Supplementary Material

1 RESULTS SIMULATION STUDY: TYPE I ERROR RATE
Table S1. Empirical Type I error rate from the simulation study with the indicators having an overall reliability of 80% and a linear relationship with the latent variable. Extreme deviations from 5% are indicated in bold.

| Setting | Linear WMW – max rel | WMW – mean | t test – max rel | t test – mean | SEM | SEM – corrected |
|---------|---------------------|------------|------------------|--------------|-----|-----------------|
| **N(0, 1)** |                    |            |                  |              |     |                 |
| m = n = 15 |                  |            |                  |              |     |                 |
| Setting 1 | 4.8 | 5.0 | 5.2 | 5.5 | 5.2 | 4.9 |
| Setting 2 | 4.4 | 4.4 | 4.3 | 4.7 | 4.8 | 4.5 |
| Setting 3 | 4.7 | 4.6 | 5.0 | 5.5 | 5.3 | 5.1 |
| Setting 4 | 4.7 | 5.1 | 5.9 | 6.3 | 6.2 | 6.2 |
| m = n = 50 |                  |            |                  |              |     |                 |
| Setting 1 | 4.8 | 4.8 | 5.3 | 4.8 | 6.1 | 5.8 |
| Setting 2 | 5.3 | 5.1 | 6.4 | 6.0 | 6.6 | 6.5 |
| Setting 3 | 4.3 | 3.8 | 4.8 | 4.6 | 5.1 | 5.1 |
| Setting 4 | 5.6 | 5.2 | 6.0 | 5.3 | 6.8 | 6.9 |
| m = n = 100 |                |            |                  |              |     |                 |
| Setting 1 | 3.9 | 3.9 | 3.8 | 3.8 | 3.8 | 3.7 |
| Setting 2 | 6.2 | 6.1 | 5.6 | 5.3 | 5.6 | 5.6 |
| Setting 3 | 5.5 | 5.5 | 6.1 | 6.0 | 6.3 | 6.3 |
| Setting 4 | 4.6 | 6.0 | 4.2 | 5.7 | 5.1 | 5.0 |

| Setting | Linear WMW – max rel | WMW – mean | t test – max rel | t test – mean | SEM | SEM – corrected |
|---------|---------------------|------------|------------------|--------------|-----|-----------------|
| **Laplace(0, 1.25)** |                    |            |                  |              |     |                 |
| m = n = 15 |                  |            |                  |              |     |                 |
| Setting 1 | 4.8 | 5.2 | 5.8 | 5.8 | 5.4 | 5.4 |
| Setting 2 | 3.8 | 3.7 | 4.4 | 3.9 | 4.8 | 4.4 |
| Setting 3 | 4.7 | 4.9 | 5.2 | 5.3 | 5.4 | 5.9 |
| Setting 4 | 4.1 | 4.1 | 4.7 | 4.5 | 5.1 | 5.4 |
| m = n = 50 |                  |            |                  |              |     |                 |
| Setting 1 | 5.0 | 5.3 | 5.6 | 5.6 | 6.0 | 6.1 |
| Setting 2 | 4.7 | 5.5 | 4.6 | 4.7 | 5.2 | 5.4 |
| Setting 3 | 4.6 | 4.7 | 4.6 | 5.1 | 5.3 | 5.5 |
| Setting 4 | 5.2 | 4.4 | 5.2 | 5.0 | 6.3 | 5.9 |
| m = n = 100 |                |            |                  |              |     |                 |
| Setting 1 | 5.1 | 5.5 | 3.9 | 3.8 | 4.1 | 4.2 |
| Setting 2 | 5.0 | 5.2 | 5.3 | 5.1 | 5.8 | 5.8 |
| Setting 3 | 5.1 | 5.4 | 5.3 | 5.3 | 5.5 | 5.7 |
| Setting 4 | 5.0 | 4.7 | 3.7 | 4.2 | 4.5 | 4.5 |

