.621    0.000

Intercepts:
                   Estimate  Std.Err  z-value  P(>|z|)
   .gotBu1_o          0.000
   .gotBu2_o          0.000
   .gotBu3_o          0.000
   .gotBu4_o          0.000
   .gotBu5_o          0.000
   .gotBu6_o          0.000
   .gotBu7_o          0.000
   .gotBu8_o          0.000
   .gotBu9_o          0.000
   .alc1_o            0.000
   .alc2_o            0.000
   .alc3_o            0.000
   .alc4_o            0.000
   .alc5_o            0.000
    gotBully          0.000
   .alcohol           0.000

Thresholds:
                   Estimate  Std.Err  z-value  P(>|z|)
```

Amelia imutation results contradict ...

gotBu1_o|t1	0.047	0.019	2.444	0.015
gotBu1_o|t2	0.575	0.020	28.255	0.000
gotBu1_o|t3	0.891	0.022	40.154	0.000
gotBu1_o|t4	1.261	0.026	48.774	0.000
gotBu2_o|t1	0.190	0.019	9.833	0.000
gotBu2_o|t2	0.711	0.021	33.825	0.000
gotBu2_o|t3	1.050	0.024	44.632	0.000
gotBu2_o|t4	1.491	0.029	50.890	0.000
gotBu3_o|t1	0.695	0.021	33.214	0.000
gotBu3_o|t2	1.169	0.025	47.228	0.000
gotBu3_o|t3	1.541	0.030	51.022	0.000
gotBu3_o|t4	1.879	0.038	49.116	0.000
gotBu4_o|t1	0.255	0.019	13.155	0.000
gotBu4_o|t2	0.856	0.022	39.020	0.000
gotBu4_o|t3	1.208	0.025	47.936	0.000
gotBu4_o|t4	1.565	0.031	51.045	0.000
gotBu5_o|t1	0.807	0.022	37.361	0.000
gotBu5_o|t2	1.255	0.026	48.678	0.000
gotBu5_o|t3	1.569	0.031	51.047	0.000
gotBu5_o|t4	1.907	0.039	48.759	0.000
gotBu6_o|t1	1.029	0.023	44.104	0.000
gotBu6_o|t2	1.486	0.029	50.869	0.000
gotBu6_o|t3	1.840	0.037	49.572	0.000
gotBu6_o|t4	2.159	0.049	44.465	0.000
gotBu7_o|t1	0.565	0.020	27.838	0.000
gotBu7_o|t2	1.047	0.024	44.557	0.000

Amelia imutation results contradict ...

```
    gotBu7_o|t3     1.344    0.027    49.830    0.000
    gotBu7_o|t4     1.707    0.034    50.668    0.000
    gotBu8_o|t1     1.140    0.024    46.644    0.000
    gotBu8_o|t2     1.623    0.032    50.997    0.000
    gotBu8_o|t3     1.929    0.040    48.459    0.000
    gotBu8_o|t4     2.191    0.050    43.819    0.000
    gotBu9_o|t1     1.212    0.025    47.998    0.000
    gotBu9_o|t2     1.675    0.033    50.827    0.000
    gotBu9_o|t3     1.960    0.041    48.011    0.000
    gotBu9_o|t4     2.191    0.050    43.819    0.000
    alc1_o|t1       1.084    0.024    45.443    0.000
    alc1_o|t2       1.809    0.036    49.888    0.000
    alc1_o|t3       2.142    0.048    44.823    0.000
    alc1_o|t4       2.325    0.057    40.814    0.000
    alc2_o|t1       0.946    0.023    41.835    0.000
    alc2_o|t2       1.800    0.036    49.973    0.000
    alc2_o|t3       2.082    0.045    45.974    0.000
    alc2_o|t4       2.423    0.063    38.450    0.000
    alc3_o|t1       1.305    0.026    49.372    0.000
    alc3_o|t2       1.794    0.036    50.027    0.000
    alc3_o|t3       2.082    0.045    45.974    0.000
    alc3_o|t4       2.361    0.059    39.948    0.000
    alc4_o|t1       0.967    0.023    42.446    0.000
    alc4_o|t2       1.575    0.031    51.048    0.000
    alc4_o|t3       1.926    0.040    48.511    0.000
    alc4_o|t4       2.197    0.050    43.682    0.000
```

Amelia imutation results contradict ...