| Setting | Linear WMW – max rel | WMW – mean | t test – max rel | t test – mean | SEM | SEM – corrected |
|---------|---------------------|------------|------------------|--------------|-----|-----------------|
| **Exp** |                     |            |                  |              |     |                 |
| m = n = 15 |                  |            |                  |              |     |                 |
| Setting 1 | 4.5 | 4.8 | 5.6 | 5.3 | 5.6 | 6.0 |
| Setting 2 | 4.0 | 3.8 | 5.4 | 4.7 | 5.1 | 5.1 |
| Setting 3 | 3.4 | 3.7 | 4.1 | 3.9 | 3.9 | 4.0 |
| Setting 4 | 4.6 | 4.5 | 4.9 | 5.5 | 5.5 | 5.1 |
| m = n = 50 |                  |            |                  |              |     |                 |
| Setting 1 | 4.1 | 4.6 | 4.6 | 4.9 | 5.3 | 5.3 |
| Setting 2 | 4.6 | 4.6 | 3.9 | 4.2 | 4.2 | 4.4 |
| Setting 3 | 3.6 | 3.8 | 3.6 | 3.9 | 4.2 | 4.2 |
| Setting 4 | 4.0 | 5.2 | 4.7 | 5.2 | 6.0 | 6.0 |
| m = n = 100 |                 |            |                  |              |     |                 |
| Setting 1 | 4.6 | 4.1 | 5.4 | 5.2 | 6.0 | 5.8 |
| Setting 2 | 5.3 | 5.2 | 4.7 | 4.6 | 4.8 | 4.9 |
| Setting 3 | 4.2 | 4.6 | 4.0 | 4.1 | 4.1 | 4.1 |
| Setting 4 | 5.3 | 5.8 | 5.1 | 5.9 | 6.0 | 6.0 |
Table S2. Empirical Type I error rate from the simulation study with the indicators having an overall reliability of 60% and a linear relationship with the latent variable. Extreme deviations from 5% are indicated in bold.

|                  | Linear |                  |                  |                  |                  |                  |
|------------------|--------|------------------|------------------|------------------|------------------|------------------|
|                  | WMW – max rel | WMW – mean | \( t \) test – max rel | \( t \) test – mean | SEM | SEM – corrected |
| \( \Lambda(0, 1) \) |        |                  |                  |                  |                  |                  |
| \( m = n = 15 \) |        |                  |                  |                  |                  |                  |
| Setting 1        | 4.2    | 4.6              | 4.6              | 5.1              | 5.1             | 4.9              |
| Setting 2        | 3.8    | 3.7              | 4.2              | 4.3              | 4.1             | 4.3              |
| Setting 3        | 4.8    | 4.8              | 5.3              | 5.4              | 4.9             | 4.9              |
| Setting 4        | 5.0    | 5.4              | 5.8              | 6.1              | 5.9             | 6.2              |
| \( m = n = 50 \) |        |                  |                  |                  |                  |                  |
| Setting 1        | 5.1    | 5.2              | 5.8              | 5.0              | 6.3             | 6.1              |
| Setting 2        | 5.4    | 5.6              | 6.4              | 6.4              | 6.9             | 6.9              |
| Setting 3        | 4.4    | 4.0              | 5.4              | 4.9              | 5.6             | 5.6              |
| Setting 4        | 6.0    | 4.9              | 5.9              | 5.7              | 6.7             | 6.6              |
| \( m = n = 100 \) |        |                  |                  |                  |                  |                  |
| Setting 1        | 4.4    | 4.7              | 4.0              | 4.0              | 4.0             | 4.1              |
| Setting 2        | 5.8    | 5.7              | 5.2              | 5.1              | 5.5             | 5.7              |
| Setting 3        | 6.0    | 6.1              | 6.3              | 6.2              | 6.6             | 6.6              |
| Setting 4        | 5.0    | 5.5              | 4.8              | 6.0              | 4.9             | 5.1              |
| \( \Lambda(0.1, 25) \) |        |                  |                  |                  |                  |                  |
| \( m = n = 15 \) |        |                  |                  |                  |                  |                  |
| Setting 1        | 4.8    | 5.2              | 5.2              | 6.5              | 5.6             | 5.2              |
| Setting 2        | 3.6    | 3.6              | 4.5              | 4.3              | 4.3             | 3.9              |
| Setting 3        | 4.4    | 4.7              | 4.7              | 5.4              | 4.9             | 5.4              |
| Setting 4        | 5.0    | 4.5              | 5.9              | 5.5              | 5.6             | 5.5              |
| \( m = n = 50 \) |        |                  |                  |                  |                  |                  |
| Setting 1        | 5.5    | 5.5              | 5.1              | 5.5              | 5.6             | 5.7              |
| Setting 2        | 5.3    | 5.1              | 5.2              | 5.1              | 6.0             | 6.0              |
| Setting 3        | 4.8    | 4.9              | 4.9              | 5.2              | 5.6             | 5.6              |
| Setting 4        | 5.0    | 4.4              | 5.1              | 4.7             | 5.5             | 5.3              |
| \( \exp(0, 1) \) |        |                  |                  |                  |                  |                  |
| \( m = n = 15 \) |        |                  |                  |                  |                  |                  |
| Setting 1        | 4.9    | 4.9              | 4.1              | 4.1              | 4.4             | 4.4              |
| Setting 2        | 4.7    | 5.4              | 5.2              | 4.9              | 5.7             | 5.6              |
| Setting 3        | 5.9    | 5.9              | 5.3              | 5.4              | 5.5             | 5.6              |
| Setting 4        | 4.5    | 4.1              | 4.2              | 3.8              | 4.9             | 4.9              |
Table S3. Empirical Type I error rate from the simulation study with the indicators having an overall reliability of 80% and a non-linear relationship with the latent variable. Extreme deviations from 5% are indicated in bold.

|               | Non-linear |               | Non-linear |               |
|---------------|------------|---------------|------------|---------------|
|               | WMW – max rel | WMW – mean | t test – max rel | t test – mean | SEM | SEM – corrected |
| \(\Lambda/(0,1)\) |           |               |            |               |     |                  |
| \(m = n = 15\) |           |               |            |               |     |                  |
| Setting 1     | 5.0       | 4.8           | 4.6        | 4.8           | 4.7 | 5.3               |
| Setting 2     | 4.4       | 4.1           | 4.1        | 4.8           | 4.9 | 4.2               |
| Setting 3     | 4.2       | 4.6           | 5.3        | 5.4           | 5.3 | 5.3               |
| Setting 4     | 5.0       | 5.2           | 5.9        | 5.4           | 6.2 | 6.6               |
| \(m = n = 50\) |           |               |            |               |     |                  |
| Setting 1     | 4.7       | 4.6           | 4.8        | 4.6           | 5.6 | 5.9               |
| Setting 2     | 5.3       | 4.8           | 5.7        | 5.8           | 6.3 | 6.4               |
| Setting 3     | 4.6       | 4.3           | 4.9        | 5.3           | 5.8 | 5.6               |
| Setting 4     | 5.6       | 5.3           | 6.6        | 5.2           | 7.1 | 7.1               |
| \(m = n = 100\) |          |               |            |               |     |                  |
| Setting 1     | 4.0       | 3.5           | 3.9        | 3.6           | 4.2 | 4.1               |
| Setting 2     | 6.1       | 6.2           | 5.0        | 4.7           | 5.6 | 5.7               |
| Setting 3     | 5.5       | 5.5           | 5.9        | 6.0           | 6.3 | 6.3               |
| Setting 4     | 5.1       | 6.1           | 3.9        | 5.6           | 4.4 | 4.5               |
| \(\tilde{\lambda}\) |           |               |            |               |     |                  |
| \(m = n = 15\) |           |               |            |               |     |                  |
| Setting 1     | 4.5       | 4.4           | 5.0        | 4.6           | 5.0 | 4.4               |
| Setting 2     | 4.8       | 4.9           | 5.4        | 5.8           | 5.3 | 5.4               |
| Setting 3     | 4.3       | 4.5           | 3.8        | 4.3           | 4.4 | 4.4               |
| Setting 4     | 4.3       | 4.8           | 4.4        | 5.7           | 5.3 | 5.4               |
| \(m = n = 50\) |           |               |            |               |     |                  |
| Setting 1     | 5.5       | 5.0           | 5.4        | 5.0           | 5.6 | 5.4               |
| Setting 2     | 3.6       | 3.5           | 4.5        | 4.2           | 4.8 | 4.6               |
| Setting 3     | 4.5       | 4.3           | 3.7        | 3.5           | 4.4 | 4.1               |
| Setting 4     | 3.6       | 4.5           | 3.7        | 4.8           | 4.8 | 4.5               |
| \(m = n = 100\) |          |               |            |               |     |                  |
| Setting 1     | 4.7       | 4.9           | 4.0        | 4.1           | 4.1 | 4.1               |
| Setting 2     | 4.8       | 5.0           | 5.1        | 4.8           | 5.6 | 5.2               |
| Setting 3     | 4.3       | 4.4           | 4.6        | 4.6           | 4.9 | 4.8               |
| Setting 4     | 4.6       | 5.9           | 4.6        | 6.3           | 5.8 | 5.7               |
Table S4. Empirical Type I error rate from the simulation study with the indicators having an overall reliability of 60% and a non-linear relationship with the latent variable. Extreme deviations from 5% are indicated in bold.