```
    alc5_o|t1          1.062    0.024   44.929    0.000
    alc5_o|t2          1.717    0.034   50.608    0.000
    alc5_o|t3          2.038    0.044   46.759    0.000
    alc5_o|t4          2.300    0.056   41.408    0.000

Variances:
                   Estimate   Std.Err   z-value   P(>|z|)
    gotBully          1.000
   .alcohol           1.000
   .gotBu1_o          0.515
   .gotBu2_o          0.487
   .gotBu3_o          0.464
   .gotBu4_o          0.482
   .gotBu5_o          0.396
   .gotBu6_o          0.357
   .gotBu7_o          0.492
   .gotBu8_o          0.392
   .gotBu9_o          0.383
   .alc1_o            0.277
   .alc2_o            0.391
   .alc3_o            0.133
   .alc4_o            0.252
   .alc5_o            0.185

Scales y*:
                   Estimate   Std.Err   z-value   P(>|z|)
```

Amelia imutation results contradict ...

```
    gotBu1_o          1.000
    gotBu2_o          1.000
    gotBu3_o          1.000
    gotBu4_o          1.000
    gotBu5_o          1.000
    gotBu6_o          1.000
    gotBu7_o          1.000
    gotBu8_o          1.000
    gotBu9_o          1.000
    alc1_o            1.000
    alc2_o            1.000
    alc3_o            1.000
    alc4_o            1.000
    alc5_o            1.000
```

Changes I would make

- The alcohol variables have empty or very small cells. All of the lavaan runs for ordinal models warn us about that. I'd probably combine levels 3, 4, 5
- Raise number of imputations to 20
- Include more auxiliary variables in the imputation model
- Fix semTable to
  - show the number of cases used in the results

References

Iannotti, R. J. (2005-200). *Health behavior in school-aged children (hbsc), 2005-2006 [Data file and code book]*. Retrieved from https://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/28241?q=HBSC

Muthén, L. K., & Muthén, B. O. (2017). *Mplus User's Guide* (8th ed.). Los Angeles, CA: Muthén & Muthén.

Rosseel, Y. (2012). lavaan: An r package for structural equation modeling. *Journal of Statistical Software*, *48*(2), 1-36. Retrieved from http://www.jstatsoft.org/v48/i02/

Session

```
sessionInfo()
```

```
R version 3.6.0 (2019-04-26)
Platform: x86_64-pc-linux-gnu (64-bit)
Running under: Ubuntu 19.04

Matrix products: default
BLAS:   /usr/lib/x86_64-linux-gnu/atlas/libblas.so.3.10.3
LAPACK: /usr/lib/x86_64-linux-gnu/atlas/liblapack.so.3.10.3

locale:
 [1] LC_CTYPE=en_US.UTF-8       LC_NUMERIC=C               LC_TIME=en_US.UTF-8
 [4] LC_COLLATE=en_US.UTF-8     LC_MONETARY=en_US.UTF-8    LC_MESSAGES=en_US.UTF-8
 [7] LC_PAPER=en_US.UTF-8       LC_NAME=C                  LC_ADDRESS=C
[10] LC_TELEPHONE=C             LC_MEASUREMENT=en_US.UTF-8 LC_IDENTIFICATION=C

attached base packages:
[1] stats     graphics  grDevices utils     datasets  methods   base

other attached packages:
[1] mitools_2.4     mice_3.5.0      lattice_0.20-38 semTable_1.6    lavaan_0.6-3

loaded via a namespace (and not attached):
 [1] stationery_0.98.6 tidyselect_0.2.5  xfun_0.7          purrr_0.3.2       splines_3.6.0
 [6] generics_0.0.2    htmltools_0.3.6   stats4_3.6.0      pan_1.6           survival_2.44-1.1
[11] rlang_0.3.4       jomo_2.6-8        pillar_1.4.0      nloptr_1.2.1      foreign_0.8-71
[16] glue_1.3.1        DBI_1.0.0         plyr_1.8.4        zip_2.0.2         kutils_1.69
[21] evaluate_0.13     knitr_1.22        parallel_3.6.0    broom_0.5.2       Rcpp_1.0.1
[26] xtable_1.8-4      backports_1.1.4   lme4_1.1-21       mnormt_1.5-5      digest_0.6.18
[31] openxlsx_4.1.0    dplyr_0.8.1       grid_3.6.0        tools_3.6.0       magrittr_1.5
[36] tibble_2.1.1      crayon_1.3.4      tidyr_0.8.3       pbivnorm_0.6.0    pkgconfig_2.0.2
[41] MASS_7.3-51.4     Matrix_1.2-17     assertthat_0.2.1  minqa_1.2.4       rmarkdown_1.12
```

Session ...

```
[46] mitml_0.3-7       R6_2.4.0          boot_1.3-22       rpart_4.1-15      nnet_7.3-12
[51] nlme_3.1-140      compiler_3.6.0
```