|                  | Non-linear |                  |                  |                  |                  |                  |                  |
|------------------|------------|------------------|------------------|------------------|------------------|------------------|------------------|
|                  |            | WMW – max rel    | WMW – mean       | t test – max rel | t test – mean    | SEM              | SEM – corrected  |
|                  |            |                  |                  |                  |                  |                  |                  |
| $\Lambda(0, 1)$ |            |                  |                  |                  |                  |                  |                  |
| $m = n = 15$     |            |                  |                  |                  |                  |                  |                  |
| Setting 1        | 4.2        | 4.5              | 4.8              | 5.1              | 5.5              | 4.9              |
| Setting 2        | 3.4        | 4.2              | 3.6              | 4.0              | 4.2              | 4.2              |
| Setting 3        | 5.0        | 5.0              | 5.3              | 5.3              | 5.3              | 5.2              |
| Setting 4        | 4.2        | 5.2              | 5.4              | 5.9              | 6.0              | 6.7              |
| $m = n = 50$     |            |                  |                  |                  |                  |                  |                  |
| Setting 1        | 5.5        | 5.4              | 5.5              | 5.2              | 6.1              | 6.2              |
| Setting 2        | 5.4        | 5.6              | 6.3              | 6.5              | 6.2              | 6.4              |
| Setting 3        | 4.4        | 4.2              | 4.7              | 5.0              | 5.1              | 5.5              |
| Setting 4        | 5.8        | 5.1              | 6.1              | 5.6              | 6.4              | 6.3              |
| $m = n = 100$    |            |                  |                  |                  |                  |                  |                  |
| Setting 1        | 4.4        | 4.4              | 4.1              | 4.4              | 4.2              | 4.1              |
| Setting 2        | 5.9        | 5.8              | 5.5              | 5.2              | 5.6              | 5.6              |
| Setting 3        | 6.0        | 6.3              | 6.4              | 6.2              | 6.7              | 6.6              |
| Setting 4        | 5.0        | 5.5              | 4.4              | 5.5              | 4.6              | 4.9              |
| $\frac{1}{\gamma}$ |            |                  |                  |                  |                  |                  |                  |
| $m = n = 15$     |            |                  |                  |                  |                  |                  |                  |
| Setting 1        | 4.2        | 4.2              | 5.3              | 4.7              | 5.0              | 4.4              |
| Setting 2        | 5.2        | 5.1              | 5.3              | 5.7              | 5.3              | 5.2              |
| Setting 3        | 4.1        | 4.3              | 4.8              | 4.6              | 5.3              | 5.2              |
| Setting 4        | 4.8        | 5.5              | 5.5              | 5.5              | 5.4              | 4.7              |
| $m = n = 50$     |            |                  |                  |                  |                  |                  |                  |
| Setting 1        | 5.7        | 5.7              | 6.0              | 4.9              | 6.6              | 6.5              |
| Setting 2        | 3.5        | 3.0              | 4.1              | 4.0              | 4.6              | 4.0              |
| Setting 3        | 4.4        | 4.2              | 3.9              | 3.6              | 4.3              | 4.1              |
| Setting 4        | 4.3        | 4.5              | 4.3              | 4.6              | 4.6              | 4.6              |
| $m = n = 100$    |            |                  |                  |                  |                  |                  |                  |
| Setting 1        | 5.1        | 4.8              | 4.0              | 4.0              | 4.3              | 4.1              |
| Setting 2        | 5.0        | 5.4              | 4.9              | 5.5              | 5.6              | 5.5              |
| Setting 3        | 5.3        | 5.0              | 4.5              | 4.6              | 4.5              | 4.5              |
| Setting 4        | 5.2        | 5.8              | 5.0              | 6.2              | 5.7              | 5.6              |
Figure S1. Q–Q plots for (A) the Patient Health Questionnaire-9 (PHQ-9), (B) the Center for Epidemiological Studies Depression Scale-10 (CESD-10) and (C) the eight-item PROMIS Depression Short Form (PROMIS D-8). A visual inspection shows that the assumption of location shift for the indicators is reasonably met.